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METHOD AND APPARATUS FOR SEPARATING COMPRESSIBLE AND
INCOMPRESSIBLE FLUIDS IN A MIXTURE THEREOF
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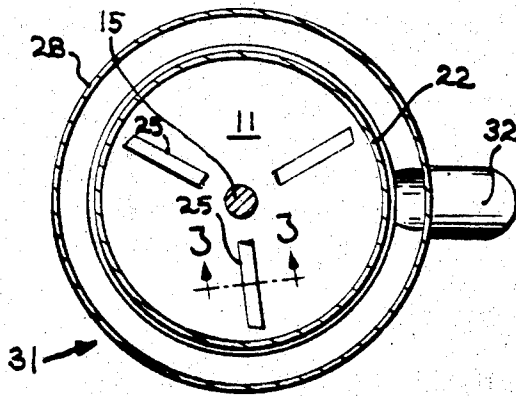


FIG. 2

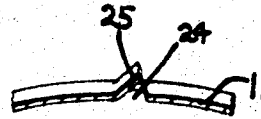


FIG. 3

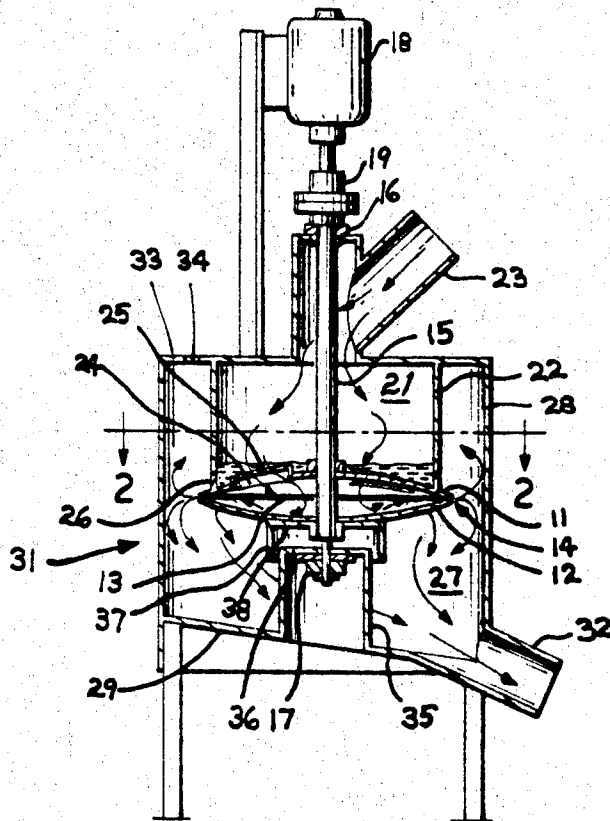


FIG. 1

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METHOD AND APPARATUS FOR SEPARATING COMPRESSIBLE AND INCOMPRESSIBLE FLUIDS IN A MIXTURE THEREOF

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ABSTRACT OF THE DISCLOSURE

An improved apparatus for effecting separation of compressible and incompressible fluids in a supply fluid including a mixture thereof is provided. Means are provided to break foam by expelling the foam bearing liquid in a thin stream from a unitary rotating chamber through a restricted orifice formed adjacent a peripheral portion of the chamber remote from means for rotating the chamber. A scoop or impeller is provided for impelling fluid into the chamber. Restricted fluid outlet means is formed within an apex portion defined by a converging portion of the wall means forming the chamber which comes together at an acute angle adjacent a peripheral portion of the chamber remote from the rotating means so that the fluid is pressurized in a relatively small area. The method and apparatus contemplated herein are especially useful in breaking the foam of black liquor filtrate from a pulp washer in a paper mill.

This invention relates to the method of, and apparatus for, separating compressible and incompressible fluids in a supply fluid comprising a mixture thereof. More particularly, the invention relates to the method of, and apparatus for, eliminating entrained air in the foam of a liquid. More particularly, the invention relates to the method of, and apparatus for, eliminating entrained air in the foam of a liquid used in the process of preparing stock for use on a papermaking machine. More particularly, the invention relates to the method of, and apparatus for, eliminating entrained air in black liquor foam from a pulp washer.

In many industrial processes involving the recycling of a treating liquid, for example a pulping liquid used in a papermaking process such as black liquor, there results in the substantial introduction of incompressible fluids, specifically air, into the treating liquid resulting in a mixture of compressible and incompressible fluids usually referred to as foam or froth. Generally speaking, the foam resulting from the entrainment of air by the treating liquid is undesirable in that it leads to reduction of mass storage capacity of storage tanks, it results in inaccurate measurements on the part of metering equipment associated with process control means, and it leads to the air binding of pumps. In papermaking operations, the foaming of pulping liquids is further undesirable in that it results in a general loss of pulp mill chemicals and by-products.

In accordance with the prior art, the use of mechanical foam breakers of a multitude of configurations is known. Such devices function to break or collapse a foamed liquid by disengaging the entrained air therefrom by subjecting the foam to mechanical action. For various reasons, however, the known devices of the prior art are inferior to devices in accordance with the present invention.

Accordingly, it is an object of the present invention to provide improved method and apparatus for separating compressible and incompressible fluids in a supply fluid comprising a mixture thereof. Stated in another way, it is an object of the present invention to provide improved apparatus and method for deaerating an aerated liquid. Specifically, it is an object of the present invention to

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provide improved apparatus and method for breaking a foam.

In accordance with the present invention, a supply fluid comprising a mixture of compressible and incompressible fluids is delivered under pressure into a pressurized region or chamber that is generally enclosed except for suitable fluid inlet port means and for restricted fluid outlet means which, preferably are of an area which is relatively small in relationship to the area of the fluid inlet port means.

The chamber containing the pressurized fluid is caused to rotate rapidly about an axis extending at a substantial angle to a plane through the fluid outlet means. In the preferred embodiment, the fluid outlet means comprises a restricted peripheral opening in a chamber of a generally circular configuration and the chamber is caused to rotate about an axis extending through the center thereof and perpendicular to the restricted peripheral opening. Rotation of the chamber in this manner results in rotation of the pressurized fluid therein thereby leading to the expulsion of pressurized fluid from the chamber through the fluid outlet means to a surrounding less highly pressurized region partly by virtue of centrifugal force and partly by virtue of the pressurization of the fluid within the chamber. Thus the depressurization of the fluid as it is expelled through the restricted fluid outlet means leads to expansion of the compressible fluid portion of the supply fluid and disengagement of a substantial portion of the compressible fluid from the remainder of the fluid. This disengagement is enhanced by the inherent small cross-sectional area of the expelled stream resulting from its expulsion through a restricted outlet.

Subsequently, the expelled liquid, which at that time comprises a compressible fluid-lean mixture of compressible and incompressible fluids, is further reduced in compressible fluid content by rapidly decelerating the fluid. The step of decelerating the compressible fluid-lean supply fluid is accomplished by circumposing the rotating chamber with a wall spaced suitably close to the outlet of the chamber to be impinged against by the fluid being expelled therefrom while said fluid is traveling at a high velocity. Preferably, the wall so circumposing the rotating chamber is disposed generally perpendicular to the direction of movement of the expelled fluid. Impingement of the rapidly moving compressible fluid-lean mixture of compressible and incompressible fluids against the circumposing wall in the foregoing manner results in further disengagement of compressible fluid from the mixture. When the fluid delivered to the rotating chamber is at a suitably high pressure and the chamber is rotated at a suitably high rotational velocity and the outlet port means therefrom is suitably restricted, the degree of disengagement of compressible fluid from the original mixture of compressible and incompressible fluids will be sufficiently complete to permit the resulting incompressible fluid to be reused without loss of tank capacity, faulty measurements, air binding of pumps, etc., which would result from attempted reuse of the supply fluid by virtue of its content of compressible fluid. For a further understanding of the invention, attention is directed to the following portion of the specification, the drawing, and the appended claims.

In the drawing:

FIG. 1 is an elevational view in cross section of a preferred embodiment of apparatus in accordance with the present invention and having utility in practicing the method in accordance with the present invention;

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1; and

FIG. 3 is a fragmentary sectional view taken on line 3—3 of FIG. 2.

In accordance with the preferred embodiment of the present invention, there is provided first and second dish-

shaped members 11 and 12 of substantially equal diameter which are disposed with their concave portions facing one another and which are suitably spaced apart from one another to define a chamber 13 having a restricted peripheral opening 14 therein. Dish-shaped members 11 and 12 are each secured to a shaft 15 which passes through central portions thereof and which extends along an axis disposed generally perpendicular to a plane through peripheral opening 14. Shaft 15 is mounted in bearings 16 and 17 and is connected to a motor 18 by means of a coupling 19 and is thereby caused to rotate at a high rotational velocity.

A supply fluid to be deaerated, for example the black liquor foam from the filters of pulp washers used in a papermaking operation, is delivered to a supply chamber 21 which is in communication with chamber 13 and which is defined by means comprising a wall 22 coaxial with shaft 15, the supply fluid being delivered to chamber 21 by way of inlet conduit 23.

Supply fluid is delivered from chamber 21 to rotating chamber 13 by providing dish-shaped member 11 with port means shown as comprising a plurality of individual ports 24. The supply fluid from chamber 21 is pressurized as it is delivered to chamber 13 through ports 24 by providing dish-shaped member 11 with an impeller or scoop 25 in the region of each port 24 for forcing supply fluid therethrough and also by constructing port means 24 with a cross-sectional area that is relatively large in relation to the cross-sectional area of peripheral opening 14.

In the illustrated embodiment of the invention, it is to be noted that the wall means defining chamber 21, in addition to comprising a stationary non-rotating wall portion 22 as previously described, also comprises an upstanding wall portion 26 axially aligned with wall 22 and attached to the top of dish-shaped member 11 and rotational therewith. The bottom of wall 22 and the top of wall 26 are spaced sufficiently close to one another as to leave a clearance therebetween sufficient only for the relative rotational movement thereof.

Rotating chamber 13 is surrounded by a region of reduced pressure 27, for example a region of atmospheric pressure, by circumposing it by a wall 28 which is also, preferably, circular. Wall 28 is disposed at a substantial angle to a plane normal to the axis of rotation of members 11 and 12, preferably perpendicular thereto, and is spaced sufficiently close to opening 14 to be impinged against by fluid expelled therefrom. Wall 28, in combination with bottom wall 29, also forms a vessel 31 for collecting incompressible fluid after disengagement of compressible fluid therefrom. The collected fluid is thereupon returned to be reused, for example to a storage tank, by way of outlet connection 32. Vessel 31 is also provided with a top wall 33 having port means 34 therein for the venting of disengaged compressible fluid.

Among the structural features of the illustrated embodiment of the invention is the structure used for the mounting of bearing 17. Bottom wall 29 is of annular configuration having an upstanding wall 35 extending from its inner edge. Wall 35 is traversed at its upper extent by another annular wall 36 to which bearing 17 is attached. A vertical wall 37 of greater diameter than wall 35 and coaxial therewith is attached to shaft 15 by means of a plate 38. Wall 37 extends down past the upper edge of wall 35 and rotation of wall 37 serves to keep liquid out of bearing 17 by means of centrifugal force.

It is believed that the best mode known to me to carry out this invention has been described above in terms sufficient full, clear, concise and exact as to enable any person skilled in the art to make and use the same. It is to be understood, however, that it is within my contemplation that certain modifications of the above-described mode of practicing the invention can be made by a skilled artisan without departing from the scope of the invention and, it is, therefore, desired to limit the invention only in accordance with the appended claims.

I claim:

1. The method of effecting separation of compressible and incompressible fluids in a supply fluid comprising a mixture of black liquor filtrate foam from a pulp washer in a paper mill, said method comprising the steps of: continuously introducing supply fluid under pressure into a pressurized region that is generally enclosed except for fluid inlet port means and restricted fluid outlet means; surrounding the pressurized region with a region of reduced pressure; providing a second region of reduced pressure in fluid communication with said pressurized region; maintaining a body of fluid in said second region; pumping fluid from said second region into said pressurized region; rotating the fluid in the pressurized region about an axis extending at a substantial angle to the outlet means to expel a thin stream of said fluid therefrom to said region of reduced pressure partly by centrifugal force; and abruptly changing the velocity of the expelled fluid in the region of reduced pressure.

2. The method of claim 1 wherein said pumping step is accomplished by providing scooping means and by effecting rapid motion of said scooping means through said body of fluid.

3. The method of breaking a foam including a gas entrapped in a liquid, said method comprising the steps of: continuously supplying foam under pressure for introduction into a pressurized chamber having foam inlet port means and restricted liquid outlet means; providing a supply region of reduced pressure communicating with the pressurized chamber from which foam is supplied into the chamber; surrounding the pressurized chamber with an expulsion region of reduced pressure in communication with the pressurized chamber into which liquid is expelled from said restricted outlet means; providing a collection region of reduced pressure maintaining a body of liquid expelled from said restricted outlet means; pumping foam from said supply region of reduced pressure into said pressurized chamber; rotating said pressurized chamber about an axis extending at a substantial angle to the outlet means pressurizing said foam in a relatively small area in said restricted liquid outlet means; and expelling a thin stream of liquid through said restricted liquid outlet means into said expulsion region of reduced pressure at least partially by centrifugal force.

4. The method of claim 3 wherein said pumping step is accomplished by providing scooping means and by effecting rapid motion of said scooping means through said foam; and providing a surface to suddenly decelerate said expelled liquid.

5. Apparatus for effecting separation of compressible and incompressible fluids in a supply fluid comprising a mixture thereof, said apparatus comprising, in combination: wall means defining a chamber having restricted fluid outlet means; rotating means for rotating said chamber about an axis extending at a substantial angle to a plane through said fluid outlet means said restricted fluid outlet means being formed within said wall means adjacent a peripheral portion of the chamber remote from the rotating means; pump means external to the chamber and attached to the chamber wall means upstream thereof for delivering said supply fluid under positive pressure to said chamber for expulsion therefrom through said outlet means; and second wall means disposed closely adjacent said outlet means externally of said chamber for said expelled fluid to impinge against.

6. Apparatus in accordance with claim 5 and further comprising: third wall means defining, with said chamber, a second chamber in fluid communication therewith for receiving said supply fluid; and wherein said pump means comprises impeller means carried by said chamber for impelling supply fluid from said second chamber into said chamber.

7. Apparatus in accordance with claim 5 wherein said rotating means comprises a shaft and means for rotating said shaft and wherein said wall means comprises first

and second members secured to said shaft, at least one of which is dish-shaped, and is disposed with its concave portions facing toward the other member, said members being suitably spaced apart from one another to define said restricted fluid outlet means.

8. Apparatus in accordance with claim 7 wherein the other of said members is also dish-shaped and is disposed with its concave surface facing the concave surface of said one member.

9. Apparatus for effecting separation of compressible and incompressible fluids in a supply fluid comprising a mixture thereof, said apparatus comprising, in combination: first and second members, at least one of which is dish-shaped and is disposed with its concave portion facing toward the other member defining a chamber, said members being suitably spaced apart from one another to define restricted fluid outlet means from said chamber; a shaft extending through said chamber and secured to each of said members; means for imparting rotational movement to said shaft; means for delivering the supply fluid to said chamber under positive pressure, said means comprising port means in one of said members, a supply fluid chamber in communication with said chamber through said port means and impeller means secured to said one of the members and located externally of said chamber for impelling supply fluid from said supply fluid chamber through said port means into said chamber when said shaft is rotated; and a wall circumposing said restricted fluid outlet means and at a location externally of said chamber for said expelled fluid to be impinged against.

10. Apparatus in accordance with claim 9 wherein the area of said port means is relatively large in relationship to the area of said fluid outlet means.

11. Apparatus for effecting separation of compressible and incompressible fluid in a supply fluid comprising a mixture thereof, said apparatus comprising, in combination: first and second dish-shaped members of substantially equal diameter generally horizontally disposed with their concave portions facing one another and being suitably spaced apart from one another to define a chamber with a restricted peripheral opening therein; a generally vertically disposed shaft extending through a generally centrally-disposed portion of each of said dish-shaped members and secured thereto; means for imparting rotational movement to said shaft and said first and second dish-shaped members; a generally vertically upstanding cylindrical wall disposed above the upper of said dish-shaped members and defining, therewith, a second chamber for receiving a supply of said supply fluid; port means in the upper of said dish-shaped members providing an inlet for supply fluid from said second chamber to said chamber; means carried by the upper of said dish-shaped members for forcing supply fluid from said second chamber through said port means into said chamber; and a second generally vertically upstanding cylindrical wall surrounding the peripheral opening of said chamber and spaced suitably close thereto to be impinged against by fluid issuing therefrom when said shaft is rotated.

12. Apparatus in accordance with claim 11 wherein said second cylindrical wall comprises: a first portion attached to the upper of the dish-shaped members and rotational therewith; and a second portion aligned with the first portion, closely adjacent thereto and being non-rotational therewith.

13. Apparatus in accordance with claim 11 wherein the area of said port means is relatively large in relationship to the area of said peripheral opening.

14. Apparatus in accordance with claim 13 and further comprising a bottom plate disposed at an elevation beneath the lower of said dish-shaped members and defining, with said second cylindrical wall, a vessel for collecting incompressible fluid after said fluid issuing from the peripheral opening has impinged against said second cylindrical wall.

15. Apparatus in accordance with claim 11 and further comprising: means for maintaining a supply of said supply fluid in said second chamber.

16. Apparatus in accordance with claim 15 wherein said vessel is provided with vent means at an elevated location for venting compressible fluid therefrom.

17. Foam deaerating apparatus comprising, in combination: a circular dish-shaped member; a second circular member facing the concave surface of the dish-shaped member and spaced apart therefrom to define a chamber therewith having a restricted peripheral opening of substantially uniform thickness; means for rotating said circular members in conjunction about an axis extending generally centrally thereof and generally perpendicular to a plane through the peripheral opening; means defining, with one of said circular members, a supply chamber; means for introducing a supply of foam into said supply chamber; port means in said one of the circular members providing communication from said supply chamber to said chamber, the area of said port means being relatively large in relationship to the area of said peripheral opening; and means carried by said one of the circular members and located externally of said chamber and rotational therewith to force foam from the supply chamber into said chamber for expulsion therefrom through said peripheral opening.

18. Apparatus in accordance with claim 17 and further comprising a wall surrounding the chamber defined by said first and second circular members and spaced proximately to the peripheral opening therein, said wall being disposed at a substantial angle to a plane normal to the axis of rotation of the circular members.

19. Apparatus in accordance with claim 18 wherein said wall is circular in transverse section and wherein said wall is concentric with the axis of rotation of the circular members.

20. Apparatus for effecting separation of compressible and incompressible fluids in a supply fluid comprising a mixture thereof, said apparatus comprising, in combination: wall means defining a chamber having restricted fluid outlet means; rotating means for rotating said chamber about an axis extending at a substantial angle to a plane through said fluid outlet means; said restricted fluid outlet means being formed within said wall means adjacent a peripheral portion of the chamber remote from the rotating means; a port in said wall means defining the chamber; and an impeller secured to said chamber adjacent said port and located externally of said chamber for impelling supply fluid through said port into said chamber.

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