SELF RETURNING CONTAMINATION BARRIER

FIELD OF THE INVENTION

The present invention relates generally to contamination barriers for pumps, and more particularly in one aspect to a breastpump assembly including an improved barrier to prevent milk from entering and possibly contaminating a pumping mechanism for the breastpump.

BACKGROUND OF THE INVENTION

Breastpumps are well known, and generally comprise a hood or shield that fits over the breast, a vacuum pump connected to the hood for generating an intermittent vacuum (or negative pressure) within the breastshield, and a receptacle for expressed milk. Negative pressure is pressure below atmospheric pressure. The intermittent suction action of the vacuum pump serves to pull on the breast and nipple and thereby express milk. The expressed milk typically flows from the hood, through a conduit structure and into a collection container, such as a baby bottle, for storage and later use.

Breastpumps can be manually or electrically operated. With manually operated pumps, the pumping action is done by reciprocating a piston or lever by hand, or compressing a flexible bulb, as shown in Medela's U.S. Publication No. 2004/0039330. With electrically operated pumps, the pumping action generated by a motor driven pump and typically conveyed by an air hose, or air line, that connects to the breastshield assembly.

In most instances, the pressure applied at the breast is a negative pressure (suction). That negative pressure is typically applied to the interior of the breastshield

in a singular fashion, that is, without any kind of differential vacuum application over the breastshield as a whole. This has ordinarily been done through a cyclic pattern, e.g., intermittent suction. Breastpumps of this kind, which only pull and release suction, are known as simple pumps.

There are also breastpumps that apply a vacuum pressure and a positive pressure, typically applied to the interior of the breastshield, known as complex pumps. Typically, a vacuum pump that generates a positive pressure, (pressure above atmospheric pressure,) assists in forcing the expressed milk through a valve and into the collection container. A breastpump of the foregoing type is shown in U.S. Patent No. 4,857,051 to Larsson, the disclosure of which is incorporated herein by reference for further details of a breastpump assembly in general.

Positive pressure opens the valve, often used with breastpumps, to assist in movement of the breast milk through the conduit structure and into the bottle. During pumping, the expelled milk will ultimately be separated from the air drawn back and forth in the air hose, and to and from the breastshield. Some breastpumps use gravity and geometry, such as a splashguard, to separate the milk and air (air being the working fluid), but these breastpumps are often difficult to clean, and the orientation of the breastshield in use may be thereby limited. Other breastpumps use a filter, for example a hydrophobic filter, to prevent milk from entering the air hose and/or pump. That filter can become saturated, shutting down pumping; it must also be cleaned and even periodically replaced. The objective of these efforts is to isolate parts of the breastpump from milk or other liquids/bacteriological material that would constitute a contaminant, or foul the works (such as milk finding its way to the pump mechanism). In institutional settings, for another example, it is desirable to have a pump that can be

transferred between mothers, yet the pump mechanism remains isolated from one mother to the next.

Some conventional electric breastpumps also use a moveable, sometimes collapsible, membrane or barrier, that separates the breastshield (including valve) from the pumping mechanism. During operation, two pressures are realized: a first pressure on the vacuum side of the membrane, or pump vacuum, and a second pressure on the breastshield side of the membrane, or breastshield vacuum. The vacuum pump communicates a negative pressure to the membrane via the air hose, such that the first pressure is greater than the second pressure, or in similar terms, the pump vacuum is greater than the breastshield vacuum. This differential vacuum causes the membrane to collapse or move. A problem with some conventional breastpumps of this type is that the membrane may not return to an initial state or position, i.e., it may end up locking or buckling.

This type of breastpump generally requires a positive pressure from the breastshield side of the membrane to push the membrane past a lock or buckle point in order to return the membrane to the non-collapsed state during a breastpump cycle. A breastpump of the foregoing type is shown in U.S. Patent No. 5,941,847 to Huber. A typical issue with these types of pumps is that leakages, evaporation, expulsion of milk and breast extension hysteresis do not ensure that the membrane returns fully to its initial non-collapsed state without the assistance of a positive pressure.

Some conventional manual breastpumps also include a collapsible or movable membrane that has a significant energy loss in "transferring" vacuum from one side to the other. The mechanical coefficient across the barrier membrane needs dramatic improvement.

Accordingly, a breastpump that reduces or eliminates contamination in the upstream pump air line and pump by isolating the pressure source from the expressed milk is desired to protect the user and prevent damage to the pump mechanism. A much more energy efficient pump system that uses a movable membrane/barrier for vacuum communication is also highly desirable.

SUMMARY OF THE INVENTION

The present invention, in perhaps one of its broadest expressions, comprises a barrier for a pump or a pumping system, that separates parts of the pump while transferring a pressure change across the barrier. When a pressure, as from a vacuum source, is applied to the barrier, the barrier achieves a distended state and when the vacuum is released, as by a return to atmospheric pressure, the barrier has a natural bias that returns it to an initial "pre-loaded" state. This advantageously can actually yield a slight positive pressure from the system and the breastshield side or the downstream side of the barrier (relative to the upstream vacuum source). "Bias" is used herein to describe the pre-set tendency of the barrier to try and return to this initial state.

Although embodiments of the present invention discussed herein are directed to breastpump systems, it is contemplated that various other applications for a self-returning barrier exist, for example, in a general sense to similar pump systems. This applies to other attributes of the invention as well.

Another object of the present invention is to provide a self-returning barrier such that a source of positive pressure from the pump is not required to return the barrier to its initial state from a distended state during a breastpump cycle, and further that the mechanical transfer of vacuum across the barrier is highly efficient. The force required to distend the barrier of the present invention is determined by material

construction, breastshield size, breast size, and the vacuum level of the pump; but in any of these systems, displacement of the barrier to a distended state requires that the pump vacuum is greater than the breastshield vacuum, i.e., there is energy lost in the mechanical transfer of vacuum from one side of the barrier to the other. The present invention achieves a highly efficient mechanical transfer.

The geometry of the inventive barrier acts as a spring in a preferred form. The barrier geometry maintains a low spring rate. A sufficient spring force designed into the barrier returns the barrier to the initial state, and further can assist in the expulsion of milk through a valve and into a collection container.

Another object of the present invention is to provide a barrier with a pre-loaded residual force when assembled. That is, the barrier is compressed along a central axis in the assembled state. The barrier is thus pre-loaded, i.e., biased when in this assembled state.

Yet another object is to provide a self-returning barrier that returns to an initial state from a distended state in a brief time frame, i.e., 150 milliseconds or less, without assistance from the pump to thereby further, minimize energy expenditure on the breastpump system.

Another object of the present invention is to provide a barrier to isolate parts of the pump, as from contaminants or the like that could otherwise pass.

Yet another aspect of the present invention is to provide a self-returning barrier that collapses uniformly as well as returns to an initial state uniformly. The barrier of the present invention thereby eliminates the need to apply force to move through non-uniform states, such as in a lock or buckle condition of the prior art. The barrier of the present invention includes a corrugated geometry to prevent it from

locking up or buckling. In one form this geometry comprises one or more undulations in the barrier that are generally concentric on a convex surface.

During collapse or achievement of a distended state, the barrier of the present invention in a preferred form never locks or buckles, even during circumstances when the pump vacuum remains less than the breastshield vacuum or when the pump vacuum is equal to the breastshield vacuum. Likewise, the barrier of the present invention never locks or buckles during return from a distended state to an initial state, even during the circumstances when the vacuum pressure is greater than the breastshield vacuum or the vacuums are equal.

Another aspect of the present invention is to provide a self-returning barrier that works with manually operated as well as electrically operated breastpumps. Furthermore, a self-returning barrier is provided that may function with complex electrical pumps providing a negative pressure and a positive pressure, and also with a simple pump providing only negative pressure (and a vent to atmosphere).

In particular, the barrier of the present invention does not require assistance from the vacuum pump, such as the positive force of air, for the barrier to return to its initial state during a breastpump cycle. The geometric and material construction of the barrier itself returns the barrier to its initial state after a suction phase.

In a broad embodiment, the present invention is a movable barrier for separating parts of a pump, as to prevent contamination that includes an initial state wherein the barrier is assembled as to possess a pre-load. When a vacuum source is applied to the barrier, the barrier achieves a distended state, and when the vacuum source is released, the barrier incrementally self-returns to an initial state.

The present invention, with application to a breastpump assembly, has a breastshield, a conduit structure and a collection container (bottle). A resilient barrier

is assembled in a pre-loaded condition in a housing, which is located in an air pressure line, typically a vacuum line. When a vacuum is applied, the barrier achieves a distended state, and when the vacuum is released, the barrier utilizes the pre-load as a spring action to assist in transforming to its initial pre-load state.

In another aspect, a breastpump assembly has a contamination barrier located in a vacuum line between a vacuum pump and a breastshield. A housing has a breastshield side and a vacuum side, also referred to herein as vacuum pump side, separated and isolated from one another by the barrier. The barrier is assembled within the housing in an initial pre-loaded state such that said barrier has a bias toward the breastshield side when no vacuum is applied. When vacuum is applied, the barrier achieves a distended state, and when the vacuum is released, the barrier returns to the initial state.

In one embodiment, the barrier has a generally convex shape at least in part as presented by a convex barrier side, and is assembled within the foregoing housing so that the bias presses the convex barrier side against an internal breastshield side sidewall of the housing in the initial state. The convex barrier side has at least one undulation formed in its surface generally concentric with the center of the convexity of the barrier. In a most preferred form, the internal breastshield side sidewall has a shape that generally conforms to that of the convex barrier side, such that the barrier and the breastshield side sidewall substantially mate when in facial engagement (in the initial pre-load state or condition).

In the foregoing embodiment, the barrier becomes inverted under vacuum, and forms another generally convex shape when distended under vacuum, at least in part, as presented by the now inside-out barrier side in the distended state. A vacuum side sidewall has in this most preferred form, a shape that generally conforms to that of the

distended barrier side, such that the barrier and the vacuum side sidewall substantially mate when in facial engagement.

In another aspect of the present invention, the barrier has a plurality of generally concentric undulations designed to provide bending moments for the barrier tending to return from a distended state to an initial state. This is contrasted with stretching of a barrier of the prior art, rather than bending.

It is yet another advantage of the present invention to provide a breastpump assembly which isolates parts of the pump in a vacuum line from contamination, such as between a breastshield and a vacuum source in communication with the breastshield via the vacuum line. The vacuum line is in communication with a housing that has a breastshield side and vacuum side. A resilient barrier having a form with a first surface that is, at least in part, generally domelike with an unassembled dome height as measured from a base of the dome to the first surface. The resilient barrier is assembled in the housing in a manner to separate and thereby isolate the breastshield housing side and vacuum housing side in an initial state with a pre-loaded condition for the barrier. The pre-loaded condition of the barrier has an assembled dome height that is less than the unassembled dome height.

Furthermore, the vacuum realized on the breastshield side follows a generally one to one relationship with the vacuum applied on the vacuum side, after an initial level of vacuum is realized on the vacuum pump side to overcome the pre-load condition. The initial level of vacuum to overcome the pre-load condition can be about 4 to 15 mmHg (negative) in one form of the invention. This yields a highly efficient vacuum transfer across the barrier. The foregoing embodiment can further include a milk conduit structure which conveys milk from the breastshield to a container via a catch chamber and a one-way valve between the catch chamber and

the container. The barrier, upon returning to an initial state with a predetermined minimum amount of milk in the catch chamber, generates an increased pressure in the catch chamber relative to the container so as to open the valve and release milk to travel into the container.

These, together with other objects and advantages will be further understood in the details of the construction and operation of the invention as more fully hereinafter described, reference being had to the accompanying drawings, forming a part hereof, wherein like numerals refer to like parts throughout, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a perspective view of a contamination barrier in a free state according to the present invention;

FIG. 1B is a perspective view of the barrier of FIG. 1A from the other side;

FIG. 2 is a side view of the contamination barrier of FIG. 1;

FIG. 3A is a front side perspective view of a breastpump assembly according to the present invention;

FIG. 3B is the breastpump of FIG. 3A from the back side;

FIG. 4 is an exploded perspective view from the front side of the breastpump assembly of FIGS. 3A and 3B according to the present invention (without the bottle);

FIG. 5 is an exploded perspective view from the back side of the breastpump assembly of FIG. 4;

FIG. 6A is a side view of the contamination barrier of FIG. 2 in a pre-loaded state according to the present invention;

FIG. 6B is a side view similar to that of FIG. 6A with the barrier distended;

FIG. 7A is a side sectional view of the breastpump assembly of FIGS. 3A and 3B;

FIG. 7B is a sectional view of the breastpump assembly of FIG. 7A.

FIG. 8 is an enlarged sectional view similar to that of FIG. 7B in one phase;

FIG. 9 is a sectional view similar to that of FIG. 8 in another phase; and

FIG. 10 is a comparison chart of performance (curves) of various membranes.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

Although the embodiments of the present invention described herein are directed to breastpump assembly systems, which is the particular environment that the invention finds its origin, it is contemplated that the present invention has various other applications, such as any pump system that requires a barrier to prevent contamination, or that may benefit from a movable membrane that is very efficient in transmitting pressure changes from a volume (or working fluid) on one side to a volume (or working fluid) on the other side.

The barrier of the present invention works with simple manually operated breastpumps that may provide only suction (and a vent to atmosphere), as well as more complex pumps, such as motorized pumps, and pumps providing both suction and a positive pressure. Thus, while described in particular respects with a source of vacuum, the pressure source could also be a positive pressure moving the barrier.

FIGS. 1A and 1B illustrate a self-returning contamination barrier 100 in a "free" state according to the present invention; that is, unassembled, and as it may be molded. The barrier includes an inner surface 102, and outer surface 104. As shown, the outer surface 104 includes three concentric circular panels 106, 108, 110, although any number of panels and any concentric shape are contemplated. The panels 106, 108, 110 are amalgamated, or joined, via sidewalls 112. Sidewall 112a joins center panel 106 to intermediate panel 108. Sidewall 112b joins intermediate panel 108 to

exterior panel 110. Exterior panel 110 is amalgamated (joined) with a rim 114 via sidewall 112c. As shown, and discussed in more detail hereafter, a valve 101 formed integral with barrier 100, but it is contemplated that the valve 101 could be separate and apart from the barrier 100.

The self-returning contamination barrier 100 is made of a resilient material, such as an elastomer, or any plastic and rubber combination that permits the barrier to function as a spring, described more fully below. The preferred embodiment is constructed of liquid injection molded silicone (LIMS), such as LIM 6050 that available from General Electric (GE).

The barrier 100 is assembled with a breastpump protection to eliminate contamination in the pump air line. FIGS. 3A and 3B illustrate a breastpump assembly 200. The assembly 200 includes a detachable breastshield 202. The breastshield 202 engages with a breast to form a seal to ensure suction to the breast, while maintaining comfortability. The front housing 204, also referred to herein as first housing, front side, or breastshield side, includes an interface or base part 205 and bottle collar 208. Breastshield 202 is detachably connected to the interface 205 of front housing 204 (although it could be made integral therewith). A collection container or bottle 210 is attached to the collar 208 of the front housing 204. The rear housing 206, also referred to herein as second housing, back side, or vacuum side, includes a port 212 to connect to an electrically operated pump, otherwise referred to as the vacuum source.

FIG. 4 and FIG. 5 illustrate an exploded view of the breastpump assembly 200 according to the present invention. The rear housing 206 includes an interior rearwall surface 402 and an exterior surface 404. The front housing 204 includes an interior frontwall surface 502, and an exterior surface 504. As assembled, the barrier 100 is

positioned between the interior rearwall surface 402 of the rear housing 206 and the interior frontwall surface 502 of the front housing 204.

The frontwall surface 502 most preferably has a shape that generally matches the outer surface 104 of the barrier 100 when it is in facial engagement in the initial state. The interior rearwall surface 402 most preferably has a shape that generally matches the inner surface 102 of the barrier 100 in a distended (inverted) state, described more fully below. The rim 114 forms a seal between the interior surface 502 of the front housing part 204 and the interior surface 402 of the rear housing part 206.

Once assembled within the housing, the barrier 100 separates and isolates the breastshield side of the housing 204 and the vacuum side of the housing 206. The barrier 100 is assembled in a pre-loaded initial state, also referred to herein as a first or initial position, or state, and maintains a concave shape as viewed from the vacuum side or a convex shape as viewed form the breastshield side, between the housing parts 204, 206, as shown in FIG. 6A. In this first position, the barrier 100 is biased toward the breastshield side of the housing 204.

As can be seen from FIG. 6A, the center panel 106 and sidewall 112a are substantially aligned with intermediate panel 108 in the pre-loaded state, i.e., when assembled. In addition, sidewalls 112b, 112c in a compressed configuration in the pre-loaded state, in comparison to the free state (FIG. 2). Looking at this another way, the barrier 100 has a dome-like shape, with a central axis. In the free state of FIG. 2, the height of the dome, as taken along this axis from rim 114 to the front surface of the convex side (panel 106), is h_1. In the pre-load state of FIG. 6A, the dome is compressed to a height of h_2, where h_2 is less than h_1. The pre-loaded state

assists in the functionality (spring action) of the barrier 100 during operation, described more fully below.

With reference to FIGS. 7A and 7B, the breastshield 202 connects to the interface (collar or shield base) 205 of the front housing 204. When milk is expressed from the breast of a nursing mother, the milk thereby flows from the breastshield 202 through a liquid conduit 702 portion to a collecting or catch chamber 704, and then to the collection container 210 (here, a bottle). At the outlet of the collection chamber 704 there is provided a valve 101 which closes the collection chamber 704, leading to bottle 210. Valve 101 in this instance is shown integrated with barrier 100, but again, it is contemplated that the valve 101 could be separate and apart from the barrier 100. This system is not dependent on this type of valve, in any event.

When a vacuum or negative pressure is applied to the breastshield 202 from a well known type of suction device 706, which may be manually operated or motor driven, the valve 101 closes the collection chamber 704, and a negative pressure is applied to the interior of the breastshield 202. Milk is collected within the collection chamber 704. When the negative pressure is released, the valve 101 opens to pass milk expressed into the breastshield 202 and thence to the collection chamber 704, to flow into the bottle 210. As noted, the valve mechanism may be of many types, for example a duckbill type.

The vacuum or suction device 706 here is a house-current driven vacuum pump using a tube, or air line 708 to convey the vacuum, although it is contemplated that the vacuum device 706 may be a manually operated piston pump, or a battery operated diaphragm pump. The invention herein is, however, not limited to any particular kind of vacuum device.

The vacuum source 706 connects via air line tube 708 to a port 212 formed on the rear housing 206. The port 212 extends through surface 402 and communicates with the interior of the rear housing 206. There is an interior surface 502 of the front housing 204, against which the barrier 100 is initially positioned, as shown in FIG. 7B. The breastshield side of the housing 204 has an aperture 207 that extends into the conduit structure communicating with interior space 209 within the connecting collar 208. The vacuum in the rear housing 206 is thereby communicated to the breastshield 202 by movement of the barrier away from the front wall surface 502, which in turn draws air through aperture 207 from space 209 and within the breastshield 202. The above describes a vacuum conduit structure which conveys the vacuum from the source 706 to the breastshield 202.

As stated, just before the vacuum source is applied, the barrier 100 is in facial engagement with the interior frontwall surface 502 of the front housing 204. The frontwall surface 502 has a shape that generally matches the outer surface 104 of the barrier 100 in this initial state. This matching engagement, which could also be less exact for substantially matching engagement, provides the smallest amount of "dead" volume on the breastshield side. It should be appreciated that the invention provides a very efficient vacuum transfer mechanism, which will use less energy and therefore extend the useful life of a battery-operated pump.

The breastpump assembly 200 of the present invention operates through a breastpump cycle of suction, air line release, and milk release. FIGS. 8 and 9 illustrate the breastpump in the first phase, or suction phase. During operation, two pressures are realized on each side (breastshield side and vacuum side) of the barrier 100: a first pressure A on the vacuum side of the barrier 100, otherwise referred to herein as pump vacuum, and a second pressure B on the breastshield side of the

barrier 100, otherwise referred to herein as breastshield vacuum. The pump 706 communicates a negative pressure to the barrier 100 via the air line 708 such that the first pressure A is at least initially greater (more negative) than the second pressure B, yielding what is known as a differential vacuum. This differential vacuum ultimately causes the barrier 100 to reach a distended state. The pump 706 draws a negative pressure (relative to atmosphere), which pulls the barrier 100 back into a second position, or distended state (see FIG. 8). The now inverted barrier 100 is in facial engagement with interior rearwall surface 402 of the rear housing 206 in the full distended state. The rearwall surface 402 has a shape that generally matches the inner surface 102 of the barrier 100 in this distended state.

As shown in FIG. 6B, when a vacuum is applied to the inner surface 102 of the barrier 100, the barrier 100 essentially turns inside out, such that an initial convex shape (FIGS. 2 and 6A) is transformed to an inverted convex shape (FIG. 6B). The center panel 106' is displaced from intermediate panel 108' via sidewall 112a', while the intermediate panel 108' is displaced from the exterior panel 110' via 112b' and the exterior panel 110' is displaced from the rim 114 via sidewall 112c'. Sidewalls 112a', 112b', 112c' are substantially lengthened in the distended state 900 in comparison to both the free state (FIG. 2) and the initial state (FIG. 6A).

As the barrier transforms to and from a distended state and an initial state, the exact position of barrier between the front housing 204 and rear housing 206 is determined by the difference between the first pressure A on the vacuum side of the barrier and the second pressure B on the breastshield side, i.e., differential vacuum. In addition to a first pressure and second pressure, the barrier 100 defines a first volume on the vacuum side and a second volume on the breastshield side. It should

be noted that as the barrier moves, the first volume and second volume (in addition to the first pressure and second pressure) change respectively.

In the collection chamber release phase, vacuum is released, typically by release to atmospheric pressure into the air line 708. The breastpump enters the air line release phase where energy stored (pre-load) in the barrier 100 causes the barrier 100 to return to its initial state (FIGS. 6A and 9). The second pressure B returns to atmospheric level if no milk has been added to the collection chamber 704. If no milk, or air from leakage around the breast, has been added to the collection chamber 704, the valve 101 does not open and the breastpump cycle repeats until milk is collected in the collection chamber 704. If milk is present, however, the air volume in the breastshield side will have been reduced by the milk volume. The barrier 100 pre-load then creates an overpressure (relative to the container) within the collection chamber 704, opening the valve 101. That is, as the barrier 100 transforms from the distended state, the differential vacuum reverses wherein the first pressure A decreases and the second pressure B increases. With a pressure equal or greater than atmospheric pressure within the collection chamber 704, milk in the pathway can flow through valve 101 from the collection chamber 704 into the collection container 210, i.e., milk release phase. The barrier 100 utilizes its pre-load during displacement to pneumatically apply a pressure to the milk thus opening the valve 101 and releasing the milk into the collection container 210. As the milk is released, the pressure applied by the barrier 100 decreases to the pre-load represented by the initial state of the barrier. After the milk is released, the valve 101 closes. The vacuum system then repeats the phases again through this cycle, beginning with the suction phase.

It will be noted that the invention may be adapted so that the barrier does not return completely to the initial state. This might be in a situation where minimum

vacuum level is to be maintained in the breastshield during pumping. The tendency of the barrier nonetheless causes it to move toward that initial state, if not achieving it.

FIG. 10 is a comparison chart of performance (curves) of various contamination barriers. As indicated in the graph of FIG. 10, pressure drop across the barrier, or differential pressure, is indicated along the y-axis (in millimeters of mercury) and vacuum side suction (in millimeters of mercury) is along the x-axis. The graph indicates values based on one pumping cycle drawn up to -250mmHg. The pressure drop is the difference between the pressure on the breastshield side of the barrier and the pressure on the pump side of the barrier.

The FREESYTLE curve was made with an embodiment of the invention. As indicated, it had a pre-load of 4 mmHg, i.e., it required that amount of vacuum before the barrier began to move. PURELY YOURS, ISIS IQ DUO and EMBRACE are commercial products. They are assembled without a pre-load. As can by seen in FIG. 10, FREESYLE, which incorporates the advantages of the present invention, had the most consistent pressure drop across the barrier for the entire vacuum range. This illustrates an excellent mechanical transfer, and a reduced amount of energy required on the breastpump system, when a barrier contemplated by the present invention is implemented. The FREESYTLE barrier is most efficient in that the energy loss is minimal once the pre-load is overcome.

It is understood that there may be many shapes, sizes, and configurations of the barrier that will fall within the scope of the invention. The use of the terms dome, concave and convex does not limit the invention to a round barrier. Any shape, e.g., non-round barrier is contemplated with material thickness and shape varying with respect to distance and angle from the center of the barrier to achieve the spring action discussed herein. It is seen that the objects set forth above, among those made

apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above constructions without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense. It is also to be understood that the following claims are intended to cover all of the generic as well as specific features of the invention herein described, and all statements of the scope of the invention that, as a matter of language, might be said to fall therebetween.

While the present invention has been described with reference to a particular embodiment, those skilled in the art will recognize that many changes may be made thereto without departing from the scope of the present invention. Each of these embodiments and variants thereof is contemplated as falling with the scope of the claimed invention, as set forth in the following claims.

The claims defining the invention are as follows:

1. A movable barrier for separating parts of a pump, as to prevent contamination, the barrier comprising a resilient membrane having a center, wherein the barrier is to be mounted along its circumference within a housing of said pump to separate parts of the pump, said barrier having an initial state and a distended state, wherein said barrier achieves said distended state in response to a pressure applied to said barrier, and said barrier has a preset bias to return to said initial state, wherein said barrier achieves said initial state in response to the release of said pressure applied to said barrier,

and wherein said barrier has a formed shape of convexity in an unassembled condition, and when mounted within said housing said barrier cannot reach said formed shape of convexity of said unassembled condition through engagement with a part of said housing, thereby restraining said barrier from further movement toward said unassembled condition.

2. The barrier of Claim 1, wherein said barrier comprises at least one concentric undulation around said center.

3. The barrier of Claim 1, wherein said distended state is responsive to a differential vacuum.

4. The barrier of Claim 3, wherein after said preset bias toward said initial state is overcome, said differential vacuum remains about the same at said distended state.

5. The barrier of Claim 1, wherein said preset bias includes a pre-load, and wherein said barrier returns towards said initial state in part by said pre-load.

6. The barrier of Claim 5, wherein said pre-load is determined in part by said barrier being made of a resilient material in combination with the shape of said barrier.

7. The barrier of Claim 1 in combination with a breastpump assembly, said breastpump assembly comprising:

a breastshield;

a conduit structure adapted to convey pressure and liquid;

a collection container communicating with said conduit structure;

a housing; and

a vacuum source communicating with said housing;

wherein said barrier is assembled in said initial state between parts of said housing, wherein said barrier achieves said distended state in response to vacuum from said vacuum source and said barrier utilizes said preset bias to assist in transforming from said distended state to said initial state.

8. The barrier device of Claim 1 in combination with a breastpump assembly, wherein said barrier is located in a pressure line between a pressure generating pump and a breastshield of said breastpump assembly, wherein the breastpump assembly further comprises:

a housing having a breastshield side and a pressure side.

9. The combination of Claim 8 wherein said barrier has a generally convex shape at least in part presented by a convex barrier side, and is assembled within said housing so that said bias presses said convex barrier side against an internal breastshield side sidewall of said housing in said initial state.

10. The combination of Claim 9 wherein said convex barrier side further has at least one undulation formed in its surface generally concentric with a center of said convexity.

11. The combination of Claim 10 wherein said internal breastshield side sidewall of said housing has a shape that generally conforms to that of said convex barrier side, such that said barrier and said breastshield side sidewall substantially mate when in facial engagement.

12. The combination of Claim 11 wherein said barrier becomes inverted in said distended state.

13. The combination of Claim 10 wherein said barrier has a plurality of generally concentric undulations designed to provide bending moments for said barrier tending to return said barrier from said distended state to said initial state.

14. The barrier device of Claim 1 in combination with a breastpump, said breastpump comprising:

a barrier housing having an interior frontwall spaced apart from an interior rearwall and defining an interior space therebetween, said rearwall having a port,

said barrier being mounted within and dividing said interior space into isolated compartments, said barrier having a generally convex shape with at least one undulation formed generally radially spaced from and concentric about the center of said barrier,

a surface of said interior frontwall having a shape that generally matches said barrier convex shape in said initial state, wherein said interior frontwall surface is in facial engagement with said barrier in said initial state;

a source of pressure to be applied from said port to said interior space to move said barrier,

a surface of said interior rearwall having a shape that generally matches said barrier shape in said distended state, said barrier being movable by application of a pressure from said pressure source from said initial state to said distended state and wherein said barrier becomes deformed in said distended state, wherein said interior rearwall surface is in facial engagement with said deformed barrier in said distended state,

said barrier being made of a resilient material which in combination with said barrier shape causes said barrier to return from said distended state to said initial state without assistance upon the release of said pressure.

15. The barrier of Claim 1 in combination with a breastpump assembly, wherein the barrier isolates parts of a vacuum line of the breastpump assembly from contamination, the breastpump assembly comprising:

a breastshield;

a vacuum source in communication with said breastshield via said vacuum line; and

a housing having a breastshield side and vacuum side, said housing being in communication with said vacuum line;

wherein said resilient barrier has a form with a first surface that is at least in part generally domelike and having an unassembled dome height as measured from a base for said dome to said first surface, said resilient barrier being assembled in said housing in a manner to separate and thereby isolate said breastshield and vacuum sides from one another and in said initial state with a pre-loaded condition wherein said barrier has an assembled dome height that is less than said unassembled dome height.

16. The combination of Claim 15 wherein said barrier has a generally convex shape and least one undulation formed generally radially spaced from and concentric about a center of said barrier, an internal sidewall of said breastshield having a surface shape that generally matches the shape of said barrier first surface such that said barrier in said pre-loaded condition substantially mates with said breastshield side internal sidewall surface in facial engagement, an internal sidewall of said vacuum side having a surface shape that generally matches the shape of said barrier in said distended state wherein when said barrier has become inverted through movement from said initial state to said distended state, said inverted barrier substantially mates with said vacuum side internal sidewall surface in facial engagement in said distended state.

17. The combination of Claim 15 wherein said barrier is made of a resilient material which in combination with said barrier shape causes said barrier to return from said distended state to said initial state on its own upon the release of said vacuum.

18. The combination of Claim 15 wherein the vacuum formed on said breastshield side follows a generally one to one relationship with the vacuum applied on said vacuum side after an initial level of vacuum is applied on said vacuum side to overcome said pre-load condition.

19. The breastpump assembly of Claim 18 further including a milk conduit structure which conveys milk from said breastshield to a container via a catch chamber and a one-way valve between said catch chamber and said container, said barrier upon returning to said initial state with a predetermined minimum amount of milk in said catch chamber generates an increased pressure in said catch chamber relative to said container so as to open said valve and release milk to travel into said container.

20. A barrier substantially as hereinbefore described with reference to the accompanying drawings.