

CLAIMS

1. A wearable breast pump system including:
 - (a) a housing shaped at least in part to fit inside a bra;
 - 5 (b) a piezo air-pump fitted in the housing and forming part of a closed loop system that drives a separate, deformable diaphragm to generate negative air pressure, that diaphragm being removably mounted on a breast shield.
- 10 2. The wearable breast pump system of Claim 1, configured as a self-contained, wearable device with an internal rechargeable battery.
3. The wearable breast pump system of Claim 1 or 2, in which the piezo air-pump is positioned at or close to the base of the housing.
- 15 4. The wearable breast pump system of any preceding Claim, in which the piezo air-pump comprises two or more individual piezo air-pumps.
5. The wearable breast pump system of Claim 4, in which the individual piezo air-pumps are mounted in a series arrangement.
- 20 6. The wearable breast pump system of Claim 4 or 5, in which the individual piezo air-pumps are mounted in a parallel arrangement.
7. The wearable breast pump system of any preceding Claim, in which the deformable diaphragm is a unitary or one-piece object that is removably mounted against
25 a part of the breast shield.
8. The wearable breast pump system of any preceding Claim, in which the deformable diaphragm is not physically connected to the piezo air-pump.
- 30 9. The wearable breast pump system of any preceding Claim, in which the deformable diaphragm is a flexible generally circular diaphragm that removably sits over a diaphragm housing that is an integral part of the breast shield.

10. The wearable breast pump system of any preceding Claim, in which a diaphragm housing includes an air hole that transfers negative air pressure to a nipple tunnel in the breast shield, the negative air pressure arising when the diaphragm moves away from the diaphragm housing, and the negative air pressure in the nipple tunnel pulling the breast
5 and/or nipple against the breast shield to cause milk to be expressed.
11. The wearable breast pump system of any preceding Claim, in which the piezo air-pump delivers in excess of 400mBar (40 kPa) stall pressure and 1.5 litres per minute free air flow.
10
12. The wearable breast pump system of any preceding Claim, in which the piezo air-pump weighs less than 10gm.
13. The wearable breast pump system of any preceding Claim, in which, in normal
15 operation, the breast pump system makes less than 30dB noise at maximum power and less than 25dB at normal power, against a 20dB ambient noise.
14. The wearable breast pump system of any preceding Claim, in which the piezo air-pump is fed by air that passes through an air filter.
20
15. The wearable breast pump system of any preceding Claim, which includes only two parts that are directly removable from the housing in normal use or normal dis-assembly: the breast shield and a rigid, non-collapsible milk container.
- 25 16. The wearable breast pump system of any preceding Claim, in which the breast shield is configured to attach to the housing with a single, sliding push action.
17. The wearable breast pump system of any preceding Claim, including a visual and/or haptic indicator that indicates whether milk is flowing or not flowing into the
30 milk container.
18. The wearable breast pump system of any preceding Claim, in which the housing includes a sensor, such as an accelerometer, that measures or determines the movement

and/or tilt angle of the housing, during a pumping session and automatically affects or adjusts the operation of the system depending on the output of the sensor.

19. The wearable breast pump system of any preceding Claim, including a control
5 interface that the user selects to indicate or record if milk is being expressed from the left or the right breast.

20. The wearable breast pump system of any preceding Claim, including (i) an air
10 pressure sensor configured to measure the negative pressure and (ii) a measurement sub-system that measures or infers milk flow or milk volume.

21. The wearable breast pump system of any preceding Claim, including:
(a) a re-useable rigid or non-collapsible milk container;
(b) at least one light emitter, configured to direct radiation towards the surface of the
15 milk;
(c) at least one light detector, configured to detect reflected radiation from the surface of the milk;

and in which the light emitters and detectors operate as part of a sub-system that measures the height of, or infers the quantity of, the milk in the container.

20 22. The wearable breast pump system of any preceding Claim, in which the centre of gravity of the pump system is, when a milk container attached to the housing is empty, substantially at or below (i) the half-way height line of the housing or (ii) the horizontal line that passes through a nipple tunnel or filling point on a breast shield, so that the
25 device is not top-heavy for a woman using the pump.

23. The wearable breast pump system of any preceding Claim, including a measurement sub-system that measures or infers milk flow into the milk container; and in which the measurement sub-system provides data to a data analysis system that
30 determines metrics that correlate with user-defined requirements for milk-flow rate or milk expression.

24. The wearable breast pump system of any preceding Claim, including a data sub-system that collects and provides data to a connected device or remote application or

remote server; and in which the collected data, in whole or in part, is used by a data analysis system that provides inputs to a social media or community function or platform.

- 5 25. The wearable breast pump system of any preceding Claim, including a microcontroller programmed to control the pumping mechanism and to permit the user to manually indicate the level of comfort that they are experiencing when the system is in use.
- 10 26. The wearable breast pump system of any preceding Claim, including a microcontroller programmed to automatically change one or more parameters of the pumping mechanism, and to automatically measure or relate milk expression data as a function of different values of one or more of these parameters.
- 15 27. The wearable breast pump system of any preceding Claim, including a re-useable rigid or non-collapsible milk container that when connected to the housing forms an integral, lower part of the housing, with a surface shaped to continue a curved shape of the housing, so that the pump system can be held comfortably inside the bra.
- 20 28. The wearable breast pump system of any preceding Claim, including a milk container that is attachable to the housing with a mechanism that releasably attaches or latches when the milk container is sufficiently pressed on to the housing with a single push action.
- 25 29. The wearable breast pump system of any preceding Claim, in which the breast shield includes a nipple tunnel shaped to receive a nipple, and includes an opening that defines the start of a milk flow path; and the system includes a re-useable milk container that when connected to the housing is positioned entirely below the opening or the milk flow path, when the breast pump is positioned or oriented for normal use.
- 30 30. The wearable breast pump system of any preceding Claim, including a milk container that is removable from the housing and is shaped or configured to also serve as a drinking bottle that is readily held by a baby because it is wider than it is tall.

Independents

31. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;
- 5 (b) a breast shield;
- (c) a rigid or non-collapsible milk container;
- and in which the breast pump system includes only two parts that are directly removable from the housing in normal use or normal dis-assembly: the breast shield and the rigid, non-collapsible milk container.
- 10
32. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;
 - (b) and a breast shield including a substantially transparent nipple tunnel, shaped to
- 15 receive a nipple, providing to the mother placing the breast shield onto her breast a clear and unobstructed view of the nipple when positioned inside the nipple tunnel, to facilitate correct nipple alignment.
33. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;
 - (b) and a breast shield including a substantially transparent nipple tunnel shaped to receive a nipple, the nipple tunnel including guide lines that define the correct spacing of the nipple from the side walls of the nipple tunnel.
- 20
- 25
34. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;
 - (b) and a breast shield that is attachable to the housing with a mechanism that latches
- 30 with an audible click when the breast shield is slid on to or against the housing with sufficient force.
35. A wearable breast pump system including:

- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;
- (b) and a breast shield configured to attach to the housing with a single, sliding push action.
- 5
36. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism
- (b) a breast shield;
- 10 (c) a milk container;
- and in which the centre of gravity of the pump system is, when the milk container is empty, substantially at or below (i) the half-way height line of the housing or (ii) the horizontal line that passes through a nipple tunnel or filling point on a breast shield, so that the device is not top-heavy for a woman using the pump.
- 15
37. A breast pump system including:
- (a) a housing including a pumping mechanism;
- (b) an illuminated control panel;
- (c) a control system that reduces or adjusts the level or colour of illumination of the
- 20 control panel at night or when stipulated by the user.
38. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;
- 25 (b) a milk container that is configured to be concealed within a bra and is hence not visible to the mother in normal use;
- (c) a visual and/or haptic indicator that indicates whether milk is flowing or not flowing into the milk container.
- 30 39. A breast pump system including:
- (a) a housing including a pumping mechanism;
- (b) a milk container;
- (c) a measurement sub-system that measures or infers milk flow into the milk container;

and in which the measurement sub-system provides data to a data analysis system that determines metrics that correlate with user-defined requirements for milk-flow rate or milk expression.

- 5 40. A breast pump system including:
- (a) a housing including a pumping mechanism;
 - (b) a milk container;
 - (c) a data sub-system that collects and provides data to a connected device or remote application or remote server;
- 10 (d) and in which the collected data, in whole or in part, is used by a data analysis system that provides inputs to a social media or community function or platform.

41. A breast pump system including a pumping mechanism and a milk container and including:
- 15 (a) a housing including the pumping mechanism;
- (b) a milk container;
 - (c) and in which the milk container or any associated part, such as a lid, includes a memory or tag that is automatically programmed to store the time and/or date it was filled with milk.

20

42. A smart bottle or container that includes or is associated with a memory or a tag that is programmed to store the date and time it is filled using data from a pump or a connected device, such as a smartphone.

- 25 43. A breast pump system including:
- (a) a housing;
 - (b) a milk container;
 - (c) the housing including a sensor, such as an accelerometer, that measures or determines the movement and/or tilt angle of the housing, during a pumping session and
- 30 automatically affects or adjusts the operation of the system depending on the output of the sensor.

44. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra;

(b) a control interface that the user can select to indicate or record if milk is being expressed from the left or the right breast.

45. A breast pump system including (i) a pumping mechanism that applies negative
5 air-pressure and (ii) an air pressure sensor configured to measure the negative pressure delivered by the negative air-pressure mechanism and (iii) a measurement sub-system that measures or infers milk flow or milk volume.
46. A breast pump system including (i) a pumping mechanism that applies negative
10 air-pressure and (ii) a microcontroller programmed to cause the pumping mechanism to deliver various pre-set pressure profiles and to permit the user to manually vary the pressure to a value or values that are in-between the values available from a pre-set pressure profile.
47. A breast pump system including (i) a pumping mechanism that applies negative
15 air-pressure and (ii) a microcontroller programmed to control the pumping mechanism and to permit the user to manually indicate the level of comfort that they are experiencing when the system is in use.
48. A breast pump system including (i) a pumping mechanism that applies negative
20 air-pressure and (ii) a microcontroller programmed to automatically change one or more parameters of the pumping mechanism, and to automatically measure or relate milk expression data as a function of different values of one or more of these parameters.
49. A breast pump system including (i) a pumping mechanism that applies negative
25 air-pressure and (ii) a microcontroller programmed to dynamically change one or more parameters of the pumping mechanism, and to automatically detect the start of milk let-down.
50. A wearable breast pump system including:
30 (a) a housing shaped at least in part to fit inside a bra;
(b) a piezo air-pump in the housing that is part of a closed loop system that drives, a separate, deformable diaphragm to generate negative air pressure.

51. A breast pump system including:
- (a) a housing;
 - (b) a piezo air-pump in the housing that is part of a closed loop system that drives, a physically separate, deformable, self-sealing diaphragm, to generate negative air pressure.
- 5
52. A breast pump system including:
- (a) a housing;
 - (b) multiple piezo air-pumps in the housing that drives a deformable diaphragm inside the housing to generate negative air pressure; in which the multiple piezo air-
- 10 pumps can be operated at different times in series-connected and in parallel-connected modes.
53. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra;
 - 15 (b) a breast shield that attaches to the housing;
 - (b) a piezo air-pump in the housing that drives a deformable diaphragm that fits directly onto the breast shield.
54. A wearable breast pump system including:
- 20 (a) a housing shaped at least in part to fit inside a bra;
 - (b) a piezo air-pump in the housing;
 - (c) and a re-useable, rigid or non-collapsible milk container that when connected to the housing forms an integral part of the housing and that is also removable from the housing.
- 25
55. A breast pump system including
- (a) a housing;
 - (b) a piezo air-pump in the housing;
 - (c) a milk container;
 - 30 (d) a data connectivity module that enables data collection relating to the operation of the piezo air-pump and transmission of that data to a data analysis system.
56. A breast pump system including:
- (a) a housing;

- (b) a piezo air-pump in the housing that drives a deformable diaphragm inside the housing to generate negative air pressure;
- (c) a heat sink to manage the heat produced by the piezo-air pump to ensure it can be worn comfortably.

5

57. A breast pump system including:

- (a) a housing;
- (b) an air-pump in the housing that drives a closed loop negative air-pressure system that applies negative pressure to a region surrounding a woman's breast to pump milk
10 form that breast;
- (c) in which the air pump also provides air to regularly or sequentially inflate one or more air bladders or liners that are configured to massage one or more parts of the breast.

15 58. A breast pump system including:

- (a) a housing;
- (b) an air-pump, such as a piezo pump, in the housing that drive a closed loop negative air-pressure system that applies negative pressure to a region surrounding a woman's breast to pump milk form that breast;
- 20 (c) in which the air pump also provides warm air to regularly or sequentially inflate one or more air chambers that are configured to apply warmth to one or more parts of the breast.

59. A wearable breast pump system configured including:

- 25 (a) a housing shaped at least in part with a curved surface to fit inside a bra and including a pumping mechanism;
- (b) and a re-useable rigid or non-collapsible milk container that when connected to the housing forms an integral, lower part of the housing, with a surface shaped to continue the curved shape of the housing, so that the pump system can be held
30 comfortably inside the bra.

60. A wearable breast pump system including:

- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;

(b) and a milk container that is attachable to the housing with a mechanism that releasably attaches or latches when the milk container is sufficiently pressed on to the housing with a single push action.

- 5 61. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;
- (b) and a re-useable milk container that is connected to the housing with a surface shaped to continue the curved or breast-like shape of the pump, so that the pump can be
- 10 held comfortably inside a bra and where the milk container includes a pouring spout for pouring milk.

62. A wearable breast pump system including:
- (a) a housing including a pumping mechanism, the housing being shaped at least in
- 15 part to fit inside a bra;
- (b) and a breast shield including a nipple tunnel shaped to receive a nipple, and including an opening that defines the start of a milk flow path;
- (c) a re-useable milk container that when connected to the housing is positioned entirely below the opening or the milk flow path, when the breast pump is positioned or
- 20 oriented for normal use.

63. A breast pump system including:
- (a) a housing including a pumping mechanism;
- (b) and a breast shield defining a region shaped to receive a nipple, the region
- 25 defining the start of a milk flow path;
- (c) a re-useable, rigid or non-collapsible milk container that when connected to the housing is positioned to form the base of the housing;
- and in which the breast shield and the milk container are made substantially of an optically clear, dishwasher safe material.

- 30 64. A wearable breast pump system including:
- (a) a housing shaped at least in part to fit inside a bra and including an air pumping mechanism;
- (b) a breast shield;

- (c) a diaphragm that flexes in response to changes in air pressure caused by the air pumping mechanism and that seals to the breast shield;
 - (d) a re-useable milk container that seals to the breast shield;
- and in which either or both of the diaphragm and the re-useable milk container
- 5 substantially self-seal under the negative air pressure provided by the pumping mechanism.

65. A wearable breast pump system configured as a single unit and including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping
- 10 mechanism;
- (b) and a milk container that forms an integral part of the housing;
 - (c) a re-useable pouring spout that is positioned at or close to the front edge of the milk container.

- 15 66. A wearable breast pump system configured as a single unit and including:
- (a) a housing shaped at least in part to fit inside a bra and including a pumping mechanism;
 - (b) a breast shield;
 - (c) a milk container that is removable from the housing and is shaped or configured
- 20 to also serve as a drinking bottle that is readily held by a baby because it is wider than it is tall.

67. A system for milk volume determination, for use as part of a breast pump, or breast milk collecting device, including:
- (a) a re-useable rigid or non-collapsible milk container;
 - (b) at least one light emitter, configured to direct radiation towards the surface of the milk;
 - (c) at least one light detector, configured to detect reflected radiation from the surface of the milk;
- 30 wherein the light emitters and detectors operate as part of a sub-system that measures the height of, or infers the quantity of, the milk in the container.

68. A liquid-level measuring system for measuring the quantity of liquid in a container for a breast pump; the system including:

- (a) one or more light emitters directing light at the surface of the liquid in the container;
- (b) one or more light receivers configured to detect light from the light emitters that has been reflected from the liquid;
- 5 (c) a sub-system that infers, measures or calculates the quantity in the liquid using measured properties of the detected light;
- (d) a collar or other fixing system that positions the system over the container.

69. A liquid-level measuring system for measuring the tilt angle of liquid in a
10 container; the system including:

- (a) one or more light emitters directing light at the surface of the liquid in the container;
- (b) one or more light receivers configured to measure properties of the light reflected from the liquid;
- 15 (c) a sub-system including an accelerometer that infers, measures or calculates the tilt angle of the liquid using measured properties of the detected light;
- (d) a collar or other fixing system that positions the system over the container.

70. A bra adjuster system for a nursing or maternity bra, the nursing or maternity bra
20 including a bra cup with a flap that can be undone to expose the nipple, and the flap attaching to the shoulder strap using a clasp, hook or other fastener attached to the flap, and a corresponding fastener attached to the shoulder strap;

and in which the bra adjuster is attachable at one end to the fastener attached to the flap, and at its other end to the fastener attached to the shoulder strap, and hence
25 increases the effective bra cup size sufficiently to accommodate a wearable breast pump, and is also detachable from the flap and shoulder strap.

71. A wearable device including multiple piezo pumps mounted together either in series or in parallel.

72. A wearable medical device including a piezo pump and a heat sink attached
30 together.

Breast shield

73. The system of any preceding Claim in which the only parts of the system that come into contact with milk in normal use are a breast shield and a milk container.
74. The system of any preceding Claim in which milk only flows through a breast shield and then directly into a milk container.
- 5 75. The system of any preceding Claim in which a breast shield and a milk container are each pressed or pushed into engagement with the housing.
76. The system of any preceding Claim in which a breast shield and milk container are each pressed or pushed into a latched engagement with the housing.
77. The system of any preceding Claim in which there are two user-removable parts,
10 namely a breast shield and milk container, and each is insertable into and removable from the housing using an action confirmed with an audible sound, such as a click.
78. The system of any preceding Claim in which a breast shield is configured to be rotated smoothly around a nipple inserted into the nipple tunnel to position a diaphragm housing portion of the breast shield at the top of the breast.
- 15 79. The system of any preceding Claim in which a breast shield slides into the housing using guide members.
80. The system of any preceding Claim in which the housing is configured to slide onto a breast shield, when the breast shield has been placed onto a breast, using guide members.
- 20 81. The system of any preceding Claim in which a breast shield latches into position against the housing.
82. The system of any preceding Claim in which a breast shield latches into position against the housing when spring plungers, such as ball bearings, in the housing locate into small indents in the breast shield.
- 25 83. The system of any preceding Claim in which a breast shield latches into position against the housing using magnets.
84. The system of any preceding Claim in which a breast shield includes or operates with a flexible diaphragm that (a) flexes when negative air pressure is applied to it by an

air pump system in the housing, and (b) transfers that negative air-pressure to pull the breast and/or nipple against the breast shield to cause milk to be expressed.

85. The system of any preceding Claim in which a breast shield includes a nipple
5 tunnel that includes on its lower surface an opening through which expressed milk flows directly into the milk container.

86. The system of any preceding Claim in which no other parts are removable from
the breast shield, apart from the flexible diaphragm.

10

Milk container

87. The system of any preceding Claim in which a milk container attaches to a lower
surface of the housing and forms the base of the breast pump system in use.

15

88. The system of any preceding Claim in which a milk container is a re-useable milk
container that when connected to the housing is positioned to form the base of the
housing.

20 89. The system of any preceding Claim in which a milk container mechanically or
magnetically latches to the housing.

90. The system of any preceding Claim in which a milk container is released by the
user pressing a button on the housing.

25

91. The system of any preceding Claim in which a milk container includes a
removable cap and a removable valve that is seated on the lid.

92. The system of any preceding Claim in which in normal use, the milk container is
30 positioned entirely within a bra.

93. The system of any preceding Claim in which no parts are removable from the
milk container, apart from a cap and a valve.

94. The system of any preceding Claim in which all parts that are user-removable in normal use are attached to either a breast shield or a milk container.

95. The system of any preceding Claim in which audible or haptic feedback confirms the pump system is properly assembled for normal use with the milk container locked to the housing and the breast shield locked to the housing.

Pump

96. The system of any preceding Claim in which a pumping mechanism is a closed loop negative air-pressure system that applies negative pressure to a region surrounding a woman's breast to pump milk from that breast.

97. The system of any preceding Claim which also includes a control sub-system that combines or relates the air-pressure measurements with the milk flow or milk volume measurements

98. The system of any preceding Claim in which a control sub-system automatically adjusts the negative air-pressure to give the optimal milk flow or milk volume.

99. The system of any preceding Claim in which a control sub-system automatically adjusts the negative air-pressure during a pumping session to give the optimal milk flow or milk volume within comfort constraints defined by the user.

100. The system of any preceding Claim in which an air pressure sensor detects pressure created by the pumping mechanism.

101. The system of any preceding Claim in which an air pressure sensor is a piezo air pressure sensor.

102. The system of any preceding Claim in which an air pressure sensor measures the negative air pressure during a normal milk expression session.

103. The system of any preceding Claim in which an air pressure sensor measures the negative air pressure during a calibration session, and the system uses the results to vary

the operation of the pumping mechanism so that it deliver consistent performance over time.

104. The system of any preceding Claim in which an air pressure sensor measures the negative air pressure during a calibration session, and the system uses the results to vary the operation of the pumping mechanism so that different pumping mechanisms in different breast pump systems all deliver consistent performance

105. The system of any preceding Claim in which an air pressure sensor measures the negative air pressure during a calibration session, and the system uses the results to determine if the pumping mechanism is working correctly, within tolerance levels.

106. The system of any preceding Claim in which the operation of a pumping mechanism is varied by altering the duty or pump cycle.

107. The system of any preceding Claim in which the operation of a pumping mechanism is varied by altering the voltage applied to the pumping mechanism.

Piezo air-pump

108. The system of any preceding Claim in which a pumping mechanism is a piezo air pump.

109. The system of any preceding Claim in which a piezo air pump forms part of a closed or closed loop system.

110. The system of any preceding Claim in which a piezo-air pump is a closed loop negative air-pressure system that applies negative pressure to a flexible diaphragm that seals, self-seals, self-energising seals or interference fit seals against a diaphragm housing that forms part of a breast shield.

111. The system of any preceding Claim in which a piezo air pump is positioned at or close to the base of the housing.

112. The system of any preceding Claim in which there are two or more piezo air pumps.
113. The system of any preceding Claim in which there are two or more piezo air
5 pumps mounted in a series arrangement.
114. The system of any preceding Claim in which there are two or more piezo air pumps mounted in a parallel arrangement.
- 10 115. The system of any preceding Claim in which a piezo pump delivers in excess of 400mBar (40 kPa) stall pressure and 1.5 litres per minute free air flow.
116. The system of any preceding Claim in which a piezo air pump weighs less than 25gm, or less than 10gm.
15
117. The system of any preceding Claim in which in operation, the breast pump system makes less then 30dB noise at maximum power and less than 25dB at normal power, against a 20dB ambient noise.
- 20 118. The system of any preceding Claim in which in operation, the breast pump system makes approximately 24dB noise at maximum power and 22dB at normal power, against a 20dB ambient noise. The piezo pump is fed by air that passes through an air filter.
- 25 119. The system of any preceding Claim in which a piezo-air pump is a closed loop negative air-pressure system that applies negative pressure to a region surrounding a woman's breast to pump milk form that breast.
- 30 **Diaphragm**
120. The system of any preceding Claim in which a closed system is separated from a 'milk' side by a flexible diaphragm.

121. The system of any preceding Claim in which a deformable diaphragm is removably mounted against a part of a breast shield.

- 5 122. The system of any preceding Claim in which a deformable diaphragm is a unitary or one-piece object that is removably mounted against a part of a breast shield.

123. The system of any preceding Claim in which a deformable diaphragm is not physically connected to the piezo air-pump.

10

124. The system of any preceding Claim in which an air-pump is a closed loop air-pump that drives a physically separate and remote deformable diaphragm that removably fits directly onto the breast shield.

- 15 125. The system of any preceding Claim in which a deformable diaphragm is a flexible generally circular diaphragm that sits over a diaphragm housing that is an integral part of a breast shield.

- 20 126. The system of any preceding Claim in which an edge of a flexible diaphragm seals, self-seals, self-energising seals, or interference fit seals against the housing when the breast shield attaches to the housing.

- 25 127. The system of any preceding Claim in which a diaphragm housing includes an air hole that transfers negative air pressure to a nipple tunnel in the breast shield, the negative air pressure arising when the diaphragm moves away from the diaphragm housing and towards the housing, and the negative air pressure in the nipple tunnel pulling the breast and/or nipple against the breast shield to cause milk to be expressed.

Flow measurement and indication

30

128. The system of any preceding Claim in which a haptic and/or visual indicator indicates if the pump is operating correctly to pump milk, based on whether the quantity and/or the height of the liquid in a milk container above its base is increasing above a threshold rate of increase

129. The system of any preceding Claim in which a haptic and/or visual indicator that indicates if the pump is operating correctly to pump milk, is a row of LEDs that changes appearance as the quantity of milk increases.

5

130. The system of any preceding Claim in which a haptic and/or visual indicator provides an indication of an estimation of the milk flow rate.

131. The system of any preceding Claim in which a visual indicator provides a colour-coded indication of an estimation of the milk flow rate.

10

132. The system of any preceding Claim in which a visual indicator provides an indication of how much of the container has been filled with milk.

133. The system of any preceding Claim in which a milk flow or quantity visual indicator is part of a user interface in a connected, companion application, running on a smartphone or other personal device, such as a smart watch or smart ring.

15

134. The system of any preceding Claim in which a milk flow or quantity haptic indicator is part of a user interface in a connected, companion application, running on a smartphone or other personal device, such as a smart watch or smart ring.

20

135. The system of any preceding Claim in which a sub-system measures or infers the quantity and/or the height of the liquid in a milk container.

25

136. The system of any preceding Claim in which a sub-system measures or infers the quantity and/or the height of the liquid in a milk container by using one or more light emitters and light detectors to detect light from the emitters that has been reflected by the liquid, and measuring the intensity of that reflected light.

30

137. The system of any preceding Claim in which a sub-system includes or communicates with an accelerometer and uses a signal from the accelerometer to determine if the liquid is sufficiently still to permit the sub-system to accurately measure or infer the quantity and/or the height of the liquid in a milk container.

138. The system of any preceding Claim in which a sub-system measures or infers the angle the top surface of the liquid in a milk container makes with respect to a baseline, such as the horizontal.

5

139. The system of any preceding Claim in which a haptic and/or visual indicator indicates if the amount of milk in a milk container has reached a preset quantity or level.

140. The system of any preceding Claim in which a haptic and/or visual indicator
10 indicates if there is too much movement of the breast pump system for viable operation.

141. The system of any preceding Claim in which, if the tilt angle of the housing exceeds a threshold, then the system automatically affects the operation of the system by warning or alerting the mother of a potential imminent spillage (e.g. from milk flowing
15 back out of a breast shield) using an audio, or visual or haptic alert, or a combination of audio, haptic and visual alerts.

142. The system of any preceding Claim in which, if the tilt angle of the housing exceeds a threshold, then the system automatically adjusts the operation of the system by
20 stopping the pump to prevent spillage.

143. The system of any preceding Claim in which, when the tilt angle of the housing reduces below the threshold, the system automatically adjusts the operation of the system by causing pumping to resume automatically.

25

144. The system of any preceding Claim in which, if the tilt angle of the housing exceeds a threshold, then the system automatically affects the operation of the system by providing the mother with an alert to change position.

30 145. The system of any preceding Claim in which there are one or more light emitters and detectors positioned in the base of the housing, the light emitters and receivers operating as part of a sub-system that measures or infers the tilt angle of the milk in the container.

146. The system of any preceding Claim in which a sub-system measures the quantity of liquid in the milk container and also takes the measured tilt angle of the housing into account.

5 147. The system of any preceding Claim in which, if the tilt angle is above a certain threshold, the system ignores the quantity of liquid measured.

148. The system of any preceding Claim in which a sub-system derives or infers the mother's activity, such as walking, standing or lying activities, from the sensor.

10

149. The system of any preceding Claim in which a sub-system stores a time-stamped record of movement and/or tilt angles of the housing in association with milk flow data.

150. The system of any preceding Claim in which one or more visual indicators on the
15 housing indicate whether the breast pump system is being set up the left or the right breast.

151. The system of any preceding Claim in which a visual indicator for the left breast
is on the right-hand side of the housing, when viewed from the front; and the visual
20 indicator for the right breast is on the left-hand side of the housing, when viewed from the front.

152. The system of any preceding Claim in which the housing includes a button
labeled to indicate the left breast and a button labeled to indicate the right breast, that are
25 respectively illuminated to indicate from which breast the milk is being expressed.

153. The system of any preceding Claim in which a sub-system measures or infers the
quantity and/or the height of the liquid in the container and shares that data with a data
connectivity module.

30

154. The system of any preceding Claim in which, where the expressed milk quantity
or level exceeds a threshold, then the pumping mechanism automatically changes mode,
e.g. from a stimulation mode to an expression mode.

155. The system of any preceding Claim in which, where the quantity or level exceeds a threshold, then the pumping mechanism automatically stops.
156. The system of any preceding Claim in which milk-flow data is captured and
5 stored.
157. The system of any preceding Claim in which, if milk-flow falls below a threshold, then a notification is provided to the mother.
- 10 158. A method of expressing and collecting milk, comprising the step of using a system as defined in any preceding Claim.