CLAIMS

1. A breast pump system comprising at least one wearable milk collection hub connected via an air line to a combined external air pump and control unit; and in which the milk collection hub(s) each comprise:

(a) a breast shield made up of a breast flange and a nipple tunnel;

(b) a flexible diaphragm that is configured to prevent milk from reaching the external air pump;

(c) an outer shell that is configured to be removably attachable to the breast shield, such that the breast shield and outer shell, when attached, form a vessel for collecting milk, and the front face of the outer shell includes a curved portion;

(d) a diaphragm cap that is configured to be secured in use over the diaphragm, and forms part of a~~the~~ front face or forward facing part of the outer shell, and includes an air port connected to the air line.

2. The breast pump system of Claim 1, in which the diaphragm cap is rotatable in the outer shell to adjust the position of the air port.

3. The breast pump system of Claim 1 or 2, in which the diaphragm cap is removable from the outer shell.

~~4. The breast pump system of any preceding Claim, in which the diaphragm cap is configured to fit or latch onto the outer shell with a single push action.~~

~~5. The breast pump system of any preceding Claim, in which the diaphragm cap includes recesses or features configured to be gripped with the fingers of one hand.~~

4~~6~~. The breast pump system of any preceding Claim, in which the diaphragm cap includes a pair of recesses configured to enable the cap to be gripped and removed from the outer shell, and installed into the outer shell, with a single hand.

57. The breast pump system of any preceding Claim, in which the diaphragm cap includes a flat portion such that the milk collection hub can rest on a flat surface positioned on this flat portion.

68. The breast pump system of any preceding Claim, in which the diaphragm cap is shaped to fit inside an inner portion of a bra.

79. The breast pump system of any preceding Claim, in which the diaphragm cap is made of a transparent or optically clear, dishwasher safe polypropylene, polycarbonate or copolyester ~~such as Tritan™~~ material.

810. The breast pump system of any preceding Claim, in which ~~the diaphragm cap and also~~ the outer shell includes or is ~~substantially~~ made from a transparent or optically clear, dishwasher safe polypropylene, polycarbonate or copolyester ~~such as Tritan™~~.

~~11. The breast pump system of any preceding Claim, in which the breast shield is rigid or semi-rigid.~~

912. The breast pump system of any preceding Claim, in which the breast shield is a transparent or optically clear, dishwasher safe polypropylene, polycarbonate or copolyester, ~~such as Tritan™,~~ breast shield.

~~13. The breast pump system of any preceding Claim, in which the breast shield integrates the breast flange and nipple tunnel as a single one-piece item with no joins.~~

1014. The breast pump system of any preceding Claim, in which the breast shield includes a diaphragm housing that has sides that are parallel to the nipple tunnel.

1115. The breast pump system of Claim 1014, in which the diaphragm housing has an outer, approximately cylindrical side wall that is generally parallel to the nipple tunnel, and an inner, approximately cylindrical side wall that ~~is also~~ is generally parallel to the nipple tunnel.

12~~16~~. The breast pump system of any of Claims 10~~14~~ - 11~~15~~, in which the diaphragm housing has a front wall that forms the end of the nipple tunnel.

13~~17~~. The breast pump system of any of Claim 10~~14~~ - 12~~16~~, in which the diaphragm housing has an annular rear wall that joins the outer and the inner sides walls and that lies over a region of the nipple tunnel that in use is subject to negative air pressure, the entire diaphragm housing being positioned towards the end of the nipple tunnel such that~~in order to give~~ the user has a clear view of the position of the nipple when positioning the breast shield or the outer shell onto the breast.

14~~18~~. The breast pump system of any of Claim 10~~14~~ - 13~~17~~, in which the diaphragm is flexible and moves within an air-pump chamber formed (i) on one side by the diaphragm housing and the flexible diaphragm includes walls that are parallel to the long or central axis of the nipple tunnel and (ii) on another side by the diaphragm cap

15~~19~~. The breast pump system of any of Claim 10~~14~~ -14~~18~~, in which the breast shield is integrated with the diaphragm housing portion as a single, one piece moulded item.

~~20. The breast pump system of any preceding Claim, in which the breast shield includes a removable perimeter seal that provides an air-tight seal between an outer edge of the breast shield and the outer shell.~~

~~21. The breast pump system of any preceding Claim, in which the outer shell is rigid.~~

16~~22~~. The breast pump system of any preceding Claim, in which the outer shell is a transparent or optically clear, dishwasher safe polypropylene, polycarbonate or copolyester, ~~such as Tritan™,~~ outer shell.

~~23. The breast pump system of any preceding Claim, in which the outer shell includes an air opening or vent hole such that atmospheric pressure is maintained inside the milk collection hub.~~

~~24. The breast pump system of any preceding Claim, in which the outer shell fits or latches onto the breast shield.~~

~~25. The breast pump system of any preceding Claim, in which the outer shell is attachable to the breast shield with a single push action.~~

~~26. The breast pump system of any preceding Claim, in which the outer shell attaches to the breast shield using magnets.~~

~~27. The breast pump system of any preceding Claim, in which the outer shell is directly removable from the breast shield in normal use or normal dis-assembly.~~

~~28. The breast pump system of any preceding Claim, in which the outer shell is removable from the breast shield together with a flexible diaphragm that is attached, permanently or removably, to the outer shell.~~

~~29. The breast pump system of any preceding Claim, in which the outer shell is removable together with the diaphragm cap.~~

~~30. The breast pump system of any preceding Claim, in which the outer shell and diaphragm are formed or joined together to form a single item.~~

~~31. The breast pump system of any preceding Claim, in which the outer shell includes a pouring opening which can be closed for transportation of the milk collection hub.~~

~~32. The breast pump system of any preceding Claim, in which the outer shell has a front surface that is curved and configured to fit inside a bra and to contact an inner surface of the bra.~~

1734. The breast pump system of any preceding Claim, in which the diaphragm is positioned at the end of the nipple tunnel, and includes a portion that extends over the end of the nipple tunnel, so as not to obstruct a mother’s view of a substantial part of the nipple tunnel when placing the collection hub onto her breast.

18~~35~~. The breast pump system of any preceding Claim, in which the diaphragm is a single flexible membrane shaped to include inner and outer substantially cylindrical walls that are generally parallel to the center axis of the nipple tunnel.

19~~36~~. The breast pump system of any preceding Claim, in which the diaphragm is shaped to be flush to a diaphragm housing that has an outer, approximately cylindrical side wall that is generally parallel to the nipple tunnel, and an inner, approximately cylindrical, concentric side wall that is also is generally parallel to the nipple tunnel.

~~37. The breast pump system of any preceding Claim, in which the diaphragm is removably attached to the outer shell.~~

~~38. The breast pump system of any preceding Claim, in which the diaphragm is permanently fixed to the outer shell.~~

20~~39~~. The breast pump system of any preceding Claim, in which the diaphragm includes portions that run substantially parallel to the center axis of the nipple tunnel.

21~~40~~. The breast pump system of any preceding Claim, in which the diaphragm includes a portion that sits over the end of the nipple tunnel, facing away from the breast.

22~~41~~. The breast pump system of any preceding Claim, in which the diaphragm is a single flexible membrane shaped to include inner and outer substantially cylindrical walls that are generally parallel to the center axis of the nipple tunnel, an annular wall that joins the inner and outer substantially cylindrical walls, and an end wall that sits over the end of the nipple tunnel.

23~~42~~. The breast pump system of any preceding Claim, in which the control unit is configured to control suction delivered to the at least one ~~or to two~~ wearable milk collection hubs, and the control unit houses an air pump subsystem that is configured to generate negative air pressure and transfer negative air pressure to the wearable milk collection hub(s) ~~or hubs~~.

2443. The breast pump system of preceding Claim 2342, in which the air pump subsystem is held in place between two blocks, each configured to absorb vibration from the pump unit.

~~44. The breast pump system of any preceding Claim, in which the control unit includes a wireless data communications system powered by a rechargeable battery.~~

~~45. The breast pump system of any preceding Claim, in which the control unit includes a visual and/or haptic indicator that indicates whether milk is flowing or not flowing into a hub.~~

~~46. The breast pump system of any preceding Claim, in which the control unit includes a visual and/or haptic indicator that indicates the activated pumping profile or pattern.~~

~~47. The breast pump system of any preceding Claim, in which the control unit includes a visual and/or haptic indicator that indicates the rechargeable battery status.~~

~~48. The breast pump system of any preceding Claim, in which the control unit includes a USB charging socket connected to the power charging circuit.~~

~~49. The breast pump system of any preceding Claim, in which the control unit is configured to attach to a flexible O-ring shaped multifunction mount.~~

2550. The breast pump system of any preceding Claim, further comprising~~in which~~ an airflow block in the control unit, the airflow block ~~is~~ configured to transfer air or suction from the pump unit and ~~also~~ to absorb vibrations from the pump unit.

~~51. The breast pump system of Claim 50, in which the airflow block is made of a compression moulded silicone.~~

~~52. The breast pump system of any of Claim 50 - 51, in which the airflow block is directly connected to the air pump subsystem outlet.~~

~~53. The breast pump system of any of Claim 50 - 52, in which the airflow block is located near a solenoid valve.~~

~~54. The breast pump system of any of Claim 50 - 53, in which the airflow block is a one-piece item.~~

~~55. The breast pump system of any preceding Claim, in which the control unit is sealed to further attenuate sound.~~

~~56. The breast pump system of any preceding Claim, in which the control unit includes a housing with a top portion and a bottom portion and the bottom and top portions are sealed together using a seal perimeter.~~

~~57. The breast pump system of any of Claim 56, in which an airflow block is integrated with a portion of the seal perimeter.~~

~~58. The breast pump system of any of Claim 50 - 57, in which the airflow block connects to an air port or hole for a tube that delivers air to the wearable milk collection hub(s).~~

2659. The breast pump system of any preceding Claim, in which a sound valve in the control unit is configured to regulate the pressure inside the control unit suchso that the inside of the control unit remains at ambient pressure and the sound valve is configuredalso to attenuate noise from the pump unit escaping from inside the control unit.

~~60. The breast pump system of Claim 59, in which the sound valve is located on the bottom portion of the control unit.~~

2761. The breast pump system ~~of any~~ of Claim 2659 ~~- 60~~, in which the sound valve includes a small cut that is configured to deform under pressure.

~~62. The breast pump system of any of Claim 59 - 61, in which the sound valve is made of silicone.~~

2863. The breast pump system of any preceding Claim, in which a solenoid foam cap in the control unit is configured to reduce the speed of air that enters the solenoid valve when the solenoid valve opens to ambient air pressure and hence to reduce the sound of that air entering the solenoid valve.

~~64. The breast pump system of Claim 63, in which the solenoid foam cap is a one piece item made of plastic.~~

~~65. The breast pump system of any of Claim 63 – 64, in which the solenoid foam cap includes one or more small opening or holes.~~

~~66. The breast pump system of any preceding Claim, in which the control unit also includes two silencers, in which one silencer is connected to a solenoid valve and the other silencer is connected to a motor for the air pump.~~

~~67. The breast pump system of any preceding Claim, in which the breast pump system is a closed system.~~

~~68. The breast pump system of any preceding Claim, in which the breast pump system has a capacity of approximately 5 fluid ounces (148ml).~~

~~69. The breast pump system of any preceding Claim, in which the width of the milk collection hub is about 5.7cm in the direction of the central axis of the nipple tunnel.~~

~~70. The breast pump system of any preceding Claim, in which the system makes less than 50dB noise at maximum power when the air pump is running and preferably less than 45dB.~~

~~71. The breast pump system of any preceding Claim, in which the wearable milk collection hub is, in-use, a bra worn milk collection hub.~~

~~72. The breast pump system of Claim 71, in which the curved portion of the outer shell is shaped to fit inside a bra.~~

73. A wearable milk collection hub for a breast pump system comprising:

(a) a breast shield made up of a breast flange and a nipple tunnel;

(b) a flexible diaphragm that is configured to prevent milk from reaching an external air pump subsystem;

(c) an outer shell that is configured to fit or latch onto the breast shield, such that the breast shield and outer shell form a vessel for collecting milk;

in which the breast shield and the outer shell are substantially transparent, providing, to the mother placing the collection hub onto her breast, a clear and unobstructed view of the nipple to facilitate correct nipple alignment.

74. A wearable milk collection hub for a breast pump system comprising:

(a) a breast shield made up of a breast flange and a nipple tunnel;

(b) a flexible diaphragm that is configured to prevent milk from reaching an external air pump subsystem;

(c) an outer shell that is configured to fit or latch onto the breast shield, such that the breast shield and outer shell form a vessel for collecting milk;

in which the breast shield and the outer shell are substantially transparent, providing simultaneously to the mother placing the collection hub onto her breast (i) a clear and unobstructed view of the nipple to facilitate correct nipple alignment and (ii) a view of the diaphragm to ensure the breast pump system is operating correctly.

75. A wearable milk collection hub for a breast pump system comprising:

(a) a breast shield made up of a breast flange and a nipple tunnel;

(b) a flexible diaphragm that is configured to prevent milk from reaching an external air pump subsystem;

(c) an outer shell that is configured to fit or latch onto the breast shield, such that the breast shield and outer shell form a vessel for collecting milk;

in which the breast shield and the outer shell are substantially transparent, providing to the mother placing the collection hub onto her breast (i) a clear and unobstructed view of the nipple to facilitate correct nipple alignment and (ii) a clear and unobstructed view of a substantial part of the nipple tunnel.

76. A wearable milk collection hub for a breast pump system comprising:

(a) a substantially transparent breast shield made up of a breast flange and a nipple tunnel;
(b) a flexible diaphragm that is configured to prevent milk from reaching an external air pump subsystem;
(c) a substantially transparent outer shell that is configured to fit or latch onto the breast shield, such that the breast shield and outer shell form a vessel for collecting milk;
in which the diaphragm is removably mounted onto the breast shield and/or the outer shell, and in which the diaphragm includes a portion that is arranged over the end or tip of the nipple tunnel.

77. A wearable milk collection hub for a breast pump system comprising:
(a) a breast shield made up of a breast flange and a nipple tunnel;
(b) a flexible diaphragm that is configured to prevent milk from reaching an external air pump subsystem;
(c) an outer shell that is configured to fit or latch onto the breast shield, such that the breast shield and outer shell form a vessel for collecting milk;
in which the diaphragm is removably mounted onto the breast shield and/or the outer shell and is positioned behind a diaphragm cap that forms part of the front or forward facing part of the outer shell, so as not to obstruct a mother's view of the nipple when placing the collection hub onto her breast.

78. A wearable milk collection hub for a breast pump system comprising:
(a) a breast shield made up of a breast flange and a nipple tunnel;
(b) a flexible diaphragm that is configured to prevent milk from reaching an external air pump subsystem;
(c) an outer shell that is configured to fit or latch onto the breast shield, such that the breast shield and outer shell form a vessel for collecting milk;
in which the outer shell includes a removable diaphragm cap that covers and seals the diphragm; and in which the diaphragm cap forms part of the front or forward facing part of the outer shell and includes an air port configured to transfer negative air pressure from the external air pump subsystem to the diaphragm.

79. A wearable milk collection hub for a breast pump system comprising:

(a) a breast shield made up of a breast flange and a nipple tunnel;

(b) a flexible diaphragm that is configured to prevent milk from reaching an external air pump subsystem;

(c) an outer shell that is configured to fit or latch onto the breast shield, such that the breast shield and outer shell form a vessel for collecting milk;

in which the outer shell includes a removable diaphragm cap that covers and seals the diaphragm; and in which the diaphragm cap forms part of the front or forward facing part of the outer shell and includes an air port configured to transfer negative air pressure from the external air pump subsystem to the diaphragm; and in which the removable diaphragm cap is configured to rotate to enable the position of the air port on the outer shell to be adjusted by a user.

80. A wearable milk collection hub for a breast pump system comprising:

(a) a breast shield made up of a breast flange and a nipple tunnel;

(b) a flexible diaphragm that is configured to prevent milk from reaching an external air pump subsystem;

(c) an outer shell that is configured to fit or latch onto the breast shield, such that the breast shield and outer shell form a vessel for collecting milk;

(d) a diaphragm cap that forms part of the front or forward facing part of the outer shell;

and in which the only user removable items from the breast shield are: the outer shell, the diaphragm, and the diaphragm cap, in normal use or normal disassembly.

81. A control unit for generating negative air pressure for a breast pump system, the control unit including:

(a) a rechargeable battery;

(b) a power charging circuit for controlling the charging of the rechargeable battery;

(c) control electronics powered by the rechargeable battery;

(d) a pump powered by the rechargeable battery and generating negative air pressure; and

(e) a motor for driving the pump;

(f) a casing;

in which the control unit further includes an airflow block that is configured to transfer suction from the pump to a suction or air port on the control unit and is further configured to attenuate sound from the pump and/or the motor reaching from reaching the casing.

82. A control unit for generating negative air pressure for a breast pump system, the control unit including:

(a) a rechargeable battery;

(b) a power charging circuit for controlling the charging of the rechargeable battery;

(c) control electronics powered by the rechargeable battery;

(d) a pump powered by the rechargeable battery and generating negative air pressure; and

(e) a motor for driving the pump;

and in which the control unit further includes a sound valve that is configured to air to pass in and out of the control unit sufficient for pressure equalisation between the inside and outside of the control unit, while minimizing sound from the pump and/or motor escaping from the control unit.

83. A control unit for generating negative air pressure for a breast pump system, the control unit including:

(a) a rechargeable battery;

(b) a power charging circuit for controlling the charging of the rechargeable battery;

(c) control electronics powered by the rechargeable battery;

(d) a pump powered by the rechargeable battery and generating negative air pressure and

(e) a motor for driving the pump;

(f) a solenoid valve for controlling the generated negative air pressure;

and in which the control unit further includes a cap or other structure that is configured to reduce the speed of air that enters the solenoid valve when the solenoid valve opens to ambient air pressure.

84. A control unit for generating negative air pressure for a breast pump system, the control unit including:

(a) a rechargeable battery;

(b) a power charging circuit for controlling the charging of the rechargeable battery;

(c) control electronics powered by the rechargeable battery;

(d) a pump powered by the rechargeable battery and generating negative air pressure and

(e) a motor for driving the pump;

and in which the control unit further includes a removable multifunction mount configured to attach to the control unit in at least two different positions, such that the control unit can be held in either upright/portrait or longwise/landscape mode.

85. A control unit for generating negative air pressure for a breast pump system, the control unit including:

(a) a rechargeable battery;

(b) a power charging circuit for controlling the charging of the rechargeable battery;

(c) control electronics powered by the rechargeable battery;

(d) a pump powered by the rechargeable battery and generating negative air pressure and

(e) a motor for driving the pump;

and in which the control unit further includes or, is removably attached to a tube management structure configured to enable an air tube attachable to the control unit to be wound around that tube management structure.