TITLE

Diaphragm vacuum pump

TECHNICAL FIELD

The present invention relates to a diaphragm vacuum pump according to the preamble of patent claim 1.

PRIOR ART

Diaphragm vacuum pumps of this type are used for various medicinal applications, in particular for drainage applications, such as wound drainage or thorax drainage. They are also well known as breastpumps for expressing human breast milk. Examples thereof include WO 96/22116, US 2009/0099511, US 2008/0287037, US 7 094 217 and US 2008/0039781.

The drive customarily consists of an electric motor which transmits the rotational movement of the motor to the diaphragm via an eccentric, a connecting rod or another force transmission unit and cyclically deflects said diaphragm. A disadvantage of many such pumps is that they are relatively large and loud. However, in particular in "hand-free" applications, the pump should be designed to be as discrete as possible and therefore as small and quiet as possible. In this context, "hands-free" means that, after being switched on, the entire device functions without hands, *i.e.* neither the pump nor the breast shield have to be held by hand.

WO 02/102437 and WO 2008/137678 show examples of "hands-free" expressing devices. The breast shield here is in each case integrated in a pump housing and serves at the same time as a diaphragm for generating a negative pressure. A stepper motor is used in each case as the drive.

PATENT CLAIMS

1. A diaphragm vacuum pump with an electrically operated drive unit and a vacuum diaphragm (94, 94' 94''), which separates a pump chamber (96, 96', 96'') into a drive-side part and a drive-remote part and which can be deflected by means of a movable part (92, 92', 92'') of the drive unit, wherein the drive unit is an electromagnetic drive unit, wherein the movement of the movable part (92, 92', 92'') is a linear movement and wherein the vacuum diaphragm (94, 94', 94'') is deflected in the direction of said linear movement which is generated electromagnetically in the drive unit.

2. The diaphragm vacuum pump as claimed in claim 1, wherein the movable part (92'') is operatively connected to a ventilation valve (903) for ventilating the diaphragm vacuum pump, wherein the linear movement generated in the drive unit optionally actuates the ventilation valve (903).

3. The diaphragm vacuum pump as claimed in claim 2, wherein the movable part (92'') has a first end and a second end opposite the first end, wherein the vacuum diaphragm (94'') is operatively connected to the first end, and the ventilation valve (903) is operatively connected to the second end.

4. The diaphragm vacuum pump as claimed in either of claims 2 and 3, wherein the ventilation valve has a ventilation diaphragm (903).

5. The diaphragm vacuum pump as claimed in claim 4, wherein the vacuum diaphragm (94'') is connected fixedly to the first end of the movable part (92'') and the ventilation diaphragm (903) is connected fixedly to the second end thereof, and wherein said diaphragms form the mounting of the movable part (92'') within the drive unit.

6. The diaphragm vacuum pump as claimed in one of claims 2 to 5, wherein the movable part (92'') is movable by means of a controller in a first and second stroke

in order to generate a vacuum in the pump chamber (96'') and is movable in a third stroke in order to actuate the ventilation valve (903), wherein the third stroke takes place in the direction of the second stroke but is larger than said second stroke.

7. The diaphragm vacuum pump as claimed in one of claims 1 to 6, wherein the drive unit has at least one permanent magnet (91, 91', 91'') and a coil former (92, 92', 92'') with a coil, wherein the coil is arranged on the coil former (92, 92', 92''), wherein the coil former (92, 92', 92'') together with the coil is held in a linearly displaceable manner in two directions along a longitudinal axis with respect to the magnet (91, 91', 91''), and wherein the coil former (92, 92', 92'') forms the movable part and is fixedly connected to the vacuum diaphragm (94, 94', 94'') and deflects the latter during the abovementioned displacement of the coil former (92, 92', 92'') in both directions of the displacement of said coil former.

8. The diaphragm vacuum pump as claimed in claim 7, wherein the coil former (92, 92', 92'') forms a piston with a first end at which the vacuum diaphragm (94, 94', 94'') is arranged.

9. The diaphragm vacuum pump as claimed in claim 8, wherein the vacuum diaphragm (94, 94', 94'') has a diameter that is much larger than the piston (92, 92', 92'').

10. The diaphragm vacuum pump as claimed in claim 9, wherein the vacuum diaphragm (94, 94', 94'') is fastened centrally on the first end of the piston (92, 92', 92'').

11. The diaphragm vacuum pump as claimed in one of claims 8 to 10, wherein the piston (92, 92', 92'') has a second end which is held in a linearly displaceable manner.

12. The diaphragm vacuum pump as claimed in one of claims 8 to 11, wherein the piston (92, 92'') has a second end to which a further diaphragm (903) is fastened.

13. The diaphragm vacuum pump as claimed in one of claims 8 to 12, wherein the coil (921, 921'') is a flat coil and wherein there is at least one permanent magnet (91, 91''), which is held in a fixed position in a housing (90, 90'') of the diaphragm

vacuum pump.

14. The diaphragm vacuum pump as claimed in one of claims 8 to 11, wherein the piston (92') has a second end, which is mounted displaceably between an iron core (911') and a magnet (91').

15. The diaphragm vacuum pump as claimed in one of claims 8 to 11 or 14, wherein the coil is a moving coil, the moving coil and the permanent magnet (91') are of rotationally symmetrical design, and an iron core (911') passes through the moving coil.

16. The diaphragm vacuum pump as claimed in one of claims 1 to 15, wherein there is at least one position detector (97, 97'; 98, 98', 98'') for determining the relative position of the movable part (92, 92', 92'') of the drive unit with respect to the remaining part of the drive unit which is in a fixed position.

17. The diaphragm vacuum pump as claimed in claim 16, wherein the position detector (97, 97'; 98, 98', 98'') generates a signal, which is used to control the vacuum pump, as a function of the relative position of the coil former (92, 92', 92'').

18. The diaphragm vacuum pump as claimed in one of claims 1 to 17, wherein there is an outlet (990) in the drive-remote part of the pump chamber (96, 96', 96''), said outlet being connected to an inlet of a second chamber (8), wherein the second chamber (8) has a further diaphragm (14), which separates said second chamber (8) into two parts (80, 81) and wherein the further diaphragm (14) serves as a means of separating media and for transferring the vacuum generated in the pump chamber.

TITLE

MEMBRANE VACUUM PUMP

TECHNICAL FIELD

The present invention relates to a diaphragm vacuum pump according to the preamble of patent claim 1.

PRIOR ART

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The drive customarily consists of an electric motor which transmits the rotational movement of the motor to the diaphragm via an eccentric, a connecting rod or another force transmission unit and cyclically deflects said diaphragm. A disadvantage of many such pumps is that they are relatively large and loud. However, in particular in "hand-free" applications, the pump should be designed to be as discrete as possible and therefore as small and quiet as possible. In this context, "hands-free" means that, after being switched on, the entire device functions without hands, *i.e.* neither the pump nor the breast shield have to be held by hand.

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PATENT CLAIMS

1. A diaphragm vacuum pump with an electrically operated drive unit and a vacuum diaphragm (94, 94' 94''), which separates a pump chamber (96, 96', 96'') into a drive-side part and a drive-remote part and which can be deflected by means of a movable part (92, 92', 92'') of the drive unit, wherein the drive unit is an electromagnetic drive unit, wherein the movement of the movable part (92, 92', 92'') is a linear movement and wherein the vacuum diaphragm (94, 94', 94'') is deflected in the direction of said linear movement which is generated electromagnetically in the drive unit, wherein the movable part (92'') is operatively connected to a ventilation valve (903) for ventilating the diaphragm vacuum pump, wherein the ventilation valve has a ventilation diaphragm (903), wherein the vacuum diaphragm (94'') is fixedly connected to a first end of the movable part (92'') and the ventilation diaphragm (903) is connected fixedly to a second end thereof, and wherein the vacuum diaphragm and the ventilation diaphragm form a mounting of the movable part (92'') within the drive unit, wherein the linear movement generated in the drive unit actuates the ventilation valve (903), wherein the movable part (92'') is movable by a controller in a first and second stroke in order to generate a vacuum in the pump chamber (96'') and is movable in a third stroke in order to actuate the ventilation valve (903), wherein the third stroke takes place in the direction of the second stroke but is larger than said second stroke.

2. The diaphragm vacuum pump as claimed in claim 1, wherein the first end of the movable part is opposite to the second end of the movable part.

3. The diaphragm vacuum pump as claimed in one of claims 1 or 2, wherein the drive unit has at least one permanent magnet (91, 91', 91'') and a coil former (92, 92', 92'') with a coil, wherein the coil is arranged on the coil former (92, 92', 92''), wherein the coil former (92, 92', 92'') together with the coil is held in a linearly displaceable manner in two directions along a longitudinal axis with respect to the magnet (91, 91', 91''), and wherein the coil former (92, 92', 92'') forms the movable part and is fixedly connected

to the vacuum diaphragm (94, 94', 94'') and deflects the latter during the abovementioned displacement of the coil former (92, 92', 92'') in both directions of the displacement of said coil former.

4. The diaphragm vacuum pump as claimed in claim 3, wherein the movable part comprises a piston formed by a coil former (92, 92', 92''), the piston comprising a first end and a second end, and wherein the vacuum diaphragm (94, 94', 94'') is arranged at the first end of the piston.

5. The diaphragm vacuum pump as claimed in claim 4, wherein the vacuum diaphragm (94, 94', 94'') has a diameter that is much larger than the piston (92, 92', 92'').

6. The diaphragm vacuum pump as claimed in claim 5, wherein the vacuum diaphragm (94, 94', 94'') is fastened centrally on the first end of the piston (92, 92', 92'').

7. The diaphragm vacuum pump as claimed in one of claims 4 to 6, wherein the second end of the piston (92, 92', 92'') is held in a linearly displaceable manner.

8. The diaphragm vacuum pump as claimed in one of claims 4 to 7, wherein the ventilation diaphragm is fastened to the second end of the piston (92, 92'').

9. The diaphragm vacuum pump as claimed in one of claims 4 to 8, wherein the coil (921, 921'') is a flat coil and wherein there is at least one permanent magnet (91, 91''), which is held in a fixed position in a housing (90, 90'') of the diaphragm vacuum pump.

10. The diaphragm vacuum pump as claimed in one of claims 4 to 9, wherein the second end of the piston (92') is mounted displaceably between an iron core (911') and a magnet (91').

11. The diaphragm vacuum pump as claimed in one of claims 4 to 7 or 10,

wherein the coil is a moving coil, the moving coil and the permanent magnet (91') are of rotationally symmetrical design, and an iron core (911') passes through the moving coil.

12. The diaphragm vacuum pump as claimed in one of claims 1 to 11, wherein there is at least one position detector (97, 97'; 98, 98', 98'') for determining the relative position of the movable part (92, 92', 92'') of the drive unit with respect to the remaining part of the drive unit which is in a fixed position.

13. The diaphragm vacuum pump as claimed in claim 12, wherein the position detector (97, 97'; 98, 98', 98'') generates a signal, which is used to control the vacuum pump, as a function of the relative position of the coil former (92, 92', 92'').

14. The diaphragm vacuum pump as claimed in one of claims 1 to 13, wherein there is an outlet (990) in the drive-remote part of the pump chamber (96, 96', 96''), said outlet being connected to an inlet of a second chamber (8), wherein the second chamber (8) has a third diaphragm (14), which separates said second chamber (8) into two parts (80, 81) and wherein the third diaphragm (14) serves as a means of separating media and for transferring the vacuum generated in the pump chamber.