Claims

1. An alternating tangential flow pressure device comprising:

a filter system comprising a cylinder and a sphere coupled to a distal end of the cylinder, the sphere including first and second hemispheres and a diaphragm positioned between the first and second hemispheres, wherein the cylinder contains a filter;

a pneumatic cylinder having a proximal end and a distal end, and defining a chamber therebetween, the proximal end of the pneumatic cylinder is directly ~~being~~ connected ~~in series~~ to the first hemisphere of the ~~a~~ filter system and ~~,~~ wherein the proximal end of the pneumatic cylinder comprises an opening to the chamber; and

a piston connecting linkage entering the pneumatic cylinder through the distal end thereof.

2. An alternating tangential flow pumping method comprising:

directly connecting a proximal end of a pneumatic cylinder to a distal end of a filter sphere base, the ~~having a~~ proximal end comprising a center opening, the pneumatic cylinder further comprising a distal end comprising a piston, and a chamber to the ~~a~~ filter sphere base comprising a center opening, lining up the center opening of the proximal end of the pneumatic cylinder with the center opening of the filter sphere base;

activating the piston with a linear servo; and

moving the piston in and out of the pneumatic cylinder, creating positive and negative pressure.

3. The method of claim 2, further comprising tracking the movement of the piston by an encoder connected to the linear servo.

~~4. An alternating tangential flow pumping system comprising: a pneumatic cylinder having a proximal end and a distal end, and defining a chamber therebetween, wherein the proximal end comprises an opening in the center of the proximal end which leads to the chamber; a piston connecting linkage entering the pneumatic cylinder through the distal end; a filter system, wherein the system comprises a sphere comprising a first and second hemisphere, wherein a diaphragm is between the first and second hemisphere, the first hemisphere connected to the distal end of a cylinder, wherein the proximal end of the cylinder~~

~~connects to a source of liquid, wherein the cylinder contains a filter, and the proximal end of the pneumatic cylinder is connected in series to the filter system.~~

~~5. The system of claim 4, wherein the filter system comprises more than one sphere and cylinder.~~

~~6. The system of claim 5, wherein the filter system connects two filters and the piston moves such that the movement of one filter is out of phase with the other.~~

~~7. The device or system of claim 1 or 4, wherein the piston further comprises a linear servo.~~

~~8. The device or system of claim 7, wherein the linear servo further comprises an encoder.~~

~~9. The device or system of claim 8, wherein the encoder provides information regarding the state of the system and/or actions occurring within the filter system.~~

4.~~10.~~ An alternating tangential flow pumping system comprising:

a first filter system and a second filter system, each of the first filter system and the second filter system including a hemisphere comprising a diaphragm, the first and second filter system each containing a filter and being connected to a source of liquid;

a ~~first~~ pneumatic cylinder having a first ~~proximal~~ end and a second ~~distal~~ end, and defining a chamber therebetween, the pneumatic cylinder ~~proximal end~~ being directly connected to the hemisphere of the first and second ~~in series to a first~~ filter systems, the pneumatic cylinder including ~~wherein the proximal end comprises an~~ openings ~~in the center of the proximal end~~ which lead~~s~~ to the chamber; and

~~a second pneumatic cylinder having a proximal end, a distal end, and containing a chamber, the proximal end being connected in series to a second filter system, wherein the proximal end comprises an opening in the center of the proximal end which leads to the chamber;~~

a piston connecting linkage entering ~~each of~~ the ~~first~~ pneumatic cylinder ~~and the second pneumatic cylinder through the distal ends of each of the first pneumatic cylinder and the second pneumatic cylinder~~;

~~the first filter system and the second filter system, wherein each of the first filter system and the second filter system comprises a hemisphere comprising a diaphragm,~~

~~the hemisphere connected to the distal end of a cylinder, wherein the proximal end of the cylinder connects to a source of liquid, and wherein the cylinder contains a filter;~~

wherein the piston moves to provide pressure to the first filter system, creating an equal vacuum on the second filter system.

~~11. A method of controlling an alternating tangential flow filtration process, the method comprising: selecting a volume or size of a diaphragm pump; selecting a volume of a fluid to be displaced by the diaphragm pump over a given period of time; selecting a duration of a pumping operation, which together with the desired volume of fluid to be displaced over the duration, generates a performance profile appropriate for a specific application; actuating the pumping operation by alternating a supply of positive and negative air flow to the diaphragm pump using a linear servo.~~

~~12. The method of claim 11, further comprising receiving a position signal from the encoder of the linear servo during at least one cycle of alternating positive and negative airflow, and comparing the position signal to a measured process variable and modifying an amplitude, duration, or other characteristic of the cycle based upon the comparison.~~

~~13. A method of actuating a diaphragm pump comprising: selecting a volume or size of a diaphragm pump; selecting a volume of a fluid to be displaced by the diaphragm pump over a given period of time; selecting a duration of a pumping operation, which together with the desired volume of fluid to be displaced over the duration, generates a performance profile appropriate for a specific application; actuating the pumping operation by alternating a supply of positive and negative air flow using a piston attached to a linear servo within a chamber connected to the diaphragm pump; monitoring the movement of the linear servo to maintain or alter the positive or negative~~

~~air flow per unit of time chamber;~~

~~optionally, monitoring a position of a diaphragm of the diaphragm pump at one or both ends of its displacement; and optionally, altering the positive or negative air flow within the chamber to influence either the position of the diaphragm at one or both ends of its displacement or a duration of a partial or full cycle of displacement or both.~~

~~14. The method of claim 13, further comprising simultaneously filtering the fluid suctioned from the bioreactor through two filters, wherein the diaphragm pump activates both in out of phase mode.~~

~~15. The method of claim 13, further comprising using the piston position to model the current state of the system.~~

~~16. The method of claim 15, further comprising using the piston position to calculate transmembrane pressure in the system.~~

5.~~17.~~ The device of claim 1, wherein the piston further comprises a linear servo.

6.~~18.~~ The device of claim 5~~17~~, wherein the linear servo further comprises an encoder.

7.~~19.~~ The device of claim 6~~18~~, wherein the position of the linear servo provides information as to actions occurring within the filter system.

8.~~20.~~ The device of claim 5~~17~~, wherein the linear servo controls speed and control of the piston movement, and then a PLC or PC command algorithm controls speed and control of the piston movement.

9.~~21.~~ The method of claim 2, wherein the linear servo controls speed and control of the piston movement, and then a PLC or PC command algorithm controls speed and control of the piston movement.

10.~~22.~~ The system of claim ~~4~~10, wherein the piston further comprises a linear servo.

11.~~23.~~ The system of claim 10~~22~~, wherein the linear servo further comprises an encoder.

12.~~24.~~ The system of claim 11~~23~~, wherein the position of the linear servo provides information as to actions occurring within the filter system.

13.~~25.~~ The system of claim 10~~22~~, wherein the linear servo controls speed and control of the piston movement, and then a PLC or PC command algorithm controls speed and control of the piston movement.