

CLAIMS

What is claimed is:

1. An intravascular blood pump, comprising:
 - a catheter configured for insertion into a blood vessel, the blood vessel defining an interior volume, through which blood flows;
 - a pump housing attached to the catheter and defining an input port and an output port, the pump housing having a longitudinal axis;
 - an impeller disposed within the pump housing and configured, when rotated, to pump blood from the input port to the output port; and
 - a filter in fluid communication between: (a) the interior volume of the blood vessel, external to the pump housing, and (b) the input port, the filter comprising a plurality of generally helical first struts wound about the longitudinal axis and a plurality of second struts, the first and second struts collectively defining a plurality of apertures therebetween.
2. An intravascular blood pump according to claim 1, wherein the pump housing, the impeller and the filter are each alternatingly radially compressible and radially expandable.
3. An intravascular blood pump according to claim 2, wherein the pump housing is configured, when radially compressed, to longitudinally lengthen an amount that depends on an amount by which the pump housing is radially compressed, and the filter is configured, when radially compressed, to longitudinally lengthen an amount that depends on an amount by which the filter is radially compressed such that, for a given amount of radial compression, the filter and the pump housing longitudinally lengthen about equal amounts.
4. An intravascular blood pump according to any previous claim, wherein the catheter, the pump housing, the impeller and the filter are configured for use in a living patient, such that each aperture of the plurality of apertures is sized to prevent ingestion, by the input port, of heart tissue of the living patient.
5. An intravascular blood pump according to any previous claim, wherein each aperture of the plurality of apertures has a largest dimension less than or equal to about 0.5 mm.
6. An intravascular blood pump according to any previous claim, wherein each aperture of the plurality of apertures has a largest dimension less than or equal to about 0.4 mm.

7. An intravascular blood pump according to any previous claim, wherein each aperture of the plurality of apertures has an area less than or equal to about 0.09 mm^2 .
8. An intravascular blood pump according to any previous claim, wherein each aperture of the plurality of apertures has an area less than or equal to about 0.16 mm^2 .
9. An intravascular blood pump according to any previous claim, wherein the plurality of apertures have a size that increases monotonically along the longitudinal axis.
10. An intravascular blood pump according to any previous claim, wherein the generally helical first struts are wound clockwise about the longitudinal axis, and the second struts are generally helically wound counterclockwise about the longitudinal axis.
11. An intravascular blood pump according to any one of claim 1-9, wherein the generally helical first struts are wound in a first direction about the longitudinal axis, and the second struts are generally helically wound in the first direction about the longitudinal axis.
12. An intravascular blood pump according to any one of claim 1-9, wherein each strut of at least a subset of the second struts lies in a respective plane that contains the longitudinal axis.
13. An intravascular blood pump according to any previous claim, wherein each aperture of at least a subset of the plurality of apertures has a general rhombus or rhomboid shape.
14. An intravascular blood pump according to any previous claim, wherein the generally helical first struts comprise a plurality of first filaments, the second struts comprise a plurality of second filaments and the first and second filaments are woven together, such that the plurality of apertures is defined between respective adjacent first and second woven filaments.
15. An intravascular blood pump according to any one of claims 1-13, wherein the filter comprises a tube having a wall, wherein the plurality of apertures comprises a plurality of openings defined through the wall.
16. An intravascular blood pump according to claim 15, wherein the tube comprises a generally funnel-shaped tube.
17. An intravascular blood pump according to any one of claims 15-16, wherein the wall is about 10-100 μm thick.

18. An intravascular blood pump according to any one of claims 15-17, wherein the pump housing comprises a plurality of third struts that collectively define a plurality of third apertures therebetween, and at least some of the first and second struts register radially over respective ones of the third struts.
19. An intravascular blood pump according to any one of claims 15-18, wherein each strut of at least a subset of the first struts comprises a fork that includes a plurality of tines, wherein a plurality of the first struts and a plurality of the second struts extend between a pair of the tines and collectively define a plurality of the apertures therebetween.
20. An intravascular blood pump according to claim 19, wherein each first strut that comprises a fork is wider than each first strut that does not comprise a fork.
21. An intravascular blood pump according to any one of claims 15-20, wherein the plurality of apertures are arranged in a plurality of generally circumferential, relative to the longitudinal axis, rows of equal-sized apertures, wherein ones of the rows have different numbers of apertures from others of the rows.
22. An intravascular blood pump according to any one of claim 21, wherein a first row of the plurality of generally circumferential rows comprises more apertures than a second row of the plurality of generally circumferential rows, and each aperture of the first row has a smaller area than each aperture of the second row.
23. An intravascular blood pump according to any one of claims 15-20, wherein the apertures are arranged in a plurality of generally circumferential, relative to the longitudinal axis, bands of about equal-sized apertures, wherein size of the apertures in each of the plurality of bands increases monotonically along the longitudinal axis.
24. An intravascular blood pump according to claim 23, wherein the filter comprises a distal portion and a proximal portion, the distal portion monotonically increases in diameter in a proximal direction along the longitudinal axis, the proximal portion monotonically decreases in diameter in the proximal direction along the longitudinal axis and at least a portion of the plurality of apertures is disposed on the distal portion.
25. An intravascular blood pump according to any previous claim, wherein the generally helical first struts and the second struts are absent any circumferential, relative to the longitudinal axis, struts.
26. A method for making a filter for an intravascular blood pump, the method comprising:
providing a catheter configured for insertion into a blood vessel, the blood vessel defining an interior volume, through which blood flows;

attaching a pump housing to the catheter, wherein the pump housing defines an input port and an output port, the pump housing having a longitudinal axis;

disposing an impeller within the pump housing, wherein the impeller is configured, when rotated, to pump blood from the input port to the output port; and

providing a filter in fluid communication between: (a) the interior volume of the blood vessel, external to the pump housing, and (b) the input port, the filter comprising a plurality of generally helical first struts wound about the longitudinal axis and a plurality of second struts, the first and second struts collectively defining a plurality of apertures therebetween.

27. A method according to claim 26, wherein the filter comprises a woven filter.

28. A method according to claim 26, wherein the filter comprises a shaped tube filter.