

We claim:

1. A delivery apparatus for an implantable prosthetic device, the delivery apparatus comprising:

a handle;

a first shaft extending distally from the handle;

a second shaft extending distally from the handle, wherein the first shaft extends through the second shaft and is movable axially relative to the second shaft;

an inflatable balloon having a proximal end portion and a distal end portion, wherein the proximal end portion of the balloon is coupled to a distal end portion of the second shaft and the distal end portion of the balloon is coupled to a distal end portion of the first shaft; and

an inflation hub assembly comprising an inflation manifold and a piston, wherein the inflation manifold comprises a main body defining a main lumen extending therethrough and an inflation port defining an inflation port lumen in fluid communication with the main lumen, wherein the piston extends into the main lumen and is slidable relative to the inflation manifold;

wherein a proximal end portion of the first shaft is coupled to the piston and a proximal end portion of the second shaft is coupled to the main body of the inflation manifold or the handle;

wherein the piston is moveable relative to the inflation manifold in proximal and distal directions such that distal movement of the piston produces distal movement of the first shaft relative to the second shaft, which increases the length of the balloon, and such that proximal movement of the piston produces proximal movement of the first shaft relative to the second shaft, which decreases the length of the balloon.

2. The delivery apparatus of claim 1, wherein the piston comprises a piston head and a piston stem, wherein the piston head comprises an annular groove and an annular seal member is disposed in the annular groove, wherein the seal member establishes a seal against an inner surface of the main lumen of the inflation manifold.

3. The delivery apparatus of any preceding claim, wherein the proximal end portion of the first shaft extends into and is secured within a lumen of the piston.
4. The delivery apparatus of any preceding claim, wherein the main lumen of the inflation manifold includes a radially projecting inner wall that is shaped to limit distal movement of the piston within the main lumen.
5. The delivery apparatus of any preceding claim, further comprising a cap member disposed on a proximal end portion of the main body of the inflation manifold, wherein the cap member comprises a projection positioned to limit proximal movement of the piston within the main lumen.
6. The delivery apparatus of claim 5, wherein the projection extends radially into the main lumen of the inflation manifold.
7. The delivery apparatus of any of claims 5-6, wherein the projection comprises a rib that extends into an axially extending groove formed on an outer surface of the piston, wherein the rib prevents rotation of the piston relative to the cap member.
8. The delivery apparatus of any of claims 5-7, wherein the cap member forms a snap fit connection with the proximal end portion of the main body of the inflation manifold.
9. The delivery apparatus of claim 8, wherein the cap member comprises a plurality of openings and the proximal end portion of the main body of the inflation manifold comprises a plurality of projections sized to extend into the openings to form the snap fit connection.
10. The delivery apparatus of any of claims 1-4, further comprising a cap member disposed on a proximal end portion of the main body of the inflation manifold, wherein the cap member is configured to permit axial movement of the piston and the first shaft relative

to the cap member in the proximal and distal directions and resist rotational movement of the piston and the first shaft relative to the cap member.

11. The delivery apparatus of any preceding claim, wherein the main lumen is in fluid communication with a fluid pathway between the first and second shafts, which is in turn is in fluid communication with the balloon such that an inflation fluid introduced into the inflation port lumen can flow through the main lumen, the fluid pathway, and into the balloon to inflate the balloon.

12. The delivery apparatus of claim 11, wherein the inflation hub assembly is configured such that withdrawing the inflation fluid from the balloon via the inflation port is effective to establish a vacuum in the inflation manifold that moves the piston and the first shaft in the distal direction.

13. The delivery apparatus of any preceding claim, further comprising a biasing member configured to bias the first shaft to move in the distal direction relative to the second shaft.

14. The delivery apparatus of claim 13, wherein the biasing member comprises a spring.

15. The delivery apparatus of claim 14, wherein the spring is disposed around the first shaft within the balloon.

16. The delivery apparatus of claim 14, wherein the spring is disposed around the piston.

17. The delivery apparatus of any preceding claim, wherein the main body of the inflation manifold is disposed in the handle.

~~18. A method of implanting a prosthetic heart valve, the method comprising:~~

~~inserting the distal end portion of a delivery apparatus and a prosthetic heart valve into the vasculature of a patient, wherein the prosthetic heart valve is in a radially compressed on a balloon of the delivery apparatus, wherein the delivery apparatus comprises a first shaft and a second shaft, the first shaft extending through the first shaft, and wherein a proximal end portion of the balloon is coupled to a distal end portion of the second shaft and a distal end portion of the balloon is coupled to a distal end portion of the first shaft;~~

~~advancing the prosthetic heart valve to an implantation location in the heart;~~

~~inflating the balloon to radially expand the prosthetic heart against surrounding tissue within the heart;~~

~~after inflating the balloon to radially the prosthetic heart valve, deflating the balloon;~~
~~and~~

~~while deflating the balloon, moving the first shaft distally relative to the second to increase the length of the balloon.~~

~~19.—The method of claim 18, wherein movement of the first shaft distally relative to the second shaft is caused by a biasing force of a biasing element.~~

~~20.—The method of claim 19, wherein the biasing element comprises a spring.~~

~~21.—The method of claim 20, wherein the spring is disposed in the balloon.~~

~~22.—The method of claim 20, wherein the spring is disposed on a piston that is coupled to a proximal end portion of the first shaft.~~

~~23.—The method of any of claims 18-22, wherein the delivery apparatus further comprises a handle and an inflation hub assembly comprising an inflation manifold and a piston, wherein the inflation manifold has a main lumen extending therethrough, wherein the piston extends into the main lumen and is slidable relative to the inflation manifold, wherein a proximal end portion of the first shaft is coupled to the piston and a proximal end portion of the second shaft is coupled to the inflation manifold or the handle.~~

~~24.—The method of claim 23, wherein movement of the first shaft distally relative to the second shaft is caused by manually moving the piston relative to the inflation manifold.~~

~~25.—The method of any of claims 23–24, wherein movement of the first shaft distally relative to the second shaft is caused by withdrawing an inflation fluid from the balloon via the inflation manifold to establish a vacuum in the inflation manifold that moves the piston and the first shaft in the distal direction.~~

2618. A delivery apparatus for an implantable prosthetic device, the delivery apparatus comprising:

a handle;

a first shaft extending distally from the handle;

a second shaft extending distally from the handle, wherein the first shaft extends through the second shaft and is movable axially relative to the second shaft in proximal and distal directions; and

an inflatable balloon having a proximal end portion and a distal end portion, wherein the proximal end portion of the balloon is coupled to a distal end portion of the second shaft and the distal end portion of the balloon is coupled to a distal end portion of the first shaft;

wherein distal movement of the first shaft relative to the second shaft moves the distal end portion of the balloon away from the proximal end portion of the balloon to increase a length of the balloon and proximal movement of the first shaft relative to the second shaft moves the distal end portion of the balloon toward the proximal end portion of the balloon to decrease the length of the balloon; and

a retaining mechanism configured to selectively retain the first shaft against distal and proximal movement relative to the second shaft.

2719. The delivery apparatus of claim 2618, further comprising an inflation hub assembly comprising an inflation manifold and a piston, wherein the inflation manifold has a main lumen extending therethrough, wherein the piston extends into the main lumen and is slidable relative to the inflation manifold, wherein a proximal end portion of the first shaft is coupled to the piston and a proximal end portion of the second shaft is coupled to the

inflation manifold or the handle such that axial movement of the piston relative to the inflation manifold is effective to produce axial movement of the first shaft relative to the second shaft.

2820. The delivery apparatus of claim 2719, wherein the retaining mechanism comprises a cap member disposed on a proximal end portion of the inflation manifold, wherein the cap member is configured to permit axial movement of the piston and the first shaft relative to the cap member in the proximal and distal directions when the piston is in a first rotational orientation relative to the cap member, and wherein the cap member is configured to resist axial movement of the piston and first shaft relative to the cap member when the piston is in a second rotational orientation relative to the cap member.

2921. The delivery apparatus of claim 2618, further comprising an inflation manifold housing a sealing member and the retaining mechanism comprises a cap member disposed on a proximal end portion of the inflation manifold, wherein the first shaft extends through the inflation manifold, the sealing member and the cap member, and wherein the cap member is configured to selectively compress the sealing member against the inner shaft to retain the inner shaft against axial movement relative to the second shaft.