CLAIMS

1. A pump with self-aligning casing, comprising:

a casing defining an interior volume, the casing including,

an inlet port that provides fluid communication with the interior volume,

an outlet port that provides fluid communication with the interior volume,

a first protruded portion extending toward the interior volume, the first protruded portion having a first land and first and second recesses,

a second protruded portion extending toward the interior volume and opposing the first protruded portion, the second protruded portion having a second land and third and fourth recesses, the first and second protruded portions disposed such that the first land and the second land confront each other and are spaced apart to define a gap;

a first fluid driver, the first fluid driver including,

a first support shaft supported by the casing, and

a first motor casing housing a first stator and a first rotor and fixedly connected to the first rotor, which drives the first motor casing in a first rotational direction, the first motor casing at least partially disposed in the first recess and the third recess, and

a first gear having a plurality of first gear teeth fixedly connected to and projecting radially outwardly from the first motor casing, the first gear teeth disposed in the gap; and

a second fluid driver, the second fluid driver including,

a second support shaft supported by the casing, and

a second motor casing housing a second stator and a second rotor and fixedly connected to the second rotor, which independently drives the second motor casing in a second rotational direction, the second motor casing at least partially disposed in the second recess and the fourth recess, and

a second gear having a plurality of second gear teeth fixedly connected to and projecting radially outwardly from the second motor casing, the second gear teeth disposed in the gap;

wherein the first and second protruded portions align the first and second fluid drivers such that the first gear teeth contact with the second gear teeth.

2. The pump of claim 1, wherein at least one of the first and second protruded portions is part of an end plate of the casing.

3. The pump of claim 1, the pump further comprising:

first bearings disposed between the first motor casing and each of the first and third recesses, and

second bearings disposed between the second motor casing and each of the second and fourth recesses.

4. The pump of claim 1, wherein at least one of the first protruded portion and the second protruded portion includes at least one cooling groove respectively disposed on at least one of the first land and the second land.

5. The pump of claim 4, wherein the at least one cooling groove extends from at least one of the first recess to the second recess and the third recess to the fourth recess.

6. The pump of claim 1, wherein the first and second protruded portions each include a first sloped segment and the first sloped segments form a converging flow path in which a cross-sectional area of at least a portion of the converging flow path extending from the inlet port to the first and second gears is reduced, and

wherein the first and second protruded portions each include a second sloped segment and the second sloped segments form a diverging flow path in which a cross-sectional area of at least a portion of the diverging flow path extending from the first and second gears to the outlet port is expanded.

7. A pump with self-aligning casing and a through-passage, comprising:

a casing defining an interior volume, the casing including,

an inlet port that provides fluid communication with the interior volume,

an outlet port that provides fluid communication with the interior volume,

a first protruded portion extending toward the interior volume, the first protruded portion having a first land and first and second recesses,

a second protruded portion extending toward the interior volume and opposing the first protruded portion, the second protruded portion having a second land and third and fourth recesses, the first and second protruded portions disposed such that the first land and the second land confront each other and are spaced apart to define a gap;

a first fluid driver, the first fluid driver including,

a first support shaft supported by the casing, and

a first motor casing housing a first stator and a first rotor and fixedly connected to the first rotor, which drives the first motor casing in a first rotational direction, the first motor casing at least partially disposed in the first recess and the third recess, and

a first gear having a plurality of first gear teeth fixedly connected to and projecting radially outwardly from the first motor casing, the first gear teeth disposed in the gap; and

a second fluid driver, the second fluid driver including,

a second support shaft supported by the casing, and

a second motor casing housing a second stator and a second rotor and fixedly connected to the second rotor, which independently drives the second motor casing in a second rotational direction, the second motor casing at least partially disposed in the second recess and the fourth recess, and

a second gear having a plurality of second gear teeth fixedly connected to and projecting radially outwardly from the second motor casing, the second gear teeth disposed in the gap;

wherein the first and second protruded portions align the first and second fluid drivers such that the first gear teeth contact with the second gear teeth; and

wherein at least one of the first support shaft and the second support shaft has a through passage along an axial centerline such that a first end of the through-passage provides fluid communication with a fluid chamber of a storage device and a second end of the through-passage, which is opposite the first end, provides fluid communication with at least one of the inlet port and the outlet port.

8. The pump of claim 7, wherein the first shaft has a first through-passage and the first end of the first through-passage provides fluid communication with the fluid chamber of the storage

device and the second shaft has a second through-passage and a first end of the second through-passage provides fluid communication with a fluid chamber of a second storage device.

9. A method of transferring fluid from an inlet port to an outlet port of a pump including a pump casing that defines an interior volume therein, the pump casing including a first protruded portion and a second protruded portion extending in to the interior volume, the pump further including a first fluid driver with a first gear having a plurality of first gear teeth, and a second fluid driver with a second gear having a plurality of second gear teeth, the method comprising:

aligning the first protruded portion to the second protruded portion so as to create a gap between a first land of the first protruded portion and a second land of the second protruded portion;

disposing the first fluid driver between a first recess in each of the first and second protruded portions and the second fluid driver between a second recess in each of the first and second protruded portions to align a first axial centerline of the first gear to a second axial centerline of the second gear and to position the plurality of first and second gear teeth in the gap;

rotating the first fluid driver to rotate the first gear about the first axial centerline in a first direction to transfer a fluid from the inlet port to the outlet port;

rotating the second fluid driver, independently of the first fluid driver, to rotate the second gear about the second axial centerline in a second direction to transfer the fluid from the inlet port to the outlet port; and

synchronizing contact between a face of at least one tooth of the plurality of second gear teeth and a face of at least one tooth of the plurality of first gear teeth to seal a fluid path between the outlet port and the inlet port such that a slip coefficient is 5% or less.

10. The method of claim 9, further comprising:

providing a portion of the fluid to first bearings disposed between the first fluid driver and each of the first recesses; and

providing a portion of the fluid to second bearings disposed between the second fluid driver and each of the second recesses.

11. The method of claim 9, further comprising:

reducing a cross-sectional area between the inlet port and the plurality of first and second gear teeth to form a converging flow path for the fluid; and

expanding a cross-sectional area between the plurality of first and second gear teeth and the outlet port to form a diverging flow path for the fluid.

12. A method of transferring fluid from an inlet port to an outlet port of a pump including a pump casing that defines an interior volume therein, the pump casing including a first protruded portion and a second protruded portion extending in to the interior volume, pump further including a first fluid driver with a first shaft and a first gear having a plurality of first gear teeth, and a second fluid driver with a second shaft and a second gear having a plurality of second gear teeth, the method comprising:

aligning the first protruded portion to the second protruded portion so as to create a gap between a first land of the first protruded portion and a second land of the second protruded portion;

disposing the first fluid driver between a first recess in each of the first and second protruded portions and the second fluid driver between a second recess in each of the first and second protruded portions to align a first axial centerline of the first gear to a second axial centerline of the second gear and to position the plurality of first and second gear teeth in the gap;

rotating the first fluid driver to rotate the first gear about the first axial centerline in a first direction to transfer a fluid from the inlet port to the outlet port;

rotating the second fluid driver, independently of the first fluid driver, to rotate the second gear about the second axial centerline in a second direction to transfer the fluid from the inlet port to the outlet port;

synchronizing contact between a face of at least one tooth of the plurality of second gear teeth and a face of at least one tooth of the plurality of first gear teeth to seal a fluid path between the outlet port and the inlet port such that a slip coefficient is 5% or less; and

transferring at least one of excess fluid to and supplemental fluid from at least one storage device via at least one through-passage disposed in at least one of the first shaft and the second shaft.

13. The method of claim 12, wherein the at least one storage device is one storage device, and

wherein the first shaft has a first through-passage and the second shaft has a second through-passage and the first and second through-passages provide fluid communication with a fluid chamber of the storage device.

14. The method of claim 12, wherein the at least one storage device is a first storage device and a second storage device, and

wherein the first shaft has a first through-passage that provides fluid communication with a fluid chamber of the first storage device and the second shaft has a second through-passage that provides fluid communication with a fluid chamber of the second storage device.

15. A pump with cooling grooves, comprising:

a casing defining an interior volume, the casing including,

an inlet port that provides fluid communication with the interior volume,

an outlet port that provides fluid communication with the interior volume,

at least one protruded portion extending toward the interior volume, each of the at least one protruded portion having a land and first and second recesses,

a first fluid driver, the first fluid driver including,

a first support shaft supported by the casing, and

a first motor casing housing a first stator and a first rotor and fixedly connected to the first rotor, which drives the first motor casing in a first rotational direction, the first motor casing at least partially disposed in one of the first recess and the second recess of the at least one protruded portion, and

a first gear having a plurality of first gear teeth fixedly connected to and projecting radially outwardly from the first motor casing, the first gear teeth disposed in a gap defined at least in part by the at least one protruded portion; and

a second fluid driver, the second fluid driver including,

a second support shaft supported by the casing, and

a second motor casing housing a second stator and a second rotor and fixedly connected to the second rotor, which independently drives the second motor casing in a second

rotational direction, the second motor casing at least partially disposed in the other of the first recess and the second recess of the at least one protruded portion,

a second gear having a plurality of second gear teeth fixedly connected to and projecting radially outwardly from the second motor casing, the second gear teeth disposed in the gap; and

at least one cooling groove disposed on at least one of the land of the at least one protruded portion and an end plate of the casing.

16. The pump of claim 15, wherein the at least one cooling groove is disposed on each land of the at least one protruded portion and the at least one cooling groove extends from the first recess to the second recess of the at least one protruded portion.

17. The pump of claim 16, wherein the at least one protruded portion is a first protruded portion and a second protruded portion, and

wherein the at least one cooling groove is disposed on the land of one of the first protruded portion and the second protruded portion.

18. The pump of claim 15, wherein the at least one cooling groove is disposed on the end plate of the casing.

19. A pump with self-aligning casing, comprising:

a casing defining an interior volume, the casing including,

an inlet port that provides fluid communication with the interior volume,

an outlet port that provides fluid communication with the interior volume,

at least one protruded portion extending toward the interior volume, each of the at least one protruded portion having a land and first and second recesses,

a first fluid driver, the first fluid driver including,

a first support shaft supported by the casing, and

a first motor casing housing a first stator and a first rotor and fixedly connected to the first rotor, which drives the first motor casing in a first rotational direction, the first motor casing at least partially disposed in one of the first recess and the second recess of the at least one protruded portion, and

a first gear having a plurality of first gear teeth fixedly connected to and projecting radially outwardly from the first motor casing, the first gear teeth disposed in a gap defined at least in part by the at least one protruded portion; and

a second fluid driver, the second fluid driver including,

a second support shaft supported by the casing, and

a second motor casing housing a second stator and a second rotor and fixedly connected to the second rotor, which independently drives the second motor casing in a second rotational direction, the second motor casing at least partially disposed in the other of the first recess and the second recess of the at least one protruded portion,

a second gear having a plurality of second gear teeth fixedly connected to and projecting radially outwardly from the second motor casing, the second gear teeth disposed in the gap; and

wherein the at least one protruded portion aligns the first and second fluid drivers such that the first gear teeth contact with the second gear teeth.

20. The pump of claim 19, wherein the at least one protruded portion is one protruded portion, and

wherein the gap is defined by the one protruded portion and an end plate of the casing.