Claims

1. A gearbox for a pump, the gearbox comprising:
   a ring gear;
   a sun gear;
   one or more planet gears arranged between the ring gear and the sun gear, the planet gears being arranged to move around the sun gear along a continuous path, wherein the ring gear, the sun gear, and the planet gears are arranged so that a radius of the path varies as the planet gears move along the path; and
   a piston, wherein the piston is associated with at least one planet gear such that an amount of compression of the piston changes as said planet gear moves along the path.

2. The gearbox of any preceding claim, wherein at least two of the ring gear, the sun gear, and the one or more planet gears have non-circular profiles, preferably, wherein each of the sun gear and the ring gear has a non-circular profile, more preferably wherein the sun gear and the ring gear have corresponding non-circular profiles.

3. The gearbox of any preceding claim, wherein the sun gear has a profile that comprises a sinusoidal wave superimposed onto an ellipse, preferably a sinusoidal wave superimposed onto a circle.

4. The gearbox of any preceding claim, wherein the ring gear has a profile that comprises a sinusoidal wave superimposed onto an ellipse, preferably a sinusoidal wave superimposed onto a circle.

5. The gearbox of any preceding claim, wherein the profile of the sun gear and/or the profile of the ring gear, and preferably the pitch circle diameter of each of the sun gear and the ring gear, is defined by the equation:

$$r(t) = \frac{P}{2} + a \cdot \sin(ft)$$

   where:
   t is a parametric variable with values from 0 to 2π;
   r is a radius of the gear at a value t;
   P is an average diameter of the gear;
   a is a wave amplitude; and
   f is a wave frequency.

6. The gearbox of any preceding claim, wherein the ring gear comprises a different number of minima and/or maxima than the sun gear, preferably wherein the ring gear comprises a greater number of minima and/or maxima than the sun gear.

7. The gearbox of any preceding claim, wherein the average diameters and the numbers of waves of the sun gear and the ring gear are linked by the equation:

$$\frac{P_{sun}}{f_{sun}} = \frac{P_{ring}}{f_{ring}}$$

   where:

   P_{sun} is an average diameter of the sun gear;
   P_{ring} is an average diameter of the ring gear;
   f_{sun} is a wave frequency of the sun gear; and

f_{ring} is a wave frequency of the ring gear.

8. The gearbox of any preceding claim, comprising a plurality of planet gears, preferably comprising at least one pair of planet gears, more preferably comprising a plurality of pairs of planet gears.

9. The gearbox of any preceding claim, comprising a number of planet gears that is equal to an order of rotational symmetry of the gearbox, preferably an order of rotational symmetry of the combination of the sun gear and the ring gear.

10. The gearbox of any preceding claim, wherein the planet gears are arranged symmetrically about a centre of rotation of the gearbox.

11. The gearbox of any preceding claim, wherein the width of the path is substantially constant.

12. The gearbox of any preceding claim, wherein a first end of the piston is associated with the planet gear and a second end of the piston is associated with a further component of the gearbox, such that the first end of that piston moves relative to the second end of the piston as the planet gear moves along the path, preferably such that the first end of the piston moves towards and/or away from the second end of the piston as the planet gear moves along the path.

13. The gearbox of claim 12, wherein the second end of the piston is connected to one or more of:
the sun gear;
the ring gear;
a further planet gear; and
a carrier of the gearbox.

14. The gearbox of any preceding claim, wherein one or more of the ring gear and the sun gear are arranged to remain stationary as the planet gears move along the path.

15. The gearbox of any of claims 1 to 13, wherein each of the sun gear and the ring gear are arranged to rotate as the planet gears move along the path.

16. The gearbox of any preceding claim, comprising a motor for driving a movement of one or more of:
the sun gear;
the ring gear;
one or more of the planet gears; and
a carrier associated with one or more of the planet gears,
preferably wherein the motor is arranged to operate in dependence on a desired pumping force.

17. The gearbox of any preceding claim, wherein:
the sun gear comprises one or more minimum points, wherein the radius of the sun gear at said minimum points is less than an average radius of the sun gear; and/or
the sun gear comprises one or more maximum points, wherein the radius of the sun gear at said maximum points is greater than an average radius of the sun gear.

18. The gearbox of claim 17, wherein:
a variation in amplitude of the minimum points of the sun gear is equal to a variation in amplitude of the maximum points of the sun gear.

19. The gearbox of any preceding claim, wherein:
    the diameter of the sun gear is:
        at least 100mm, at least 200mm, and/or at least 500mm, and/or
        no more than 1000mm, no more than 800mm, and/or no more than 500mm; and/or
    the diameter of the planet gears is:
        at least 50mm, at least 100mm, and/or at least 200mm, and/or
        no more than 500mm, no more than 400mm, and/or no more than 300mm.

20. The gearbox of any preceding claim, wherein one or more of, and preferably each of, the sun gear, the ring gear, and the planet gears may comprise a plurality of teeth, preferably wherein the teeth are arranged regularly about the profile of said gear.

21. A pump comprising the gearbox of any preceding claim.

22. The pump of claim 21, wherein the piston is arranged such that the change in the compression of the piston causes a pumping of a fluid associated with the pump.

23. A method of operating the gearbox of any of claims 1 to 20, wherein the method comprises driving one or more of: the sun gear, the ring gear, and one or more of the planet gears.

24. The method of claim 23, wherein the method comprises driving said gear(s) in dependence on a desired pumping force.

25. A kit of parts for the gearbox of any preceding claim, the kit of parts comprising:
    the ring gear;
    the sun gear;
    one or more planet gears; and
    one or more pistons.