CLAIMS:

1. An energy transduction apparatus, including:

a base;

a first magnet coupled to or comprising the base;

a piezoelectric transducer disposed adjacent the first magnet;

a magnet arrangement co-axial with the piezoelectric transducer, wherein the magnet arrangement is disposed on opposite sides of or at least partly around the piezoelectric transducer, or the piezoelectric transducer is disposed on opposite sides of or at least partly around the magnet arrangement, wherein the magnet arrangement is poled to have a first end of the magnet arrangement attracted to the first magnet;

a second magnet poled to be attracted to a second end of the magnet arrangement that is opposite the first end;

a vibratable mass coupled to or comprised by the second magnet;

electrical conductors electrically connected to the piezoelectric transducer to conduct current between the piezoelectric transducer and external circuitry; and

wherein the first magnet, the piezoelectric transducer, the magnet arrangement, and the second magnet are substantially coaxial;

wherein the first magnet, the second magnet and the magnet arrangement cooperate to keep the piezoelectric transducer in compression;

wherein vibrational movement of the second magnet is directly related to compression of the piezoelectric transducer and current flow in the electrical conductors; and

wherein the apparatus is configured to convert current in the electrical conductors into vibration of the vibratable mass in a frequency range of about 300 Hz to about 100 kHz to thereby act as an acoustic projector.

2. The apparatus of claim 1, wherein the magnet arrangement is disposed at least partly around the piezoelectric transducer.

3. The apparatus of claim 1 or claim 2, wherein the vibratable mass comprises a resonant mass.

4. The apparatus of any one of claims 1 to 3, wherein the piezoelectric transducer includes a relaxor ferroelectric single crystal (RFSC).

5. The apparatus of claim 4, wherein the piezoelectric transducer includes a ternary piezoelectric single crystal.

6. The apparatus of claim 4, wherein the piezoelectric transducer is a PMN-PT or PZN-PT crystal.

7. The apparatus of claim 4, wherein the piezoelectric transducer is a PIN-PMN-PT crystal.

8. The apparatus of claim 4, wherein the piezoelectric transducer is a Mn-PIN-PMN-PT crystal or a Mn-PMN-PZT crystal.

9. The apparatus of any one of claims 4 to 8, wherein a piezoelectric crystal of the piezoelectric transducer is poled [011] and arranged to operate in transverse extension (3-2) mode, with a 2 axis of the piezoelectric crystal being substantially coaxial with the first magnet, the magnet arrangement, the spacer, the second magnet and the vibratable mass.

10. The apparatus of any one of claims 1 to 9, wherein the first magnet, the magnet arrangement and the second magnet are rare earth magnets.

11. The apparatus of any one of claims 1 to 10, further comprising a first thin shim disposed between the first magnet and a first end of the piezoelectric transducer and a second thin shim disposed between the second magnet and an opposite second end of the piezoelectric transducer.

12. The apparatus of claim 11, wherein the first thin shim and the second thin shim are formed of a machinable glass ceramic material.

13. The apparatus of any one of claims 1 to 12, wherein the piezoelectric transducer includes a spacer positioned between the first magnet and the second magnet, the spacer being significantly more compressible than the magnet arrangement and the piezoelectric transducer.

14. The apparatus of claim 13, wherein the spacer defines an aperture to receive the piezoelectric transducer therethrough.

15. The apparatus of claim 13 or claim 14, wherein the spacer has an axial thickness of between about 1 mm and about 3 mm when the vibratable mass is at rest.

16. The apparatus of claim 15, wherein the spacer has an axial thickness of between about 2.4 mm and about 2.8 mm when the vibratable mass is at rest.

17. The apparatus of any one of claims 1 to 16, wherein the magnet arrangement defines a passage through which the piezoelectric transducer extends, and wherein the magnet arrangement and the piezoelectric transducer do not contact each other in the passage.

18. The apparatus of claim 17, wherein the magnet arrangement is symmetrical about multiple axes.

19. The apparatus of claim 17 or claim 18, wherein the magnet arrangement comprises a unitary magnet body.

20. The apparatus of claim 17 or claim 18, wherein the magnet arrangement comprises multiple magnet bodies fixed in position relative to each other.

21. The apparatus of claim 20, wherein an axial spacer is disposed between two of the multiple magnet bodies.

22. The apparatus of claim 20 or claim 21, further including an alignment disc disposed between and coaxial with two of the multiple magnet bodies, the alignment disc defining an alignment aperture in a centre of the alignment disc to receive and axially align the piezoelectric transducer.

23. The apparatus of claim 22, wherein the alignment disc is formed of a magnetically inert material.

24. The apparatus of any one of claims 17 to 23, wherein the magnet arrangement is substantially cylindrical.

25. The apparatus of any one of claims 13 to 16, wherein the spacer comprises a plurality of compressible ligaments arranged to separate the magnet arrangement and the second magnet, wherein an axial length of the piezoelectric transducer is substantially the same as a combined axial length of the spacer and the magnet arrangement.

26. The apparatus of any one of claims 1 to 25, wherein the magnet arrangement and the second magnet are configured to exert between about 50 Newtons and about 500 Newtons of substantially static compressive force to the piezoelectric transducer.

27. The apparatus of any one of claims 1 to 25, wherein the magnet arrangement and the second magnet are configured to exert between about 5 Newtons and about 50 Newtons of substantially static compressive force to the piezoelectric transducer.

28. The apparatus of any one of claims 1 to 26, wherein the apparatus is configured to convert current in the electrical conductors into vibration of the vibratable mass in a frequency range of about 300 Hz to about 50 kHz to thereby act as an acoustic projector.

29. The apparatus of claim 1, wherein the magnet arrangement is disposed concentrically with the piezoelectric transducer.

30. The apparatus of claim 29, wherein the piezoelectric transducer at least partially surrounds the magnet arrangement.

31. The apparatus of claim 29 or claim 30, wherein the piezoelectric transducer comprises multiple stacked piezoelectric transducer elements.

32. The apparatus of any one of claims 29 to 31, wherein the magnet arrangement comprises a cylindrical magnet that is one of:

in contact with the first magnet or the second magnet but not both; and

in contact with a thin bonding layer that bonds the cylindrical magnet to the first magnet or the second magnet.

33. The apparatus of any one of claims 29 to 32, wherein the combination of the first magnet, the magnet arrangement and the second magnet is configured to exert between about 50 Newtons and about 500 Newtons of substantially static compressive force to the piezoelectric transducer.

34. The apparatus of any one of claims 29 to 32, wherein the combination of the first magnet, the magnet arrangement and the second magnet is configured to exert between about 5 Newtons and about 50 Newtons of substantially static compressive force to the piezoelectric transducer.

35. The apparatus of claim 33 or claim 34, wherein the static compressive force and the movement of the piezoelectric transducer are aligned in a same axial direction.

36. A watercraft comprising the apparatus of any one of claims 1 to 35 mounted on the watercraft to project vibration energy from the watercraft during use of the watercraft.

37. The apparatus of any one of claims 1 to 36, further comprising an impedance matching layer disposed at an outer end of the second magnet.

38. The apparatus of any one of claims 1 to 37, further comprising an acoustic lens disposed at an outer end of the second magnet.

~~39. An energy transduction device, including:~~

~~a piezoelectric transducer;~~

~~electrical conductors electrically coupled to the piezoelectric transducer;~~

~~an axially aligned magnet assembly arranged to apply static compressive force to the piezoelectric transducer, the magnet assembly being coupled to a base at one end and having a free opposite end;~~

wherein the magnet assembly is coaxial with the piezoelectric transducer and at least part of the magnet assembly is concentric with the piezoelectric transducer;

wherein the magnet assembly defines a gap between axially adjacent parts of the magnet assembly, wherein the gap is dimensioned to be sufficiently small that the magnet assembly applies a static compressive force of between about 5 Newtons and about 50 Newtons to the piezoelectric transducer while being sufficiently large to allow for axial movement of the piezoelectric transducer without closing the gap.

40. The device of claim 39, wherein the gap defines an axial separation between axially adjacent parts of the magnet assembly of between about 0.2 mm and about 1.0 mm.

41. The device of claim 39 or claim 40, wherein the static compressive force is between about 90 Newtons and about 400 Newtons.

42. An acoustic projection system, comprising multiple ones of the apparatus of any one of claims 1 to 38 or the device of any one of claims 39 to 41 mounted to one or more mounting bodies to project vibration energy away from the one or more mounting bodies.

43. An acoustic detection system, comprising multiple ones of the apparatus of any one of claims 1 to 38 or the device of any one of claims 39 to 41 mounted to one or more mounting bodies and configured to detect vibration energy when the respective ones of the apparatus or device are not being used for acoustic projection.

44. The acoustic projection system of claim 42 or the acoustic detection system of claim 43, wherein ones of the apparatus or device are positioned at spaced locations on the one or more mounting bodies.

45. The acoustic projection system of claim 42 or the acoustic detection system of claim 43, wherein multiple ones of the apparatus or device are arranged in an array or bank on the one or mounting bodies.

46. The acoustic projection system of claim 42 or the acoustic detection system of claim 43, wherein multiple ones of the apparatus or device are arranged to face a same direction.

47. The acoustic projection system of claim 42 or the acoustic detection system of claim 43, wherein multiple ones of the apparatus or device are arranged to face a different direction.