CLAIMS

1. A directional acoustic warning device, suitable for creating a greater sound pressure at a selected target than around the target, wherein the device has a sound pressure generating source coupled to a sound guiding structure, wherein the sound pressure generating source comprises an electronic signal generating system connected to a transducer, the transducer being capable of converting electronic signals from the signal generating system to sound pressure waves, and wherein
the signal generating system is arranged to produce a first signal having a waveform with a frequency which is varied around the first resonant frequency of the human ear canal, and wherein
the sound guiding structure includes
an open-ended cone-shaped horn having a narrow end and a wide end, wherein the narrow end of the horn is located toward the sound pressure generating source and,
a horn ring of acoustically absorbent material provided at the wide end of the horn, and,
a phase plug provided within the horn, and
a phase plug ring of acoustically absorbent material provided around a part of the phase plug, and wherein
the dimensions of the horn and the phase plug and the position and dimensions of the horn ring and phase plug ring are selected to maximise the directionality of the sound and minimise sound level exposure to a user of the device and bystanders at frequencies around the first resonant frequency of the human ear canal.

2. A directional acoustic warning device in accordance with claim 1, wherein the signal generating system is arranged to produce a signal having a waveform with a frequency which is modulated between a lower limit and an upper limit.

3. A directional acoustic warning device in accordance with claim 2, wherein the lower limit is 3 kHz and the upper limit is 5 kHz.

4. A directional acoustic warning device in accordance with claim 2, wherein the lower limit is 3.5 kHz and the upper limit is 4.0 kHz.

5. A directional acoustic warning device in accordance with claim 2 to 4, wherein the frequency is modulated between the lower limit and the upper limit repeatedly at a

constant modulation rate.

6. A directional acoustic warning device in accordance with claim 5, wherein the modulation rate is within the range 0.1 to 0.5 seconds.

7. A directional acoustic warning device in accordance with claim 5, wherein the modulation rate is within the range 0.15 to 0.25 seconds.

8. A directional acoustic warning device in accordance with claims 2 to 7, wherein the frequency is modulated such that it increases from the lower limit to the upper limit in each modulation cycle.

9. A directional acoustic warning device in accordance with any preceding claim wherein the signal generating system is arranged to produce a second signal contemporaneously with the first signal, and wherein the frequency of the second signal is related to the frequency to the first signal.

10. A directional acoustic warning device in accordance with claim 9, wherein the frequency of the second signal is a multiple of the critical bandwidth from the frequency of the first signal.

11. A directional acoustic warning device in accordance with claim 10, wherein the multiple is in the range 0.2 to 0.3.

12. A directional acoustic warning device in accordance with claim 9, wherein the frequency of the second signal is modulated such that it decreases from the upper limit to the lower limit of the frequency of the first signal as the first signal increases from the lower limit to the upper limit.

13. A directional acoustic warning device in accordance with any preceding claim, wherein the waveform is a sinusoidal waveform.

14. A directional acoustic warning device in accordance with any preceding claim, where the signal generating system is arranged to also produce a pink noise signal.

15. A directional acoustic warning device in accordance with any preceding claim, wherein the cone-shaped horn is a straight-walled hollow cone, having a throat end

connected to the transducer and an open mouth end.

16. A directional acoustic warning device in accordance with claim 15, wherein the throat diameter is in the range 1 centimetre to 10 centimetres.

17. A directional acoustic warning device in accordance with claim 15, wherein the throat diameter is in the range 3.5 cm to 4.0 cm.

18. A directional acoustic warning device in accordance with claims 15 to 17, wherein the mouth diameter is in the range 10 cm to 100 cm.

19. A directional acoustic warning device in accordance with claims 15 or 17, wherein the mouth diameter is in the range 30.5 cm to 31.5 cm.

20. A directional acoustic warning device in accordance with any one of claims 15 to 19, wherein the distance between the throat and the mouth is in the range 20 cm to 150 cm.

21. A directional acoustic warning device in accordance with any one of claims 15 to 19, wherein the distance between the throat and the mouth is in the range 67.0 cm to 68.0 cm.

22. A directional acoustic warning device in accordance with any preceding claim, wherein the acoustically absorbent material is acoustically absorbent foam.

23. A directional acoustic warning device in accordance with claim 22, wherein a portion of the horn ring is covered in loose-fitting fabric.

24. A directional acoustic warning device in accordance with any one of claims 15 to 23, wherein the phase plug is mounted within the horn and spaced from the inner wall of the horn.

25. A directional acoustic warning device in accordance with any preceding claim, wherein the phase plug is a bi-conic shape, formed from first and second straight-walled cones each cone having a tip end and a base end which is wider than the tip end, wherein the cones are joined at their base ends to form an apex of the bi-conic shape, and mounted within the horn such that a first cone of the phase plug has a tip

end towards the throat of the horn cone.

26. A directional acoustic warning device in accordance with any preceding claim, wherein the length of the phase plug is substantially equal to the length of the straight-walled hollow cone.

27. A directional acoustic warning device in accordance with claim 25 or 26, wherein the tip end of the phase plug near the throat of the horn is rounded.

28. A directional acoustic warning device in accordance with claim 27, wherein the radius of curvature of the tip end is between 0.1cm and 10cm

29. A directional acoustic warning device in accordance with claim 27, wherein the radius of curvature of the tip end is between 0.1cm and 1.0cm

30. A directional acoustic warning device in accordance with any one of claims 25 to 29, wherein the tip end of the phase plug near the mouth of the horn is rounded.

31. A directional acoustic warning device in accordance with claim 30, wherein the curvature of the with a radius of curvature of the tip end is between 0.1cm and 10cm

32. A directional acoustic warning device in accordance with claim 30, wherein the curvature of the with a radius of curvature of the tip end is between 0.1cm and 1.0cm

33. A directional acoustic warning device in accordance with any one of claims 25 to 32, wherein the apex where the base ends of the cones of the phase plug are joined is rounded.

34. A directional acoustic warning device in accordance with claim 33, wherein the radius of curvature at the apex of the phase plug is between 0.1 to 20cm

35. A directional acoustic warning device in accordance with claim 33, wherein the radius of curvature at the apex of the phase plug is between 0.5 to 2.0cm

36. A directional acoustic warning device in accordance with any preceding claim wherein the total length of the phase plug is between 10 and 100cm

37. A directional acoustic warning device in accordance with any preceding claim wherein the total length of the phase plug is between 65.0 and 75.0cm

38. A directional acoustic warning device in accordance with any preceding claim, wherein the diameter of the phase plug is between 5 and 50cm

39. A directional acoustic warning device in accordance with any preceding claim, wherein the diameter of the phase plug is between 14.0 and 15.0cm

40. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is mounted on the exterior of the horn.

41. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is between 0.5cm and 25cm thick and/or protrudes between 0cm and 50cm in front of the horn mouth and/or extends between 0cm and 50cm to the rear of the horn mouth.

42. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is between 4.0cm and 6.0cm thick and/or protrudes between 4.0cm and 6.0cm in front of the horn mouth and/or extends between 10.0cm and 20.0cm to the rear of the horn mouth.

43. A directional acoustic warning device in accordance with claims 25 to 42, wherein the second cone of the phase plug has a ring of acoustically absorbent foam coaxially mounted on its surface.

44. A directional acoustic warning device in accordance with claims 25 to 42, wherein the horn ring is positioned between 0cm and 50cm from the apex of the phase plug.

45. A directional acoustic warning device in accordance with claims 25 to 42, wherein the horn ring is positioned between 9.0cm and 10.0cm from the apex of the phase plug.

46. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is between 1cm and 50cm in width and/or between 1cm and 20cm in thickness.

47. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is between 4.0cm and 6.0cm in width and/or between 1.5cm and 2.5cm in thickness.

48. A directional acoustic warning device in accordance with any preceding claim, wherein a sound limiter is provided in communication with the signal generating system, which is arranged to limit the sound pressure level at the target.

49. A directional acoustic warning device in accordance with claim 48, wherein a laser range finder is provided to determine the distance between the device and a target and the sound limiter is arranged to limit the sound level at the target based on the distance between the device and the target as determined by the laser range finder.

50. A directional acoustic warning device in accordance with claim 48 or 49, wherein the sound limiter is arranged to limit the duration of the signals produced by the signal generator and/or the period between use of the device.

51. A directional acoustic warning device in accordance with any preceding claim, wherein a video camera is provided for aiming the device.

52. A directional acoustic warning device in accordance with claim 51, wherein the output of the video camera is recorded.

53. A directional acoustic warning device in accordance with claim 51 or 52, wherein a GPS position unit is incorporated for determining the geographical position of the device, and wherein the device is further capable of recording GPS position, time, date, target range and duration of exposure of the target to sound pressure produced by the device and video footage of the target, for evidence purposes.

54. A directional acoustic warning device in accordance with any preceding claim, wherein the device is portable.

55. A sound guiding structure for an acoustic device, including a straight-walled cone-shaped horn having a throat end for connecting to a sound pressure source and an open mouth end, wherein the throat end is narrower than the mouth end, and wherein a phase plug is mounted within the horn and spaced from the inner wall of the horn, wherein the phase plug is a bi-conic solid shape, formed from first and

second straight-walled cones joined at their bases, and mounted within the horn such that the first cone of the phase plug has a tip end towards the throat of the horn cone, and wherein the second cone of the phase plug has a ring of acoustically absorbent material coaxially mounted on its surface.

56. A sound guiding structure for an acoustic device, including a cone-shaped horn having a throat end for connecting to a sound pressure source and an open mouth end, wherein the throat end is narrower than the mouth end, and wherein a horn ring of acoustically absorbent material is provided at the wide end of the horn, wherein the horn ring is mounted on the exterior of the horn.

CLAIMS

1. A directional acoustic warning device, suitable for creating a greater sound pressure at a selected target than around the target, wherein the device has a sound pressure generating source coupled to a sound guiding structure, wherein the sound pressure generating source comprises an electronic signal generating system connected to a transducer, the transducer being capable of converting electronic signals from the signal generating system to sound pressure waves, and wherein
the signal generating system is arranged to produce a first signal having a waveform with a frequency which is varied around the first resonant frequency of the human ear canal, and wherein
the sound guiding structure includes
an open-ended cone-shaped horn having a narrow end and a wide end, wherein the narrow end of the horn is located toward the sound pressure generating source and,
a horn ring of acoustically absorbent material provided at the wide end of the horn, and,
a phase plug provided within the horn, and
a phase plug ring of acoustically absorbent material provided around a part of the phase plug, and wherein
the dimensions of the horn and the phase plug and the position and dimensions of the horn ring and phase plug ring are selected to maximise the directionality of the sound and minimise sound level exposure to a user of the device and bystanders at frequencies around the first resonant frequency of the human ear canal.

2. A directional acoustic warning device in accordance with claim 1, wherein the signal generating system is arranged to produce a signal having a waveform with a frequency which is modulated between a lower limit and an upper limit.

3. A directional acoustic warning device in accordance with claim 2, wherein the lower limit is 3 kHz and the upper limit is 5 kHz.

4. A directional acoustic warning device in accordance with claim 2, wherein the lower limit is 3.5 kHz and the upper limit is 4.0 kHz.

5. A directional acoustic warning device in accordance with claim 2 to 4, wherein the frequency is modulated between the lower limit and the upper limit repeatedly at a

constant modulation rate.

6. A directional acoustic warning device in accordance with claim 5, wherein the modulation rate is within the range 0.1 to 0.5 seconds.

7. A directional acoustic warning device in accordance with claim 5, wherein the modulation rate is within the range 0.15 to 0.25 seconds.

8. A directional acoustic warning device in accordance with claims 2 to 7, wherein the frequency is modulated such that it increases from the lower limit to the upper limit in each modulation cycle.

9. A directional acoustic warning device in accordance with any preceding claim wherein the signal generating system is arranged to produce a second signal contemporaneously with the first signal, and wherein the frequency of the second signal is related to the frequency to the first signal.

10. A directional acoustic warning device in accordance with claim 9, wherein the frequency of the second signal is a multiple of the critical bandwidth from the frequency of the first signal.

11. A directional acoustic warning device in accordance with claim 10, wherein the multiple is in the range 0.2 to 0.3.

12. A directional acoustic warning device in accordance with claim 9, wherein the frequency of the second signal is modulated such that it decreases from the upper limit to the lower limit of the frequency of the first signal as the first signal increases from the lower limit to the upper limit.

13. A directional acoustic warning device in accordance with any preceding claim, wherein the waveform is a sinusoidal waveform.

14. A directional acoustic warning device in accordance with any preceding claim, where the signal generating system is arranged to also produce a pink noise signal.

15. A directional acoustic warning device in accordance with any preceding claim, wherein the cone-shaped horn is a straight-walled hollow cone, having a throat end

connected to the transducer and an open mouth end.

16. A directional acoustic warning device in accordance with claim 15, wherein the throat diameter is in the range 1 centimetre to 10 centimetres.

17. A directional acoustic warning device in accordance with claim 15, wherein the throat diameter is in the range 3.5 cm to 4.0 cm.

18. A directional acoustic warning device in accordance with claims 15 to 17, wherein the mouth diameter is in the range 10 cm to 100 cm.

19. A directional acoustic warning device in accordance with claims 15 or 17, wherein the mouth diameter is in the range 30.5 cm to 31.5 cm.

20. A directional acoustic warning device in accordance with any one of claims 15 to 19, wherein the distance between the throat and the mouth is in the range 20 cm to 150 cm.

21. A directional acoustic warning device in accordance with any one of claims 15 to 19, wherein the distance between the throat and the mouth is in the range 67.0 cm to 68.0 cm.

22. A directional acoustic warning device in accordance with any preceding claim, wherein the acoustically absorbent material is acoustically absorbent foam.

23. A directional acoustic warning device in accordance with claim 22, wherein a portion of the horn ring is covered in loose-fitting fabric.

24. A directional acoustic warning device in accordance with any one of claims 15 to 23, wherein the phase plug is mounted within the horn and spaced from the inner wall of the horn.

25. A directional acoustic warning device in accordance with any preceding claim, wherein the phase plug is a bi-conic shape, formed from first and second straight-walled cones each cone having a tip end and a base end which is wider than the tip end, wherein the cones are joined at their base ends to form an apex of the bi-conic shape, and mounted within the horn such that a first cone of the phase plug has a tip

end towards the throat of the horn cone.

26. A directional acoustic warning device in accordance with any preceding claim, wherein the length of the phase plug is substantially equal to the length of the straight-walled hollow cone.

27. A directional acoustic warning device in accordance with claim 25 or 26, wherein the tip end of the phase plug near the throat of the horn is rounded.

28. A directional acoustic warning device in accordance with claim 27, wherein the radius of curvature of the tip end is between 0.1cm and 10cm

29. A directional acoustic warning device in accordance with claim 27, wherein the radius of curvature of the tip end is between 0.1cm and 1.0cm

30. A directional acoustic warning device in accordance with any one of claims 25 to 29, wherein the tip end of the phase plug near the mouth of the horn is rounded.

31. A directional acoustic warning device in accordance with claim 30, wherein the curvature of the with a radius of curvature of the tip end is between 0.1cm and 10cm

32. A directional acoustic warning device in accordance with claim 30, wherein the curvature of the with a radius of curvature of the tip end is between 0.1cm and 1.0cm

33. A directional acoustic warning device in accordance with any one of claims 25 to 32, wherein the apex where the base ends of the cones of the phase plug are joined is rounded.

34. A directional acoustic warning device in accordance with claim 33, wherein the radius of curvature at the apex of the phase plug is between 0.1 to 20cm

35. A directional acoustic warning device in accordance with claim 33, wherein the radius of curvature at the apex of the phase plug is between 0.5 to 2.0cm

36. A directional acoustic warning device in accordance with any preceding claim wherein the total length of the phase plug is between 10 and 100cm

37. A directional acoustic warning device in accordance with any preceding claim wherein the total length of the phase plug is between 65.0 and 75.0cm

38. A directional acoustic warning device in accordance with any preceding claim, wherein the diameter of the phase plug is between 5 and 50cm

39. A directional acoustic warning device in accordance with any preceding claim, wherein the diameter of the phase plug is between 14.0 and 15.0cm

40. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is mounted on the exterior of the horn.

41. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is between 0.5cm and 25cm thick and/or protrudes between 0cm and 50cm in front of the horn mouth and/or extends between 0cm and 50cm to the rear of the horn mouth.

42. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is between 4.0cm and 6.0cm thick and/or protrudes between 4.0cm and 6.0cm in front of the horn mouth and/or extends between 10.0cm and 20.0cm to the rear of the horn mouth.

43. A directional acoustic warning device in accordance with claims 25 to 42, wherein the second cone of the phase plug has a ring of acoustically absorbent foam coaxially mounted on its surface.

44. A directional acoustic warning device in accordance with claims 25 to 42, wherein the horn ring is positioned between 0cm and 50cm from the apex of the phase plug.

45. A directional acoustic warning device in accordance with claims 25 to 42, wherein the horn ring is positioned between 9.0cm and 10.0cm from the apex of the phase plug.

46. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is between 1cm and 50cm in width and/or between 1cm and 20cm in thickness.

47. A directional acoustic warning device in accordance with any preceding claim, wherein the horn ring is between 4.0cm and 6.0cm in width and/or between 1.5cm and 2.5cm in thickness.

48. A directional acoustic warning device in accordance with any preceding claim, wherein a sound limiter is provided in communication with the signal generating system, which is arranged to limit the sound pressure level at the target.

49. A directional acoustic warning device in accordance with claim 48, wherein a laser range finder is provided to determine the distance between the device and a target and the sound limiter is arranged to limit the sound level at the target based on the distance between the device and the target as determined by the laser range finder.

50. A directional acoustic warning device in accordance with claim 48 or 49, wherein the sound limiter is arranged to limit the duration of the signals produced by the signal generator and/or the period between use of the device.

51. A directional acoustic warning device in accordance with any preceding claim, wherein a video camera is provided for aiming the device.

52. A directional acoustic warning device in accordance with claim 51, wherein the output of the video camera is recorded.

53. A directional acoustic warning device in accordance with claim 51 or 52, wherein a GPS position unit is incorporated for determining the geographical position of the device, and wherein the device is further capable of recording GPS position, time, date, target range and duration of exposure of the target to sound pressure produced by the device and video footage of the target, for evidence purposes.

54. A directional acoustic warning device in accordance with any preceding claim, wherein the device is portable.

55. A sound guiding structure for an acoustic device, including a straight-walled cone-shaped horn having a throat end for connecting to a sound pressure source and an open mouth end, wherein the throat end is narrower than the mouth end, and wherein a phase plug is mounted within the horn and spaced from the inner wall of the horn, wherein the phase plug is a bi-conic solid shape, formed from first and

second straight-walled cones joined at their bases, and mounted within the horn such that the first cone of the phase plug has a tip end towards the throat of the horn cone, and wherein the second cone of the phase plug has a ring of acoustically absorbent material coaxially mounted on its surface.

56. A sound guiding structure for an acoustic device,including a cone-shaped horn having a throat end for connecting to a sound pressure source and an open mouth end, wherein the throat end is narrower than the mouth end, and wherein a horn ring of acoustically absorbent material is provided at the mouth end of the horn, wherein the horn ring is mounted on the exterior of the horn and extends beyond the mouth end of the horn to reduce acoustic emissions away from the central axis of the horn, wherein the horn ring is in the form of a truncated cone.