Claims

1. An acoustic antenna (ANT) intended to equip a sonar, the antenna being centered around a first longitudinal axis (A1) and comprising at least a first set of at least two~~one~~ transducers (T1) and a second set of at least two transducers (T2) stacked along said longitudinal axis, each transducer having at least one radial mode having a resonance frequency, referred to as the radial frequency, and one cavity mode having a resonance frequency, referred to as the cavity frequency, characterized in that the transducers of the first set are configured to transmit sound waves in a first continuous frequency band extending at least between the cavity frequencies and the radial frequencies of the transducers of the first set and the transducers of the second set are configured to transmit sound waves in a second continuous frequency band extending at least between the cavity frequencies and the radial frequencies of the transducers of the second set, in that the cavity frequency of a transducer of the second set is substantially equal to the radial frequency of a transducer of the first set plus or minus (fr1-fc1)/10, fr1 being the radial frequency of the transducer of the first set and fc1 being the cavity frequency of the transducer of the first set and characterized in that the transducers of the second set are placed between the transducers of the first set and in that no transducer of the first set is placed between the transducers of the second set.

~~2. The acoustic antenna as claimed in claim 1, wherein the first set of transducers comprises at least two transducers and the transducers of the second set are placed between the transducers of the first set.~~

2~~3~~. The acoustic antenna as claimed in~~ one of~~ claim~~s~~ 1~~ and 2~~, wherein the transducers of the second set are divided into sub-groups, each sub-group comprising at least two transducers of the second set, the spacing between each sub-group being greater than or equal to the spacing between two transducers of one and the same

sub-group, and each sub-group having at least one cavity mode having a resonance frequency, referred to as the group cavity frequency.

34. The acoustic antenna as claimed in claim 23, wherein the second set comprises seven transducers divided into three sub-groups, the first sub-group (SG1) comprising two transducers, the second group (SG2) comprising three transducers, the third sub-group (SG3) comprising two transducers, and the second sub-group being placed between the first and the third sub-group.

45. The acoustic antenna as claimed in one of claims 23 and 34, wherein the group cavity frequency of at least one sub-group is equal to the radial frequency of the transducers of the first set plus or minus (fr1-fc1)/10 and the group cavity frequency of at least one other sub-group is equal to the cavity frequency of the transducers of the first set plus or minus (fr1-fc1)/10, fr1 being the radial frequency of the transducer of the first set and fc1 being the cavity frequency of the transducer of the first set.

56. The acoustic antenna as claimed in one of the preceding claims comprising passive elements (P1) stacked along the first longitudinal axis, surrounding the transducers of the second set and having at least one radial mode having a resonance frequency, referred to as the radial frequency, equal to a radial frequency of the transducers of the second set plus or minus 0.1 x fr2, advantageously equal to a radial frequency of the transducers of the second set plus or minus 0.05 x fr2, with fr2 the radial frequency of the transducers of the second set and also having at least one cavity mode having a resonance frequency, referred to as the cavity frequency, within the first frequency band.

67. The acoustic antenna as claimed in claim 56, wherein the passive elements are made of a material such that the E/ρ ratio of this material is higher than that of the material forming the transducers of the second set, E being the Young's modulus and ρ the density of the materials.

7~~8~~. The acoustic antenna as claimed in claim 6~~7~~, wherein the passive elements are cylinders having a diameter larger than that of the transducers of the second set.

8~~9~~. The acoustic antenna as claimed in one of the preceding claims, wherein the transducers are FFR ("free-flooded ring") transducers made of piezoelectric ceramic or of magnetostrictive ceramic or of electrostrictive ceramics.

9~~10~~. The acoustic antenna as claimed in one of the preceding claims, wherein the transducers of the first set and of the second set have a circular, trapezoidal or polygonal cross section.

10~~11~~. The acoustic antenna as claimed in one of the preceding claims comprising at least a third set of at least two transducers (T3) stacked along K longitudinal axes (A2, A3) parallel to the first longitudinal axis (A1), K being greater than 1, the transducers of the third set having at least one radial mode having a resonance frequency, referred to as the radial frequency, and one cavity mode having a resonance frequency, referred to as the cavity frequency, equal to the radial frequency of the transducers of the second set plus or minus (fr2-fc2)/10, fr2 being the radial frequency of the transducers of the second set and fc2 the cavity frequency of the transducers of the second set, the transducers of the third set being configured to transmit sound waves in a third continuous frequency band extending at least between their cavity frequency and their radial frequency, the third frequency band having at least one frequency higher than the frequencies of the first and second frequency bands, and the meeting of the first, second and third frequency bands forming a continuous frequency band.

11~~12~~. The acoustic antenna as claimed in claim 10~~11~~, wherein the K longitudinal axes are coincident with the first longitudinal axis.

12~~13~~. The acoustic antenna as claimed in one of the preceding claims comprising at least a first phase-shifter (D1) arranged so as to introduce a first phase shift (Δφ1) between an excitation signal of the transducers of the first set and an excitation signal of at least a sub-group of transducers of the second set.

13~~14~~. The acoustic antenna as claimed in claim 12~~13~~ additionally comprising at least a second phase-shifter (D2) arranged so as to introduce a second phase shift (Δφ2) between excitation signals of different sub-groups of transducers of the second set.

14~~15~~. The acoustic antenna as claimed in one of the preceding claims comprising N+1 groups of transducers of the same type and N phase-shifters arranged so as to introduce a phase shift between an excitation signal of the transducers of the first group and an excitation signal of another group, N being an integer greater than 1.

15~~16~~. A method for calibrating an acoustic antenna as claimed in one of claims 12~~13~~ to 14~~15~~, characterized in that it comprises the following steps:

a. exciting a first group of transducers of the same type and shorting the other transducers;
b. far-field measuring the phase of the pressure waves generated by the transducers of the first group;
c. exciting a second group of transducers of the same type and shorting the other transducers;
d. far-field measuring the phase of the pressure waves generated by the transducers of the second group;
e. calculating the phase difference between the phase obtained in step b and the phase obtained in step d;
f. adjusting a phase-shifter so that it introduces a phase shift equal to the difference calculated in step e to the excitation signal sent to the transducers of the second group.