



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.06.2023 Bulletin 2023/25

(51) International Patent Classification (IPC):
H04R 1/02 ^(2006.01) **H04R 1/28** ^(2006.01)

(21) Application number: **21020638.9**

(52) Cooperative Patent Classification (CPC):
H04R 1/021; H04R 1/2819; H04R 1/2834;
H04R 1/2876

(22) Date of filing: **14.12.2021**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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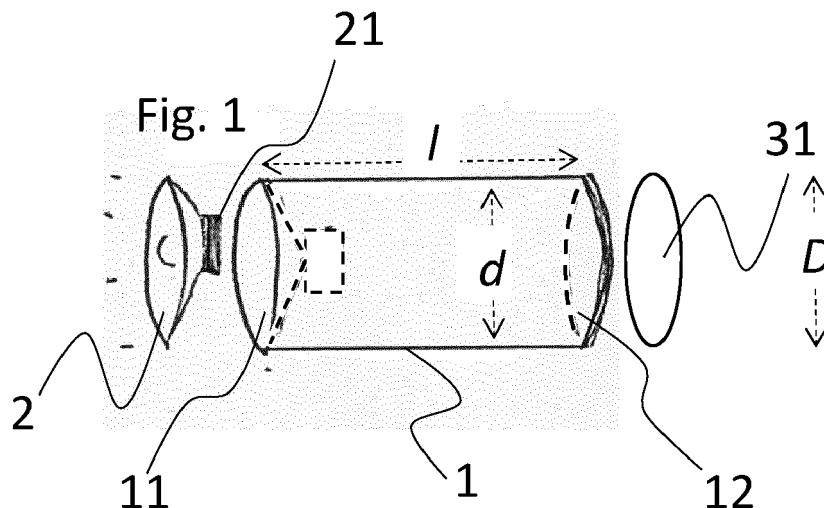
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(54) **SUBWOOFER**

(57) A subwoofer comprises:
a driver;
an enclosure comprising an at least essentially tube-shaped element having a first, at least essentially circular, opening provided at a first end of said

tube-shaped element; wherein
the driver is mounted on and/or in the first opening;,
wherein
the tube-shaped element is made of concrete.



Description

[0001] The invention pertains the field of sound, in particular music, reproduction. It relates, in particular, to a subwoofer in accordance with the independent patent claim.

[0002] For high-quality audio reproduction, dedicated low-frequency loudspeakers can be used to reproduce low frequencies, in particular bass and sub-bass. Frequency ranges for such dedicated speakers may have an upper limit of at least approximately 200Hz for consumer products, of at least approximately 100Hz for high-fidelity or professional stage and/or live equipment, and at least approximately 80Hz for movie theaters. A lower limit of the frequency range is usually below 20Hz and may reach down to 10Hz or even 5Hz.

[0003] Such dedicated low-frequency loudspeakers are often referred to as subwoofers. While both the expressions loudspeaker and subwoofer are often used to refer to a so-called (speaker) driver or driver unit only, in what follows the terms shall denote a combination of a driver or driver unit with a loudspeaker enclosure (frequently referred to in brief as an "enclosure") or (loudspeaker) cabinet, which combination may constitute at least a part of what is sometimes called a loudspeaker system.

[0004] The driver unit may comprise a so-called diaphragm which may be excited, in particular brought to oscillate, by electric, in particular electrostatic and/or electromagnetic means, thus creating acoustic waves.

[0005] In air at average room temperature and humidity, acoustic wavelengths for frequencies between 10Hz and 100 Hz range from around 34m to 3.4 m. There is broad consent that under such conditions, for reasons of elementary physics, a diaphragm should be as large as possible to be able to efficiently induce acoustic oscillations and/or waves in the surrounding air. Common subwoofer diaphragm sizes, in particular diameters, thus start at approximately 25cm (10"), and reach up to 46cm (18") or more.

[0006] Enclosures for diaphragms of such dimensions, which enclosures are usually box shaped and often at least approximately cubic, consequently (need to) have impressive sizes, with the size of a front panel of the enclosure dictated by the need to accommodate the driver, and a depth in a direction perpendicular to a plane defined by the front panel dictated by a requirement to control acoustic waves emitted from a back side of the diaphragm.

[0007] While a mere physical size of the enclosures as described above already necessitates a substantial amount of material for manufacturing a subwoofer, requirements in respect of rigidity and/or stiffness of the cabinet further increase a volume and/or mass of material needed. Rigidity and/or stiffness are required to allow for the cabinet to sufficiently well dampen and/or control acoustic waves emitted from the back side of the diaphragm, and/or to avoid and/or suppress resonances of

the cabinet itself. Larger enclosures, in particular from wood or composite material, often need reinforcing elements and/or structures like e.g. reinforcing beams, wedges, etc., provided in an inside or internal volume to achieve the desired rigidity and/or stiffness, further adding to weight and material consumption.

[0008] For the reasons given above, a manufacture of current subwoofers generally consumes a lot of resources, and the subwoofers themselves require a lot of volume in a home environment. In addition, many current subwoofers tend to be very heavy, which makes the difficult to transport and place, in particular for a single person.

[0009] It is thus an objective of the invention to provide a subwoofer which may be manufactured with reduced consumption of resources and/or in a lightweight manner.

SUMMARY OF THE INVENTION

[0010] The above objective and other objectives may be solved by a subwoofer in accordance with claim 1.

[0011] A subwoofer in accordance with an aspect of the invention as hereinafter claimed may comprise the features of claim 1 below.

[0012] A subwoofer in accordance with an aspect of the invention may comprise:

a. a driver;

b. an enclosure comprising an at least essentially tube-shaped element having a first, at least essentially circular, opening provided at a first end of said tube-shaped element; wherein

c. the driver is mounted on, over, and/or in the first opening; and wherein

d. the tube-shaped element is made of concrete.

[0013] The subwoofer may, in particular, have an upper cutoff frequency or an upper corner frequency between 80 and 200Hz, wherein the cutoff frequency may be defined as the frequency at which a frequency dependent response has fallen to 50% or -3dB of a maximum value of said response.

[0014] The subwoofer may comprise a (speaker) driver or driver unit, which may in turn comprise a diaphragm, in particular made of paper, plastic or composite material, in particular fiber-reinforced composite material. The diaphragm may, in particular, at least approximately have the shape of a cone. A first end of the diaphragm may be attached to a chassis (which may also be referred to as frame or basket), in particular a first side of a chassis, by a flexible material, in particular a flexible cone surround, allowing the diaphragm to move forward and backward along a first direction, which may correspond to a first longitudinal axis of the cone, about which first longitudinal axis the cone may be at least approximately ro-

tationally symmetric. A voice coil may be attached to the diaphragm at a second end, in particular an end of the cone having a smaller diameter.

[0015] The voice coil may be placed and/or situated in a magnetic field of a (permanent) magnet, which may also be attached to the chassis at a distance from the first side of the diaphragm, in particular at a second side of the chassis opposite and at a distance from the first side.

[0016] An AC current through the voice coil, which may be provided by an amplifier, may then cause the diaphragm to oscillate about an equilibrium or resting position.

[0017] The enclosure may comprise, in particular consist of, an at least essentially tube-shaped, or tubular, element having a first, at least essentially circular, opening provided at a first end or front end of said tube-shaped element. The tube-shaped element may be round, i.e. may have an at least essentially circular cross section, which may at least essentially remain constant over a length of the tube-shaped element, as may an inner and/or outer diameter of the tube-shaped element. The tube-shaped element may in particular be a pipe. The tube-shaped or tubular element may define a second longitudinal axis about which second longitudinal axis the tube-shaped element may be at least approximately rotationally symmetric. A plane defined by the first opening may be perpendicular to the second longitudinal axis. The tube-shaped element may at least essentially be straight. A length l of the tube-shaped element, in particular along the second longitudinal axis, may at least approximately equal an outer diameter D and/or a square

root $\sqrt{A}$ of an outer cross section A of the tube-shaped element, in particular in a direction perpendicular to the second longitudinal axis. Alternatively, the length l of the tube-shaped element, may be larger than the outer di-

ameter D and/or the square root $\sqrt{A}$ of the outer cross section A of the tube-shaped element, in particular with

$l > 2D$ and/or $l > 2\sqrt{A}$.

[0018] An interior of the enclosure, in particular the tube-shaped element, may essentially be empty and/or free of material other than air, with the possible exception of a portion of the driver extending into the former, and/or electric circuitry, in particular cables, for electrically connecting the voice coil to terminals provided on an outside of the enclosure.

[0019] Alternatively, the interior of the enclosure may at least partially be filled with a damping material for absorbing acoustic waves emitted from a back side of the driver. The damping material may in particular comprise a (plastic) foam, e.g. polyurethane foam, and/or fiber material, e.g. glass fiber. While damping material may, in particular, be provided in relatively "short" subwoofers,

in particular with $l \approx D$ and/or $l \approx \sqrt{A}$, relatively "long"

subwoofers, in particular with $l > 2D$ and/or $l > 2\sqrt{A}$

[0020] The driver may be placed in and/or attached to and/or over an opening provided in the enclosure, and may in particular cover and/or airtightly seal said opening, in particular the first opening of the tube-shaped element as described above. The first direction, the first longitudinal axis and second longitudinal axis may extend in parallel, in particular with the first and second longitudinal axes coinciding.

[0021] An inner diameter d of the tube-shaped element may at least approximately equal a diaphragm size, in particular a (maximum) diameter of the diaphragm.

[0022] The tube-shaped element may at least partially be closed at a second end or back end of said tube-shaped element opposite and/or at a distance from the first end along the second longitudinal axis. A back wall, in particular a solid and/or rigid back wall may be provided to close the tube-shape element at the second end. The back wall may be provided as an integral part of the tube-shaped element. Alternatively, a passive driver may be provided

[0023] The tube-shaped element may have a second opening provided at a second end or back end of said tube-shaped element opposite and/or at a distance along the second longitudinal axis. A cross section of the second opening may at least approximately equal a cross section of the first opening. Alternatively, the cross section of the second opening may be smaller, in particular significantly smaller, than a cross section of the first opening. The second opening may then, in particular, be formed in a back wall of the tube-shaped element, and/or may form a and/or serve as a bass reflex opening.

[0024] A passive driver, in particular free of any voice coil, may be placed in and/or attached to and/or over the second opening, and may in particular cover and/or airtightly seal said second opening. The passive driver may comprise a second diaphragm, in particular made of paper, plastic or composite material, in particular fiber-reinforced composite material. The second diaphragm may, in particular, at least approximately have the shape of a cone. A first end of the second diaphragm may be attached to a second chassis, in particular a first side of a second chassis, by a flexible material, in particular a flexible cone surround, allowing the second diaphragm to move forward and backward along a third direction, which may correspond to a second longitudinal axis of the cone, about which second longitudinal axis the cone may be at least approximately rotationally symmetric.

[0025] The first direction, the first longitudinal axis and second longitudinal axis may extend in parallel, in particular with the first and second longitudinal axes coinciding.

[0026] The tube-shaped element may have the form of a cylinder jacket, cylinder shell or cylinder surface, which cylinder jacket, cylinder shell or cylinder surface may in particular be open on a first side and a second side located opposite from one another. The first and

second openings may thus be provided as an integral part of the tube-shaped element.

[0027] While the back wall may be formed integrally with the tube-shaped element as described above, it may alternatively be provided as a separate back wall element which may be attached, in particular releasably attached, at, in or over the second side of the cylinder jacket, cylinder shell or cylinder surface. The second opening may then, in particular, be formed in said separate back wall element. The separate back wall element may easily be removed and/or replaced by an owner and/or user of the subwoofer. A set of different back wall elements, in particular with and without second opening, with second openings having different dimensions, in particular diameters, and/or with different stiffness, material etc. may be provided with the subwoofer to allow for changing and/or adapting sonic properties, in particular a bass reflex characteristic, of the subwoofer.

[0028] One or more bushings may be provided in the tube-shaped element and/or the separate back wall element to allow for electric connection, in particular cables, to be provided between the voice coil and electric terminals provided on an outside of the subwoofer, to which an amplifier may be connected.

[0029] The tube-shaped element may be made from and/or consist of concrete. The separate back wall element may, where present, also be for be made from and/or consist of concrete. Concrete provides excellent stiffness and rigidity and may relatively easily be formed into a large variety of desired shapes, in particular by casting, and without the need to provide any reinforcing elements and/or structures inside the tube-shaped element. In addition, tube-shaped elements of various dimensions are readily available from stock, a length of which may be easily reduced to desired values. While a density of concrete is relatively high when compared to other common construction materials for loudspeaker enclosures, the easy and uncomplicated availability of different shapes and dimensions allows to closely match driver and enclosure dimensions, while keeping enclosure material requirements close to a physical minimum. In particular, for a given diaphragm size, a subwoofer with superior sonic and/or acoustic quality may be provided at very reasonable size and weight.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The subject matter of the invention will be explained with respect to further optional detail in the following text with reference to further exemplary embodiments which are illustrated in the attached drawings.

Fig 1 shows an exploded view drawing of an exemplary subwoofer in accordance with the invention as hereinafter claimed;

Fig. 2 shows an exploded view drawing of another exemplary subwoofer in accordance with the inven-

tion as hereinafter claimed;

Fig. 3 shows an exploded view drawing of another exemplary subwoofer in accordance with the invention as hereinafter claimed.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0031] Fig. 1 shows an exploded view drawing of an exemplary subwoofer in accordance with the invention as hereinafter claimed. A concrete tube 1 having a length l , constant outer diameter D and constant inner diameter d , constitutes an enclosure consisting of a single, tube-shaped element. In an assembled state of the subwoofer, a driver 2 with a voice coil 22 is inserted into a first opening 11 provided at a first end of the concrete tube (to the left side of the figure) at a position as indicated by dashed lines. Also in the assembled state of the subwoofer, a separately formed back wall 31 is inserted into the tube 1 at a second end 12 of the concrete tube at a distance, in particular corresponding to length l , from the first end, to form a closed enclosure together with the tube 1. Driver and back wall 31 may be firmly attached to the tube 1, e.g. by screws, which may in particular extend into a wall of the tube 1 and/or parallel to a longitudinal direction of the tube.

[0032] Fig. 2 shows an exploded view drawing of another exemplary subwoofer in accordance with the invention as hereinafter claimed. In contrast to the exemplary embodiment from Fig. 1, the back wall 31' comprises a second opening which connects an interior volume 10 of the subwoofer with an outside through an optional bass reflex tube 311. Some or all other aspects may at least essentially correspond to what is described above in relation to Fig. 1.

[0033] Fig. 3 shows an exploded view drawing of another exemplary subwoofer in accordance with the invention as hereinafter claimed. In contrast to the exemplary embodiment from Fig. 1, a passive driver 33 without a voice coil is inserted into the tube 1 at the second end 12 of the tube in the assembled state of the subwoofer. Some or all other aspects may at least essentially correspond to what is described above in relation to Fig. 1.

[0034] This description and any accompanying drawings that illustrate aspects and embodiments of the present invention should not be taken as limiting the claims defining the protected invention. In other words, while the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. Various mechanical, compositional, structural, electrical, and operational changes may be made without departing from the spirit and scope of this description and the claims. In some instances, well-known circuits, structures and techniques have not been shown in detail in order not to obscure the invention. Thus, it will be understood that changes and

modifications may be made by those of ordinary skill within the scope and spirit of the following claims. In particular, the present invention covers further embodiments with any combination of features from different and/or individual embodiments as described above and below. Embodiments in accordance with the invention may, in particular, include further and/or additional features, elements, aspects, etc. not shown in the drawings or described above.

[0035] The disclosure also covers all further features shown in any Figure, individually, although they may not have been described in the afore or following description. Also, individual alternatives of the embodiments described in any Figure and the description and individual alternatives of features thereof can be disclaimed from the subject matter of the invention or from disclosed subject matter. The disclosure comprises subject matter consisting of the features defined in the claims or the exemplary embodiments as well as subject matter comprising said features.

[0036] The present disclosure also includes embodiments with any combination of features which are mentioned or shown above and/or below, in various embodiments or variants. It also includes individual features as shown in the Figures, even if they are shown there in connection with other features and/or are not mentioned above or below. The disclosure comprises embodiments which exclusively comprise the features described in the claims or the exemplary embodiments, as well as those which comprise additional other features. The steps of any method disclosed above or claimed below may preferably be carried out according the order in which they are presented, but may also be carried out in a different order.

[0037] Furthermore, in the claims the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single unit or step may fulfil the functions of several features recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. The terms "essentially", "substantially", "about", "approximately" and the like in connection with an attribute or a value particularly also define exactly the attribute or exactly the value, respectively. The term "about" in the context of a given numerate value or range refers to a value or range that is, e.g., within 20%, within 10%, within 5%, or within 2% of the given value or range. Components described as coupled or connected may be electrically or mechanically directly coupled, or they may be indirectly coupled via one or more intermediate components. Any reference signs in the claims should not be construed as limiting the scope.

[0038] Unless stated otherwise, it shall be assumed throughout this entire document that a statement $a \approx b$ may imply that $|a-b|/(|a|+|b|) < 0.2$, preferably $|a-b|/(|a|+|b|) < 0.05$, wherein a and b may represent ar-

bitrary quantities, parameters and/or variables as described and/or defined anywhere in this document, or as otherwise known to a person skilled in the art. Further, a statement that a is at least approximately equal or at least approximately identical to b may imply that $a \approx b$, and not exclude that $a = b$. Further, unless stated otherwise, throughout this entire document, a statement $a \gg b$ may imply that $a > 5b$, preferably $a > 10b$; and statement $a \ll b$ may imply that $5a < b$, preferably $10a < b$. A statement that a is significantly larger than b may imply that $a \gg b$. A statement that a is significantly smaller than b may imply that $a \ll b$.

15 Claims

1. A subwoofer comprising:

- a. a driver;
- b. an enclosure comprising an at least essentially tube-shaped element having a first, at least essentially circular, opening provided at a first end of said tube-shaped element; wherein
- c. the driver is mounted on and/or in the first opening;,,
- d. the tube-shaped element is made of concrete.

2. The subwoofer of claim 1, **characterized by** the tube-shaped element having a second, at least essentially circular, opening provided at a second end of said tube-shaped element, said second end provided opposite and/or at a distance from the first end.

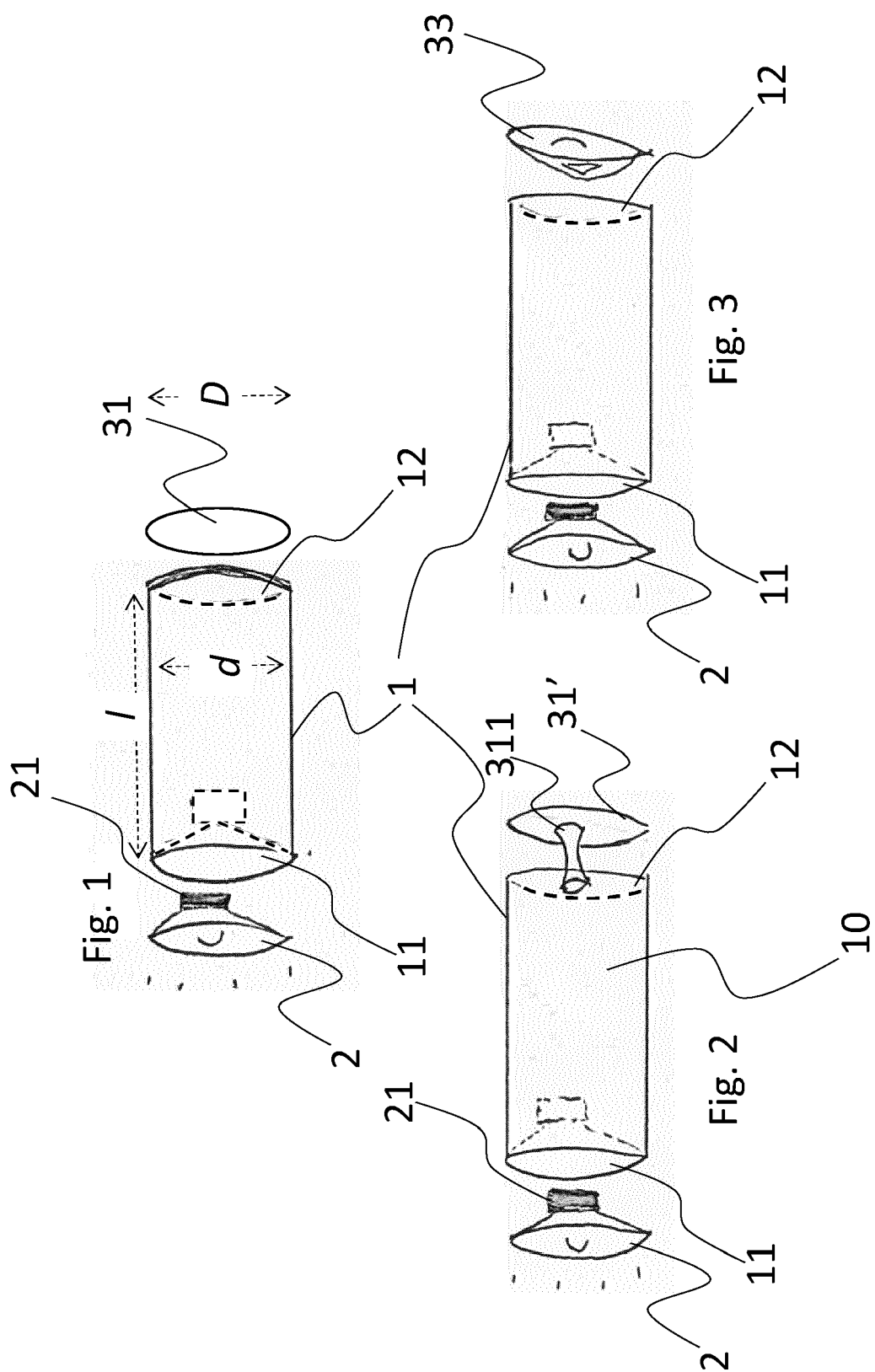
3. The subwoofer of claim 1, **characterized in that** the tube-shaped element is closed at a second end opposite and/or at a distance from the first end.

4. The subwoofer of any preceding claim, **characterized in that** the tube shape element comprises, in particular consists of, a body having at least essentially the shape of a cylinder jacket, a cylinder barrel and/or a cylinder casing.

5. The subwoofer of any preceding claim, **characterized in that** a length l of the tube-shaped element exceeds an outer diameter D of the tube-shaped element, in particular with $l > 2D$.

6. The subwoofer of any preceding claim, **characterized in that** a diameter of the subwoofer driver is between 16cm and 1m.

7. The subwoofer of any preceding claim, **characterized in that** a frequency response of the subwoofer is between 0Hz and 400Hz, preferably between 5Hz and 200Hz.





EUROPEAN SEARCH REPORT

Application Number

EP 21 02 0638

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2006/147075 A1 (VU VINH T [US] ET AL) 6 July 2006 (2006-07-06) * paragraph [0050] - paragraph [0090]; figures 2A, 2B, * -----	1-7	INV. H04R1/02 ADD. H04R1/28
Y	GB 1 591 042 A (BIBBY P J) 10 June 1981 (1981-06-10) * page 1, line 8 - line 90; figure 1 * -----	1-7	
Y	GB 2 187 061 A (COWLEY STEVEN JOHN; COWLEY ROBERT JOHN) 26 August 1987 (1987-08-26) * page 1, line 15 - page 2, line 95; figure 2 * -----	1-7	
A	DE 42 27 696 A1 (CHEMNITZ REINHARD [DE]) 24 February 1994 (1994-02-24) * column 3, line 21 - column 4, line 24; figure 2 * -----	1-7	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC) H04R

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EPO FORM 1503 03.82 (P04C01)

Place of search Munich	Date of completion of the search 17 May 2022	Examiner Duffner, Orla
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document		

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 21 02 0638

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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17-05-2022

10	Patent document cited in search report	Publication date	Patent family member(s)	Publication date
	US 2006147075 A1	06-07-2006	NONE	

15	GB 1591042 A	10-06-1981	NONE	

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