(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 383 066 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
07.10.2020 Bulletin 2020/41

(51) Int Cl.:
H04R 1/28 *(2006.01)* ***H04R 9/06*** *(2006.01)*
H04R 9/02 *(2006.01)*

(21) Application number: **18164190.3**

(22) Date of filing: **27.03.2018**

(54) **LOUDSPEAKER WITH VIBRATION CONTROL SYSTEM**

LAUTSPRECHER MIT SCHWINGUNGSSTEUERUNGSSYSTEM

HAUT-PARLEUR AVEC UN SYSTÈME DE COMMANDE DE VIBRATION

(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

(30) Priority: **29.03.2017 IT 201700034713**

(43) Date of publication of application:
03.10.2018 Bulletin 2018/40

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Description

[0001] The present patent application for industrial invention relates to a solution for controlling the vibrations generated by a loudspeaker and induced on a baffle (box, panel, door panel, rear shelf, etc.) where the loudspeaker is mounted.

[0002] With reference to Figs. 1 and 2, a loudspeaker (100) of traditional type comprises a magnetic assembly (M) wherein an air gap (T) is generated. The magnetic assembly (M) comprises a magnet (28) disposed between a lower polar plate (2) and an upper polar plate (29).

[0003] The lower polar plate (2) has a "T"-shaped section and is commonly known as a "T-yoke". The lower polar plate (2) comprises a cylindrical shank, known as core (20). The magnet (28) and the upper polar plate (29) have a toroidal shape. The air gap (T) is formed between the core (20) of the lower polar plate and the upper polar plate (29).

[0004] A voice coil (3) is mounted on a cylindrical support (30) and is disposed in the air gap (T) of the magnetic assembly, with possibility of moving in axial direction. A basket (4) is fixed to the magnetic assembly (M).

[0005] A centering device (5) is fixed to the basket (4) and to the cylindrical support (30) of the voice coil in such way as to maintain the voice coil (3) in the air gap (T) of the magnetic assembly. A membrane (6) is fixed to the basket (4) and to the cylindrical support (30) of the voice coil.

[0006] The loudspeaker (100) is suitable for being connected to a baffle (not shown) by means of the external edge of the basket (4).

[0007] When the voice coil (3), which is immersed in a radial magnetic field, is crossed by electrical current, according to the Lorentz law, a force is generated, which causes the axial movement of the cylindrical support (30) of the voice coil, causing the movement and the vibration of the membrane (6) that generates a sound. Therefore the loudspeaker (100) produces sounds because of the displacement of the membrane (6).

[0008] The loudspeaker comprises a moving part comprising: the membrane (6), the centering device (5), and the cylindrical support (30) with the voice coil (3). Because of the movement of its inertial mass, the moving part can generate vibrations induced on the baffle where the loudspeaker is mounted. As a result, the baffle can vibrate and generate spurious sounds.

[0009] With reference to Fig. 1A, it must be noted that, in a traditional loudspeaker, peripheral magnetic induction lines (I), which are dispersed outside and are not used, are generated in the vicinity of the peripheral edge of the magnetic assembly (M).

[0010] Moreover, in some applications, it is necessary to increase the vibrations of the baffle in correspondence of the low frequency sounds emitted by the loudspeaker. In such a case, a system capable of effectively controlling the vibrations of the baffle is desirable.

[0011] US4720868 discloses a dynamic speaking device having a small-sized vibrating plate for reproducing a high frequency sound and an additional coil in the vicinity of the magnet assembly of the speaker.

[0012] The purpose of the present invention is to eliminate the drawbacks of the prior art by disclosing a loudspeaker with vibration control system that is capable of controlling the vibrations of the baffle whereon the loudspeaker is mounted.

[0013] Another purpose is to obtain such a loudspeaker that is compact, inexpensive and simple to make and install.

[0014] These purposes are achieved according to the invention with the characteristics of the independent claim 1.

[0015] Advantageous embodiments of the invention appear from the dependent claims.

[0016] In order to oppose the vibrations of the baffle whereon the loudspeaker is mounted, the invention provides for integrating a shaker in the loudspeaker structure. The shaker, which is suitably powered with an electrical signal, generates induced vibrations on the baffle, which are suitable for opposing and reducing/suppressing the undesired vibrations that are induced by the movement of the moving part of the loudspeaker.

[0017] Additional features of the invention will appear clearer from the detailed description below, which refers to merely illustrative, not limiting embodiments, wherein:

Fig. 1 is an axial sectional view of a traditional loudspeaker;
Fig. 1A is a detailed view of Fig. 1 that shows the magnetic induction lines in a traditional loudspeaker;
Fig. 2 is an exploded perspective view of the various elements of the loudspeaker of Fig. 1;
Fig. 3 is an axial sectional view of a loudspeaker according to the invention;
Fig. 3A is a detailed view of Fig. 3 that shows the magnetic induction lines in the loudspeaker according to the invention;
Fig. 4 is an exploded perspective view of the various parts of the loudspeaker of Fig. 3;
Figs. 5 and 6 are sectional views that show additional embodiments of the loudspeaker according to the invention; and
Fig. 7 is a diagrammatic view of the loudspeaker according to the invention for a mechanical study.

[0018] In the following description the parts that are identical or correspond to the parts described above are identified with the same numerals, omitting their detailed description.

[0019] With reference to Figs. 3 and 4, a loudspeaker according to the invention is disclosed, which is generally indicated with reference numeral 1.

[0020] The loudspeaker (1) comprises an external cylinder (7) disposed around said magnetic assembly (M). The external cylinder is made of ferromagnetic material. The external cylinder (7) supports at least one control coil (71, 72) directed towards the magnetic assembly (M).

[0021] At least one elastic suspension (8, 8') is connected to the external cylinder (7) and to the magnetic assembly (M) in such way as to maintain the external cylinder (7) in coaxial position relative to the magnetic assembly. In view of the above, when powering the control coil (71, 72), the external cylinder (7) can move axially, using the magnetic field of the magnetic assembly (M). The movement of the external cylinder (7) relative to the magnetic assembly (M) permits to control the vibration on the baffle (not shown in the drawings) where the loudspeaker is mounted.

[0022] The magnetic assembly (M), the external cylinder (7) that supports at least one control coil (71, 72), and the elastic suspension (8, 8') operate as a shaker having the external cylinder (7) that supports at least one control coil (71, 72) as inertial mass.

[0023] In the example of Figs. 3 and 4, the loudspeaker (1) comprises a first control coil (71) and a second control coil (72) mounted on the external cylinder (7). The first control coil (71) and the second control coil (72) are respectively disposed in the lower polar plate (2) and in the upper polar plate (29) of the magnetic assembly.

[0024] The loudspeaker (1) comprises:

- a first elastic suspension (8) fixed to the lower polar plate (2) and to a lower edge of the external cylinder (7) and
- a second elastic suspension (8') fixed to the upper polar plate (29) and to an upper edge of the external cylinder (7).

[0025] Each elastic suspension (8, 8') comprises an internal ring (80) suitable for being fixed to the magnetic assembly (M), and an external ring (81) suitable for being fixed to the external cylinder (7). A plurality of spokes (81) connects the internal ring (80) to the external ring (81) of the elastic suspension. The spokes (82) have a very low thickness in order to bend elastically. The spokes (82) have a substantially "S"-shaped curvilinear shape. The external ring (81) has a groove (83) suitable for receiving one edge of the external cylinder (7). The internal ring (80) has a planar surface that is suitable for being glued on the magnetic assembly (7).

[0026] The lower polar plate (2) comprises:

- a central portion (21) from where the core (20) protrudes, and
- a peripheral portion (22) that is recessed with respect to the central portion (21).

[0027] Obviously, the lower polar plate (2) can have a lower planar surface.

[0028] The internal ring (80) of the elastic suspension is fixed to the peripheral portion (22) of the lower polar plate and is provided with a suitable thickness so that the lower surface of the elastic suspension is substantially at the same level as the lower surface of the central portion (21) of the lower polar plate.

[0029] With reference to Fig. 3A, an air gap (T') with peripheral magnetic induction lines (I) is generated between the peripheral edges of the magnetic assembly (M) and the external cylinder (7) of the loudspeaker (1). Radial peripheral lines (I') that affect the air gap (T') are found between said peripheral lines. In such a case, unlike in traditional loudspeakers, the peripheral magnetic induction lines (I) are not dispersed outside, but are conveyed by the ferromagnetic external cylinder (7) and radially pass through the air gap (T') where the control coils (71, 72) fixed to the external cylinder (7) are positioned. When the electrical current powers the control coils (71, 72), the Lorentz force causes a displacement of the control coils (71, 72) and of the external cylinder (7) whereon they are glued.

[0030] The two control coils (71, 72) are generally connected in series. In the control coils (71, 72) the current generally circulates in opposite direction.

[0031] Fig. 5 shows a second embodiment of the loudspeaker (100), wherein the external cylinder (7) is integrated in a cup (70) that extends under the magnetic assembly (M). The cup (70) is connected to the lower polar plate (22) of the magnetic assembly through at least one elastic suspension (8).

[0032] The elastic suspension (8) can comprise leaf springs, helical springs, wave springs or elastic elements of plastic material (rubber, silicone rubber, polyurethane foam, etc.). As shown in Fig. 3, two elastic suspensions (8) may be provided, which comprise an internal ring fixed to the lower polar plate (2), an external ring fixed to the external cylinder (7) and spokes that connect the internal ring and the external ring.

[0033] The external cylinder (7) can be made in one piece with the cup (70); in such a case, the entire part will be made of ferromagnetic material.

[0034] Alternately, the cup (70) can be partially made of plastic material, in the bottom of the cup. In such a case, the plastic portion of the cup (70) can integrate the elastic suspensions, at least partially. The cup (70) can comprise the external cylinder (7) of ferromagnetic material and the bottom of plastic material obtained, for example, by co-molding two different materials (a ferromagnetic material and a plastic material). The plastic portion of the cup (70) can integrate two elastic suspensions.

[0035] In the solutions shown in Figs. 3 and 5, two air gaps are obtained in correspondence of the two control coils

(71, 72). Nevertheless, the loudspeaker (1) can be provided with only one control coil that is immersed in an air gap.

[0036] Fig. 6 shows a third embodiment of the loudspeaker (1), which is provided with only one control coil (72) disposed in correspondence of the peripheral edge of the upper polar plate (29). In such a case, the inertial mass of the shaker is represented by the mass of the control coil (72) and of the external cylinder (7), eventually integrated with additional masses (not shown in the drawings) fixed to the external cylinder (7). In this case, the external cylinder should not be made of ferromagnetic material because it would interfere with the magnetic induction lines in the air gap.

[0037] The external cylinder (7) that supports the control coil (72) is fixed to the upper polar plate (29) by means of an elastic suspension (8').

[0038] The external diameter of the lower polar plate (22) is higher than the diameter of the magnet (28) and of the upper polar plate (29). The lower polar plate (22) has a peripheral collar (24) that protrudes in upper position from the edge of the lower polar plate and is disposed outside the external cylinder (7). In view of the above, an air gap (T') is formed between the upper polar plate (29) and the peripheral collar (24) of the lower polar plate. Therefore the control coil (72) is disposed in said air gap (T').

[0039] The loudspeaker (100) of the invention provides for integrating a traditional loudspeaker (with a vibrating membrane) with an inertial system (shaker) that provides for one external cylinder (7) with at least one control coil (71, 72) disposed in the magnetic field generated outside the magnetic assembly (M) of the traditional loudspeaker. The control coil (71, 72) of the inertial system is electrically powered with suitable signals in order to:

- reduce the vibrations induced on the baffle, in noise reduction applications, or
- enhance the vibrations induced on the baffle, in bass enhancement applications (bass booster).

[0040] The bass booster applications are required when a vibratory sensation is desired, together with an acoustic sensation. For instance, said bass enhancement applications can be obtained by integrating the loudspeaker (1) according to the invention in a seat. In this way, the user will perceive an increase of the seat vibrations produced by the movement of the shaker, simultaneously with the acoustic emission of the low frequencies produced by the movement of the membrane (6) of the loudspeaker.

[0041] The control coil of the loudspeaker (1) can be electrically powered by means of DSPs, amplifiers and filters.

[0042] The loudspeaker (1) of the invention is compact and can be used in noise/vibration control applications, in ANC (active noise control) systems or in applications used to reinforce the vibrations generated by the low frequencies in audio reproduction systems.

[0043] With reference to Fig. 7, a mechanical study of the loudspeaker (1) according to the invention is described.

[0044] In mechanics the shaker fixed to the loudspeaker can be identified and studied as a damper for dynamic vibrations, which is frequently known as a 2-DOF (two degrees of freedom) TMD (Tuned Mass Damper). A TMD is a system suitable for damping the width of an oscillator (loudspeaker) by coupling a second oscillator (shaker).

[0045] M, K, C represent the mass, stiffness and damping of the loudspeaker, respectively, whereas m, k, c represent the mass, stiffness and damping of the shaker, respectively.

[0046] With reference to Fig. 4, the mass of the loudspeaker is the weight of the cylindrical support (30), of the voice coil (3), of the centering device (5) and of the membrane (6). Instead, the mass of the shaker is the weight of the external cylinder (7) and of the control coils (71, 72).

[0047] x1 and x2 represent the absolute positions of M and m, respectively; x2 can be substituted with the relative position of m relative to M, assuming x2-x1.

[0048] Assuming that the damping force is proportional to the speed and a force *p0 cos* (ωt) is applied on M, simplifying with C=0, the motion of the system can be expressed in differential equations:

$$Mx1'' + Kx1 + k(x1 - x2) + c(x1' - x2') = p0\,cos\,(\omega t)$$

$$mx2'' + k(x2 - x1) + c(x2' - x1') = 0$$

where *x*1' is the derivative in time of *x*1, substituting the first equation with the sum of the two:

$$Mx1'' + Kx1 + mx2'' = p0\,cos\,(\omega t)$$

$$mx2'' + k(x2 - x1) + c(x2' - x1') = 0$$

[0049] Then the periodical solutions are obtained in the form:

$$x1 = a\cos(\omega t) + bsen(\omega t)$$

$$x2 = c\cos(\omega t) + dsen(\omega t)$$

[0050] Substituting in the differential equations, the equation system is obtained:

$$\begin{pmatrix} K - M\omega^2 & 0 & -m\omega^2 & 0 \\ 0 & K - M\omega^2 & 0 & -m\omega^2 \\ -k & -c\omega & k - m\omega^2 & c\omega \\ c\omega & -k & -c\omega & k - m\omega^2 \end{pmatrix}\begin{pmatrix} a \\ b \\ c \\ d \end{pmatrix} = \begin{pmatrix} p0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

[0051] Calling the matrix coefficients M, M can be written in blocks and inverted:

$$W = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix},$$

therefore $M = \begin{pmatrix} A & B \\ C & D \end{pmatrix}$, where:

$$A = r1I,\ B = r2I,\ C = r3I - s1W,\ D = r4I + s1W,$$

$$r1 = K - M\omega^2,\ r2 = -m\omega^2,\ r3 = -k,\ r4 = k - m\omega^2,\ s1 = c\omega$$

[0052] Commuting A and B, we obtain:

$$M^{-1} = \begin{pmatrix} (AD - BC)^{-1} & 0 \\ 0 & (AD - BC)^{-1} \end{pmatrix}\begin{pmatrix} D & -B \\ -C & A \end{pmatrix}$$

[0053] Now let's define rand s

$$AD - BC = (r1r4 - r2r3)I + s1(r1 + r2)W = rI + sW$$

[0054] As a result

$$(AD - BC)^{-1} = \frac{1}{r^2 + s^2}(rI - sW)$$

$$\begin{pmatrix} a \\ b \\ c \\ d \end{pmatrix} = \frac{p0}{r^2 + s^2}\begin{pmatrix} \mathrm{rr4} + \mathrm{ss1} \\ -\mathrm{rs1} + \mathrm{sr4} \\ -\mathrm{rr3} + \mathrm{ss1} \\ -\mathrm{rs1} - \mathrm{sr3} \end{pmatrix}$$

[0055] The width of x1 is $A1=\sqrt{a^2 + b^2}$ and the width of x2 is

$$A2=\sqrt{c^2 + d^2}$$

$$A1 = \frac{p0}{r^2 + s^2}(r4^2 + s1^2)$$

$$A2 = \frac{p0}{r^2 + s^2}(r3^2 + s1^2)$$

[0056] Explicitly, we can write A1^2 and A2^2

$$A1^2 = p0^2 \frac{c^2\omega^2 + (k - m\omega^2)^2}{[(K - M\omega^2)(k - m\omega^2) - (k - m\omega^2)]^2 + c^2\omega^2 + (K - M\omega^2 - m\omega^2)^2}$$

$$A2^2 = p0^2 \frac{c^2\omega^2 + k^2}{[(K - M\omega^2)(k - m\omega^2) - (k - m\omega^2)]^2 + c^2\omega^2 + (K - M\omega^2 - m\omega^2)^2}$$

[0057] From here we can write the following constants:

autofrequencies: $\omega 1^2 = \frac{K}{M} \omega 2^2 = \frac{k}{m}$

mass ratio: $\mu = \frac{m}{M}$

damping ratio: $\xi_2 = \frac{c}{2m\omega 2^2}$ wherefrom

$$c = 2\xi_2 m\,\omega 2^2$$

$$C = 2\xi_1 m\,\omega$$

[0058] The stiffness relation is $k = \mu K$

[0059] The best approximation for the damper frequency is given when the damper is tuned at the fundamental of the structure, that is:

$$\omega 2 = \omega 1$$

$f = \frac{\omega 2}{\omega 1}$ wherefrom the optimal frequency $\omega 2 = f_{opt}\omega 1$

If we consider the periodical excitation:

$$p = p0\ sen\ (\Omega t)$$

the response is given by

$$u1 = x1\ sen(\Omega t + \delta 1)$$

$$u2 = x2\ sen(\Omega t + \delta 1 + \delta 2)$$

where x and δ indicate the width of the displacement and the phase shift, respectively. The critical load is in the resonance condition $\Omega = \omega$, in such a case the solution has the following form:

$$x1 = \frac{p0}{K\mu}\sqrt{\frac{1}{1+\left(\frac{2\xi_1}{\mu}+\frac{1}{2\xi_2}\right)^2}} \qquad (1)$$

$$x2 = \frac{1}{2\xi_2}x1 \qquad (2)$$

$$tan\,\delta 1 = \left[\frac{2\xi_1}{M}+\frac{1}{2\xi_2}\right]$$

$$tan\,\delta 2 = -\frac{\pi}{2}$$

[0060] The response without damper is given by:

$$x1 = \frac{p0}{K}\left(\frac{1}{2\xi_1}\right)$$

$$\delta 1 = -\frac{\pi}{2}$$

[0061] To compare these two cases, (1) is expressed in terms of equivalent damping ratio:

$$x1 = \frac{p0}{K}\left(\frac{1}{2\xi_e}\right)$$

where

$$\xi_e = \frac{\mu}{2}\sqrt{1+\left(\frac{2\xi_1}{M}+\frac{1}{2\xi_2}\right)^2} \qquad (3)$$

(3) represents the relative contribution of the damper parameters to the total damping. When the mass ratio increases, the damping will increase.

Dimensioning of the loudspeaker according to the invention

[0062] Let's suppose that $\xi = 0$ with a damping ratio of 10%. By using (3) and inserting $\xi_e = 0.1$, we obtain the following relation between μ and ξ_2

$$\frac{\mu}{2}\sqrt{1+\left(\frac{2\xi_1}{M}+\frac{1}{2\xi_2}\right)^2} = 0.1 \tag{4}$$

[0063] The relative displacement is given by (2):

$$x2 = \frac{1}{2\xi_2}x1 \tag{5}$$

[0064] Combining (4) and (5) and substituting $\xi = 0$ we obtain:

$$\frac{\mu}{2}\sqrt{1+\left(\frac{x2}{x1}\right)^2} = 0.1 \tag{6}$$

[0065] Approximating (6), eliminating the root and the square with

$$\frac{\mu}{2}\left(\frac{x2}{x1}\right) \approx 0.1 \tag{7}$$

[0066] The generalized form of (7) follows from (3)

$$\mu \approx 2\xi_e\left(\frac{1}{\frac{x2}{x1}}\right)$$

[0067] For example, selecting $x2 = \frac{x1}{20}$ we reach an estimate of μ:

$$\mu = \frac{2\,(0.1)}{\frac{1}{20}} = 4 \tag{8}$$

whereas from (2), we obtain

$$\xi_2 = \frac{1}{2}\left(\frac{x1}{x2}\right) = 10$$

[0068] From the stiffness relation $k = \mu K$ we obtain

$$k = \mu K = 20K$$

[0069] In the specific case, considering 10% damping, from (8) we obtain a mass (m) of the moving assembly of the shaker that is four times higher than the mass (M) of the moving assembly of the loudspeaker. In similar solutions, advantageously, the mass (m) of the moving assembly of the shaker can be 3-5 times higher than the mass (M) of the moving assembly of the loudspeaker.

[0070] Numerous equivalent variations and modifications can be made to the present embodiments of the invention, which are within the reach of an expert of the field, falling in any case within the scope of the invention.

Claims

1. Loudspeaker (1) with vibration control system comprising:

   - a magnetic assembly (M) comprising a magnet (28) disposed between a lower polar plate (2) and an upper polar plate (29) wherein the lower polar plate (2) comprises a core (20) in such a way to generate an air gap (T) between the core (20) of the lower polar plate and the upper polar plate (29),
   - a voice coil (3) supported by a cylindrical support (30),
   - a basket (4) connected to the magnetic assembly (M),
   - a centering device (5) connected to the basket (4) and to the cylindrical support (6) in such a way that the voice coil (3) is disposed in the air gap (T), said centering device (5) being intended to move elastically to allow for an axial movement of the cylindrical support (30) with respect to the magnetic assembly (M), and
   - a membrane (6) connected to the basket (4) and to the cylindrical support (30),
   - an external cylinder (7) disposed around said magnetic assembly (M),
   - at least one elastic suspension (8, 8') connected to said external cylinder (7) to allow for an axial movement of the external cylinder (7) with respect to the magnetic assembly (M),

   characterized in that

   the loudspeaker also comprises two control coils (71, 72) supported by said external cylinder (7) and respectively disposed in correspondence of said lower polar plate (22) and said upper polar plate (29).

2. The loudspeaker (1) of claim 1, wherein the external cylinder is made of ferromagnetic material.

3. The loudspeaker (1) of claim 1 or 2, wherein said elastic suspension (8, 8') comprises an internal ring (80) connected to the magnetic assembly (M), an external ring (81) connected to the external cylinder (7) and a plurality of elastically flexible spokes (81) that connect the internal ring (80) to the external ring (81) of the elastic suspension.

4. The loudspeaker (1) of claim 1 or 2, comprising a cup (70) wherein said external cylinder (7) is integrated; said cup (70) having a bottom portion disposed under said magnetic assembly (M).

5. The loudspeaker (1) of claim 4, wherein said elastic suspension (8) connects the cup (70) to said lower polar plate (22) of the magnetic assembly and said elastic suspension (8) comprises leaf springs, helical springs, wave springs or elastic elements made of plastic material.

6. The loudspeaker (1) of claim 4, wherein said bottom portion of the cup (70) is made of elastic plastic material and said elastic suspensions are integrated, at least partially, in said bottom portion of the cup (70).

7. Loudspeaker (1) with vibration control system comprising:

   - a magnetic assembly (M) comprising a magnet (28) disposed between a lower polar plate (2) and an upper polar plate (29) wherein the lower polar plate (2) comprises a core (20) in such a way to generate an air gap (T) between the core (20) of the lower polar plate and the upper polar plate (29),
   - a voice coil (3) supported by a cylindrical support (30),
   - a basket (4) connected to the magnetic assembly (M),
   - a centering device (5) connected to the basket (4) and to the cylindrical support (6) in such a way that the voice coil (3) is disposed in the air gap (T), said centering device (5) being intended to move elastically to allow for an axial movement of the cylindrical support (30) with respect to the magnetic assembly (M), and
   - a membrane (6) connected to the basket (4) and to the cylindrical support (30),
   - an external cylinder (7) disposed around said magnetic assembly (M),
   - an elastic suspension (8') connected to said external cylinder (7) to allow for an axial movement of the external cylinder (7) with respect to the magnetic assembly (M),

   characterized in that

   the loudspeaker also comprises only one control coil (72) supported by said external cylinder (7) and disposed in correspondence of the peripheral edge of the upper polar plate (29), wherein the external cylinder (7) that supports said control coil (72) is connected to the upper polar plate (29) by means of said elastic suspension (8').

8. The loudspeaker (1) of claim 7, wherein the lower polar plate (22) has a higher external diameter than the diameter of the magnet (28) and of the upper polar plate (29);
the lower polar plate (22) has a peripheral collar (24) that protrudes on top from the edge of the lower polar plate and is disposed outside the external cylinder (7), in such a way to form an air gap (T') between the upper polar plate (29) and the peripheral collar (24) of the lower polar plate;
the external cylinder (7) being made of non-ferromagnetic material; and
the control coil (72) being disposed in said air gap (T').

9. The loudspeaker (1) of any one of the preceding claims, comprising:

- a first mobile assembly comprising the cylindrical support (30), the voice coil (3), the centering device (5) and the membrane (6), and
- a second mobile assembly comprising the external cylinder (7) and said at least one control coil (71, 72);

wherein the mass of the second mobile assembly is 3-5 times higher than the mass of the first mobile assembly.

Patentansprüche

1. Lautsprecher (1) mit Vibrationssteuersystem, umfassend:

- eine Magneteinheit (M), umfassend einen Magneten (28), der zwischen einer unteren Polplatte (2) und einer oberen Polplatte (29) angeordnet ist, wobei die untere Polplatte (2) einen Kern (20) umfasst, derart, dass ein Luftspalt (T) zwischen dem Kern (20) der unteren Polpatte und der oberen Polplatte (29) erzeugt wird,
- eine Schwingspule (3), die von einem zylindrischen Träger (30) getragen wird,
- einen Korb (4), der mit der Magneteinheit (M) verbunden ist,
- eine Zentriervorrichtung (5), die mit dem Korb (4) und dem zylindrischen Träger (6) verbunden ist, derart, dass die Schwingspule (3) sich in dem Luftspalt (T) befindet, wobei die Zentriervorrichtung (5) dazu geeignet ist, sich elastisch zu bewegen, um eine axiale Bewegung des zylindrischen Trägers (30) in Bezug auf die Magneteinheit (M) zu ermöglichen, und
- eine Membran (6), die mit dem Korb (4) und dem zylindrischen Träger (30) verbunden ist,
- einen äußeren Zylinder (7), der um die Magneteinheit (M) angeordnet ist,
- mindestens eine elastische Aufhängung (8, 8'), die mit dem äußeren Zylinder (7) verbunden ist, um eine axiale Bewegung des äußeren Zylinders (7) in Bezug auf die Magneteinheit (M) zu ermöglichen,
dadurch gekennzeichnet, dass er ferner umfasst
zwei Steuerspulen (71, 72), die von dem äußeren Zylinder (7) getragen werden und jeweils an der unteren Polplatte (22) bzw. der unteren Polplatte (29) angeordnet sind.

2. Lautsprecher (1) nach Anspruch 1, wobei der äußere Zylinder (7) aus ferromagnetischem Material hergestellt ist.

3. Lautsprecher (1) nach Anspruch 1 oder 2, wobei die elastische Aufhängung (8, 8') einen inneren Ring (80) umfasst, der mit der Magneteinheit (M) verbunden ist, einen äußeren Ring (81), der mit dem äußeren Zylinder (7) verbunden ist und eine Mehrzahl von elastisch nachgiebigen Speichen (81), die den inneren Ring (80) mit dem äußeren Ring (81) der elastischen Aufhängung verbinden.

4. Lautsprecher (1) nach Anspruch 1 oder 2, umfassend eine Tasse (70), in die der äußere Zylinder (7) integriert ist, wobei die Tasse (70) einen Bodenabschnitt aufweist, der unter der Magneteinheit (M) angeordnet ist.

5. Lautsprecher (1) nach Anspruch 4, wobei die elastische Aufhängung (8) die Tasse (70) mit der unteren Polplatte (22) der Magneteinheit verbindet und die elastische Aufhängung (8) Blattfedern, Spiralfedern, Wellenfedern oder elastische Elemente aus Kunststoff umfasst.

6. Lautsprecher (1) nach Anspruch 4, wobei der Bodenabschnitt der Tasse (70) aus elastischem Kunststoff hergestellt ist und die elastischen Aufhängungen mindestens teilweise in den Bodenabschnitt der Tasse (70) integriert sind.

7. Lautsprecher (1) mit Vibrationssteuersystem, umfassend:

- eine Magneteinheit (M), umfassend einen Magneten (28), der zwischen einer unteren Polplatte (2) und einer oberen Polplatte (29) angeordnet ist, wobei die untere Polplatte (2) einen Kern (20) umfasst, derart, dass ein Luftspalt (T) zwischen dem Kern (20) der unteren Polpatte und der oberen Polplatte (29) erzeugt wird,
- eine Schwingspule (3), die von einem zylindrischen Träger (30) getragen wird,
- einen Korb (4), der mit der Magneteinheit (M) verbunden ist,
- eine Zentriervorrichtung (5), die mit dem Korb (4) und dem zylindrischen Träger (6) verbunden ist, derart, dass die Schwingspule (3) sich in dem Luftspalt (T) befindet, wobei die Zentriervorrichtung (5) dazu geeignet ist, sich elastisch zu bewegen, um eine axiale Bewegung des zylindrischen Trägers (30) in Bezug auf die Magneteinheit (M) zu ermöglichen, und
- eine Membran (6), die mit dem Korb (4) und dem zylindrischen Träger (30) verbunden ist,
- einen äußeren Zylinder (7), der um die Magneteinheit (M) angeordnet ist,
- eine elastische Aufhängung (8'), die mit dem äußeren Zylinder (7) verbunden ist, um eine axiale Bewegung des äußeren Zylinders (7) in Bezug auf eine Magneteinheit (M) zu ermöglichen,

dadurch gekennzeichnet, dass er ferner umfasst
nur eine Steuerspule (72), die von dem äußeren Zylinder (6) getragen wird und an dem peripheren Rand der oberen Polplatte (29) angeordnet ist, wobei der äußere Zylinder (7), der die Steuerspule (72) trägt, mit der oberen Polplatte (29) mittels der elastischen Aufhängung (8') verbunden ist.

8. Lautsprecher (1) nach Anspruch 7, wobei die untere Polplatte (22) einen Außendurchmesser aufweist, der größer als der Durchmesser des Magneten (28) und der oberen Polplatte (29) ist;
die untere Polpatte (22) einen peripheren Bund (24) aufweist, der oberseitig aus dem Rand der unteren Polplatte herausragt und außerhalb des äußeren Zylinders (7) angeordnet ist, derart, dass ein Luftspalt (T') zwischen der unteren Polplatte (29) und dem peripheren Bund (24) der unteren Polplatte gebildet wird;
wobei der äußere Zylinder (7) aus nicht ferromagnetischem Material hergestellt ist; und
die Steuerspule (72) in dem Luftspalt (T') angeordnet ist.

9. Lautsprecher (1) nach einem der vorstehenden Ansprüche, umfassend:

- eine erste bewegliche Einheit, umfassend den zylindrischen Träger (30), die Schwingspule (3), die Zentriervorrichtung (5) und die Membran (6), und
- zweite bewegliche Gruppe, umfassend den äußeren Zylinder (7) und die mindestens eine Steuerspule (71, 72);

wobei die Masse der zweiten beweglichen Gruppe 3-5 Mal größer als die Masse der ersten beweglichen Gruppe ist.

Revendications

1. Haut-parleur (1) doté de système de contrôle des vibrations comprenant :

- un ensemble aimanté (M) comprenant un aimant (28) disposé entre une plaque polaire inférieure (2) et une plaque polaire supérieure (29), où la plaque polaire inférieure (2) comprend un noyau (20) de manière à générer un entrefer (T) entre le noyau (20) de la plaque polaire inférieure et de la plaque polaire supérieure (29),
- une bobine de phonie (3) soutenue par un support cylindrique (30),
- un panier (4) relié à l'ensemble aimanté (M),
- un dispositif de centrage (5) relié au panier (4) et au support cylindrique (6) de façon à ce que la bobine de phonie (3) se trouve dans l'entrefer (T), ledit dispositif de centrage (5) étant apte à se déplacer de manière élastique pour permettre un mouvement axial du support cylindrique (30) par rapport à l'ensemble aimanté (M), et
- une membrane (6) reliée au panier (4) et au support cylindrique (30),
- un cylindre externe (7) disposé autour du dit ensemble aimanté (M),
- au moins une suspension élastique (8, 8') reliée au dit cylindre externe (7) pour permettre un mouvement axial du cylindre externe (7) par rapport à l'ensemble aimanté (M),

caractérisé en ce qu'il comprend également
deux bobines de contrôle (71, 72) soutenues par ledit cylindre externe (7) et disposées respectivement en correspondance de ladite plaque polaire inférieure (22) et de ladite plaque polaire supérieure (29) ;

2. Haut-parleur (1) selon la revendication 1, où le cylindre externe est réalisé en matériel ferromagnétique.

3. Haut-parleur (1) selon la revendication 1 ou 2, où ladite suspension élastique (8, 8') comprend une bague interne

(80) reliée à l'ensemble aimanté (M), une bague externe (81) reliée au cylindre externe (7) et une pluralité d'ailettes (81), flexibles de manière élastique, qui relient la bague interne (80) à la bague externe (81) de la suspension élastique.

4. Haut-parleur (1) selon la revendication 1 ou 2, comprenant une cuvette (70) dans laquelle ledit cylindre externe (7) est intégré ; ladite cuvette (70) ayant une portion de fond disposée sous ledit ensemble aimanté (M).

5. Haut-parleur (1) selon la revendication 4, où ladite suspension élastique (8) relie la cuvette (70) à ladite plaque polaire inférieure (22) de l'ensemble aimanté et ladite suspension élastique (8) comprend des ressorts à lames, des ressorts hélicoïdaux, des ressorts à vague ou des éléments élastiques de matériel plastique.

6. Haut-parleur (1) selon la revendication 4, où ladite portion de fond de la cuvette (70) est réalisée en matériel plastique élastique et lesdites suspensions élastiques sont intégrées au moins partiellement dans ladite portion de fond de la cuvette (70).

7. Haut-parleur (1) doté de système de contrôle des vibrations comprenant :

- un ensemble aimanté (M) comprenant un aimant (28) disposé entre une plaque polaire inférieure (2) et une plaque polaire supérieure (29), où la plaque polaire inférieure (2) comprend un noyau (20) de manière à générer un entrefer (T) entre le noyau (20) de la plaque polaire inférieure et de la plaque polaire supérieure (29),,
- une bobine de phonie (3) soutenue par un support cylindrique (30),
- un panier (4) relié à l'ensemble aimanté (M),
- un dispositif de centrage (5) relié au panier (4) et au support cylindrique (6) de façon à ce que la bobine de phonie (3) se trouve dans l'entrefer (T), ledit dispositif de centrage (5) étant apte à se déplacer de manière élastique pour permettre un mouvement axial du support cylindrique (30) par rapport à l'ensemble aimanté (M), et
- une membrane (6) reliée au panier (4) et au support cylindrique (30),
- un cylindre externe (7) disposé autour du dit ensemble aimanté (M),
- une suspension élastique (8') reliée au dit cylindre externe (7) pour permettre un mouvement axial du cylindre externe (7) par rapport à l'ensemble aimanté (M),

caractérisé en ce qu'il comprend également
une seule bobine de contrôle (72) soutenue par ledit cylindre externe (7) et disposée en correspondance du bord périphérique de la plaque polaire supérieure (29), où ledit cylindre externe (7) qui soutient ladite bobine de contrôle (72) est relié à la plaque polaire supérieure (29) moyennant ladite suspension élastique (8').

8. Haut-parleur (1) selon la revendication 7, où la plaque polaire inférieure (22) a un diamètre externe majeur par rapport au diamètre de l'aimant (28) et de la plaque polaire supérieure (29) ;
la plaque polaire inférieure (22) est munie d'un collier périphérique (24) qui déborde supérieurement du bord de la plaque polaire inférieure et qui se dispose à l'extérieur du cylindre externe (7), de façon à former un entrefer (T') entre la plaque polaire supérieure (29) et le collier périphérique (24) de la plaque polaire inférieure ;
le cylindre externe (7) étant réalisé en matériel non ferromagnétique ; et
la bobine de contrôle (72) étant disposée dans ledit entrefer (T').

9. Haut-parleur (1) selon l'une quelconque des revendications précédentes, comprenant :

- un premier groupe mobile comprenant le support cylindrique (30), la bobine de phonie (3), le dispositif de centrage (5) et la membrane (6), et
- un second groupe mobile comprenant le cylindre externe (7) et ladite au moins une bobine de contrôle (71, 72) ; où la masse du second groupe mobile est 3-5 fois majeure par rapport à la masse du premier groupe mobile.

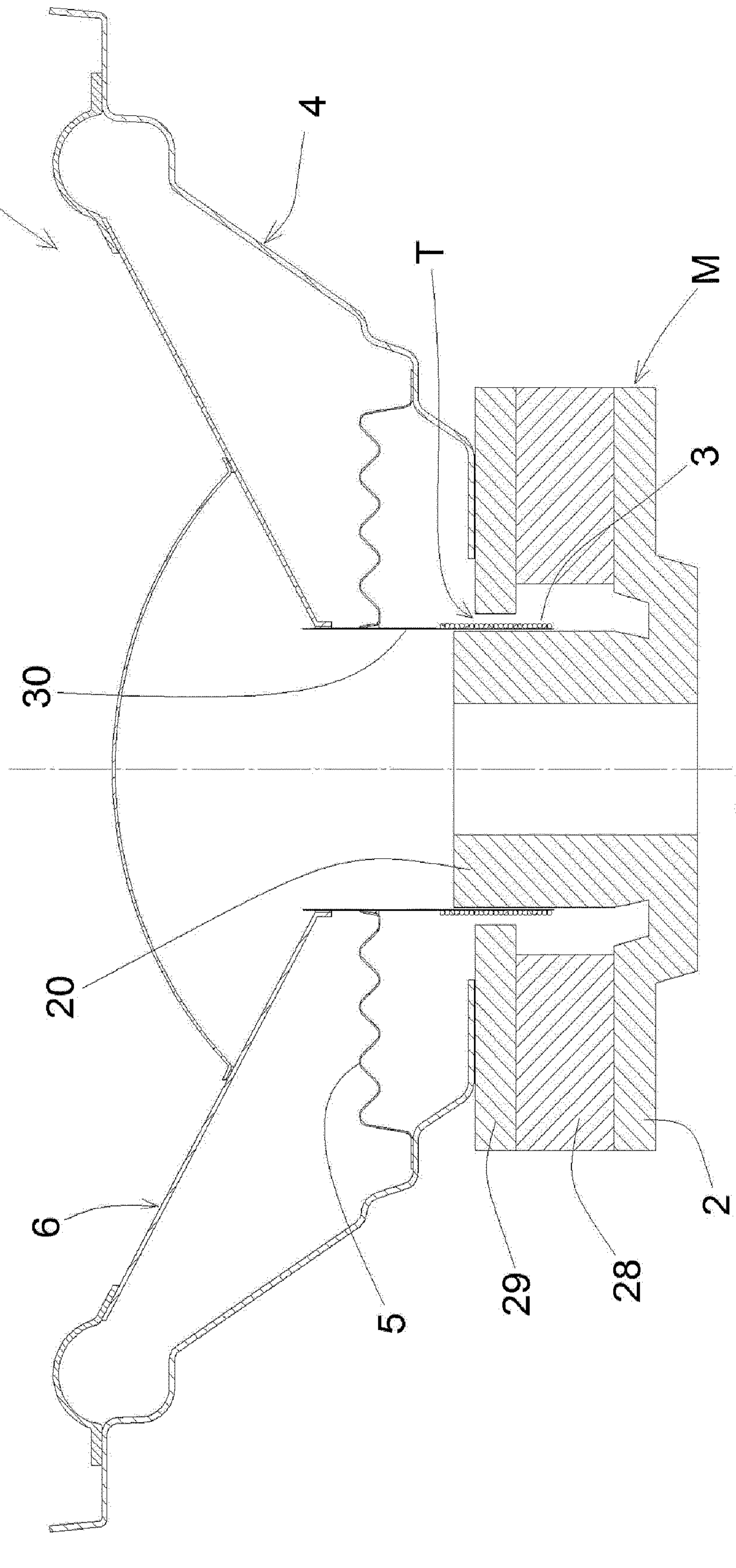

FIG. 1
PRIOR ART

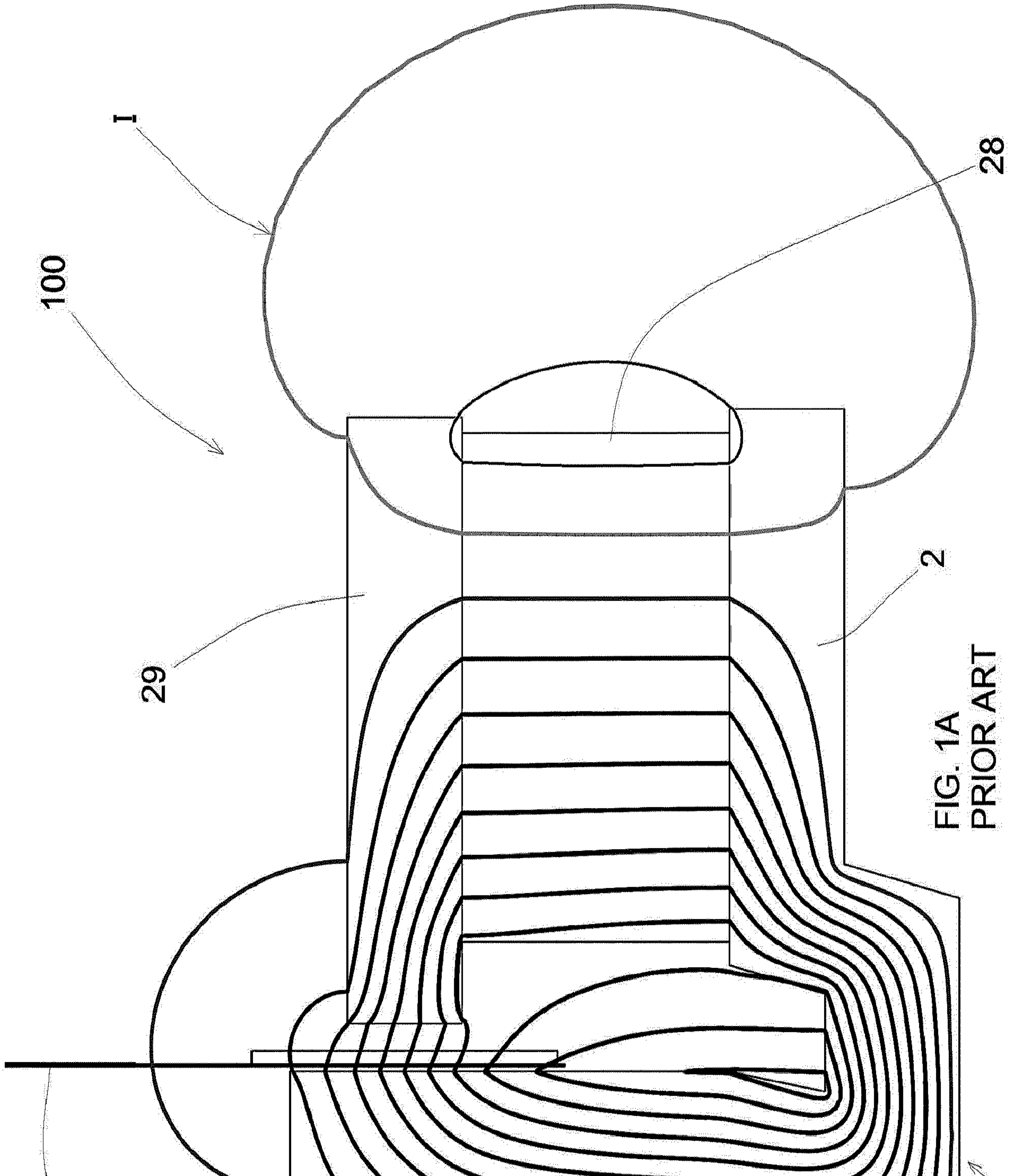

FIG. 1A
PRIOR ART

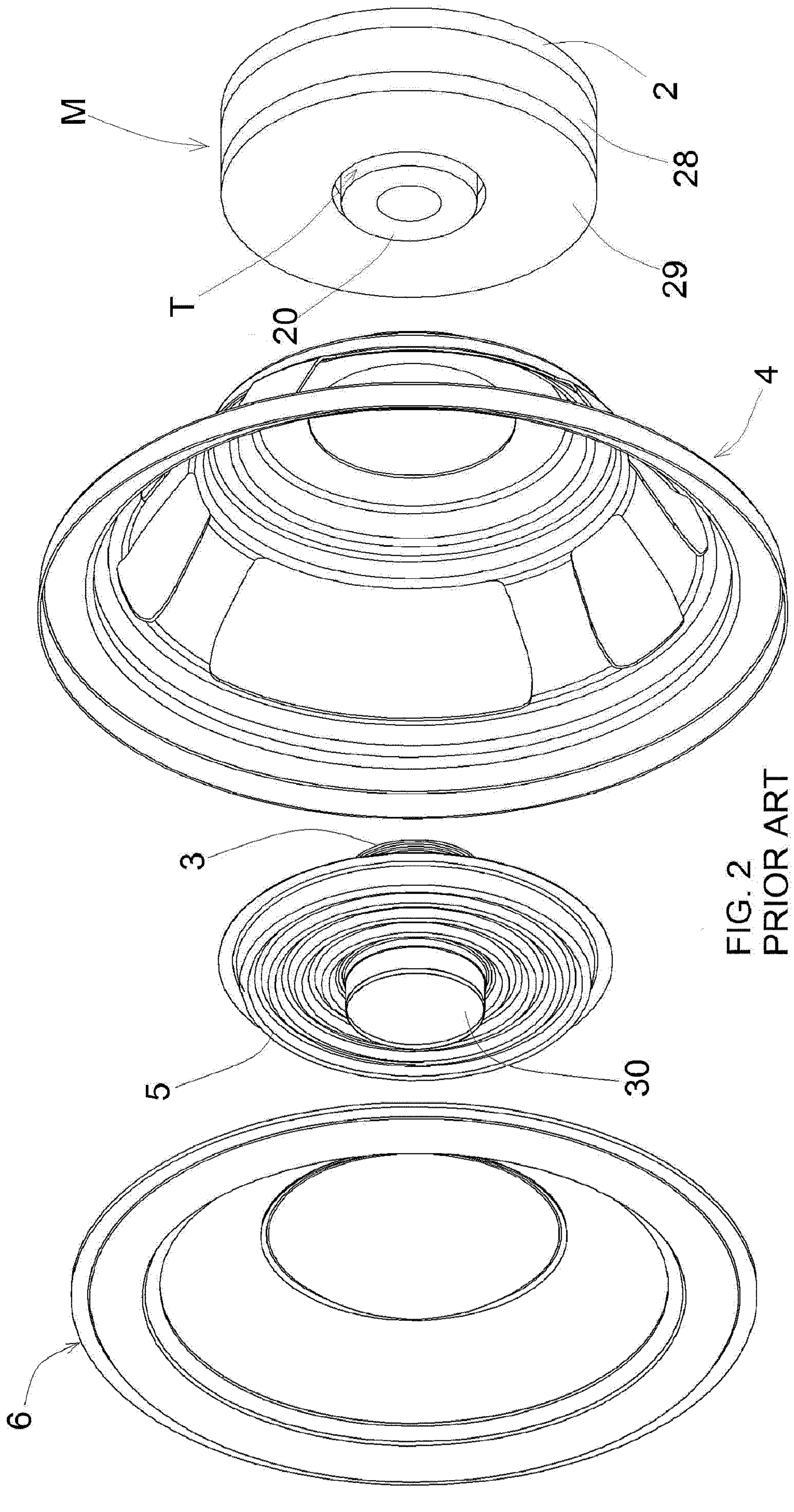

FIG. 2
PRIOR ART

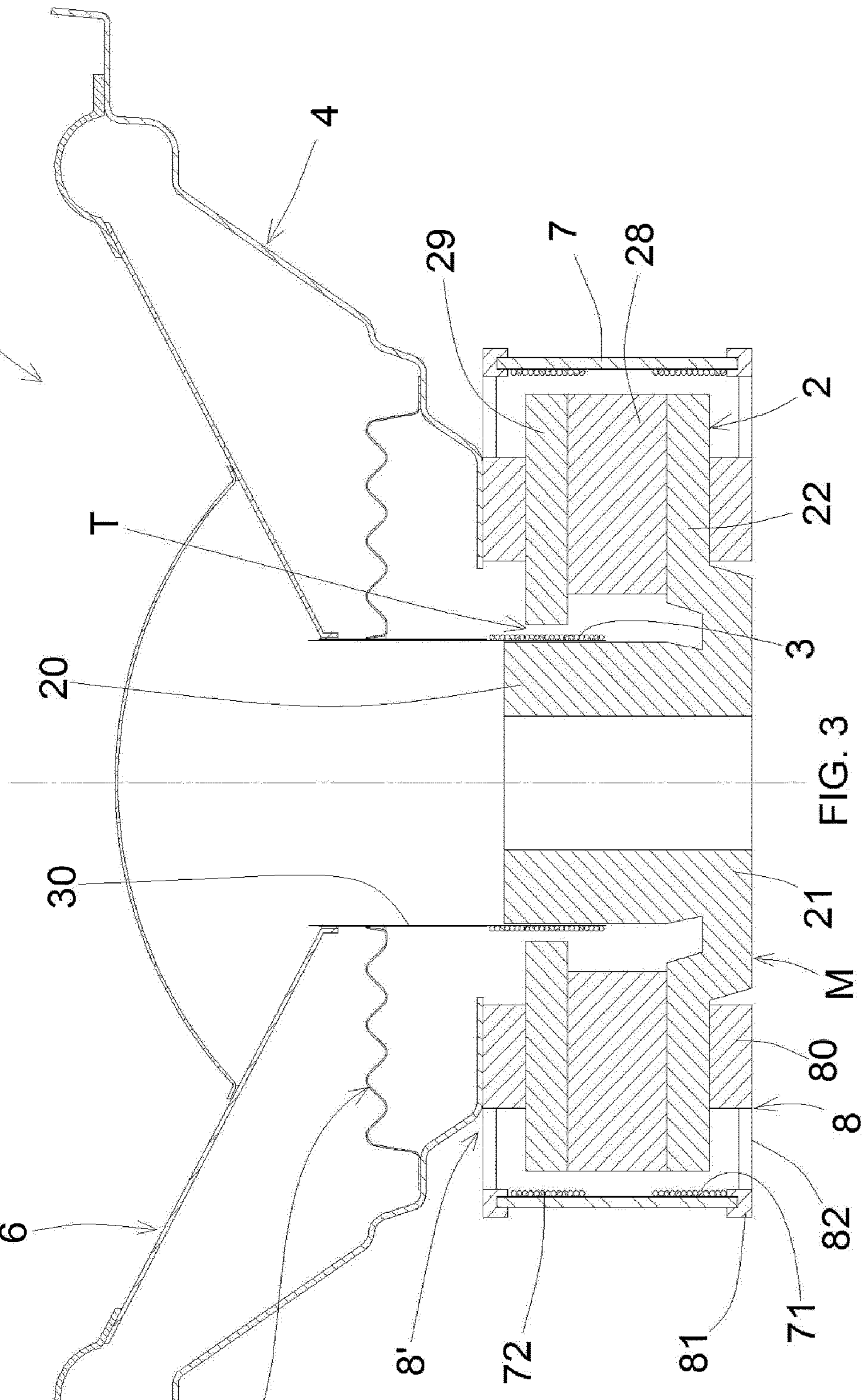

FIG. 3

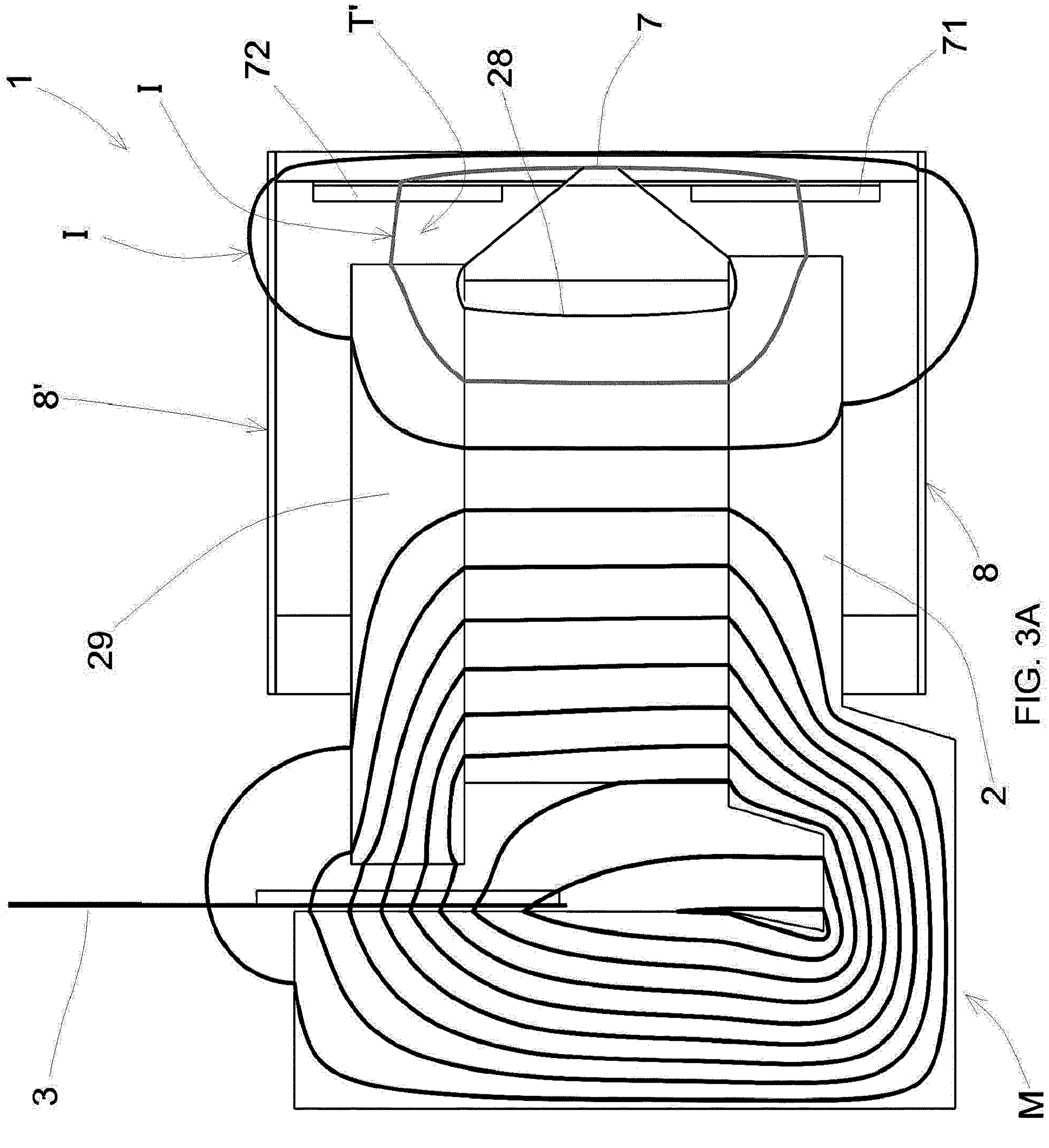

FIG. 3A

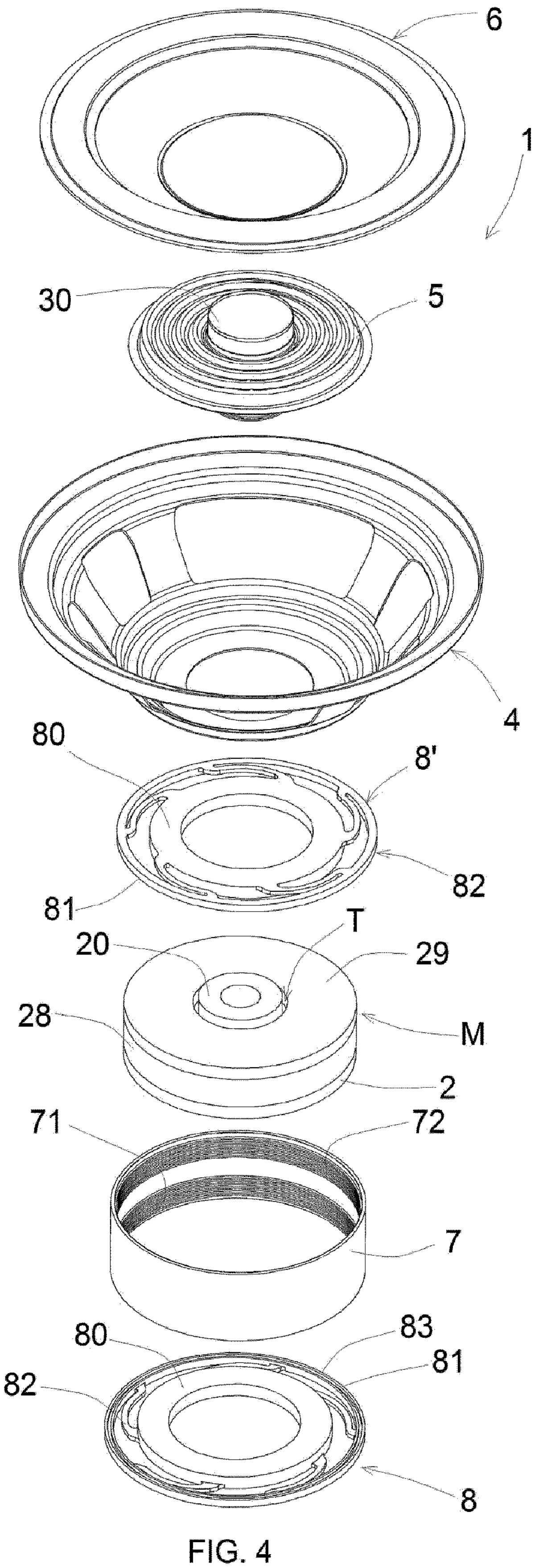

FIG. 4

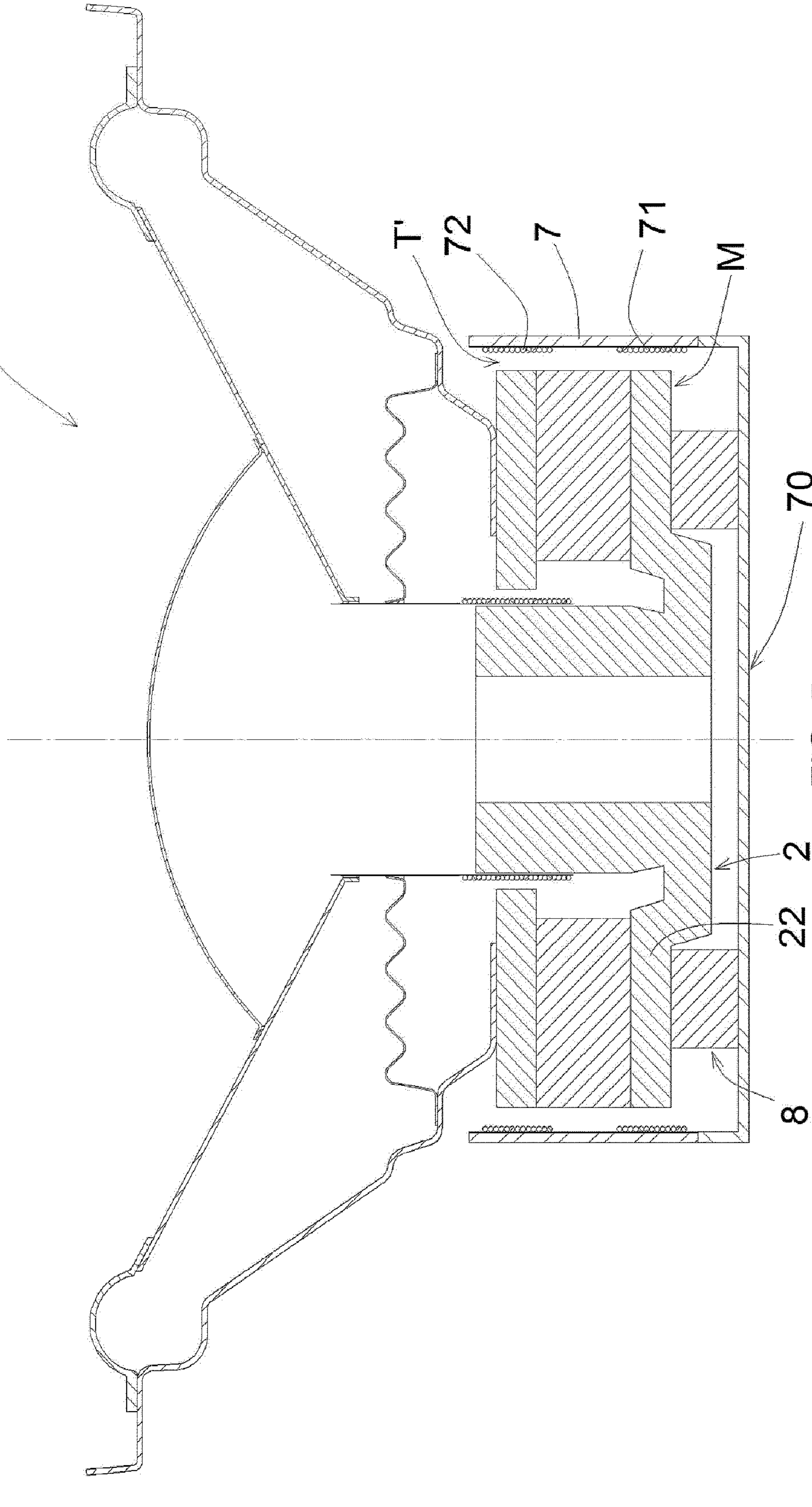

FIG. 5

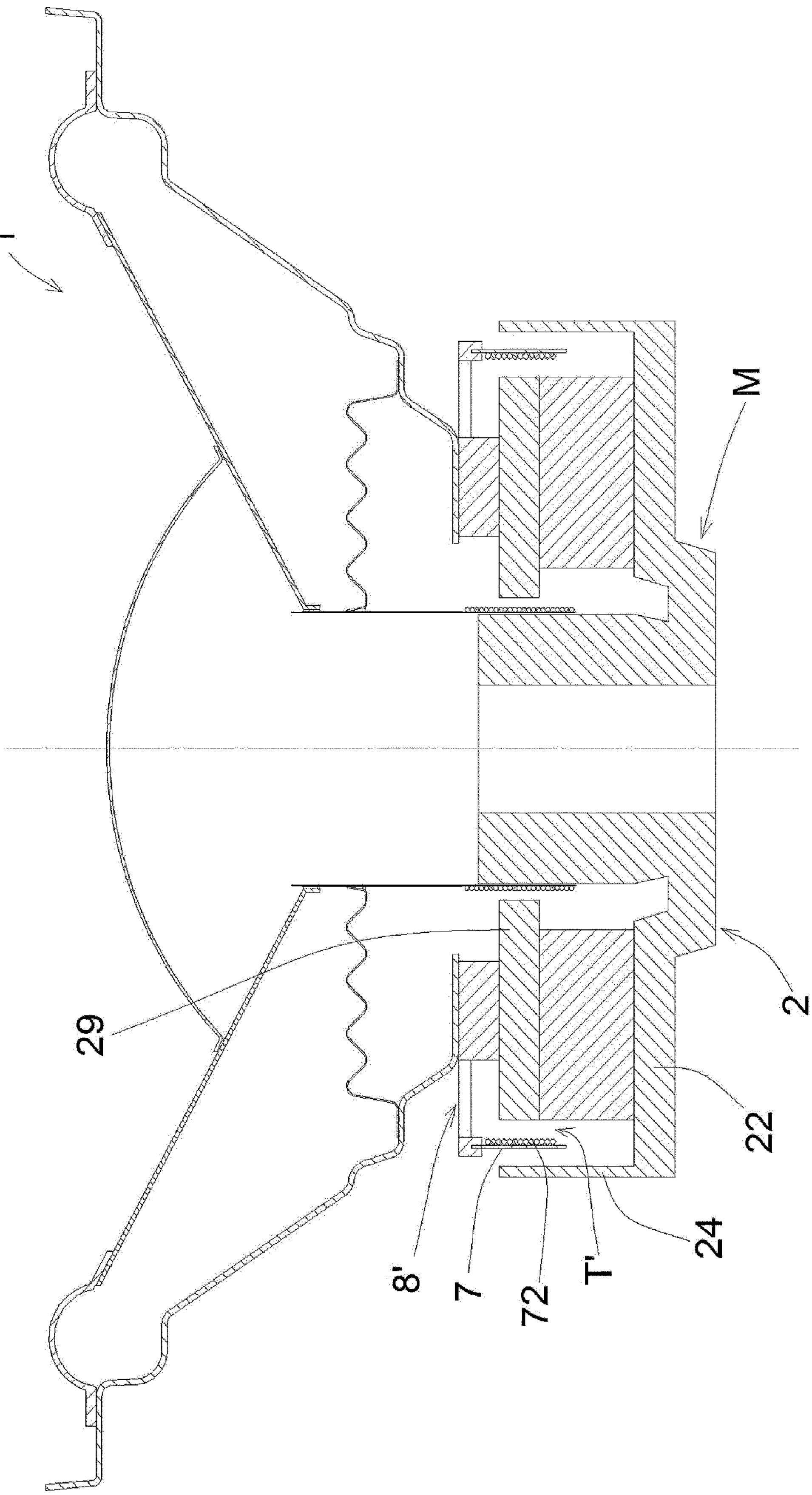

FIG. 6

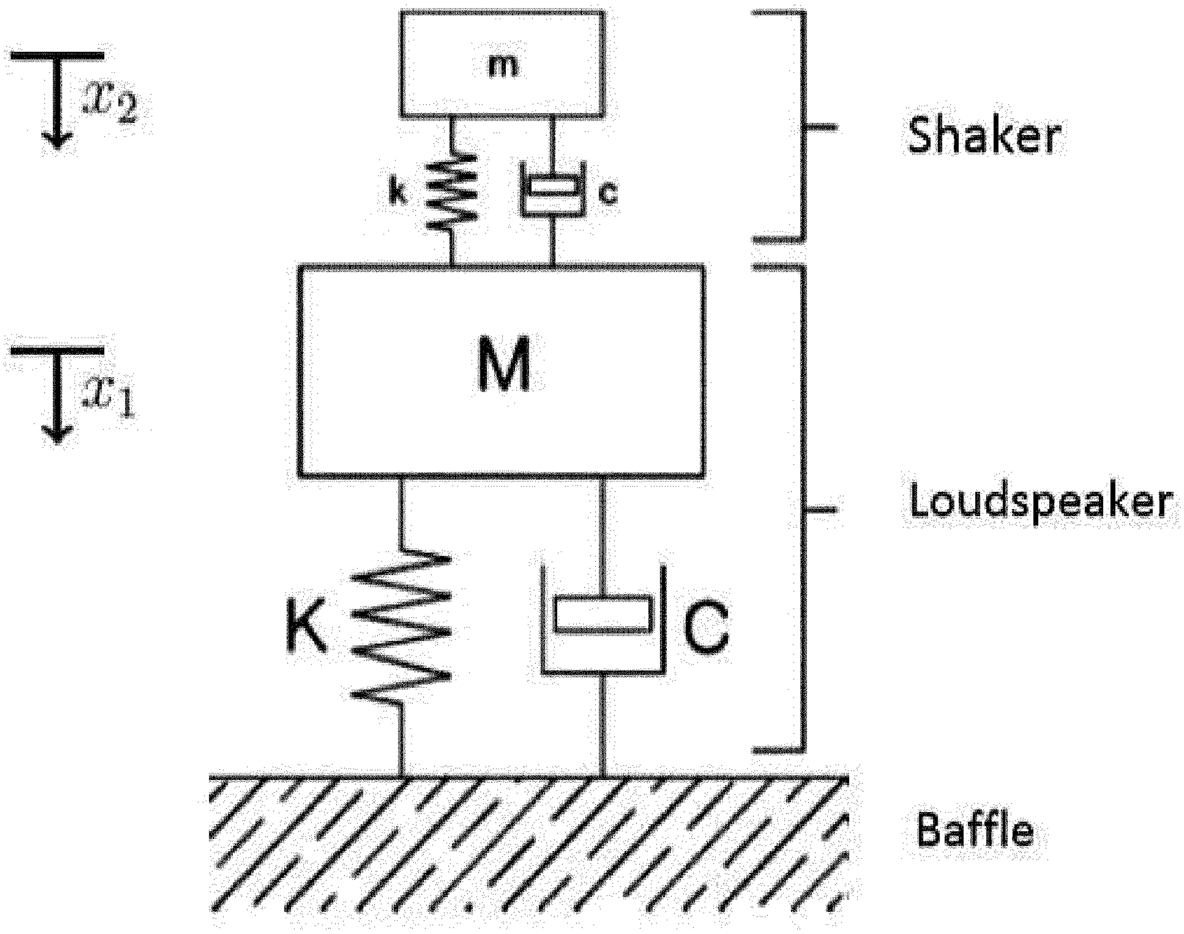

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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