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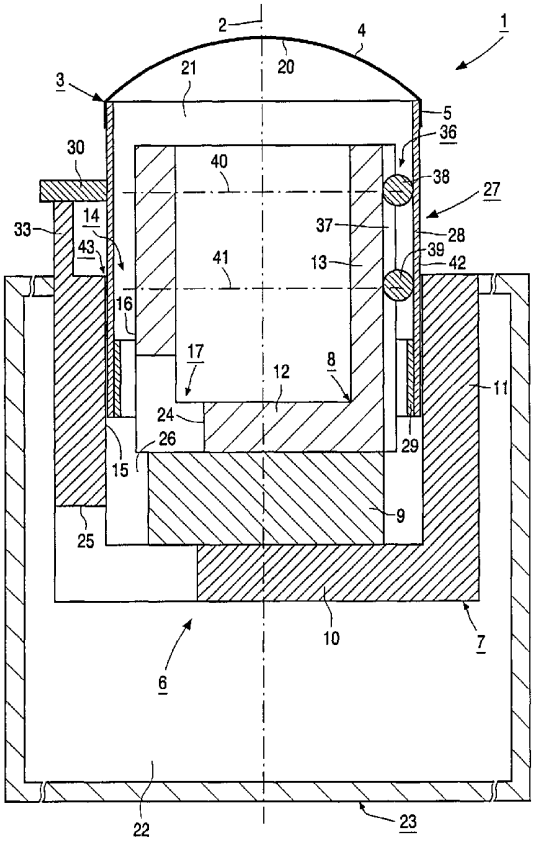
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(54) Title: ELECTROACOUSTIC TRANSDUCER BEING ACOUSTICAL TIGHT IN THE AREA OF ITS AIR GAP FOR ITS MOVING COIL



(57) Abstract: A transducer (1) with a transducer axis (2), with a membrane (3), with a magnet system (6) having an outer magnet system part (7) and an inner magnet system part (8), with a moving coil configuration (27) connected to the membrane (3) and having a coil carrier (28) and a moving coil (29) held by the coil carrier (28) in an air gap (14) between the two magnet system parts (7, 8), and with guide means (36) for a rectilinear guidance of the moving coil configuration (27) parallel to the transducer axis (2), wherein the moving coil configuration (27) has a cylindrical boundary surface (42) which together with a cylindrical boundary surface (15) of the outer magnet system part (7) delimits a cylindrical gap (43) which is acoustically impermeable above a lower limit frequency of at most 100 Hz.

WO 02/065810 A2

Electroacoustic transducer being acoustical tight in the area of its air gap for its moving coil

The invention relates to an electroacoustic transducer with a transducer axis and a membrane, with a magnet system with an external magnet system part and an internal magnet system part which together enclose an air gap, with a moving coil configuration which is connected to the membrane and has a coil carrier and a moving coil supported by the coil carrier and held in the air gap, and with guide means by which the moving coil configuration is guided rectilinearly parallel to the transducer axis.

Such an electroacoustic transducer is known from patent document GB 383,376. The hollow cylindrical moving coil in the known transducer lies opposite a cylindrical boundary surface of the outer magnet system part such that there is a relatively large space between the moving coil and the cylindrical boundary surface of the outer magnet system part (there is no information in this patent document on the free contours of said moving coil opposite the bush-like coil carrier), with the consequence that the gap-like area lying between the moving coil and the boundary surface of the outer magnet system part is acoustically impermeable only to relatively high frequencies, i.e. to frequencies above a range of about 900 Hz to 1100 Hz, whereas this gap-like area is not acoustically impermeable to lower frequencies. As a result, the known electroacoustic transducers are suitable only for achieving a perfect reproduction of signals above a frequency range of about 900 Hz to 1100 Hz, whereas a reproduction of signals of lower frequencies with a satisfactory quality is practically impossible.

The invention has for its object to avoid the circumstances described above and to create an improved electroacoustic transducer.

To achieve this object in an electroacoustic transducer according to the invention, features according to the invention are provided so that an electroacoustic transducer according to the invention can be characterized in the manner given below, as follows:

An electroacoustic transducer with a transducer axis and with a membrane capable of oscillation parallel to the transducer axis, with a magnet system comprising an outer magnet system part and an inner magnet system part which together enclose an air gap limited by a cylindrical boundary surface of the outer magnet system part and a cylindrical boundary surface of the inner magnet system part, which magnet system has at least one passage which is provided to put a rear chamber volume connecting directly to the rear of the membrane in communication with an additional rear chamber volume parallel to the direction of the transducer axis and lying remote from the rear of the membrane, with a moving coil configuration connected to the membrane and having a hollow cylindrical coil carrier and a moving coil of hollow cylindrical shape and connected to the coil carrier, which moving coil is retained so as to lie at least substantially in the air gap and is adjustable in relation to the magnet system, and with guide means for the moving coil configuration, which guide means guide the moving coil configuration parallel to the transducer axis upon adjustment of the moving coil in relation to the magnet system, while the moving coil configuration has a cylindrical boundary surface in its area lying opposite the cylindrical boundary surface of the outer magnet system part, and the cylindrical boundary surface of the outer magnet system part and the cylindrical boundary surface of the moving coil configuration are arranged so as to be mutually coaxial and delimit a cylindrical gap which is acoustically impermeable above a lower limit frequency of at most 100 Hz.

The measures according to the invention in a constructionally simple manner provide an electroacoustic transducer in which the cylindrical boundary surface of the moving coil configuration is held at a slight and always constant distance from the cylindrical boundary surface of the outer magnet system part, even during operation of the transducer, while the width of the cylindrical gap formed between the cylindrical boundary surface of the moving coil configuration and the cylindrical boundary surface of the outer magnet system part in said transducer is so small that this cylindrical gap is acoustically impermeable above a lower limit frequency of at most 100 Hz, which means that perfect acoustic signal reproduction is guaranteed down to a low frequency of 100 Hz.

In an electroacoustic transducer according to the invention it was found to be very advantageous if the cylindrical boundary surface of the outer magnet system part and the cylindrical boundary surface of the moving coil configuration delimit a cylindrical gap which is acoustically impermeable above a lower limit frequency of 50 Hz. This means that a perfect acoustic signal reproduction is guaranteed down to a low frequency of 50 Hz. It was found to be particularly advantageous if an acoustically impermeable behavior of the gap

above a lower limit frequency of 20 Hz is guaranteed with a correspondingly shaped gap. It should be mentioned that the cylindrical gap can have such a structure, namely such a gap width and gap length parallel to the transducer axis, that this gap is acoustically impermeable above a lower limit frequency of no more than 10 Hz or even 5 Hz.

In an electroacoustic transducer according to the invention, the moving coil may be embedded in a plastic casing and may be placed with its plastic casing on an outer boundary surface of the hollow cylindrical coil carrier, in which case the plastic casing has an exactly cylindrical outer boundary surface which forms the cylindrical boundary surface of the moving coil configuration and is arranged opposite the cylindrical boundary surface of the outer magnet system part. It was, however, found to be particularly advantageous if the cylindrical boundary surface of the moving coil configuration is formed by an outer boundary surface of the hollow cylindrical coil carrier, and the moving coil is provided inside the hollow cylindrical coil carrier and connected to the coil carrier. Such a design has proved very advantageous in tests.

In a transducer according to the invention the guide means may be formed by guide strips and guide grooves running parallel to the transducer axis, said guide strips projecting into the guide grooves. It was, however, found to be particularly advantageous if the guide means are formed by a ball-bearing configuration which has at least two trough-like ball cages running parallel to the transducer axis, while balls are arranged in two axial levels enter the cages. Such a design has proved advantageous in view of a rectilinear guidance of the moving coil with maximum ease of movement. Such a design may also be achieved with high precision, which is of great advantage in view of a manufacture of a cylindrical gap which is as narrow as possible and has a uniform width.

In such a ball-bearing configuration it was found to be particularly advantageous if the balls are made of a synthetic resin material, for example polyacetal or polyurethane. Preferably ground balls are provided.

It was found to be particularly advantageous in the electroacoustic transducer according to the invention if the membrane is connected only to the hollow cylindrical coil carrier of the moving coil configuration. This advantageously means that there is no mechanical connection of any type between the membrane and other transducer parts, as is the case, for example, in the transducer shown in Fig. 4 of the patent document GB 383 376 cited above, in which known transducer the return means for the moving coil connection are also connected to the membrane. With the design according to the invention, in which the membrane is connected only to the hollow cylindrical coil carrier, practically any low natural

resonance frequencies can be advantageously achieved by the assembly formed from the membrane and moving coil configuration, which benefits a high quality reproduction of signals at low frequency.

The above and further aspects of the invention will become evident from the embodiment described below and will be explained with reference to this embodiment.

The invention will be described below with reference to an embodiment shown in the drawing to which, however, the invention is not limited.

Fig. 1 shows in plan view an electroacoustic transducer according to an embodiment of the invention.

Fig. 2 shows in a section taken on the line II-II in Fig. 1 the electroacoustic transducer according of Fig. 1.

Fig. 3 is a bottom view taken in the line III-III in Fig. 2 of the electroacoustic transducer of Figs. 1 and 2.

Fig. 4 shows in a manner similar to that of Fig. 2, but on a larger scale, the electroacoustic transducer of Figs. 1 to 3 with the electroacoustic transducer held in a housing.

Figs. 1 to 4 show an electroacoustic transducer 1. The electroacoustic transducer 1 in this case is an electrodynamic loudspeaker. The special features of this electrodynamic loudspeaker are that this speaker has small external dimensions, i.e. an overall external diameter in the range of around 20 to 25 mm, and that this speaker despite its small size has a particularly high reproduction quality, i.e. hi-fi reproduction quality, and that it is also achieved with this speaker that very low frequencies which lie in the range between 20 and 50 Hz can be reproduced by this speaker with an excellent quality.

The transducer 1 has a transducer axis 2. The transducer 1 is fitted with an membrane 3 capable of oscillation parallel to the transducer axis 2. The membrane 3 in the present case is mainly cup- or dome-like and has a cup- or dome-like portion 4 and a hollow cylindrical fixing portion 5 projecting from the portion 4 parallel to the transducer axis 2.

The transducer 1 is also fitted with a magnet system 6. The magnet system has an outer magnet system part 7 and an inner magnet system part 8 as well as a permanent magnet 9. The outer magnet system part 7 is pot-shaped and has a base wall 10 and a hollow

cylindrical side wall 11. The inner magnet system part 8 is also pot-shaped and has a base wall 12 and a hollow cylindrical side wall 13. The permanent magnet 9 has a circular disc-like structure and is provided between the base wall 10 of the outer magnet system part 7 and the base wall 12 of the inner magnet system part 8. The two magnet system parts 7 and 8 are made of a magnetically highly permeable material, preferably soft iron.

The two magnet system parts 7 and 8 enclose an air gap 14 in the area of the two side walls 11 and 13. The air gap 14 is limited by a cylindrical boundary surface 15 of the outer magnet system part 7 and a cylindrical boundary surface 16 of the inner magnet system part 8.

As regards the magnet system 6,. it should be kept in mind that the magnet system 6 in the present case has three passages 17, 18 and 19 which are provided so as to put a rear chamber volume 21, connecting directly to the rear 20 of the membrane 3, in communication with an additional rear chamber volume 22 lying remote from the rear 20 of the membrane 3 parallel to the direction of the transducer axis 2. The additional rear chamber volume 22 is - as is evident from Fig. 4 - limited by a housing 23 which is not shown with its full dimensions in directions transverse to transducer axis 2 in Fig. 4. As is apparent from Figs. 2 and 4 showing the passage 17, each of the three passages 17, 18 and 19 consists of a slot-like recess 24 in the inner magnet system part 8 and an equally slot-like recess 25 in the outer magnet system part 7, which two recesses 24 and 25 are inter connected via an intermediate chamber 26 which lies adjacent the permanent magnet 9 and which may accordingly be allocated to a passage 17 or 18 or 19. The three passages 17, 18 and 19 thus serve to enlarge the rear chamber volume 21 connecting directly to the rear 20 of membrane 3 by the additional rear chamber volume 22, which is necessary if a perfect-quality acoustic reproduction of signals with low frequencies in a frequency range between 20 Hz and a few 100 Hz is to be guaranteed.

The transducer 1 is also fitted with a moving coil configuration 27. The moving coil configuration 27 is connected to the membrane 3. The moving coil configuration 27 has a hollow cylindrical coil carrier 28 which is formed by a plastic bush. Furthermore, the moving coil configuration 27 has a hollow cylindrical moving coil 29 connected to a coil carrier 28. The moving coil 29 in the present case is held so as to lie fully in the air gap 24. The moving coil 29 can be adjusted in relation to the magnet system 6. When the transducer 1 is operated, the moving coil 29 is supplied with electric signals with the result that the moving coil 29 is set in oscillation in relation to the magnet system 6 in accordance with the

signals supplied and parallel to the direction of the transducer axis 2, which oscillations are converted into sound waves by means of the membrane 3.

Figs. 2 and 4 show the moving coil configuration 27 in a home position. The home position of the moving coil configuration 27 is defined in that the coil carrier 28 is connected to three rubber webs 30, 31 and 32 which in the area of their free ends are connected to retaining blocks 33, 34 and 35 projecting from the side wall 11 of the outer magnet system part 7 parallel to the direction of the transducer axis 2. The rubber webs 30, 31 and 32 offer the advantage that practically always the same return forces are exerted on the moving coil configuration 27, both in the case of a positive deflection from the home position shown in figures 2 and 4 and in the case of a negative deflection. The rubber webs 30, 31 and 32 are thus used not only to define the home position of the moving coil configuration 27 but also as a means for returning the moving coil configuration 27 to its home position. It should be noted that the home position of the moving coil configuration 27 may alternatively be established in another manner, for example through the use of helically wound compression springs or leaf springs or other springs, but also without mechanical aids, for example with return means in which magnetic return forces are utilized. It is also conceivable to achieve the return function with the use of the magnet system 6 of the transducer 1 which is present in any case.

The transducer 1 also has guide means 36 for the moving coil configuration 27. The guide means 36 guide the moving coil configuration 27 exactly parallel to the transducer axis 2 during an adjustment of the moving coil 29 in relation to the magnet system 6. The guide means 36 in the transducer 1 are formed by a ball-bearing configuration 36 which in the present case has three groove-type ball cages 37 running parallel to the transducer axis 2, of which ball cages 37 only one ball cage 37 is visible in Figs. 2 and 4. Furthermore, the ball-bearing configuration 36 has balls 38 and 39 which enter the ball cages 37 and are arranged at two axial levels indicated with dotted lines 40 and 41. The transducer 1 thus has a total of six such balls 38 and 39, of which only two balls 38 and 39 are visible in Figs. 2 and 4.

The transducer 1 is advantageously structured such that the moving coil configuration 27 has a cylindrical boundary surface 42 in its area lying opposite the cylindrical boundary surface 15 of the outer magnet system part 7, and the cylindrical boundary surface 15 of the outer magnet system part 7 and the cylindrical boundary surface 42 of the moving coil configuration 27 are arranged so as to be mutually coaxial, defining a cylindrical gap 43 here. The cylindrical gap 43 has a gap width in the radial direction and a

gap length parallel to the transducer axis 2 such that these two gap dimensions guarantee that the gap 43 is acoustically impermeable above a lower limit frequency of around 20 Hz, i.e. has an acoustically impermeable behavior.

In a sample of the transducer 1 constructed during development, a cylindrical gap 43 was produced, the gap width of which had a value of approximately 0.1 mm and the gap length of which had a value of approximately 10 mm. However, further samples were also manufactured in which the cylindrical gap 43 was made substantially narrower, for example 0.05 mm and also 0.02 mm to 0.01 mm. Despite these very narrow gaps 43, and because of the precise linear guidance of the moving coil configuration 27 by means of the ball-bearing configuration 36 parallel to the transducer axis 2, no serious problems were ever encountered with regard to an undesirable knocking of the moving coil configuration 27 against the cylindrical boundary surface 15 of the outer magnet system part 7. As a result of the small gap width of the cylindrical gap 43, this gap 43 is effectively acoustically impermeable down to very low limit frequencies, which is an extremely important condition for enabling a perfect acoustic reproduction of low frequency signals.

The cylindrical boundary surface 42 of the moving coil configuration 27 in the transducer 1 is formed by an outer boundary surface 42 of the hollow cylindrical coil carrier 28, which has the advantage that the cylindrical boundary surface 42 of the moving coil configuration 27 is realized with an exactly constant diameter over its entire axial dimension because the cylindrical boundary surface 42 is determined only by a single component, i.e. the coil carrier 28.

The transducer 1 has the further advantage that the moving coil 29 is provided inside the hollow cylindrical coil carrier 28 and is connected to the coil carrier 28 inside the coil carrier 28. Connecting the moving coil 29 to the coil carrier 28 is here achieved by means of an adhesive joint (not shown). The connection, however, may alternatively be achieved in a different manner.

With regard to the gap length running parallel to the transducer axis 2 of the cylindrical gap 43, it is to be noted that this gap length is sufficiently large to guarantee an acoustically impermeable behavior of the gap 43, even in the case in which the moving coil configuration 27 is in its extreme stroke position lying furthest away from the base wall 10 of the outer magnet system part 7.

The membrane 3 of the transducer 1 is connected only to the hollow cylindrical coil carrier 28 of the moving coil configuration 27 by means of the hollow cylindrical fixing portion 5 which projects from the oscillation portion 4 of the membrane 3

parallel to the transducer axis 2 and is placed on the coil carrier 28 and connected to the coil carrier 28 by means of an adhesive joint. Consequently there is no mechanical connection between the membrane and parts other than the coil carrier 28, which is particularly advantageous because as a result practically any low resonance frequencies of the component consisting of the membrane 3 and moving coil configuration 27 can be achieved.

In the transducer 1 according to the invention:

1) the acoustic impermeability necessary in such a transducer 1 between the area lying in front of the membrane 3 and the area lying behind the membrane 3;

2) the precise axial guidance of the moving coil configuration 27; and

3) the return of the moving coil configuration 27 are each achieved in a constructionally simple and reliable manner by three independent means, which offers the major advantage that each of these means can be dimensioned and structured independently of the other means, so that optimum conditions can be created for each of the functions to be achieved by these means. The transducer 1 according to the invention is therefore ideally suited for large membrane strokes while simultaneously guaranteeing a high transfer linearity.

It should be noted that the coil carrier 28 and the moving coil 29 of the moving coil configuration 27 in the transducer 1 of Figs. 1 to 4 are formed by two separately manufactured parts connected together after manufacture. It is alternatively possible to produce and structure a moving coil configuration 27 such that the moving coil configuration 27 has a moving coil 29 which is first wound alone as a freestanding coil, whereupon this moving coil 29 is connected to the coil carrier 28 formed by molding around the moving coil 29, in which case the coil carrier 28 will be formed substantially longer than the axial dimension of the moving coil 29 and thus, in the same way as the transducer 1 described above with reference to Figs. 1 to 4, can be guided by means of a ball-bearing configuration.

It should be noted that the transducer 1 of Figs. 1 to 4 has the cylindrical boundary surface 15 of the outer magnet system part 7 and the cylindrical boundary surface 16 of the inner magnet system part 8 and the cylindrical boundary surface 42 of the moving coil configuration 27 and the hollow cylindrical gap 43. Preferably, there is a circular cylindrical design here, but this is not absolutely essential, as the cylindrical design need not necessarily have a circular shape as its base surface, but may alternatively have a square or triangular or polygonal shape as its base surface.

Roller bearings may be used as the guide means instead of a ball-bearing configuration.

CLAIMS:

1. An electroacoustic transducer (1)

- with a transducer axis (2),

- with a membrane (3) capable of oscillation parallel to the transducer axis (2),

- with a magnet system (6) comprising an outer magnet system part (7) and an inner magnet system part (8) which together enclose an air gap (14) limited by a cylindrical boundary surface (15) of the outer magnet system part (7) and a cylindrical boundary surface (16) of the inner magnet system part (8), which magnet system (6) has at least one passage (17, 18, 19) which is provided to put a rear chamber volume (21) connecting directly to the rear (20) of the membrane (3) in communication with an additional rear chamber volume (22) lying remote from the rear (20) of the membrane (3) parallel to the direction of the transducer axis (2),

- with a moving coil configuration (27) connected to the membrane (3) and having a hollow cylindrical coil carrier (28) and a moving coil (29) of hollow cylindrical shape connected to the coil carrier (28), which moving coil (29) is retained so as to lie at least substantially in the air gap (14) and is adjustable in relation to the magnet system (6), and

- with guide means (36) for the moving coil configuration (27), which guide means (36) guide the moving coil configuration (27) parallel to the transducer axis (2) upon adjustment of the moving coil (29) in relation to the magnet system (6), while the moving coil configuration (27) has a cylindrical boundary surface (42) in its area lying opposite the cylindrical boundary surface (15) of the outer magnet system part (7), and the cylindrical boundary surface (15) of the outer magnet system part (7) and the cylindrical boundary surface (42) of the moving coil configuration (27) are arranged so as to be mutually coaxial and delimit a cylindrical gap (43) which is acoustically impermeable above a lower limit frequency of at most 100 Hz.

2. A transducer (1) as claimed in claim 1, wherein the cylindrical boundary surface (15) of the outer magnet system part (7) and the cylindrical boundary surface (42) of the moving coil configuration (27) delimit a cylindrical gap (43) which is acoustically impermeable above a lower limit frequency of at most 50 Hz.

3. A transducer (1) as claimed in claim 2, wherein the cylindrical boundary surface (15) of the outer magnet system part (7) and the cylindrical boundary surface (42) of the moving coil configuration (27) delimit a cylindrical gap (43) which is acoustically impermeable above a lower limit frequency of maximum 20 Hz.

4. A transducer (1) as claimed in claim 1, wherein the cylindrical boundary surface (42) of the moving coil configuration (27) is formed by an outer boundary surface (42) of the hollow cylindrical coil carrier (28), and wherein the moving coil (29) is provided inside the hollow cylindrical coil carrier (28) and is connected to said coil carrier (28).

5. A transducer (1) as claimed in claim 1, wherein the guide means (36) are formed by a ball-bearing configuration (36), which has at least two groove-type ball cages (37) running parallel to the transducer axis (2) and balls (38, 39) entering said ball cages (37), which balls (38, 39) are arranged at two axial levels (40, 41).

6. A transducer (1) as claimed in claim 1, wherein the membrane (3) is connected only to the hollow cylindrical coil carrier (28) of the moving coil configuration (27).

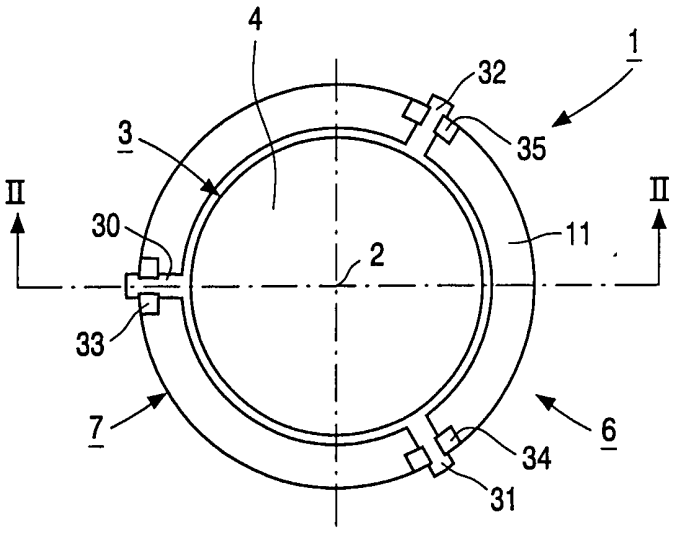


FIG. 1

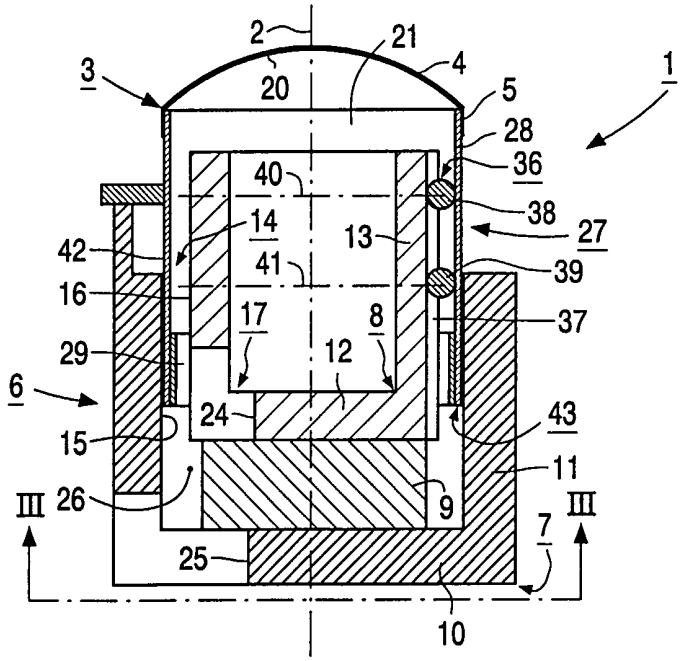


FIG. 2

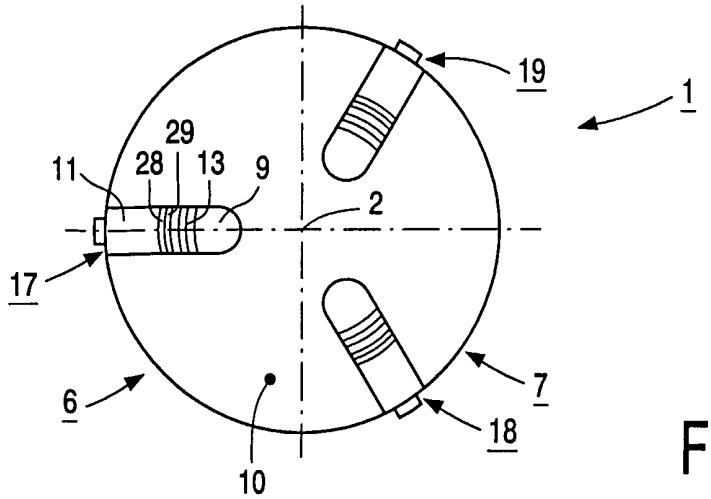


FIG. 3

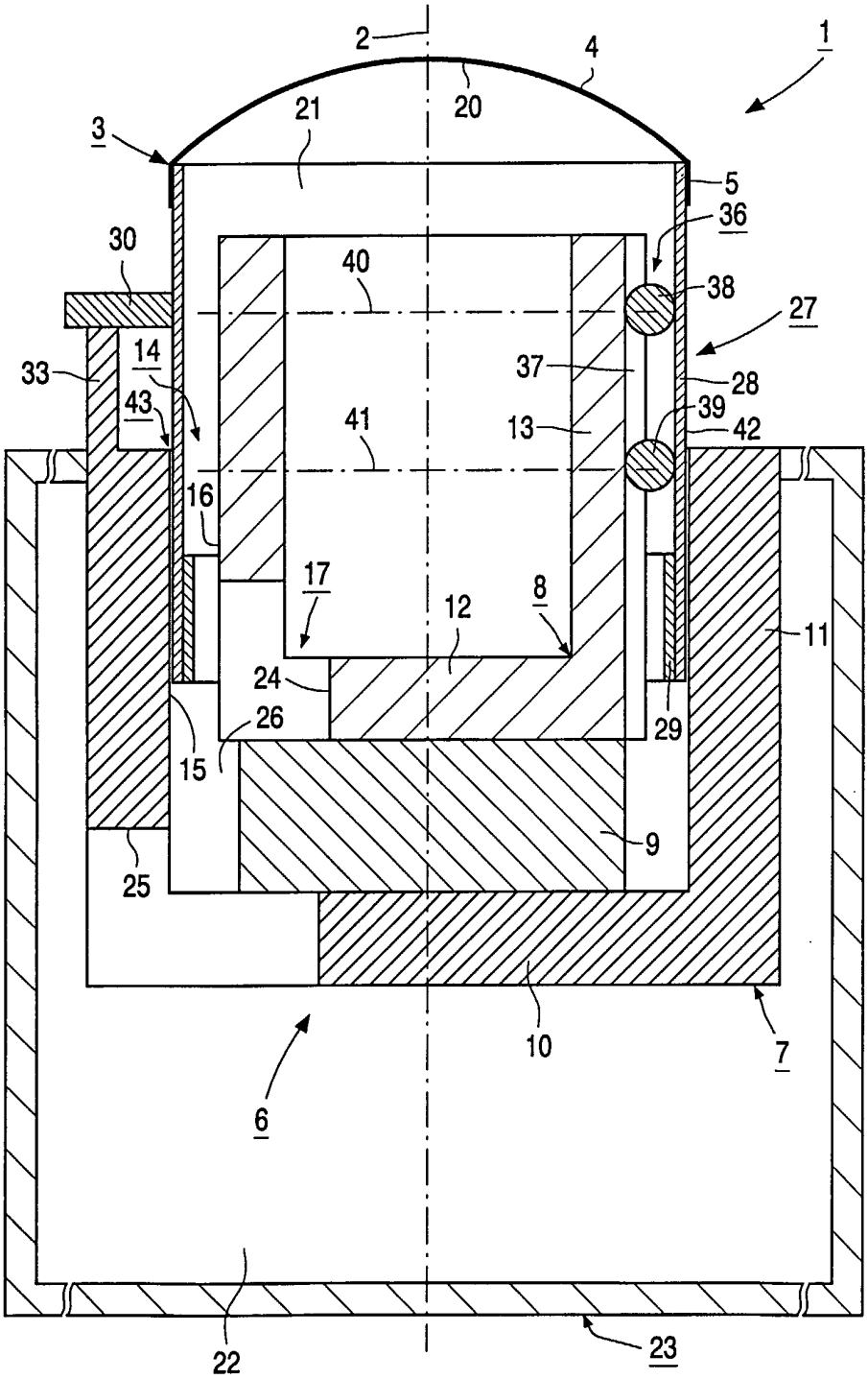

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FIG. 4