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(54) Whirlpool bath with ultrasound emission devices

(57) Whirlpool bath (10) comprising a plurality of ultrasonic micromassage devices (13) distributed over the walls (11) of the bath (10), in which each of the ultrasonic micromassage devices (13) comprises a device (23, 30) for orientating the direction of emission of the ultrasound in a solid angle; the whirlpool bath (10) being characterized in that each ultrasonic micromassage device (13) also comprises a plate (26) providing electrical insulation between the external environment and the live parts of the device (13), and in that the plate (26) permits the correct propagation of the ultrasonic waves from a piezoelectric element (25) associated with the device (13) to the water in the said bath (10).

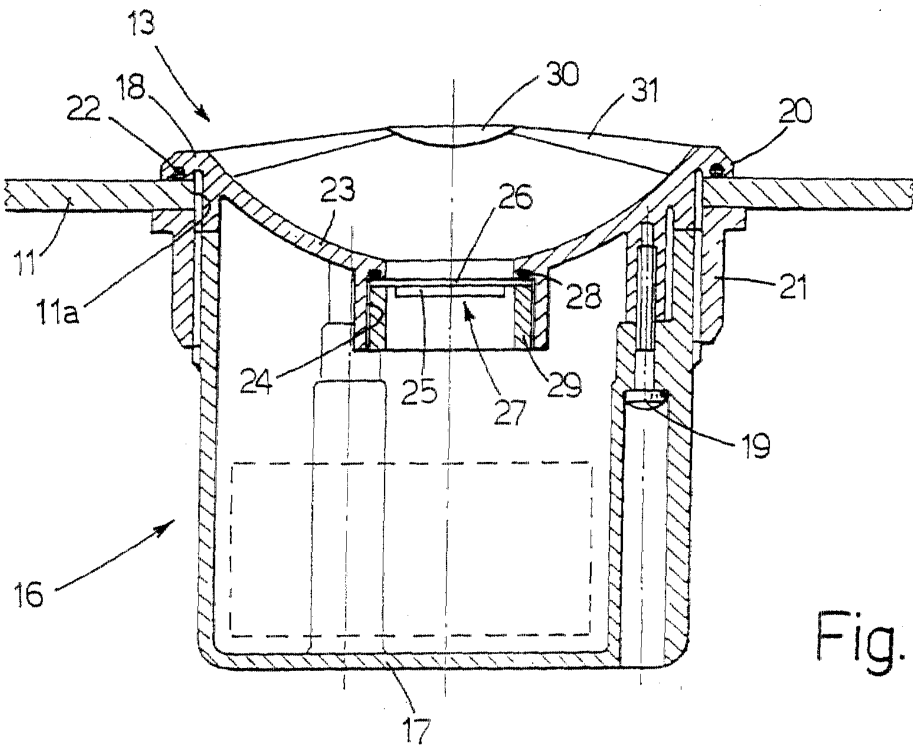

Fig.2

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Description

[0001] The present invention relates to a bath comprising a whole-body massage system provided with a plurality of nozzles from which jets of pressurized water are emitted to strike the body of the user, and additionally comprising an ultrasonic micromassage system provided with a plurality of sound wave generation devices.

[0002] In particular, the present invention relates to an element capable of electrically insulating the live parts, in such a way as to prevent any unintended contact between the user's body and the live parts of the ultrasonic micromassage system.

[0003] Italian patent applications MI93A002341 and MI95A000778 disclose a bath provided with whole-body massage and micromassage systems. The micromassage is carried out by means of devices capable of generating beams of ultrasound to be sent into the interior of the bath. In particular, Italian patent application MI95A000778 describes and claims a whirlpool bath in which the distribution of the ultrasonic waves is improved by the use of ultrasound emission devices which comprise means for orientating the direction of emission of the ultrasonic waves in a solid angle of not less than 30°, preferably more than 40°, and in particular at least 50°.

[0004] Although this type of device for emitting ultrasound in a whirlpool bath represents an indisputable advance towards a better distribution of the ultrasonic waves in a whirlpool bath, it has the problem of bringing the outer surface of the live piezoelectric element into contact with the water in the bath, and therefore, possibly, with parts of the user's body. Moreover, the present electrical safety standards require that, in installations where no specialized health personnel are in attendance, there shall be no live part which might, even accidentally, come into contact with parts of the user's body immersed in the bath.

[0005] Therefore the problem is one of providing effective electrical insulation of the live parts of each device capable of producing ultrasonic waves to be emitted into the bath. The use of a circular plate of ceramic material, particularly steatite, to be bonded to the piezoelectric element from which the ultrasound is emitted, has been considered for this purpose. It has also been discovered, by an inventive step, that this ceramic plate must have a preferred thickness, in order to prevent negative interference of this resonating plate with the ultrasonic waves emitted from the piezoelectric element.

[0006] Consequently, by an inventive step, it was discovered that, for the best results, the thickness of the ceramic plate which forms both the insulating element and the resonating element, must be one quarter of the wavelength of the ultrasonic wave in the material from which the plate is made.

[0007] In other words, the object of the present invention was to reconcile the requirement to provide effective electrical insulation of the live parts of the device for producing ultrasound with the requirement to provide correct transmission of the ultrasonic waves from the generating piezoelectric element to the water of the bath and then to the user's body.

[0008] To achieve this, use has been made of theoretical studies and laboratory experiments which indicate that, in addition to the transmission of the ultrasonic wave from the piezoelectric element to the ceramic insulating plate and from the insulating plate to the water in the bath, there is a further phenomenon of back-reflection of the ultrasonic wave. Consequently, this ultrasonic wave, while being transmitted, obviously in phase, is also reflected in phase opposition from the water of the bath towards the insulating resonating plate. For this reason, if the insulating resonating plate does not have appropriate dimensional characteristics, phase differences will be created within it between the outgoing and the returning waves, which will considerably perturb the vibratory motion of the whole vibration unit formed by the piezoelectric element and the insulating resonating plate.

[0009] As is known, the piezoelectric effect is produced by subjecting a special element to an alternating electrical voltage. The effect of expansion and constriction of the piezoelectric element results in the creation of two ultrasonic waves emitted from the two main faces of the element. It has been found theoretically, and proved experimentally, that optimal results are obtained when the thickness of the piezoelectric element is equal to half of the length of the ultrasonic wave produced within the piezoelectric element. This is because, in this case, a constructive interference is generated between the ultrasonic wave emitted from the front face and that emitted from the rear face.

[0010] For example, it has been found that, for an ultrasonic wave having a frequency of 1.5 MHz and a speed of 4000 m/s in the material from which the piezoelectric element is made, the optimal thickness of the piezoelectric element is 1.35 mm.

[0011] As regards the insulating resonating plate bonded to the piezoelectric element, it should be noted that, in order to prevent this plate from interfering negatively with the ultrasonic waves which are about to leave the piezoelectric element, the thickness of this plate must be made equal to a quarter of the length of the ultrasonic wave within the plate, so that allowance is additionally made for the ultrasonic wave reflected from the water towards the piezoelectric unit.

[0012] Furthermore, the electronic exciting circuit must be tuned to the resonant frequency of the piezoelectric element. Therefore, the insulating resonating plate must also have a resonant frequency equal to that of the piezoelectric element, in such a way that the whole unit consisting of the piezoelectric element and the insulating resonating plate is made to resonate with the electronic exciting circuit.

[0013] In order to determine the correct thickness of the insulating resonating plate, use was made of mathematical models in which the plate is considered schematically as a plate of uniform thickness, not subjected to any potential difference and fixed rigidly to a solid ring.
[0014] The following theoretical formula, the results of which have been confirmed experimentally, was used:

$$f = \frac{0{,}467 \cdot t}{R^2} \cdot \sqrt{\frac{E}{\rho \cdot (1-\sigma^2)}}$$

in which:

t = thickness in centimetres of the plate element
R = radius in centimetres of the plate element
ρ = density in grams per cubic centimetre
σ = Poisson's ratio
E = Young's modulus expressed in dynes per square centimetre.

[0015] When the values for a ceramic material are inserted in the formula, together with the value of the fundamental frequency used in ultrasound production devices used in whirlpool baths (normally approximately 3 MHz), an optimal value of thickness of the insulating resonating plate is obtained, which, as stated above, is equal to a quarter of the length of the ultrasonic wave in the material from which the plate is made.
[0016] The object of the present invention is therefore to provide a bath, using a water jet whole-body massage system and an ultrasonic micromassage system, which is free of the disadvantages described above.
[0017] Therefore, according to the present invention, a whirlpool bath is constructed, comprising a plurality of ultrasonic micromassage devices distributed over the walls of the bath, in which each ultrasonic micromassage device comprises means for orientating the direction of emission of the ultrasound in a solid angle; the whirlpool bath being characterized in that each ultrasonic micromassage device additionally comprises means of electrical insulation between the external environment and the live parts of the device, and in that the means of electrical insulation permit the correct propagation of the ultrasonic waves from a piezoelectric element associated with the device to the water in the bath.
[0018] The present invention will now be described with reference to the attached drawings, which show, without restrictive intent, an example of embodiment in which:

- Figure 1 shows a side view of a whirlpool bath comprising a plurality of ultrasonic micromassage devices, each provided with the insulating resonating plate according to the present invention;
- Figure 2 shows schematically and in section an ultrasound emitter included in the whirlpool bath of Figure 1 and provided with the insulating resonating plate according to the present invention;
- Figure 3 shows a front view of the emitter of Figure 2;
- Figure 4 shows a front view of an insulating resonating plate according to the present invention, combined with the corresponding piezoelectric element; and
- Figure 5 shows a side view of the plate with the corresponding piezoelectric element shown in Figure 4.

[0019] With reference to Figure 1, the number 10 indicates a whirlpool bath on whose walls 11 there is located a first plurality of nozzles 12 for emitting jets of pressurized water mixed with air, these jets being capable of providing the usual whole-body massage effect on a body (not shown) immersed in the whirlpool bath 10. On the same walls 11 there is also located a second plurality of ultrasonic wave devices 13 which are capable of carrying out micromassage. The nozzles 12 are connected in a conventional way to a recirculating pump 14, while the devices 13 are connected electrically to at least one electric generator 15 at ultrasonic frequency.
[0020] The whirlpool system comprising the nozzles 12 and the micromassage system which consists of the plurality of the devices 13 are of conventional types and will not, therefore, be described here in greater detail. In particular, the nozzles 12 controlled by an electronic controller (not shown) emit jets of water mixed with air when so commanded. This produces a beneficial whole-body massage effect on the user's body. At the same time, by activating the devices 13 for producing ultrasound by means of the electric generator 15, it is possible to associate the aforesaid whole-body massage effect, in a way which is also known, with a micromassage effect due to the impact of the ultrasonic wave on the user's body immersed in the water in the bath 10.
[0021] As described fully in the cited applications MI93A002341 and MI95A000778, the whole-body massage action due to the action of jets of water mixed with air, combined with the micromassage action due to the action of the ultrasound, has a toning and relaxing effect on the user.
[0022] According to the description and claims of the cited application MI95A000778, the spatial distribution and the uniformity of treatment improve significantly if use is made of ultrasound emission devices capable of emitting wave fronts of greater width than the conventional ones. In particular, it has been found advantageous to have a beam width of not less than 30°, preferably more than 40°, and in particular at least 50° (for example 60°), with a power advantageously in the range from 100 mW to 3 W supplied to each emitter and a frequency in the range from 0.5 MHz to 5 MHz. The power applied to the immersed body of the user can advantageously be at least 100 mW/cm^2.
[0023] Figure 2 shows an embodiment of a device 13 capable of emitting ultrasound, in which the innovative

principles of the present invention are applied.

[0024] The device 13 comprises an essentially box-shaped main body 16 formed by a rear shell 17 and a front cover 18 connected to the rear shell 17 by means of screws 19. The device 13 is fitted in a through hole 11a in the wall 11 of the bath 10, and is fixed in its position by means of a flange 20 of the front cover 18 and a locking nut 21 screwed on to a corresponding threaded portion of the shell 17, in such a way that the edge of the hole 11a is trapped between the flange 20 and the nut 21. A seal 22, preferably made from plastic material, ensures the watertightness of the device 13 in the hole 11a.

[0025] The front cover 18 is made with its concave surface 23 facing the interior of the bath 10. A piezoelectric element 25 is positioned in the centre of the concave surface 23, in a suitable threaded seat 24, and is supplied with current, in a way described below, by the electric generator 15. This piezoelectric element 25 is bonded (Figures 4, 5) to an insulating resonating plate 26, whose principal characteristics are described in greater detail below, in such a way as to form a resonating unit 27. This resonating unit 27 rests on an annular seal 28 (Figure 2) and is held in the threaded seat 24 by a securing collar 29, threaded on its outer surface, which can be screwed into the threaded seat 24.

[0026] As shown in Figure 2, the outer surface of the plate 26. faces a dispersing reflecting element 30 supported by the cover 18 by means of thin radial arms 31.

[0027] The surface 23, like the element 30, is made from ultrasound reflecting material, in such a way that the beam of ultrasound emitted by the unit 27 with a relatively narrow solid angle is reflected by the convex element 30 on to the concave reflecting surface 23, which, in turn, sends the beam of ultrasound back towards the interior of the bath 10, this time with a relatively large solid angle. The size of this solid angle depends, as will be evident to a person skilled in the art, on the curvature of the surface 23 and on the distance between this surface 23 and the element 30. However, the solid angle is not less than 30°, and is advantageously greater than 50°, which in any case is considerably larger than the natural divergence of the source of ultrasound represented by the unit 27.

[0028] At this point it will be clearly understood that the specified objects are achieved by providing a whirlpool bath in which ultrasound is emitted at discrete points but with a large divergence of the beams, which unexpectedly has been found to provide greater efficiency than, for example, a large number of emitters with small apertures spaced apart from each other.

[0029] With emitters having a large beam aperture, a high uniformity of distribution of the power of the ultrasonic waves is also achieved, with the avoidance of shadow areas, which are particularly detrimental to the efficiency of the treatment.

[0030] In particular, the presence of the plate 26 makes it possible to electrically insulate the piezoelectric element 25 from the surrounding environment, in such a way as to prevent direct contact of the live parts of the device 13 with portions of the user's body which is immersed in the bath 10. Additionally, the plate 26 permits correct propagation of the ultrasonic waves from the piezoelectric element 25 to the water contained in the bath 10.

[0031] Figures 4 and 5 show in greater detail the way in which the piezoelectric element 25 is joined to the plate 26. It should be pointed out in the first place that this joining is carried out by bonding to form the resonating unit 27. This resonating unit 27 will preferably have a total thickness which is essentially equal to the sum of a quarter of the length of the ultrasonic wave in the piezoelectric element 25 and half the length of the ultrasonic wave in the plate 26.

[0032] As shown in greater detail in Figure 4, the piezoelectric element 25 comprises, in addition to a central body 25a, preferably made from a ceramic material, two covering layers 25b and 25c, preferably made from silver, located, respectively, on the visible face of the piezoelectric element 25 and on the concealed face of the said piezoelectric element 25, which is located between the plate 26 and the piezoelectric element 25. Additionally, the covering layer 25b extends over approximately three quarters of the respective visible face of the element 25, while the covering layer 25c covers the whole of the concealed face of the element 25, extends in the direction of the thickness of the element 25, and also occupies a portion essentially equal to the remaining uncovered quarter of the visible face of the piezoelectric element 25. Thus the two silver layers 25b, 25c can easily be connected to the electrical generator 15 by means of the two electrical cables 32, 33 respectively.

[0033] At this point, it is therefore possible to electrically excite the piezoelectric element 25 by means of an alternating current which is emitted by the electrical generator 15 in such a way as to generate the desired beam of ultrasonic waves.

Claims

1. Whirlpool bath (10), comprising a plurality of ultrasonic micromassage devices (13) distributed over the walls (11) of the bath (10), in which each of the said ultrasonic micromassage devices comprises means (23, 30) for orientating the direction of emission of the ultrasound in a solid angle, the whirlpool bath (10) being **characterized in that** each ultrasonic micromassage device (13) additionally comprises means (26) of electrical insulation between the external environment and the live parts of the device (13), and **in that** the said means (26) of electrical insulation permit the correct propagation of the ultrasonic waves from a piezoelectric element (25) associated with the device (13) to the water in the bath (10).

2. Bath (1) as claimed in Claim 1, in which the thickness of the said means (26) of electrical insulation is equal to a quarter of the length of the ultrasonic wave in the said means (26).

3. Bath (1) as claimed in Claim 2, in which the total thickness of a resonating unit (27), consisting of the said piezoelectric means (25) for the generation of ultrasound and the said means (26) of electrical insulation, is essentially equal to the sum of a quarter of the length of the ultrasonic wave in the said means (25) and a half of the length of the ultrasonic wave in the said means (26).

4. Bath (1) as claimed in any one of Claims 2 and 3, in which the visible face of the said piezoelectric element (25) has three quarters of its surface covered by a first conducting layer (25b), while the remaining quarter of the surface of the said visible face is covered by a second conducting layer (25c), which, after being bent around the thickness of the said piezoelectric element (25), covers essentially all of the surface of the second, concealed, face of the said piezoelectric element (25).

5. Bath (1) as claimed in Claim 4, in which the said conducting layers (25b, 25c) are made from silver.

6. Bath (1) as claimed in any one of the preceding claims, in which the said means (26) consist of steatite.

7. Bath (1) as claimed in Claim 3, in which the resonant frequency of the said electrical generator (15) is essentially equal to the resonant frequency of the said resonating unit (27).

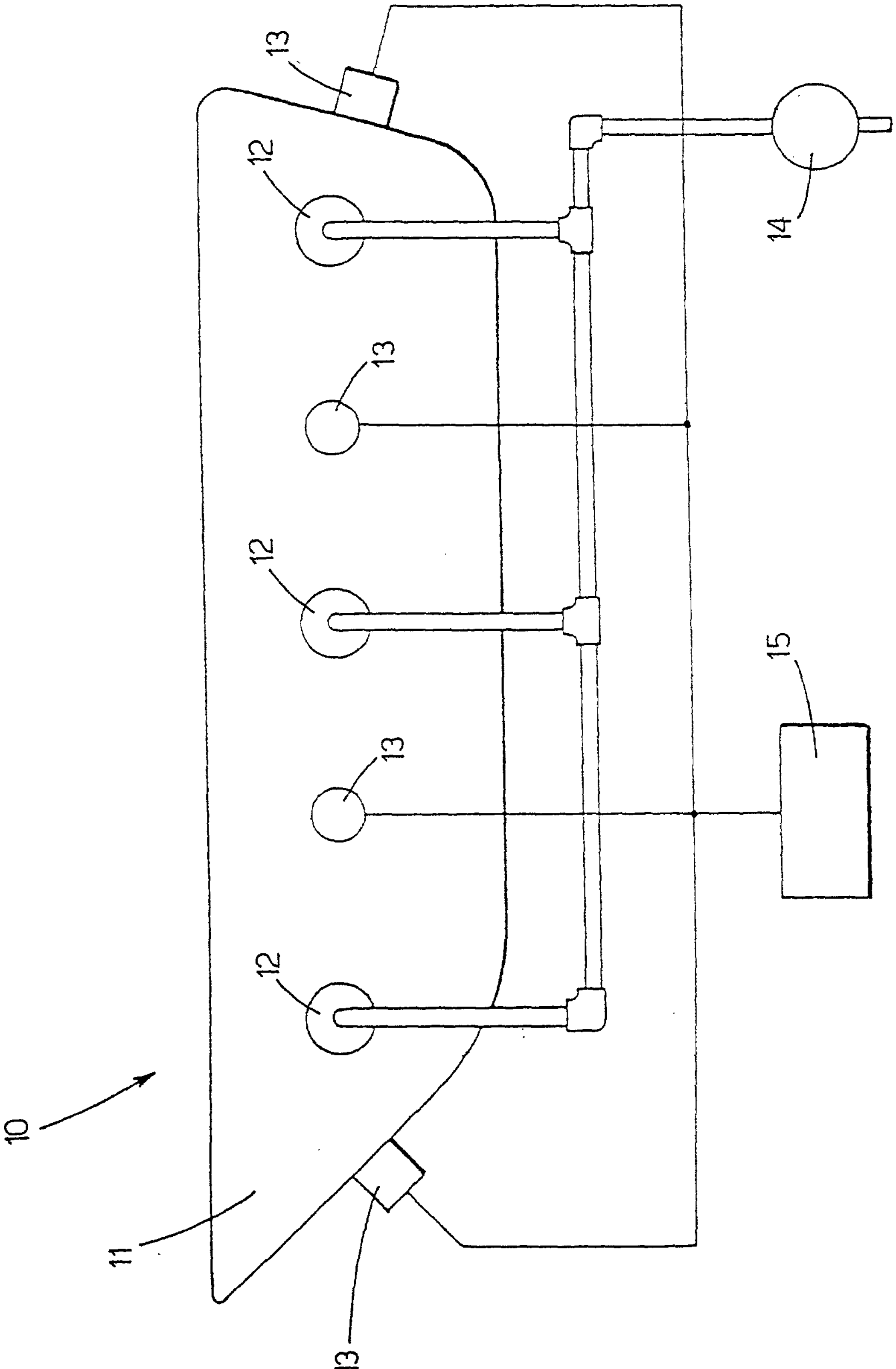

Fig.1

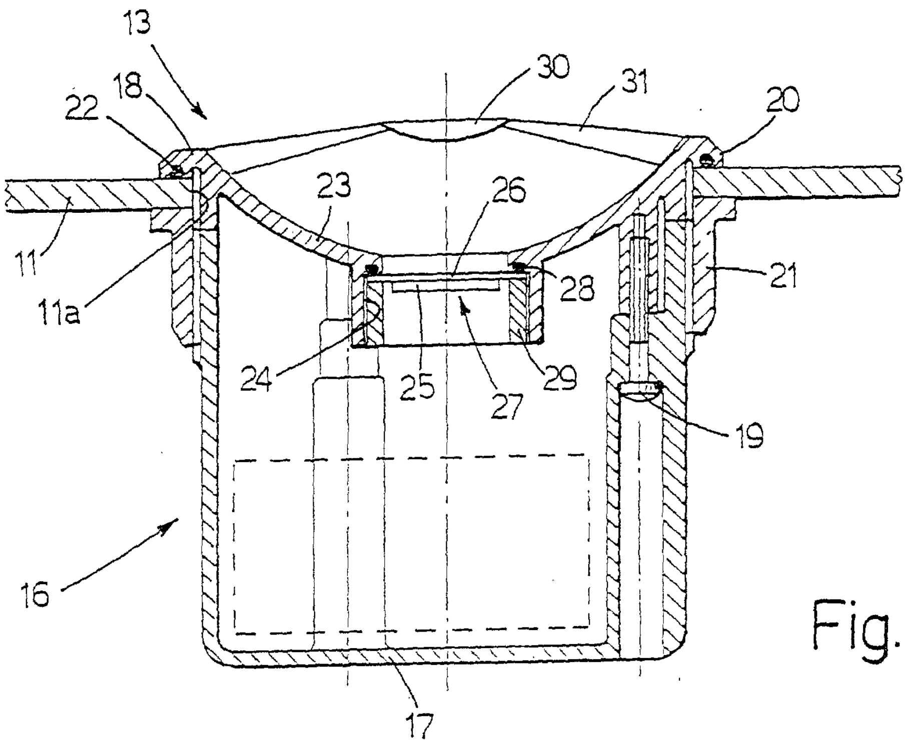
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Fig.2

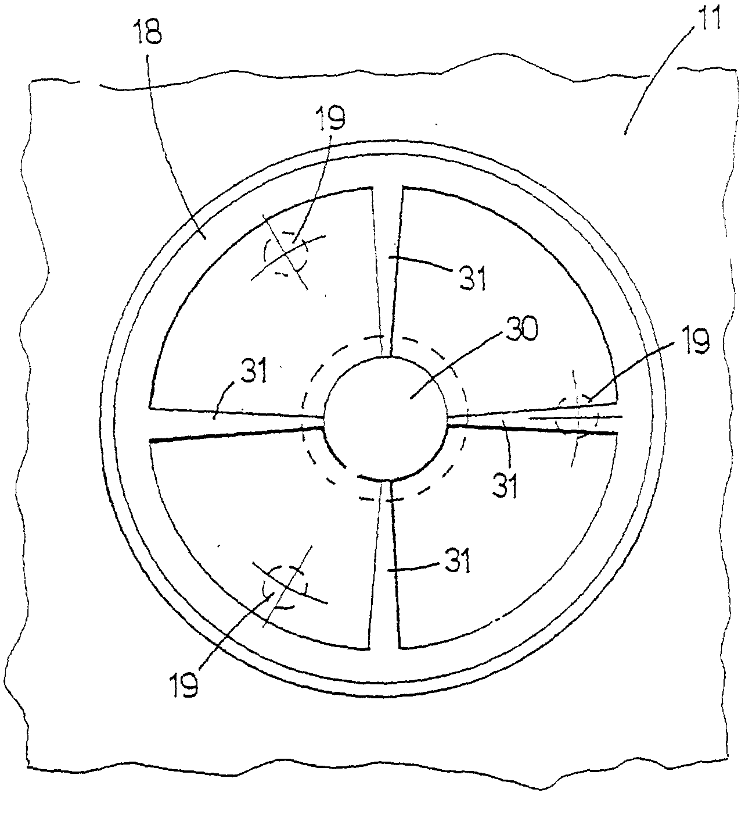
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Fig.3

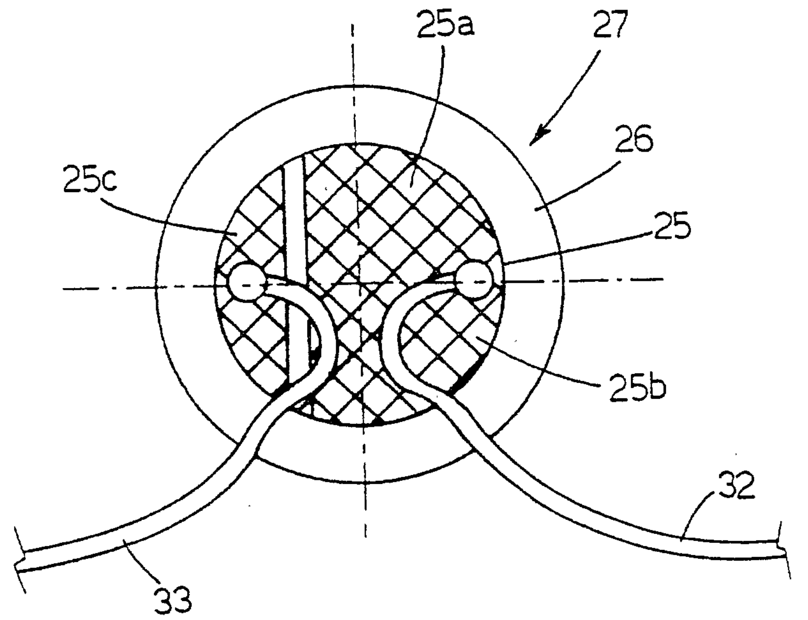

Fig.4

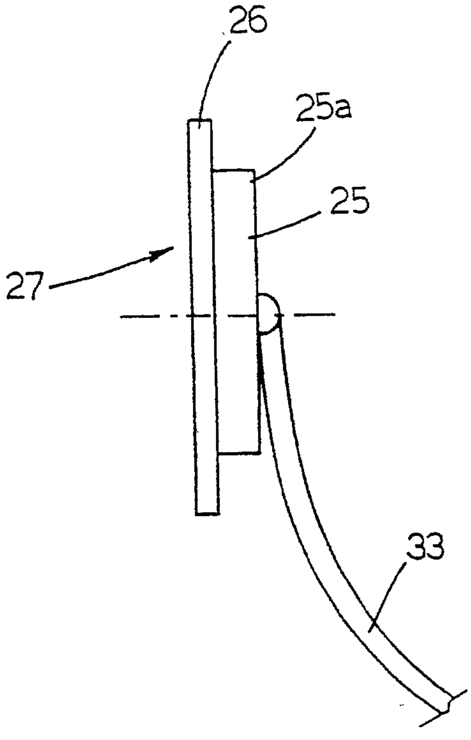

Fig.5

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EUROPEAN SEARCH REPORT

Application Number
EP 01 11 0860

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Y	US 3 550 586 A (BALAMUTH LEWIS) 29 December 1970 (1970-12-29) * column 14, line 17 - line 363; figure 7 *	1	
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A	US 5 339 804 A (KEMP WILLIAM H) 23 August 1994 (1994-08-23) * column 2, line 68 - column 3, line 2; figures *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 August 2001	Jones, T

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 11 0860

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