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(54) **Dome-like speaker system.**

(57) A dome-like speaker comprising a spherical wave horn baffle formed so as to diffuse into an acoustic field space acoustic waves from a dome-like vibrating plate 1 without disturbing the spherical wave on the basis of the fact that acoustic waves from the dome-like vibrating plate 1 are similar to spherical waves is formed in such a manner that the spherical wave horn baffle includes a slope 4 joined to a flat baffle surface 2 of the cabinet, the slope 4 being joined to the baffle surface 2 so as to have no discontinuity portion.

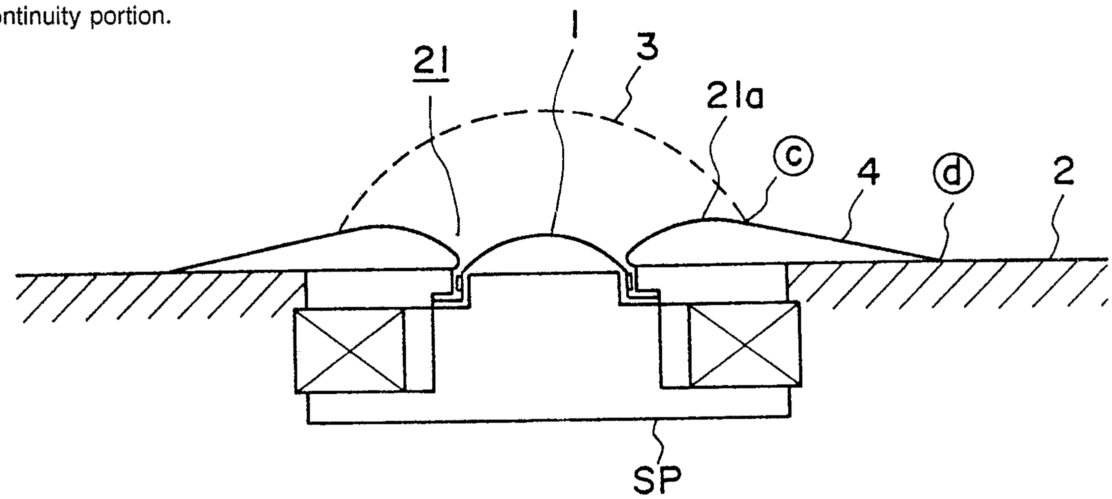

FIG. 1A

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DOME-LIKE SPEAKER SYSTEM

Field of the Invention

This invention relates to a dome-like speaker system and, more particularly, to a dome-like speaker system which has a spherical wave horn baffle to diffuse into an acoustic field space, acoustic waves from a dome-like vibrating plate so as not to cause reflection and/or refraction, on the basis of the fact that the acoustic waves from the vibrating plate are similar to spherical waves.

Prior Art

Many of recent speaker systems employ a dome-like vibrating plate in a tweeter and/or a midrange.

As shown in Fig. 4, when such dome-like speaker is mounted on a flat baffle 2, disturbances in the frequency characteristic of the speaker are often encountered. This is due to the reflection caused by rapid expansion of acoustic waves into the acoustic field space and the interference of acoustic waves between the baffle surface and vibrating plate 1.

When acoustic radiation by the vibrating plate 1 placed in the flat baffle 2 as shown in Fig. 4 is measured, it is understood that as shown in Fig. 5, the frequency characteristic and directional characteristic of the vibrating plate exhibit many crests and valleys therein and it is hence presumed that reflection, interference and refraction have occurred.

When the state of acoustic waves in the vicinity of the vibrating plate 1 is observed using acoustic intensities diagram at 6320 and 8000 Hz, it is seen that as shown in Figs. 6A and 6B, the acoustic waves exhibit a wave front close to that of a spherical wave at a place near the dome-like vibrating plate 1 while the wave front is disturbed at a place remoter slightly from the vibrating plate 1.

It is confirmed from this fact that, basically, the acoustic waves radiated from the vibrating plate 1 may be handled as spherical waves and that disturbances in the wave front is due to reflection, interference or refraction of acoustic waves caused by an improper shape of the baffle 2. Therefore, in order to flatten the characteristics of the dome-like speaker, it is necessary to take the shape of the baffle into account.

As just described above, it is confirmed in the dome-like vibrating plate 1 that the wave front of acoustic waves generated due to the shape of the vibrating plate 1 may be handled as spherical waves, so that in order to provide flat characteristics, it is necessary to expand those spherical waves into an acoustic field space so as to avoid reflection or refraction.

Thus the applicant has previously proposed as a new baffle shape through Japanese U.M. application 59-189547 filed December 15, 1984, the "spherical wave horn baffle" which introduces the concept of a horn thereinto.

The reason why the concept of such spherical wave horn baffle is basically introduced is that the horn is conventionally used as means for diffusing acoustic waves into an acoustic field space without causing reflection or refraction.

It is designed that when the dome-like vibrating plate is constituted as a part of a spherical surface, the horn is formed so as to prevent rapid expansion of acoustic waves from the vibrating plate into the acoustic field space and that the cross sectional area of the horn is gradually expanded relative to the surface of the vibrating plate. In the conventional horn, the cross sectional area of the horn is calculated by handling the wave front in the horn as plane waves while in the applicant's speaker the horn is formed by calculating the cross sectional area of the horn by handling the wave front in the horn as spherical waves. This horn is used as a dome-like speaker baffle to be defined as a spherical wave horn baffle. In that case, the problem is where the center of the spherical waves is. In this respect, it is assumed that the initial wave front as the origin of spherical waves substantially coincides with the surface shape of the dome-like vibrating plate. Here, the dome-like vibrating plate is handled as a part of a spherical surface and the center of the sphere is handled as the center of the spherical waves.

The spherical wave baffle horn proposed previously by the applicant takes the form of a horn such as that shown in Fig. 7 by giving partial surfaces of the horn using the following formulas,

$$Sx = 2\pi(R + x)\,Hx \qquad (1)$$

$$So = 2\pi RHo \qquad (2)$$

The shape of this horn varies as shown in Fig. 8 by changing the cut off frequency fc.

As will be seen in Fig. 7, in the spherical wave horn baffle 21 defined here, the horn wall 21a extends behind the vibrating plate 1 and is closed. Thus the resulting wave front may be regarded as being equivalent to that generated by a breathing sphere.

Therefore, the characteristics provided by the spherical wave horn baffle 21 may be replaced theoretically by those generated by a breathing sphere. It is to be noted that the breathing sphere does not theoretically exhibit directionality, but as the wave front propagates actually behind the vibrating plate 1, the acoustic pressure attenuates, so that the breathing sphere will have directionality.

As shown in Fig. 8, even at the same dome-like vibrating plate, the size of baffle varies as the cut off frequency fc is changed. It is to be noted that when the baffle is employed in an actual dome-like speaker, it is necessary to specifically take into account how the characteristics to be desired should be and to determine the size of the baffle.

Fig. 9 shows an example of a dome-like speaker SP for reproduction of a high frequency band, employing a spherical wave horn baffle 21.

Fig. 10 shows the frequency and directionality characteristics of the horn baffle.

It will be seen in Fig. 10 that the characteristics have no crests and valleys and that acoustic waves radiated from the dome-like vibrating plate causes neither reflection nor refraction. Particularly, the features of the directionality are that the 30° characteristic exhibits substantially the same curve as the 0° characteristic and that the level difference is 3 - 4 dB, which is large on average compared to that between the characteristics obtained when the flat baffle 2 shown in Fig. 4 is used. This tendency is applicable to the 60° characteristics. This implies that the frequency characteristic of a direct sound is substantially the same in a range of about 30° right and left relative to the central axis irrespective of the position where the sound is heard, and that the acoustic energy reflected by side walls, etc., is small to thereby improve the location or positioning of an acoustic image. Therefore, the spherical wave horn baffle is an excellent one which satisfies both opposing matters of irrelevance to the hearing position and excellent location or positioning of an acoustic image.

Figs. 11A and 11B show the results using acoustic intensities in order to see the state of acoustic waves in the vicinity of a dome-like vibrating plate. Comparison of Figs. 11A and 11B and Figs. 6A and 6B exhibits that disturbances in the wave front of Figs. 11A and 11B are extremely small even at a position remote from the dome-like vibrating plate 1 compared to Figs. 6A and 6B.

The dome-like speaker provides the flat characteristics, and improves the directional characteristic, and the location of an acoustic image by employing the new spherical wave horn baffle in the speaker.

Summary of the Invention

It is now obvious from the foregoing that the horn baffle of Figs. 7 and 9 has a very excellent shape for a dome-like speaker to radiate acoustic waves without causing reflection, interference and refraction.

However, with such shape, it is difficult to mount such horn baffle onto the flat baffle 2 of the cabinet although it is possible to mount such horn baffle on a conventional speaker cabinet.

There is the problem that when a dome-like speaker SP with a spherical wave horn baffle 21 is mounted on the flat baffle 2 of the cabinet by performing required processing, as shown in Fig. 12, a discontinuity portion ⓐ is produced at the junction of the horn wall 21a of the baffle 21 and the flat baffle 2 to cause disturbances in the acoustic waves to thereby adversely influence the frequency characteristic and acoustic quality.

In order to solve this problem, it is necessary to join the horn wall 21a of the baffle 21 and the flat baffle 2 surface of the cabinet so as not to produce a discontinuity portion therebetween.

Thus the applicant previously proposed a structure in which the horn wall 21a was joined to the flat baffle 2 surface at a junction ⓑ without forming any discontinuity portion therebetween, as shown in Fig. 13.

Such structure of Fig. 13 serves to decrease disturbances in the acoustic waves due to reflection and refraction in the frequency characteristic. However, with such structure of Fig. 13, it is impossible to use a long horn, and the dome-like vibrating plate adversely influence the acoustic quality because the dome-like vibrating plate 1 is disposed considerably deeply within the cabinet rather than at the surface of the flat baffle 2.

This invention derives from contemplation of the above problems. The object of this invention is to solve the above problems, and to provide a dome-like speaker in which the horn wall of the spherical wave horn baffle and the flat baffle surface of the cabinet are joined to each other without any discontinuity portion therebetween to thereby improve the frequency characteristic and acoustic quality.

A dome-like speaker according to this invention solves the problems by forming a slope on a spherical wave horn baffle provided on the outer periphery of the dome-like vibrating plate and joining the slope to the flat baffle surface of the cabinet so as not to produce any discontinuity portions with the flat baffle surface.

By the slope continuous to the horn wall of the spherical wave horn baffle provided on the dome-like speaker, the baffle can be joined to the flat baffle surface with no or little discontinuity portions to make it difficult to cause reflection and refraction of acoustic waves and provide a smooth frequency characteristic.

Brief Description of the Drawings

Figs. 1 - 3 show embodiments of a dome-like speaker according to this invention. Fig. 1A is a cross section view of the essential portion of a first embodiment, Fig. 1B is cross section view of the essential portion of a second embodiment, Figs. 2A and 2B show frequency characteristics, Figs. 3A and 3B show characteristics illustrating the state of acoustic waves in the vicinity of the dome-like vibrating plate. Figs. 4 - 13 show a conventional speaker. Fig. 4 is a cross section view of the essential portion of a structure in which the dome-like speaker is mounted on the flat baffle of the cabinet, Fig. 5 is a frequency characteristic diagram, Figs. 6A and 6B are characteristic diagrams showing the state of acoustic waves in the vicinity of the dome-like vibrating plate, Fig. 7 illustrates the principle of a spherical wave horn baffle, Fig. 8 illustrates a change in the size of a baffle required when the cut off frequency of the dome-like vibrating plate varies, Fig. 9 is a cross section view of the essential portion of a high-frequency band reproducing dome-like speaker which employs a spherical wave horn baffle, Fig. 10 is a frequency characteristic diagram, Figs. 11A and 11B are characteristic diagrams showing the state of acoustic waves in the vicinity of the dome-like vibrating plate of Fig. 9, Fig. 12 is a cross section view of the essential portion of a dome-like speaker having a spherical wave horn baffle mounted on the flat baffle of the cabinet, Fig. 13 is a cross section view of the essential portion of an example which a spherical wave horn baffle is joined to the flat baffle surface of the cabinet.

Detailed Description of the Drawings

An embodiment of a dome-like speaker according to this invention will now be described with reference to Figs. 1A, 1B to Figs. 3A, 3B.

Fig. 1A is a cross section view of the essential portion of a first embodiment of this invention and Fig. 1B is a cross section view of the essential portion of a second embodiment.

Figs. 2A and 2B are frequency characteristic diagrams and Figs. 3A and 3B show the state of acoustic waves in the vicinity of the dome-like vibrating plate using acoustic intensities at 6320 and 8000 Hz.

(Embodiment 1)

The first embodiment of this invention will now be described with reference to Fig. 1A.

When a spherical horn baffle 21 provided on the dome-like speaker SP is mounted on the surface of a flat baffle 2 of the cabinet, they are not simply joined as shown in Fig. 12, but the baffle 2 surface and the horn wall 21a are continuously joined through a slope 4.

The slope 4 is formed such that the tangent line at an end point ⓒ on the spherical wave horn baffle is smoothly connected to the surface of the flat baffle 2 at a point ⓓ without discontinuity.

Reference numeral 3 inFigs. 1A and 1B denotes the front surface of the opening in the horn 21.

By such structure, the frequency and directional characteristics of the speaker do not substantially show disturbances, as shown in Fig. 2A. The relationship between the 30° and 60° characteristics and the 0° level is substantially similar to that of Fig. 10 and sufficiently maintains the closed characteristic of Fig. 7.

By use of the acoustic intensity diagrams in the vicinity of the vibrating plate 1, the characteristics of Figs. 3A and 3B exhibit significantly reduced disturbances compared to those of Figs. 6A and 6B.

As shown in Fig. 2B, comparison with the characteristic ⓔ of Fig. 12 having a discontinuity portion ⓐ at the junction exhibits that the speaker of Fig. 1A having the slope 4 considerably suppresses the reflection and refraction of acoustic waves to thereby provide smoothed characteristics, as shown by ⓕ in Fig. 2B.

(Embodiment 2)

A second embodiment of this invention will now be described with reference to Fig. 1B.

This embodiment shows a structure in which the slope 4 which comprises an extension of a tangent line to the horn wall 21a of the spherical wave horn baffle 21 mounted on the dome-like speaker SP and the surface of the flat baffle 2 of the cabinet on which a dome- like speaker SP is mounted are joined with a discontinuity portion or a step at ⓖ therebetween.

In the particular embodiment, the rise or discontinuity portion at the junction ⓖ is formed to be sufficiently small compared to the wavelengths in the frequency band used of the speaker SP.

Thus, the influence of the discontinuity portion on acoustic waves is substantially negligible and an effect similar to that of the first embodiment is obtained.

According to the inventive dome-like speaker, the influence of reflection and refraction of acoustic waves by a discontinuity portion at the junction where the spherical wave horn baffle mounted on the dome-like speaker is joined to the flat baffle surface of the cabinet in which the speaker is mounted is reduced, so that disturbances in the frequency characteristic are greatly reduced and the acoustic quality is improved. The horn length can be increased compared to that of Fig. 13, so that the effect of the spherical wave horn baffle is improved. Furthermore, the dome-like vibrating plate can be disposed further forwardly compared to that of Fig. 13, so that the inventive structure is very preferable in acoustic characteristic.

Thus the dome-like speaker having the spherical wave horn baffle can be easily mounted on the flat baffle surface of the cabinet to thereby improve greatly the characteristic of the speaker.

Claims

1. A dome-like speaker comprising a spherical wave horn baffle formed so as to diffuse into an acoustic field space acoustic waves from a dome-like vibrating plate without disturbing the spherical wave on the basis of the fact that acoustic waves from the dome-like vibrating plate are similar to spherical waves, characterized in that
the spherical wave horn baffle includes a slope joined to a flat baffle surface of a cabinet, the slope being joined to the baffle surface so as to have no discontinuity portion.

2. A dome-like speaker comprising a spherical wave horn baffle formed so as to diffuse into an acoustic field space acoustic waves from a dome-like vibrating plate without disturbing the spherical wave on the basis of the fact that acoustic waves from the dome-like vibrating plate are similar to spherical waves, characterized in that
the spherical wave horn baffle includes a slope joined to a flat baffle surface of a cabinet and that a discontinuity portion formed at the junction of the slope and the baffle surface is formed sufficiently small compared to wavelengths in a reproduction zone of the dome-like vibrating plate.

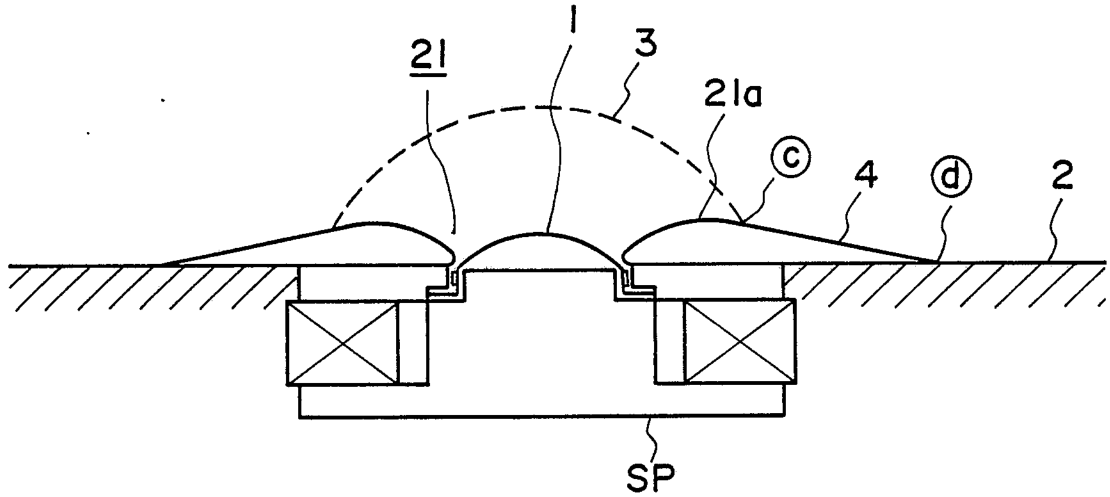

FIG. 1A

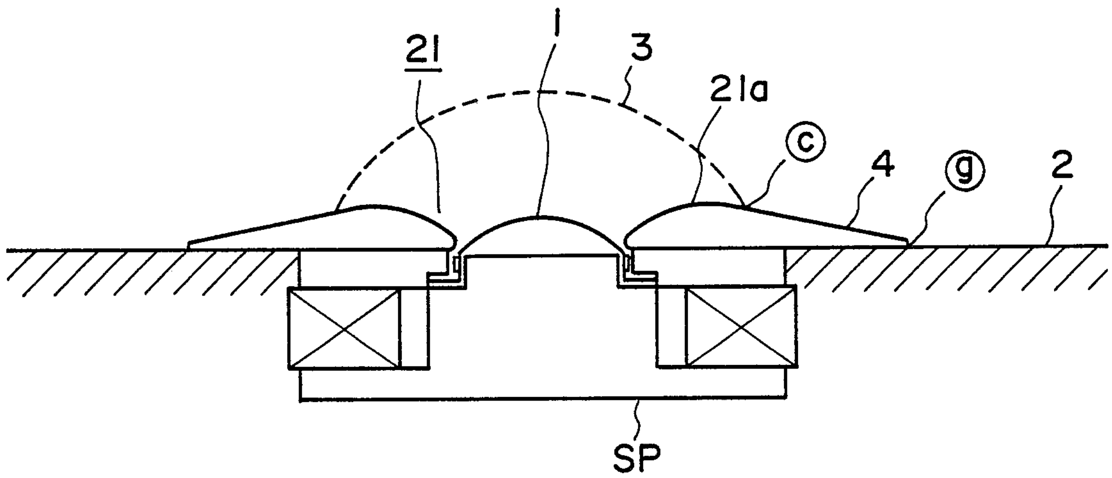

FIG. 1B

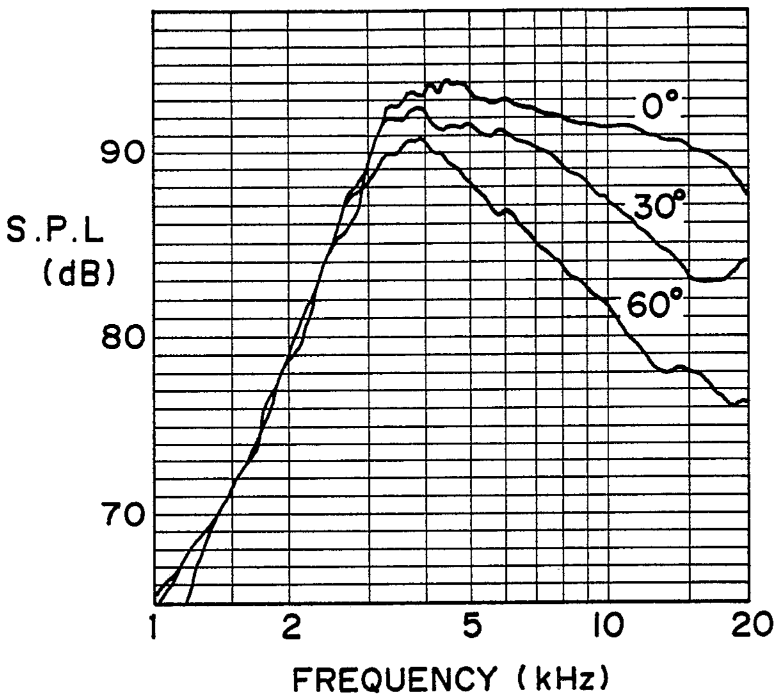
S.P.L
(dB)
90
80
70
0°
30°
60°
1
2
5
10
20
FREQUENCY (kHz)

FIG. 2A

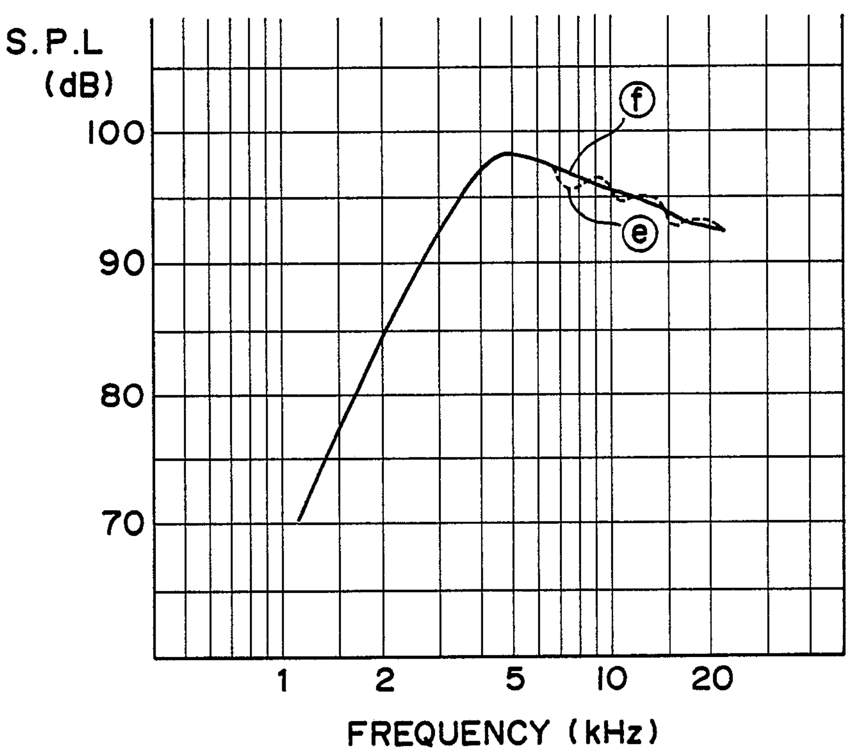
S.P.L
(dB)
100
90
80
70
f
e
1
2
5
10
20
FREQUENCY (kHz)

FIG. 2B

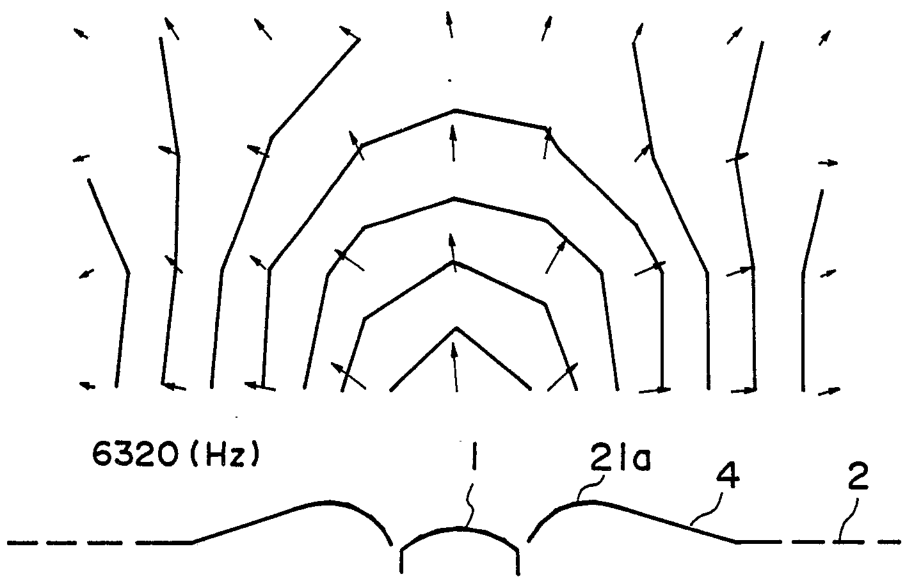

FIG. 3A

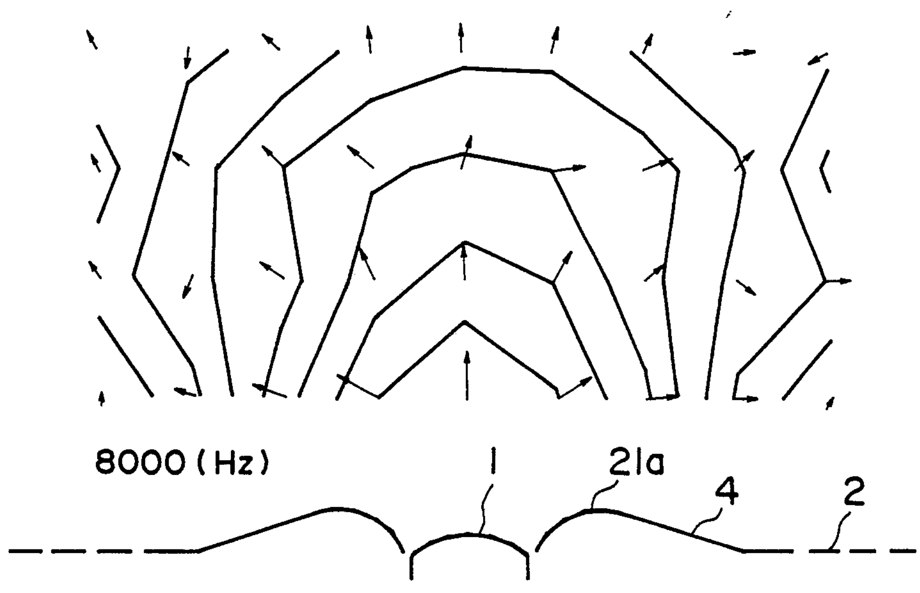

FIG. 3B

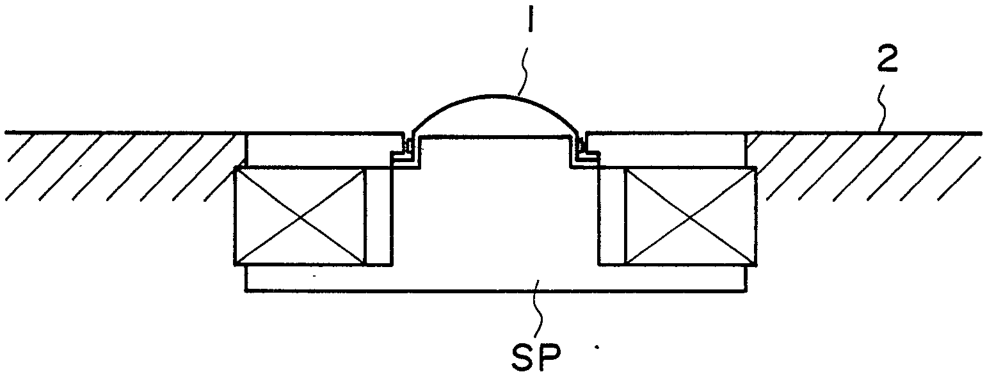

FIG. 4

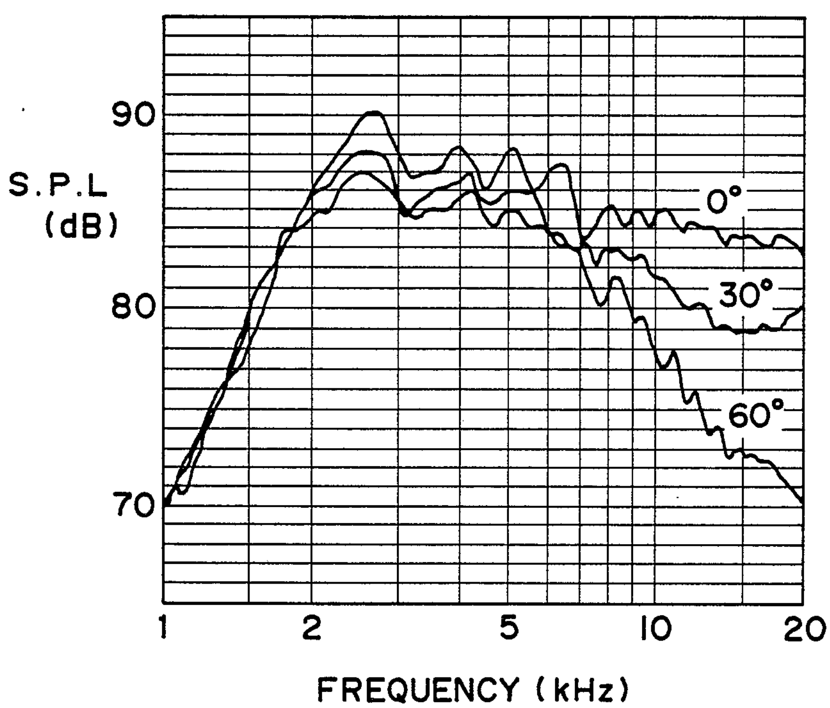

FIG. 5

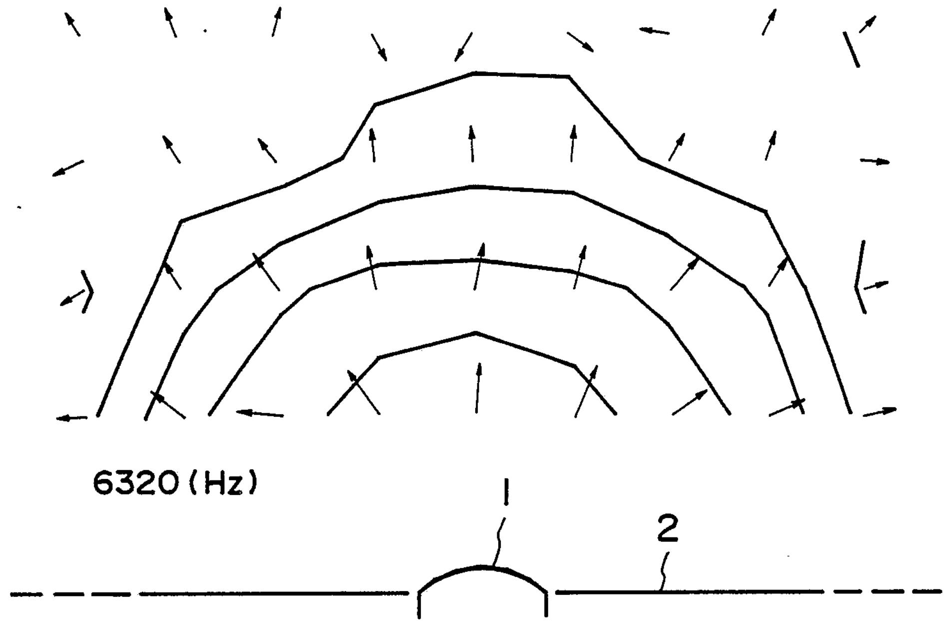

FIG. 6A

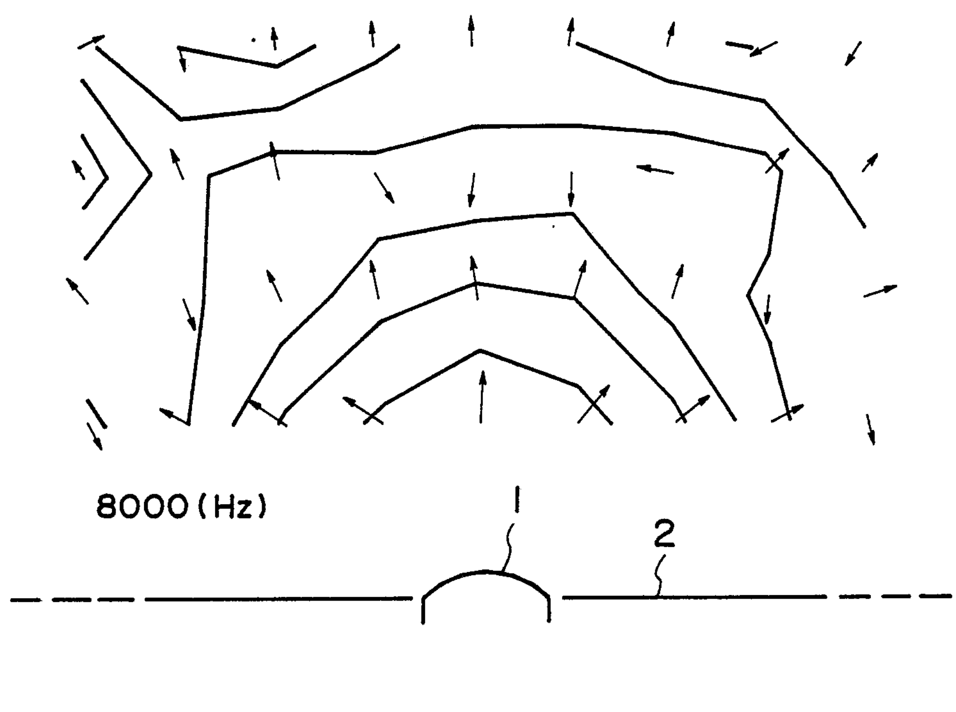

FIG. 6B

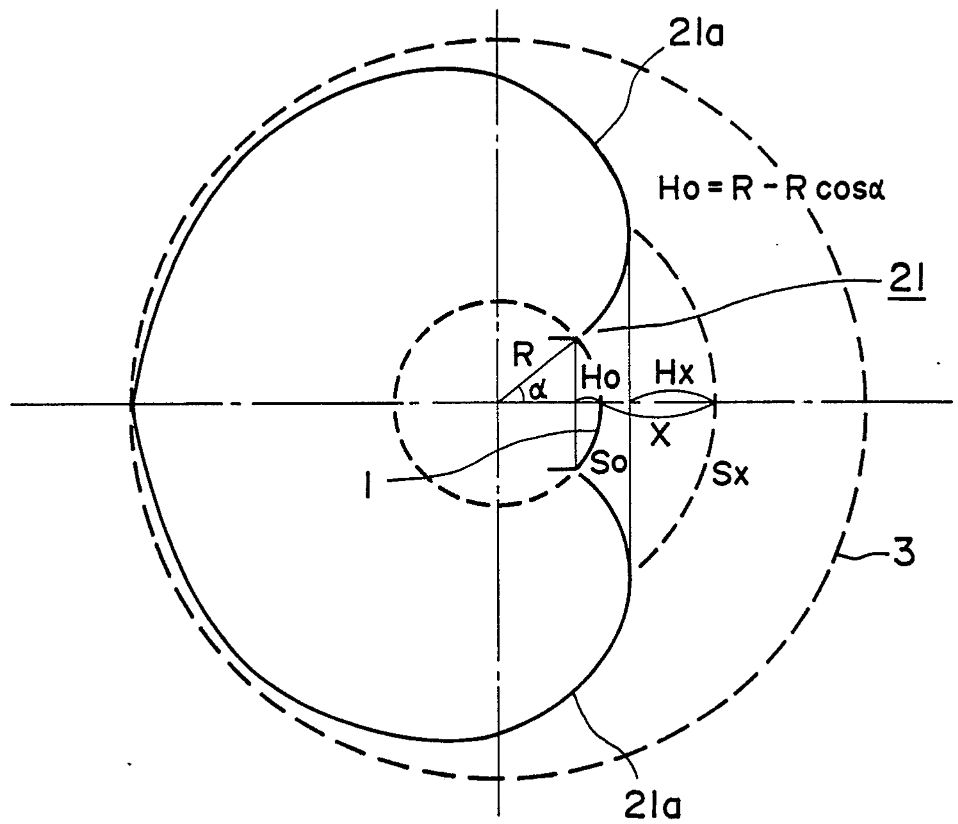
21a
Ho = R − R cosα
21
R
α
Ho
Hx
X
1
So
Sx
3
21a

FIG. 7

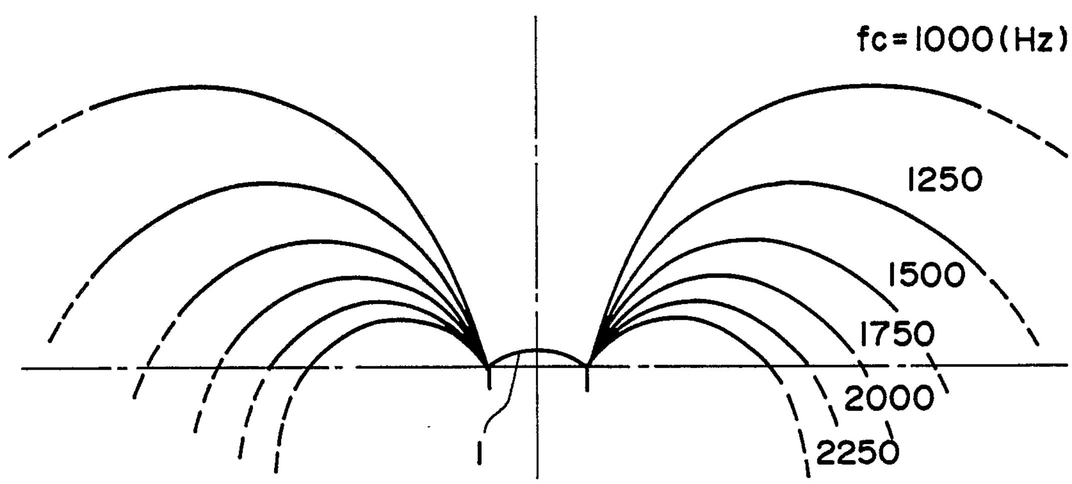
fc=1000(Hz)
1250
1500
1750
2000
2250
1

FIG. 8

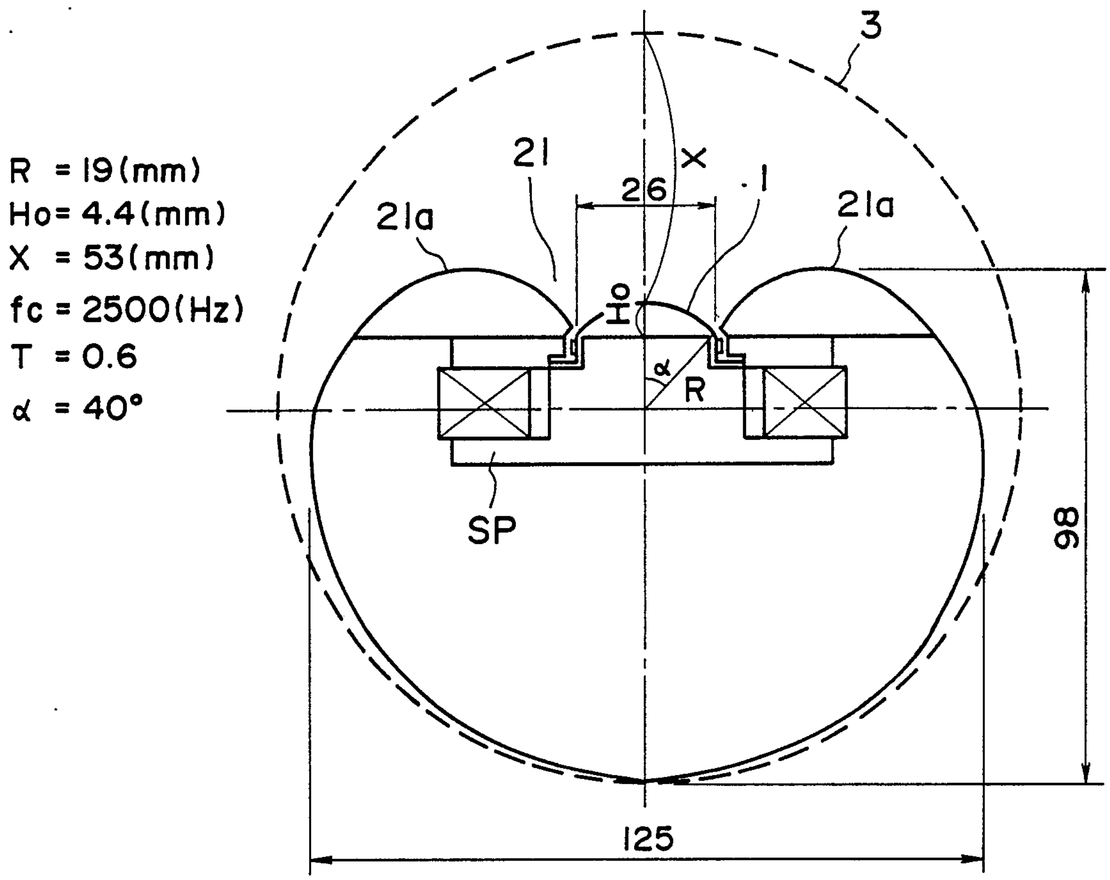
R = 19(mm)
Ho= 4.4(mm)
X = 53(mm)
fc = 2500(Hz)
T = 0.6
α = 40°
3
21
X
26
1
21a
21a
Ho
α
R
SP
98
125

FIG. 9

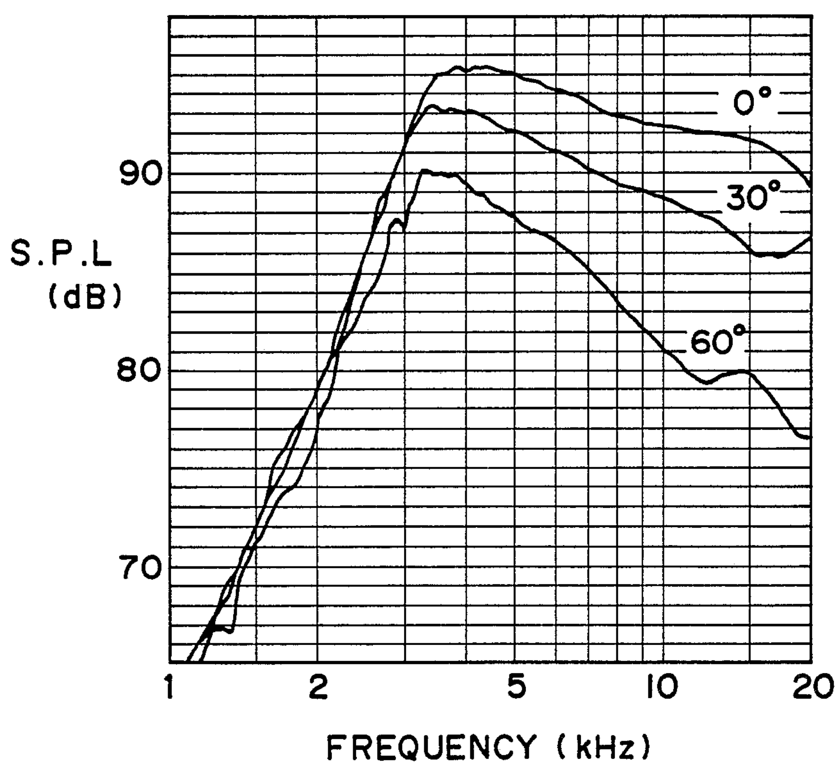
0°
30°
60°
90
80
70
S.P.L (dB)
1
2
5
10
20
FREQUENCY (kHz)

FIG. 10

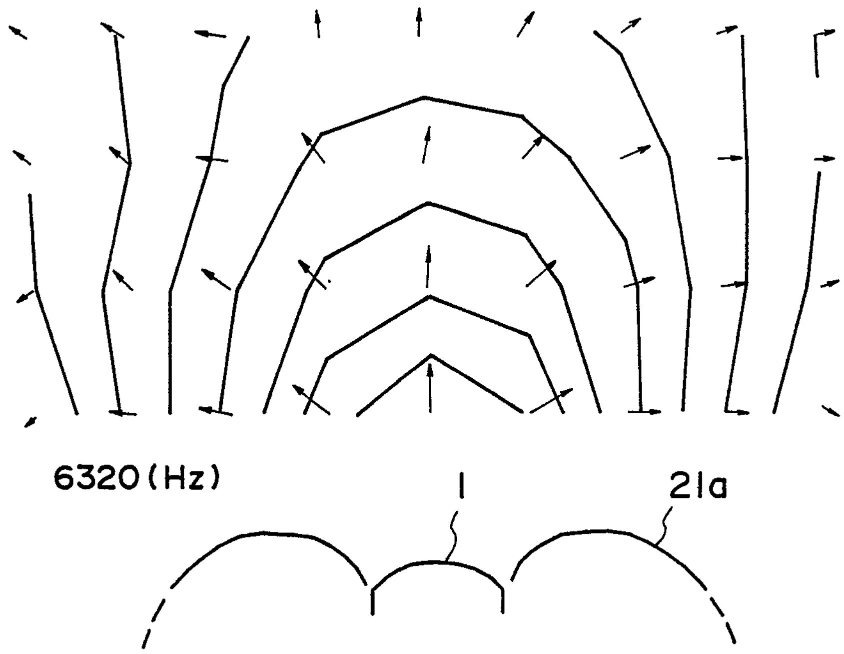

FIG. 11A

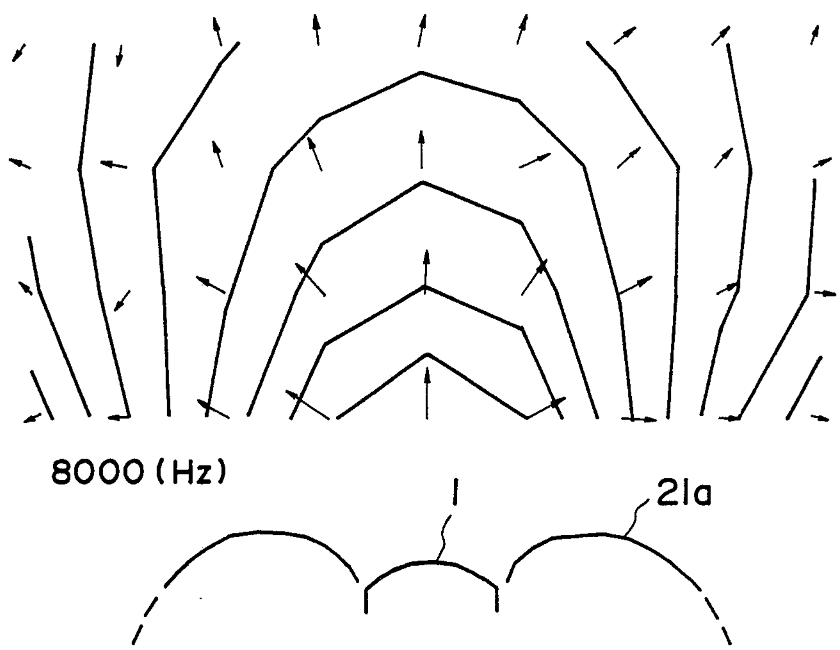

FIG. 11B

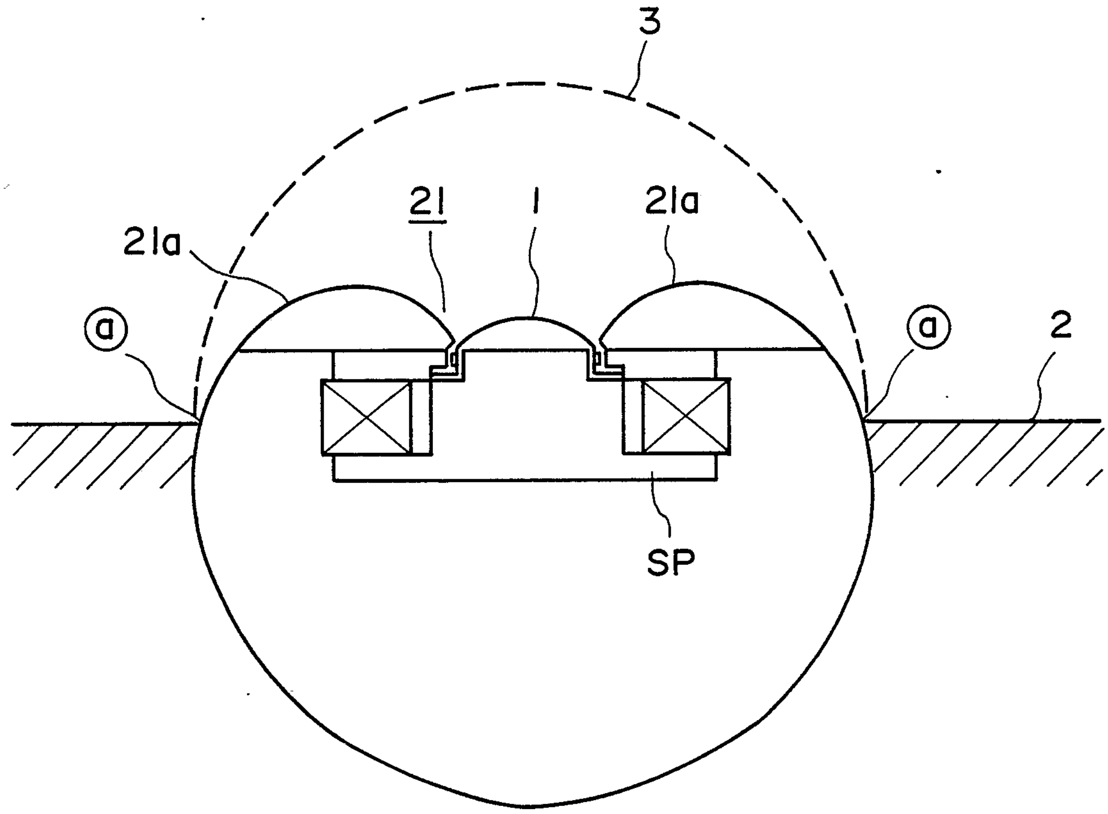

FIG. 12

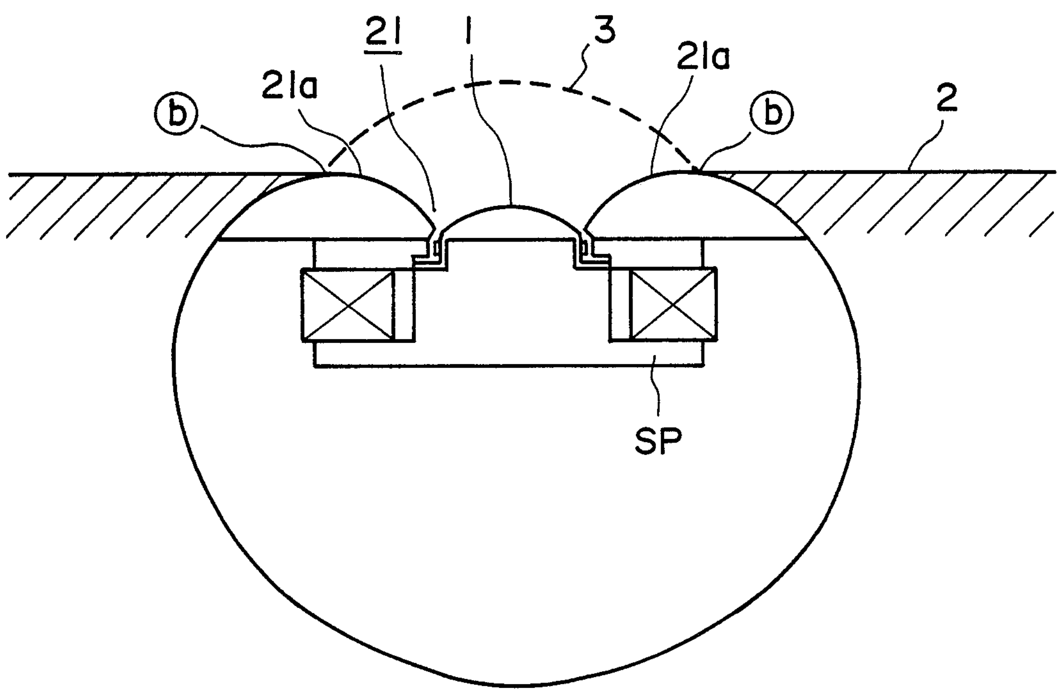

FIG. 13