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(54) Magnetron for microwave oven.

(57) A magnetron for microwave oven can suppress undesirable noises, especially the sixth harmonic and the seventh harmonic.

The magnetron for microwave oven having an oscillating frequency of 2450 MHz band comprises:

a cathode 12 placed inside an anode cylinder 11;
a plurality of vanes 13 arranged radially toward the cathode 12 from an inner wall of the anode cylinder 11;
a pair of first strap rings 14a connecting alternately every other vane at top ends and bottom ends of the plurality of vanes 14;
a pair of second strap rings 14b placed inside the first strap rings 14a and connecting alternately every other vane at top ends and bottom ends of the plurality of vanes,

wherein an inner diameter of the second strap ring 14b is 1.45 times to 1.53 times as large as a distance between inner ends of two vanes 13 placed on a diameter of the anode cylinder 11.

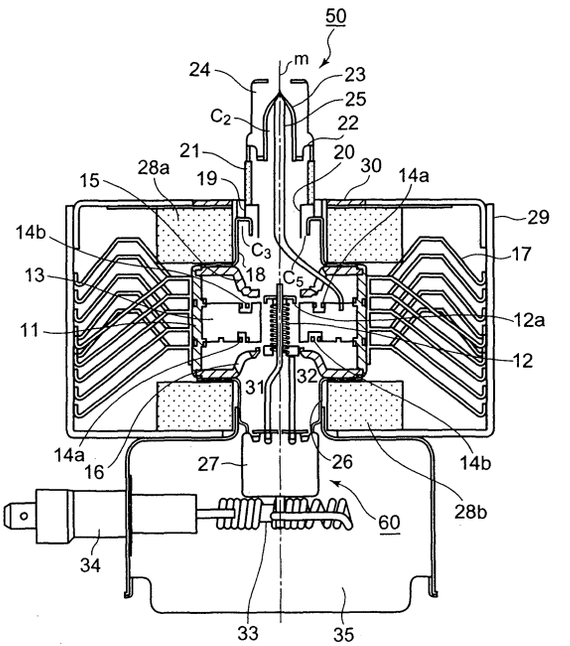

FIG. 1

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Description

Technical Field

[0001] The present invention relates to a magnetron for microwave oven used for microwave heating sources of microwave ovens, etc.

Background art

[0002] The magnetron for microwave oven is an electron tube generating a high frequency electric wave, which has an oscillating body portion comprising an anode cylinder, a cathode located in the inner space of the anode cylinder, a plurality of vanes arranged radially toward the cathode from the inner wall of the anode cylinder, etc.

[0003] With the configuration mentioned above, the structure supplies an electric power to the cathode through an input portion and derives a high frequency wave generated at the oscillating body portion to the outside through an output portion such as an antenna.

[0004] The magnetron for microwave oven generates noises over a wide range from several hundred kHz to several tens GHz as well as the fundamental wave of 2450 MHz in operation. These noises leak to the outside through the antenna constituting the output portion or through the input terminal supplying an electric power to the cathode, and interfere with various communications.

[0005] Therefore, many kinds of methods for suppressing noises have been proposed for a conventional magnetron for microwave oven. For example, the output portion is provided with a choke structure interrupting high frequency waves, and the input portion is provided with a filter circuit constituted of a feed-through capacitor and a choke coil.

[0006] The abovementioned conventional magnetron for microwave oven is disclosed by, for example, Japanese Laid Open Patent Hei5-251004.

[0007] A conventional magnetron for microwave oven suppresses undesirable noises such as higher harmonic waves by means of the choke structure having a length equal to 1/4 of wavelength λ for the purpose of suppressing higher harmonic waves provided in the output portion and the filter circuit provided in the input portion.

[0008] In the meantime, the frequency range applied in C.I.S.P.R. (International Special Committee on Radio Interference) is up to the fifth harmonic so far for a microwave oven employing a magnetron for microwave oven. Accordingly, conventional magnetrons for microwave oven have a structure that can cope sufficiently with the high frequency interference up to the fifth harmonic.

[0009] Japanese Patent Publication No. Hei1-45936 discloses a technology to set a strap ring on the anode vane to a predetermined position instead of providing a choke for suppressing the fifth harmonic. However, the technology has an effect for suppressing the fifth harmonic to some extent but not sufficient. Therefore, a choke for the fifth harmonic prepared on the output top is used together even if such regulation of the position of strap ring is employed. The inner diameter of the inner ring of the strap rings is usually set to be not less than 1.6 times as large as the distance between the inner ends of two vanes placed on a diameter of the anode cylinder in consideration of oscillation efficiency. However, harmonics higher than that cannot be suppressed sufficiently in some cases with this configuration.

Disclosure of Invention

[0010] The present invention is intended to obtain a magnetron for microwave oven that can suppress undesirable noises, especially the sixth harmonic and the seventh harmonic.

[0011] An aspect of the present invention is characterized in a magnetron for microwave oven having an oscillating frequency of 2450 MHz band comprising:

an anode cylinder;
a cathode placed inside an anode cylinder;
a plurality of vanes arranged radially toward the cathode from an inner wall of the anode cylinder;
a pair of first strap rings connecting alternately every other vane at top ends and bottom ends of the plurality of vanes;
a pair of second strap rings placed inside the first strap rings and connecting alternately every other vane at top ends and bottom ends of the plurality of vanes,

wherein an inner diameter of the second strap ring is 1.45 times to 1.53 times as large as a distance between inner ends of two vanes placed on a diameter of the anode cylinder.

[0012] In accordance with the present invention, a magnetron in which undesirable harmonics, especially the sixth and the seventh harmonics are suppressed will be realized upon setting the inner diameter of the second strap ring

located inner side and having a smaller diameter to be 1.45 times to 1.53 times as large as the distance between the inner ends of two vanes positioned on a diameter of the anode cylinder.

Brief Description of the Drawings

[0013]

FIG. 1 is a schematic cross-sectional drawing explaining an embodiment of the present invention.
FIG. 2 is a schematic top view of the main portion picked up from the anode for explaining an embodiment of the present invention.
FIG. 3 is a schematic cross-sectional drawing showing the oscillating portion including the anode for explaining an embodiment of the present invention.
FIG. 4 is a schematic cross-sectional drawing for describing principally the output portion for explaining an embodiment of the present invention.
FIG. 5 is a characteristic diagram explaining an embodiment of the present invention.
FIG. 6 is a characteristic diagram explaining an embodiment of the present invention.

(Embodiments)

[0014] Referring to FIG. 1, an embodiment of the present invention will be explained.

[0015] A spirally wound cathode 12 is located inside an anode cylinder 11 constituting an oscillating body portion of a magnetron for microwave oven. The cathode 12 is positioned along the tube axis m. A plurality of, for example, even number pieces, e.g. ten pieces of vanes 13 are provided toward the cathode 12 from the inner wall of the anode cylinder 11 and at an equal interval in the direction of the circle of the anode cylinder 11. Each outer end portion of the vane 13 is fixed to the inner wall of the anode cylinder 11 and each inner end portion thereof is an idle edge. The upper side in the figure and the lower side in the figure of each vane 13 are connected alternately with every other vane through a pair of first strap rings 14a having a larger diameter and a pair of second strap rings 14b located inside the first strap ring 14a and having a diameter smaller than that of the first strap ring 14a.

[0016] For example, the upper sides in the figure of the vanes 13 are connected together with each odd number vane 13 counted from a certain vane 13 through the first strap ring 14a, and connected together with each even number vane 13 through the second strap ring 14b. To the contrary, the lower sides in the figure of the vanes 13 are connected together with each odd number vane 13 through the second strap ring 14b, and connected together with each even number vane 13 through the first strap ring 14a.

[0017] Upper and lower opening portions of the anode cylinder 11 are provided with a first pole piece 15 and a second pole piece 16 respectively, and cooling fins 17 to cool the anode cylinder 11 are arranged on the periphery of the anode cylinder 11.

[0018] A first metallic envelope 18 is hermetically sealed to the first pole piece 15, and a first metallic ring 19 is hermetically sealed to the first metallic envelope 18. A second metallic ring 20 is bonded to the first metallic ring 19, and an insulating cylinder 21 is hermetically sealed to the second metallic ring 20. Besides, a sealing ring 22 is hermetically sealed to the insulating cylinder 21, and an exhausting tube 23 is sealed to the sealing ring 22. The sealing ring 22 and the exhausting tube 23 are protected by a cap 24. Furthermore, one end of an antenna 25 constituting an output portion is connected with the exhausting tube 23. The other end of the antenna 25 is connected with one of the vanes 13 via inside spaces of the insulating cylinder 21, etc.

[0019] At some portions such as the first metallic envelope 18 and the second metallic ring 20, double cylindrical wall structure portions C1, C2 are formed so as to provide a choke structure with a so-called 1/4 length of a wavelength λ, which interferes a higher harmonic.

[0020] Additionally, the second metallic envelope 26 is hermetically sealed to the second pole piece 16, and a cathode stem 27, which constitutes a part of an input portion 60, is extended along the tube axis m and fixed to the second metallic envelope 26.

[0021] Annular permanent magnets 28a, 28b are arranged above the first pole piece 15 and below the second pole piece 16 respectively. A magnetic yoke 29 forming a magnetic circuit is arranged so as to surround the anode cylinder 11, the cooling fins 17, and the permanent magnets 28a, 28b. A conductive gasket 30 is provided at the inner portion of the magnetic yoke 29 surrounding the first metallic ring 19.

[0022] A center rod 31 and a side rod 32 are arranged at the inner portion of the cathode stem 27. The center rod 31 is connected with an end hat 12a of the output end portion located on the upper side of the cathode 12 in the figure, and the side rod 32 is connected with the input end portion located on the lower side of the cathode 12 in the figure. A coil 33 and a capacitor 34 which constitute together a filter circuit are connected with the outer portion of the cathode stem 27.

[0023] The cathode stem 27 and the coil 33 are surrounded by a filter case 35, and the capacitor 34 is mounted in such a manner as to pierce the filter case 35.

[0024] Referring to FIG. 2 showing a schematic top view of some portions such as the anode cylinder 11 and the vanes 13 and FIG. 3 showing a partial cross section of the main part of the oscillating portion picked up from FIG. 1, the anode portion constituting the oscillating body portion will be explained in the next place. In FIG. 2 and FIG. 3, each portion corresponding to that of FIG. 1 is denoted by the same mark as FIG. 1, and duplicated explanation will be partly omitted.

[0025] A plurality of, e.g. ten pieces of vanes 13a to 13j are provided at an equal interval in the direction of the circle of the anode cylinder 11 and toward the central direction from the inner wall of the anode cylinder 11 in the inside space of the anode cylinder 11. In this case, two vanes 13, for example, 13a and 13f, 13b and 13g, etc. are positioned in pairs facing to each other on a diameter of the anode cylinder 11.

[0026] Now, the inner diameter of the anode cylinder 11 is represented by 2rv; the distance between inner end portions of two vanes located on a diameter of the anode cylinder 11, e.g. the vane 13a and the vane 13f is represented by 2ra; the outer diameter of the first strap ring 14a is represented by LS; and the inner diameter of the second strap ring 14b is represented by SS.

[0027] The ratio (2ra/2rv) of the distance (2ra) between two vane ends to the inner diameter (2rv) of the anode cylinder being in the range from 0.22 to 0.28 and the ratio (LS/2ra) of the outer diameter (LS) of the first strap ring to the distance (2ra) between two vane ends being in the range from 2 to 2.3 are defined as designing conditions for the resonator in the present invention. Under these designing conditions, the ratio (SS/2ra) of the inner diameter (SS) of the second strap ring to the distance (2ra) between two vane ends is set to be in the range from 1.45 to 1.53.

[0028] In the configuration mentioned above, an electric power is supplied from the input portion 60 to the cathode 12, and a high frequency wave generated at the oscillating body portion is derived to the outside through the output portion comprising the antenna 25, etc.

[0029] Magnetrons for microwave oven generate noises over a wide range from several hundred kHz to several tens GHz as well as the fundamental wave of 2450 MHz (±50MHz) in operation. As shown in FIG. 1, these noises can be prevented from leaking to the outside by choke C2 prepared at the top of the output portion, choke C3, choke C5 prepared halfway in the output portion 50 and the filter circuit prepared at the input portion 60 side.

[0030] Explanation for suppressing the sixth and the seventh harmonics will be carried out next. General dimensions of the anode portion of a magnetron for microwave oven are as follows:

Inner diameter of the anode cylinder (2vr)	34 to 37 mm
Number of vanes	10
Height of vanes	7 to 10 mm
Thickness of vanes	1.8 to 2.5 mm
Distance between Inner ends of vanes (2ra)	8 to 10 mm

[0031] The inventor has fabricated magnetron tubes for the embodiments 1 to 10 and the comparative examples 1 to 3, all of which have the choke C2 for the second harmonic at the top of the antenna 25 and the choke C5 for the fifth harmonic surrounding the antenna 25 in the output portion as shown in FIG. 4, wherein dimensions of the first strap ring 14a and the second strap ring 14b are varied as follows in the range of the anode dimension described above. The same mark as that of FIG. 1 designates the same portion. Table 1 shows the result of measuring the characteristics of the higher harmonics 3f, 5f, 6f, and 7f for these magnetron tubes.

(The first strap ring)	
Outer diameter (LS) Width (t)	17 to 21 mm 0.5 to 1.5 mm
(The second strap ring)	
Inner diameter (SS) Width (t)	12 to 15 mm 0.5 to 1.5 mm

[0032] For the embodiments and the comparative examples mentioned above, the ratio (SS/2ra) of the inner diameter (SS) of the second strap ring to the distance (2ra) between ends of two vanes was varied in the range from 1.43 to 1.59.

Table 1

		Higher harmonic wave			
	SS/2ra	3f	5f	6f	7f
Embodiment 1	1.45	-1.8(dBm)	-16.0	-50.3	-44.7
Embodiment 2	1.45	-5.2	-23.0	-52.5	-45.7
Embodiment 3	1.45	-6.5	-17.6	-46.7	-39.6
Embodiment 4	1.45	-11.8	-20.0	-53.8	-33.3
Embodiment 5	1.49	-7.7	-18.8	-53.8	-44.1
Embodiment 6	1.49	-12.0	-18.3	-50.2	-44.1
Embodiment 7	1.53	-17.1	-16.3	-55.3	-45.2
Embodiment 8	1.53	-12.4	-18.4	-58.6	-44.9
Embodiment 9	1.53	-12.9	-17.7	-54.3	-35.4
Embodiment 10	1.53	-14.7	-24.9	-50.4	-41.6
Comparative expl. 1	1.43	-4.1	-19.5	-41.9	-42.3
Comparative expl. 2	1.58	-14.7	-24.9	-50.4	-41.6
Comparative expl. 3	1.59	-19.4	-16.7	-31.4	-32.3

[0033] FIG. 5 is a graph plotted with the data of Table 1, which explains relationship between the ratio (SS/2ra) of the inner diameter (SS) of the second strap ring 14b to the distance (2ra) between inner ends of two vanes and the noise level. Characteristics of the second harmonic 2f and the fourth harmonic 4f are also represented in the figure though they are not shown in Table 1.

[0034] The horizontal axis of FIG. 5 is (SS/2ra), and the vertical axis is the noise level (dBm). Curves 2f to 7f designates the noise levels of the second harmonic to the seventh harmonic respectively.

[0035] As shown in FIG. 3, the sixth harmonic 6f and the seventh harmonic 7f are suppressed when (SS/2ra) is in the range from 1.45 to 1.53, preferably in the range from 1.48 to 1.52.

[0036] The third harmonic 3f is characterized in that it decreases in the range of (SS/2ra) from 1.45 to 1.53 as (SS/2ra) increases. Therefore if the third harmonic needs to be suppressed as well, it is desirable that (SS/2ra) should be set to be approximately 1.53.

[0037] Generation of higher harmonics in a magnetron is caused by large disturbance of a microwave field in the interaction space formed by the anode and the cathode. Therefore, suppression of higher harmonics relates to not only the choke having a length of 1/4 of the wavelength λ for higher harmonic suppression of the output side but also some factors such as the anode structure and the shape of the pole piece; besides, they mutually affect to one another. FIG. 6 shows the suppression characteristics for the sixth harmonic and the seventh harmonic when the choke C5 for the fifth harmonic is removed from the structure of FIG. 4. The structure without C5 has a different operating point from the structure with C5 because of the structure having been changed. Nevertheless, the suppression characteristics for the higher harmonics 6f, 7f are substantially maintained as is understood in comparison with the characteristics of FIG. 5. That is to say, suppressing effect for 6f and 7f is ensured in accordance with the present invention regardless of the structural change of the output portion i.e. the presence or absence of the choke for the fifth harmonic.

[0038] In accordance with the configuration mentioned above, a magnetron for microwave oven that suppresses undesirable noises, especially the sixth harmonic and the seventh harmonic can be realized.

Claims

1. A magnetron for microwave oven having an oscillating frequency of 2450 MHz band comprising:

an anode cylinder;
a cathode placed inside the anode cylinder;
a plurality of vanes arranged radially toward the cathode from an inner wall of the anode cylinder;
a pair of first strap rings connecting alternately every other vane at top ends and bottom ends of the plurality

of vanes;
a pair of second strap rings placed inside the first strap rings and connecting alternately every other vane at top ends and bottom ends of the plurality of vanes,

characterized in that an inner diameter of the second strap ring is 1.45 times to 1.53 times as large as a distance between inner ends of the two vanes placed on a diameter of the anode cylinder.

2. The magnetron for microwave oven as stated in Claim 1, wherein the inner diameter of the second strap ring is 1.48 times to 1.52 times as large as the distance between inner ends of the two vanes placed on a diameter of the anode cylinder.

3. The magnetron for microwave oven as stated in Claim 1, wherein a ratio (2ra)/(2rv) of the distance (2ra) between inner ends of the two vanes to the inner diameter (2rv) of the anode cylinder is in a range from 0.22 to 0.28.

4. The magnetron for microwave oven as stated in Claim 1, wherein a pole piece and an output portion accommodating an antenna extended from the vane are extending from one end surface of the anode cylinder, and another pole piece and an input portion including a cathode stem are extending from another end surface of the anode cylinder, the output portion being provided with chokes including at least a choke for suppressing higher harmonics up to fifth harmonic.

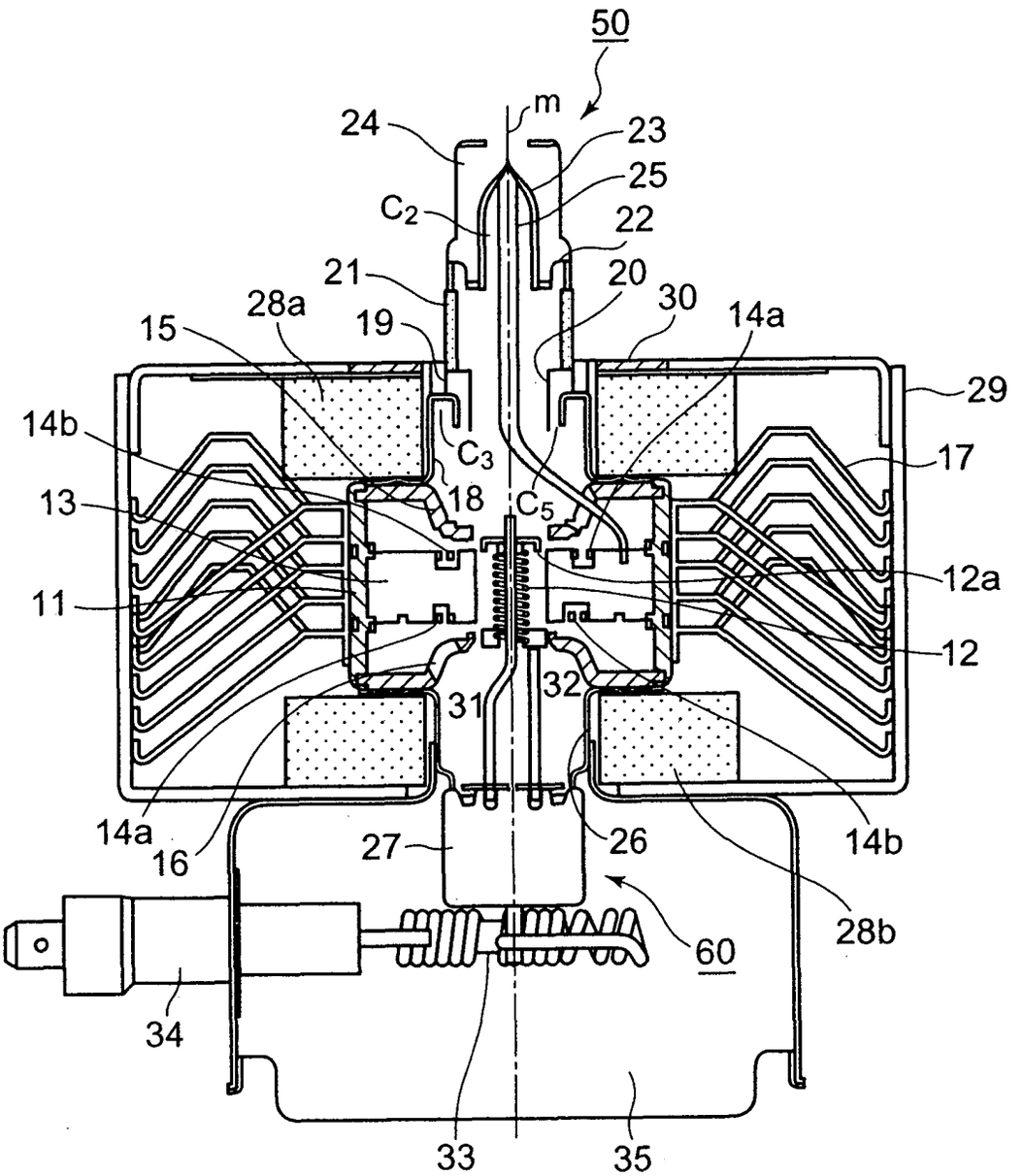
50
m
24
23
25
C2
22
21
20
30
14a
28a
19
15
29
14b
C3
17
13
18
C5
12a
11
12
32
31
14a
16
27
26
14b
28b
60
34
33
35

FIG. 1

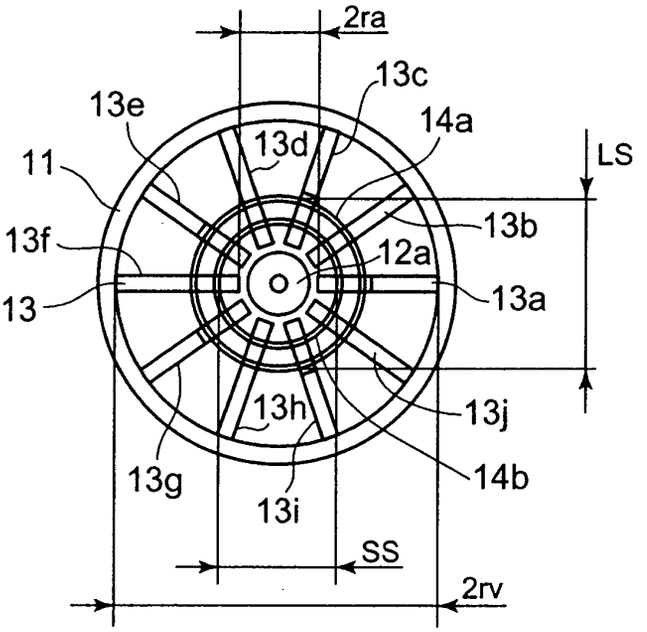
2ra
13c
13e
14a
13d
11
LS
13b
13f
12a
13
13a
13h
13j
13g
14b
13i
SS
2rv

FIG. 2

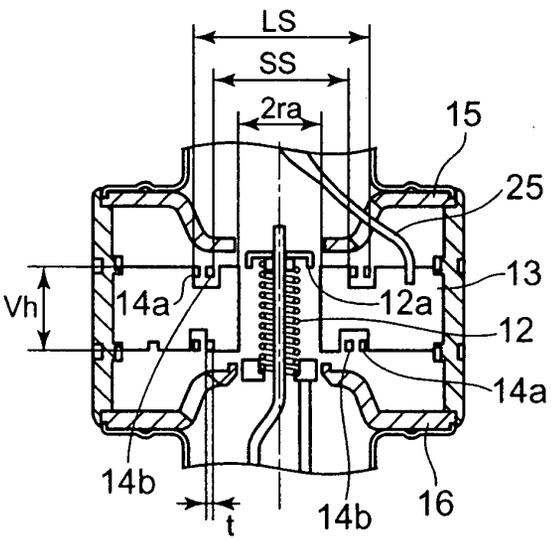
LS
SS
2ra
15
25
13
Vh
14a
12a
12
14a
14b
14b
16
t

FIG. 3

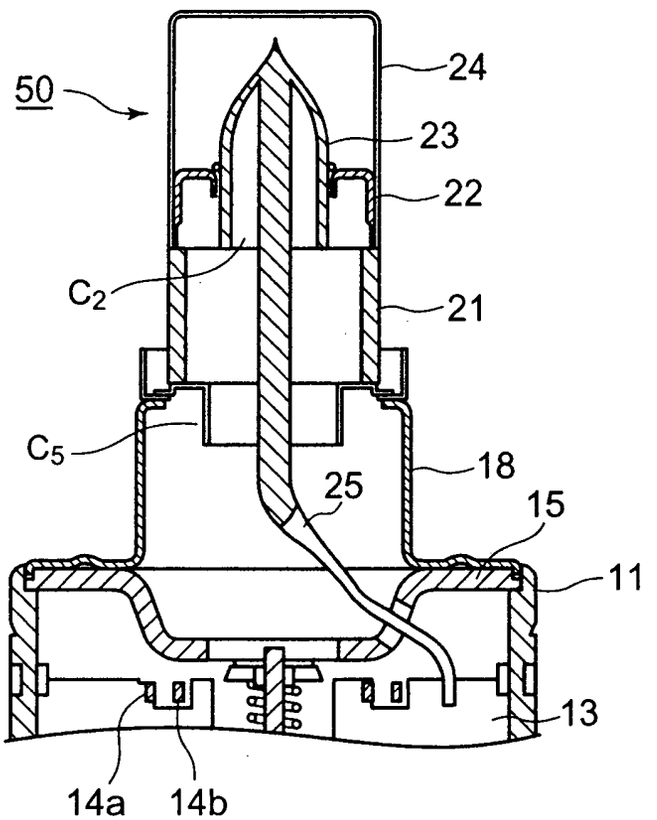

FIG. 4

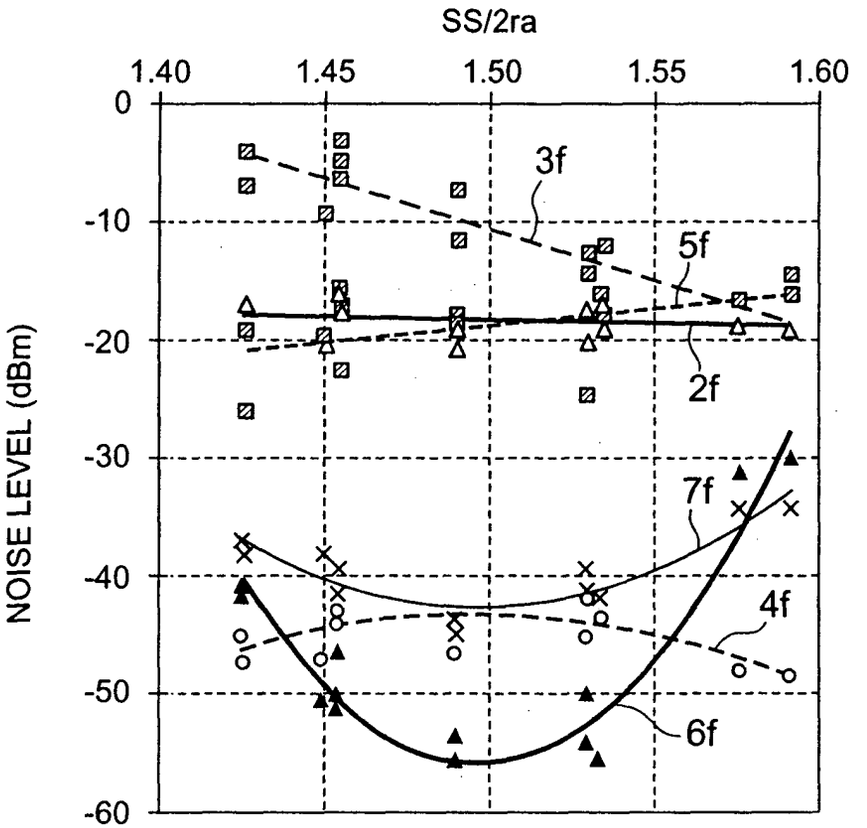
SS/2ra
1.40
1.45
1.50
1.55
1.60
0
-10
-20
-30
-40
-50
-60
NOISE LEVEL (dBm)
3f
5f
2f
7f
4f
6f

FIG. 5

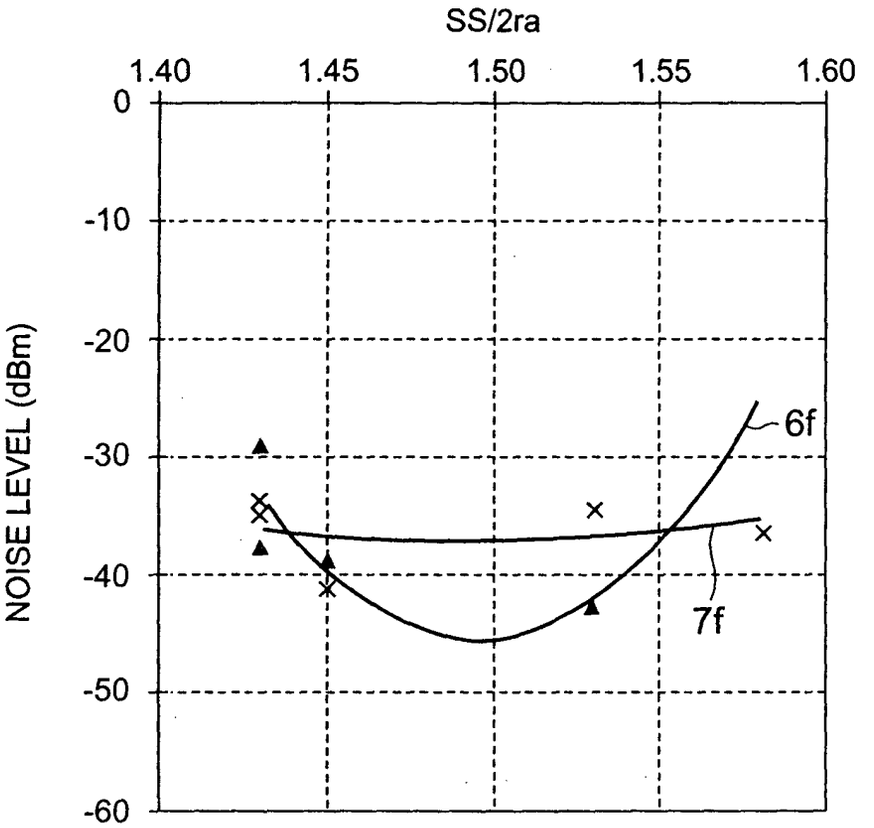
SS/2ra
1.40
1.45
1.50
1.55
1.60
0
-10
-20
-30
-40
-50
-60
NOISE LEVEL (dBm)
6f
7f

FIG. 6