



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.10.2010 Bulletin 2010/40

(51) Int Cl.:
H01J 23/10^(2006.01) H01J 25/587^(2006.01)

(21) Application number: **10156389.8**

(22) Date of filing: **12.03.2010**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA ME RS

(71) Applicant: **Toshiba Hokuto Electronics Corporation**
Hokkaido (JP)

(72) Inventor: **Kato, Naoya**
Hokkaido (JP)

(30) Priority: **30.03.2009 JP 2009080797**

(74) Representative: **Gendron, Vincent Christian et al**
Cabinet Fédit-Loriot
38 avenue Hoche
75008 Paris (FR)

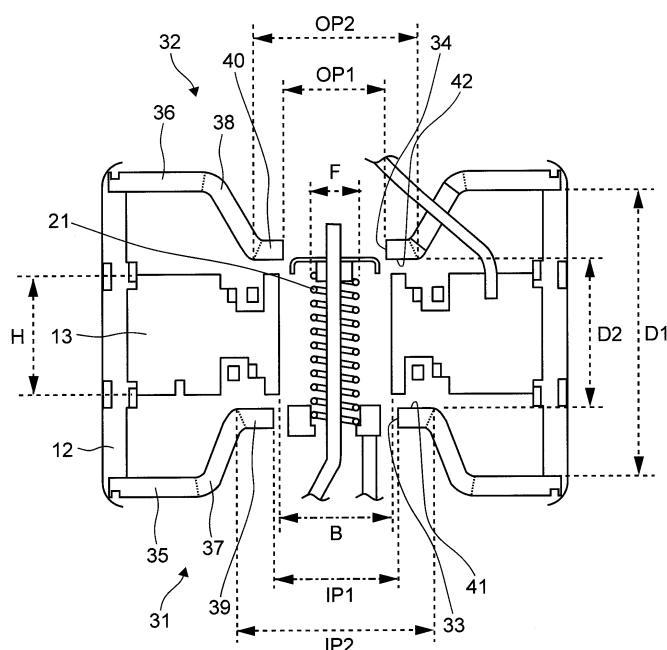
(54) **Magnetron for microwave oven**

(57) Unnecessary noises generated from a magnetron for a microwave oven are suppressed.

In a magnetron 10 for a microwave oven, the diameter IP1 of the through-hole 33 of the input side pole piece 31 is 8.6 to 9.1 mm and the outer diameter IP2 of the internal surface 41 of the input side pole piece 31 is 15 to 16 mm, while the diameter OP1 of the through-hole 34 of the output side pole piece 32 is 7.9 to 8.1 mm and

the outer diameter OP2 of the internal surface 42 of the output side pole piece 32 is 11 to 13 mm. Additionally, the interval distance D1 between the outer annular portion 35 of the input side pole piece 31 and the outer annular portion 36 of the output side pole piece 32 is 11.5 to 13.5 mm and the interval distance D2 between the inner annular portion 39 of the input side pole piece 31 and the inner annular portion 40 of the output side pole piece 32 is 10.2 to 11.2 mm.

Fig. 2



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a magnetron to be used for a microwave oven.

[0002] The oscillator section of a magnetron to be used for a microwave oven (to be simply referred to as "magnetron" hereinafter) has an anode section and a cathode section. The anode section has an anode cylinder and vanes. The cathode section has a helical filament. The oscillator section generates not only a fundamental wave in the ISM bands (2400 to 2500 MHz) but also electromagnetic waves in frequency bands out of the ISM bands.

[0003] Funnel-shaped pole pieces are arranged face to face as a pair and fixed respectively to the ends of the anode cylinder. Additionally, metallic sealing members provided as a pair are fixed respectively to the corresponding ends of a pair of pole pieces. An insulation cylinder is fixed to an end of the metallic sealing member arranged at the output side. An exhaust pipe is fixed to an end of the insulation cylinder. An antenna is led out from one of the plurality of vanes and the front end of the antenna is pinched by the exhaust pipe. A number of chokes are formed at the output section of the magnetron in order to suppress the output of electromagnetic waves in the high order frequency bands of the fundamental wave (2450 MHz).

[0004] For example, a magnetron described in Patent Document 1 (Jpn. Pat. Appln. Laid-Open Publication No. 2007-335351) includes ten vanes in the anode section, which have a height of 7.0 to 8.0 mm as viewed in the central axis direction with a diameter of the inscribed circle of the vanes of 8.0 to 8.8 mm and a filament in the cathode section with an outer diameter of 3.5 to 3.9 mm. The base sections of the pair of funnel-shaped pole pieces secured to the respective opposite ends of the anode section are separated from each other by a gap of 21.5 to 23.5 mm and the bottom sections of the pair of pole pieces are separated from each other by a gap of 10.2 to 11.2 mm. Furthermore, the inner diameter of the through-holes of the pole pieces is 8.3 to 8.5 mm and the outer diameter of the bottom sections of the pole pieces is 11.0 to 16.0 mm.

[0005] As described above, the output of electromagnetic waves of high order frequency bands of the fundamental wave (2450 MHz) is suppressed by means of a plurality of chokes formed in the output section. However, electromagnetic waves (unnecessary noises) in the near low frequency bands located outside the ISM bands (2400 to 2500 MHz), any leakage of which from microwave ovens is prohibited by the Japanese Radio Law, cannot be suppressed by chokes.

[0006] Patent Document 1 discusses about the design value of the diameter of the through-holes and the design value of the outer diameter of the bottom portions of pole pieces. However, the diameter of the output side and the diameter of the input side are same and the document

does not consider suppression of unnecessary noises in the near low frequency bands (2300 to 2400 MHz) located outside the ISM bands.

BRIEF SUMMARY OF THE INVENTION

[0007] The present invention is made to solve the above-described problem.

Therefore, the object of the present invention is to suppress the unnecessary noises produced from a magnetron to be used for a microwave oven.

[0008] According to an aspect of the present invention, there is provided a magnetron for a microwave oven comprising: an anode section including an anode cylinder and ten plate-shaped vanes arranged radially in radial directions of a central axis of the anode cylinder, each of the vanes being joined to an inner wall of the anode cylinder at one of the opposite sides of each of them and left as free end at another of the opposite sides; a cathode section including a helical filament extending along the central axis of the anode cylinder and arranged in the anode cylinder with a gap interposed between the free ends of the vanes; and a funnel-shaped input side pole piece and a funnel-shaped output side pole piece arranged face to face, each having an outer annular portion bonded to an end of the anode cylinder and an inner annular portion having a through-hole formed at the center thereof, wherein a diameter of the through-hole of the input side pole piece being greater than a diameter of the through-hole of the output side pole piece, an outer diameter of a internal surface of the input side pole piece being greater than an outer diameter of a internal surface of the output side pole piece, the diameter of the through-hole of the input side pole piece being 8.6 to 9.1 mm, the outer diameter of the internal surface of the input side pole piece being 15 to 16 mm, the diameter of the through-hole of the output side pole piece being 7.9 to 8.1 mm, and the outer diameter of the internal surface of the output side pole piece being 11 to 13 mm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The above and other features and advantage of the present invention will become apparent from the discussion herein below of specific, illustrative embodiments thereof presented in conjunction with accompanying drawings, in which:

FIG. 1 is a longitudinal cross-sectional view of a magnetron according to an embodiment of the present invention.

FIG. 2 is an enlarged view around the oscillator section in FIG. 1.

FIG. 3 shows an oscillation spectrum of the fundamental wave of a magnetron (diameter of through-hole of input side pole piece: 8.7 mm, outer diameter of internal surface of input side pole piece: 15 mm) according to an embodiment (Example 1) of the

present invention.

FIG. 4 shows an oscillation spectrum of the fundamental wave of a magnetron (diameter of through-hole of input side pole piece: 8.7 mm, outer diameter of internal surface of input side pole piece: 16 mm) according to an embodiment (Example 2) of the present invention.

FIG. 5 shows an oscillation spectrum of the fundamental wave of a magnetron (diameter of through-hole of input side pole piece: 9.0 mm, outer diameter of internal surface of input side pole piece: 16 mm) according to an embodiment (Example 3) of the present invention.

FIG. 6 shows an oscillation spectrum of the fundamental wave of a magnetron (diameter of through-hole of input side pole piece: 8.4 mm, outer diameter of internal surface of input side pole piece: 12 mm) of Comparative Example 1.

FIG. 7 shows an oscillation spectrum of the fundamental wave of a magnetron (diameter of through-hole of input side pole piece: 8.4 mm, outer diameter of internal surface of input side pole piece: 14 mm) of Comparative Example 2.

FIG. 8 shows an oscillation spectrum of the fundamental wave of a magnetron (diameter of through-hole of input side pole piece: 8.7 mm, outer diameter of internal surface of input side pole piece: 14 mm) of Comparative Example 3.

FIG. 9 shows an oscillation spectrum of the fundamental wave of a magnetron (diameter of through-hole of input side pole piece: 8.4 mm, outer diameter of internal surface of input side pole piece: 15 mm) of Comparative Example 4.

FIG. 10 shows an oscillation spectrum of the fundamental wave of a magnetron (diameter of through-hole of input side pole piece: 8.4 mm, outer diameter of internal surface of input side pole piece: 16 mm) of Comparative Example 5.

FIG. 11 is a table showing in comparison the measurement conditions and the presence or absence of unnecessary noises of the spectrums illustrated in FIGS. 3 through 10.

FIG. 12 is a graph illustrating the correlation of the diameter of the through-hole and the outer diameter of the internal surface of the input side pole piece and the magnetizing voltage of magnetron.

FIG. 13 is a graph illustrating the correlation of the diameter of the through-hole and the outer diameter of the internal surface of the input side pole piece and the output efficiency of magnetron.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Magnetrons according to embodiments of the present invention will be described with reference to the accompanying drawings.

[0011] Firstly, the structure of a magnetron according to an embodiment of the present invention will be briefly

described by referring to FIG. 1. FIG. 1 is a longitudinal cross-sectional view of a magnetron according to the embodiment of the present invention.

[0012] The anode section 11 has an anode cylinder 12 and ten vanes 13. The anode cylinder 12 extends cylindrically along the central axis 100. Each of the ten plate-shaped vanes 13 is joined to the inner wall of the anode cylinder 12 at one of the opposite sides thereof and left as free end at the other opposite side. The free ends of the vanes 13 are arranged on a same cylindrical surface extending along the central axis 100. The same cylindrical surface formed the free ends of the ten vanes will be referred to as vane-inscribed cylindrical surface 14 hereinafter. The ten vanes 13 radially spread from the vane-inscribed cylindrical surface 14 to the inner wall of the anode cylinder 12. The ten vanes 13 are joined alternately by large and small pairs of strap rings 15 and 16 soldered at the top and bottom ends of the ten vanes.

[0013] The cathode section 21 is a helical filament extending along the central axis 100 and arranged in the anode cylinder 12. The cathode section 21 is arranged in the inside of the vane-inscribed cylindrical surface 14 with a gap interposed between the cathode section 21 and the free ends of the ten vanes 13. The gap is an electronic interaction space. The anode section 11 and the cathode section 21 operate as oscillator section that generates high frequency waves. The input side end (the lower end in FIG. 1) of the cathode section 21 is fixed to a ring-shaped end hat 22. The output side end (the upper end in FIG. 1) of the cathode section 21 is fixed to a disk-shaped end hat 23.

[0014] A center support rod 24 runs through the center of the helical filament and is connected to the disk-shaped end hat 23. A side support rod 25 is connected to the ring-shaped end hat 22. Both the center support rod 24 and the side support rod 25 support the cathode section 21 and also take a role of supplying electric current to the cathode section 21.

[0015] The magnetron has a pair of an input side pole piece 31 and an output side pole piece 32. The input side pole piece 31 is joined to the input side end section (the lower end in FIG. 1) of the anode cylinder 12. The output side pole piece 32 is joined to the output side end (the upper end in FIG. 1) of the anode cylinder 12. The input side pole piece 31 and the output side pole piece 32 are arranged face to face. The input side pole piece 31 and the output side pole piece 32 are formed like funnel having through-holes 33 and 34 at the center respectively. The centers of the through-holes 33 and 34 are located on the central axis 100.

[0016] An input side metallic sealing member (the lower metallic sealing member in FIG. 1) 51 is formed as a hollow cylinder. The input side metallic sealing member is fixed to the input side end of the anode cylinder 12 and also to the input side pole piece 31. An insulation stem 53 is joined to the input side metallic sealing member 51 at the end (the lower end in FIG. 1) thereof that is remote from the input side pole piece 31.

[0017] On the other hand, an output side metallic sealing member (the upper metallic sealing member in FIG. 1) 52 is formed as a hollow cylinder. The output side metallic sealing member is fixed to the output side end of the anode cylinder 12 and also to the output side pole piece 32. An insulation cylinder 54 is joined to the output side metallic sealing member 52 at the end thereof that is remote from the output side pole piece 32. An exhaust pipe 55 is joined to the insulation cylinder 54 at the end thereof that is remote from the metallic sealing member 52. An antenna 56 is led out from one of the ten vanes 13. The antenna 56 runs through the output side pole piece 32 and extends in the inside of the metallic sealing member 52 and also in the inside of the insulation cylinder 54. And the tip of the antenna 56 is pinched and fixed by the exhaust pipe 55. A cap 57 covers the exhaust pipe 55.

[0018] Ring-shaped magnets 61 and 62 are arranged respectively below and above the anode cylinder 12 and outside the metallic sealing members 51 and 52. The ring-shaped magnets 61 and 62 are magnetized in the direction of the central axis 100. Yokes 63 and 64 surround the anode cylinder 12 and the magnets 61 and 62. A magnetic circuit is formed by the magnets 61 and 62 and the yokes 63 and 64. A radiator 65 for cooling the oscillator section is arranged between the anode cylinder 12 and the yoke 63.

[0019] Now, the structure of the oscillator section and a peripheral area thereof that characterizes the magnetron of this embodiment will be described below in detail by referring to FIG. 2. FIG. 2 is an enlarged view around the oscillator section in FIG. 1.

[0020] The vanes 13 have a height H of 7 to 8 mm in the direction of the central axis 100. The vane-inscribed cylindrical surface 14 has a diameter B of 8.1 mm (manufacturing error: ± 0.1 mm). The filament that constitutes the cathode section 21 has an outer diameter F of 3.7 mm (manufacturing error: ± 0.1 mm).

[0021] The input side pole piece 31 is formed by an outer annular portion 35, a taper section 37 and an inner annular portion 39 which are integrally combined to show a funnel-shaped profile. The outer annular portion 35 is a flat plate-shaped annular member. The outer periphery of the outer annular portion 35 is joined to the input side end of the anode cylinder 12 and also to the metallic sealing member 51. The inner annular portion 39 is a flat plate-shaped annular member. The outer diameter of the inner annular portion 39 is smaller than the inner diameter of the outer annular member 35. The through-hole 33 of the input side pole piece 31 is formed at the center of the inner annular portion 39. The taper section 37 is an annular member. The taper section 37 links the inner edge of the outer annular portion 35 and the outer edge of the inner annular portion 39.

[0022] The inner edge of the outer annular portion 35 defines the boundary between the flat plane of the outer annular portion 35 and the tapered surface of the taper section 37. Similarly, the outer edge of the inner annular portion 39 defines the boundary between the flat plane

of the inner annular portion 39 and the tapered surface of the taper section 37.

[0023] It will be appreciated that, like the input side pole piece 31, the output side pole piece 32 is also formed by an outer annular portion 36, a taper section 38 and an inner annular portion 40.

[0024] In this embodiment, the diameter IP1 of the through-hole 33 is 8.7 to 9.0 mm (manufacturing error: ± 0.1 mm). The outer diameter IP2 of the flat plane of the inner annular portion 39 that is arranged internally in the oscillator section (to be referred to as "internal surface 41 of input side pole piece 31" hereinafter) is 15 to 16 mm.

[0025] On the other hand, the diameter OP1 of the through-hole 34 of the output side pole piece 32 is 8.0 mm (manufacturing error: ± 0.1 mm). The outer diameter OP2 of the flat plane of the inner annular portion 40 that is arranged internally in the oscillator section (to be referred to as "internal surface 42 of output side pole piece 32" hereinafter) is 12 mm (manufacturing error: ± 1 mm).

[0026] Thus, the diameter IP1 of the through-hole 33 of the input side pole piece 31 is designed to be greater than the diameter OP1 of the through-hole 34 of the output side pole piece 32. Additionally, the outer diameter IP2 of the internal surface 41 of the input side pole piece 31 is designed to be greater than the outer diameter OP2 of the internal surface 42 of the output side pole piece 32.

[0027] The interval distance D2 between the inner annular portion 39 of the input side pole piece 31 and the inner annular portion 40 of the output side pole piece 32, or the interval distance D2 between the internal surface 41 of the input side pole piece 31 and the internal disposed surface 42 of the output side pole piece 32, is 22.5 mm (manufacturing error: ± 1 mm). The interval distance D1 between the outer annular portion 35 of the input side pole piece 31 and the outer annular portion 36 of the output side pole piece 32 (the distance between the oppositely disposed surfaces) is 11.2 mm (manufacturing error: ± 1 mm).

[0028] Now, oscillation spectrums of the fundamental wave of the magnetrons of embodiments will be described below by referring to FIGS. 3 through 11. FIGS. 3 through 5 show oscillation spectrums of the fundamental wave of magnetrons according to examples of the present invention. On the other hand, FIGS. 6 through 10 show oscillation spectrums of the fundamental wave of the magnetrons of comparative examples. FIG. 11 is a table showing in comparison the measurement conditions and the presence or absence of unnecessary noises of the oscillation spectrums illustrated in FIGS. 3 through 10.

[0029] As seen from FIG. 11, same design values are selected for all the magnetrons of Example 1 through Example 3 and Comparative Example 1 through Comparative Example 5 except the diameter IP1 of the through-hole 33 of the input side pole piece 31 and the outer diameter IP2 of the internal surface 41 of the input side pole piece 31. The magnetron of Comparative Example 1 is an embodiment of magnetron for a microwave

oven described in Patent Document 1 (Jpn. Pat. Appln. Laid-Open Publication No. 2007-335351).

[0030] 2400 through 2500 MHz in FIG. 3 through FIG. 11 correspond to the ISM bands and hence are in the frequency band necessary for microwave ovens. On the other hand, the spectrums from 2300 to 2400 MHz show unnecessary noises.

[0031] As seen from FIGS. 3 through 10, in Examples 1 to 3, unnecessary noises between 2300 and 2400 MHz are suppressed if compared with Comparative Examples 1 through 5.

[0032] As the diameter IP1 of the through-hole 33 of the input side pole piece 31 and the outer diameter IP2 of the internal surface 41 of the input side pole piece 31 are increased, unnecessary noises between 2300 and 2400 MHz are suppressed.

[0033] Therefore, from the viewpoint of suppressing unnecessary noises, it is preferable that the diameter IP1 of the through-hole 33 of the input side pole piece 31 is designed to be not less than 8.7 mm (manufacturing error: ± 0.1 mm) and the outer diameter IP2 of the internal surface 41 of the input side pole piece 31 is designed to be not less than 15 mm.

[0034] Now, the magnetizing voltage and the output efficiency of the magnetron of the embodiments will be described by referring to FIGS. 12 and 13. FIG. 12 is a graph illustrating the correlation of the diameter of the through-hole and the outer diameter of the internal surface of the input side pole piece and the magnetizing voltage of magnetron. FIG. 13 is a graph illustrating the correlation of the diameter of the through-hole and the outer diameter of the internal surface of the input side pole piece and the output efficiency of the magnetron. Note that same design values (design values listed in FIG. 11) are selected for all the magnetrons that are objects of measurement of FIGS. 12 and 13 except the diameter IP1 of the through-hole 33 of the input side pole piece 31 and the outer diameter IP2 of the internal surface 41 of the input side pole piece 31.

[0035] As seen from FIG. 12, as the diameter IP1 of the through-hole 33 of the input side pole piece 31 is increased, the magnetizing voltage ebm of the magnetron 10 is reduced. Additionally, as the outer diameter IP2 of the internal surface 41 of the input side pole piece 31 is increased, the magnetizing voltage ebm of the magnetron 10 is reduced.

[0036] As seen from FIG. 13, as the diameter IP1 of the through-hole 33 of the input side pole piece 31 is increased, the output efficiency η of the magnetron 10 is reduced. Additionally, as the outer diameter IP2 of the internal surface 41 of the input side pole piece 31 is increased, the output efficiency η of the magnetron 10 is reduced.

[0037] Therefore, it is preferable from the viewpoint of magnetizing voltage ebm and output efficiency η that the diameter IP1 of the through-hole 33 of the input side pole piece 31 is designed to be not greater than 9.0 mm (manufacturing error: ± 0.1 mm) and the outer diameter IP2

of the internal surface 41 of the input side pole piece 31 is designed to be not greater than 16 mm.

[0038] On the basis of the above description, in the magnetrons 10 of the above embodiments, the diameter IP1 of the through-hole 33 of the input side pole piece 31 is designed to be 8.6 to 9.1 mm and the outer diameter IP2 of the internal surface 41 of the input side pole piece 31 is designed to be 15 to 16 mm.

[0039] Now, the operation and the advantages of the magnetrons of the above embodiments will be described below.

[0040] With the embodiments, unnecessary noises between 2300 and 2400 MHz can be suppressed by designing the diameter IP1 of the through-hole 33 of the input side pole piece 31 to be 8.6 to 9.1 mm and the outer diameter IP2 of the internal surface 41 of the input side pole piece 31 to be 15 to 16 mm.

Claims

1. A magnetron for a microwave oven comprising:

an anode section including an anode cylinder extending cylindrically along a central axis and ten plate-shaped vanes arranged radially in radial directions of the central axis, each of the vanes being joined to an inner wall of the anode cylinder at one of the opposite sides of each of them and left as free end at another of the opposite sides;

a cathode section including a helical filament extending along the central axis and arranged in the anode cylinder with a gap interposed between the free ends of the vanes; and

a funnel-shaped input side pole piece and a funnel-shaped output side pole piece arranged face to face, each having an outer annular portion bonded to an end of the anode cylinder and an inner annular portion having a through-hole formed at the center thereof, wherein

a diameter of the through-hole of the input side pole piece being greater than a diameter of the through-hole of the output side pole piece,

an outer diameter of a internal surface of the input side pole piece being greater than an outer diameter of a internal surface of the output side pole piece,

the diameter of the through-hole of the input side pole piece being 8.6 to 9.1 mm,

the outer diameter of the internal surface of the input side pole piece being 15 to 16 mm,

the diameter of the through-hole of the output side pole piece being 7.9 to 8.1 mm, and

the outer diameter of the internal surface of the output side pole piece being 11 to 13 mm.

2. The magnetron for a microwave oven according to

claim 1, wherein

an interval distance between the outer annular portion of the input side pole piece and the outer annular portion of the output side pole piece is 11.5 to 13.5 mm, and

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an interval distance between the inner annular portion of the input side pole piece and the inner annular portion of the output side pole piece is 10.2 to 11.2 mm.

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3. The magnetron for a microwave oven according to claim 1 or 2, wherein

a diameter of a vane-inscribed cylindrical surface formed by the free ends of the ten vanes is 8.0 to 8.2 mm and a height of the vanes is 7 to 9 mm.

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4. The magnetron for a microwave oven according to any one of claims 1 through 3, wherein an outer diameter of the filament is 3.6 to 3.8 mm.

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Fig. 1

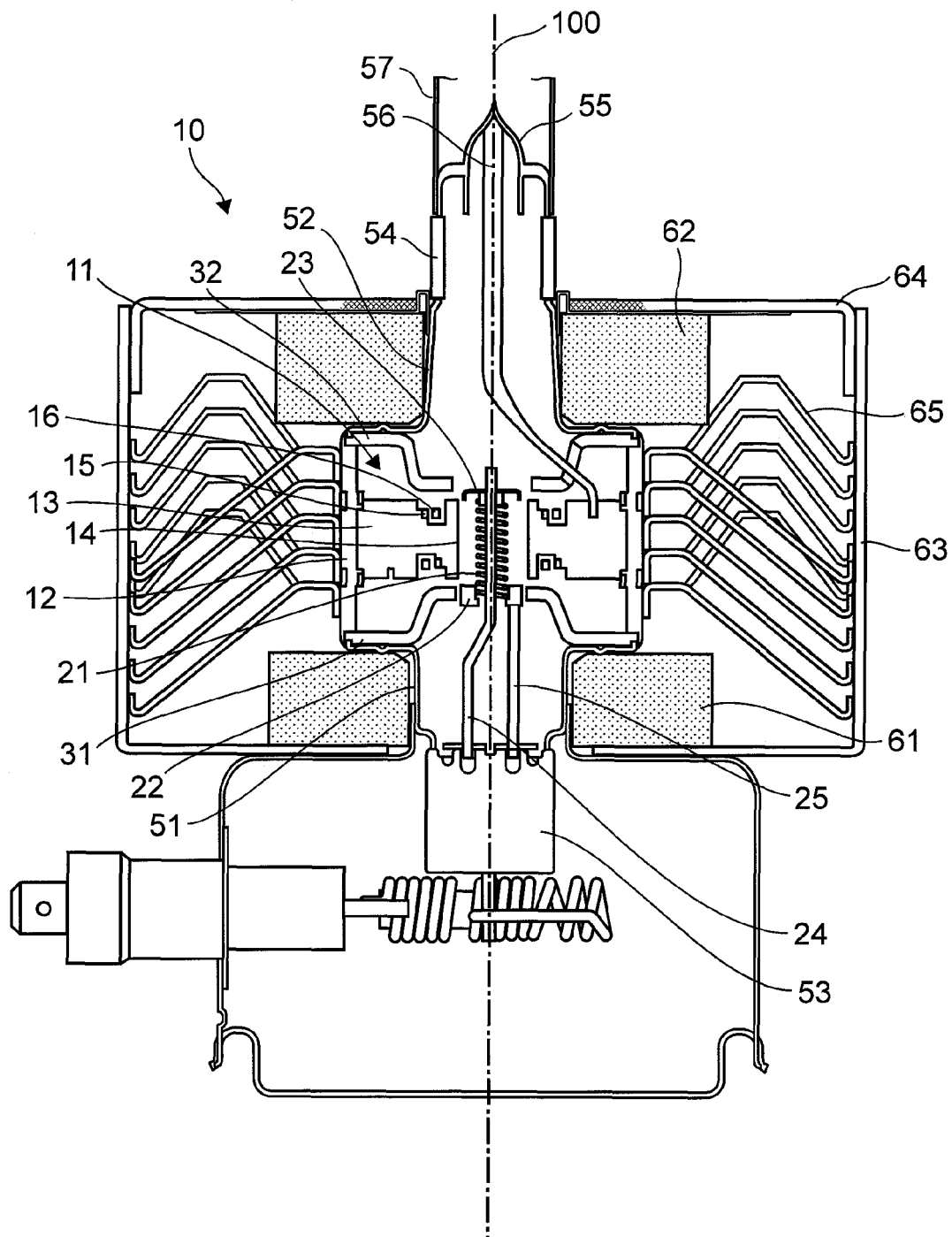


Fig. 2

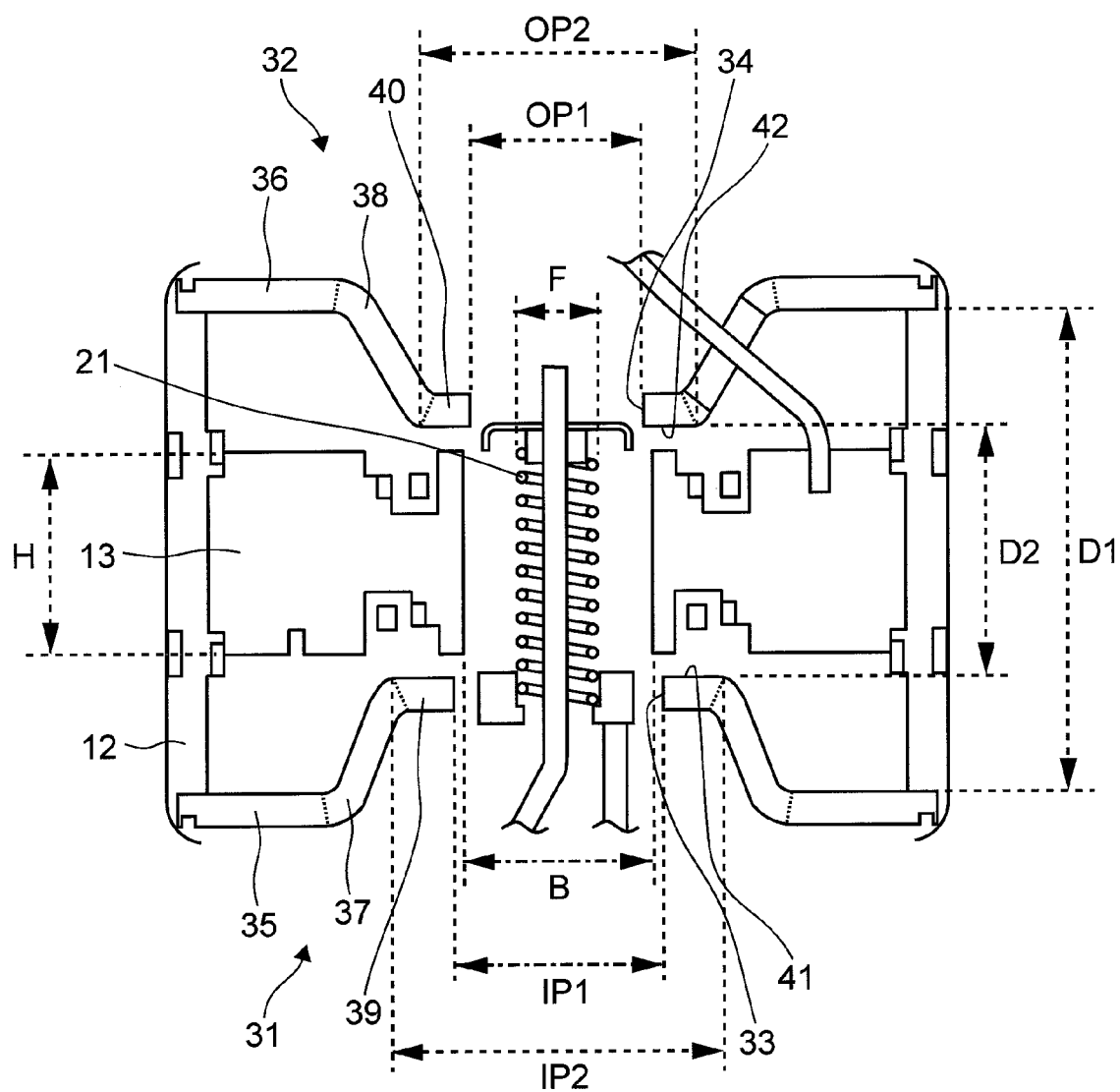


Fig. 3

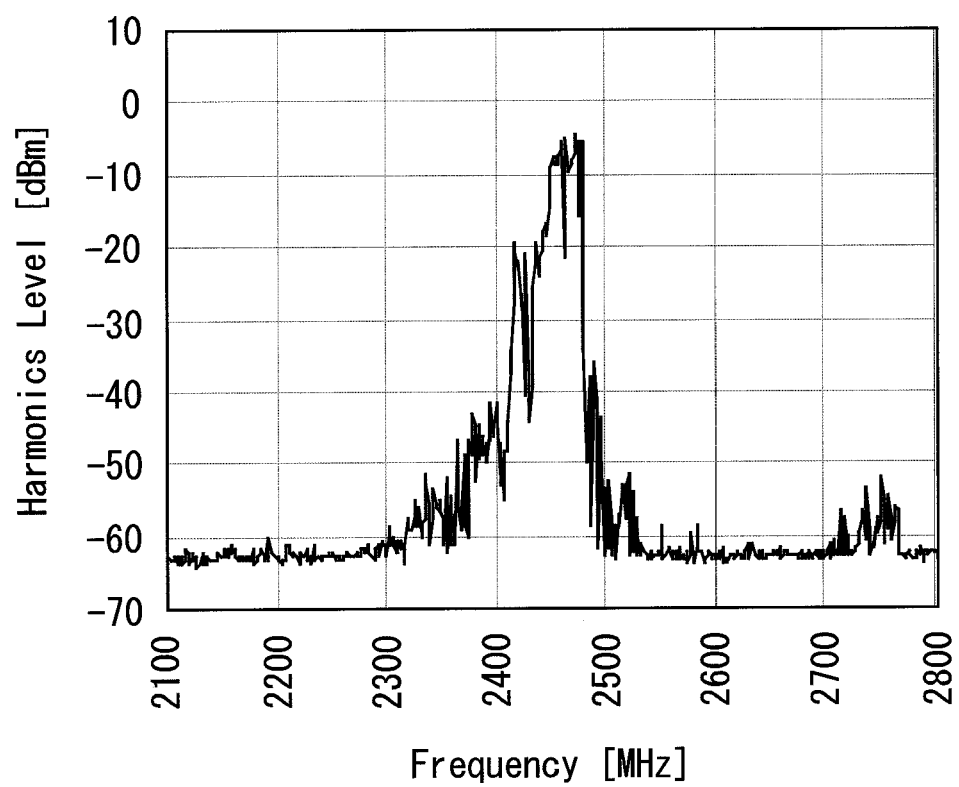


Fig. 4

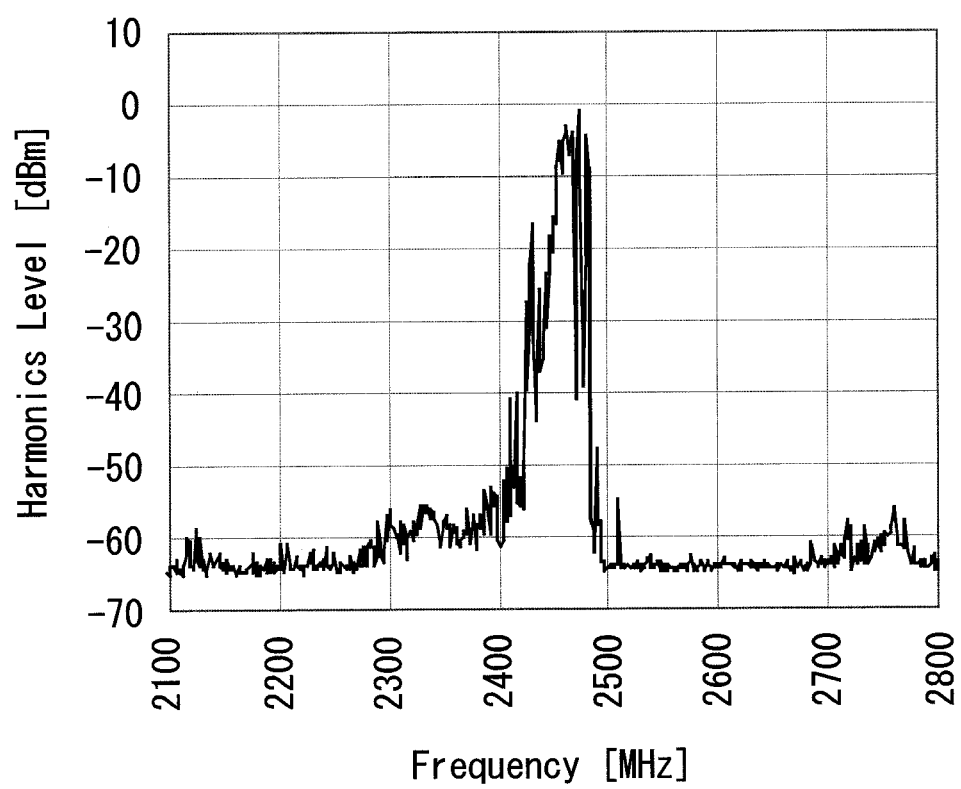


Fig. 5

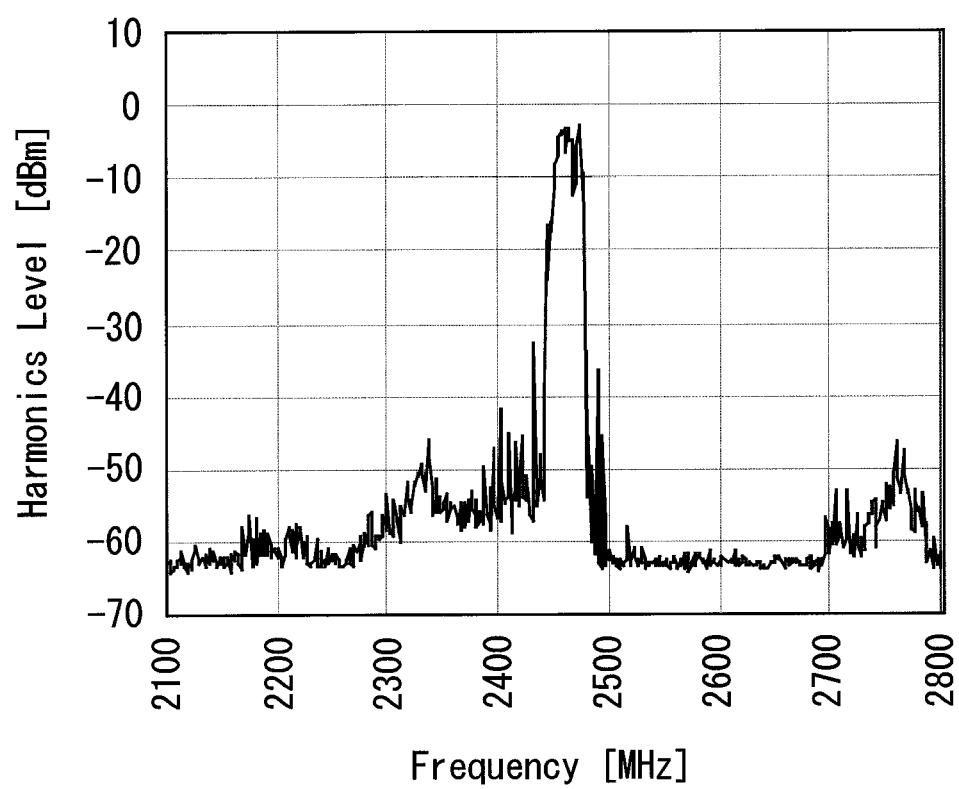


Fig. 6

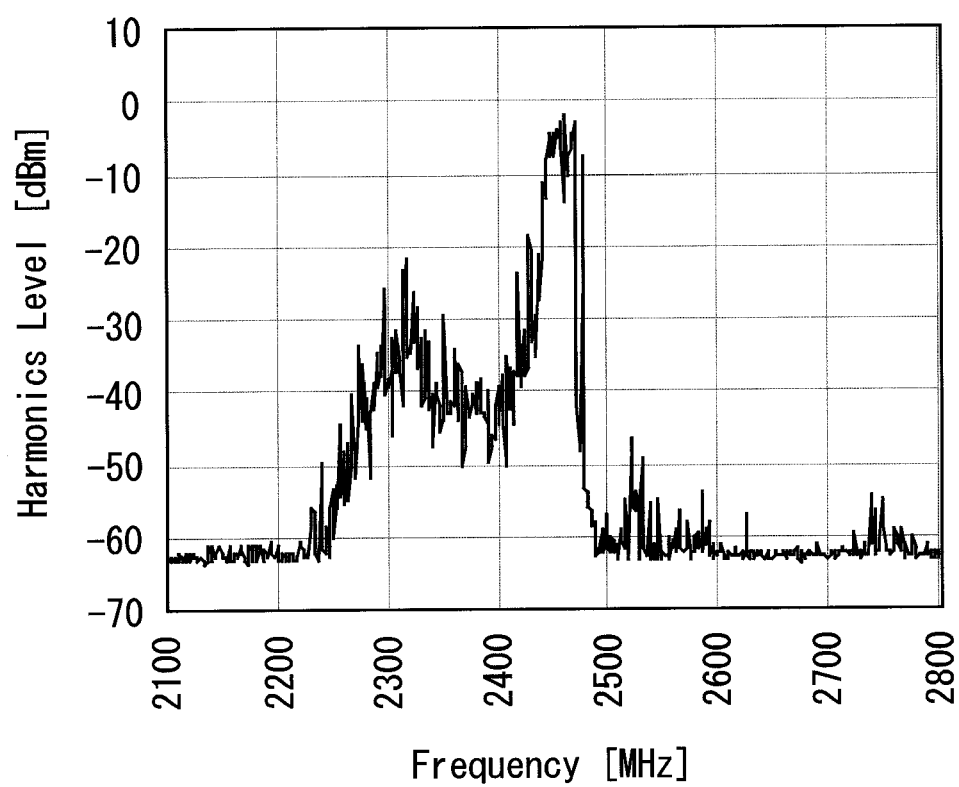


Fig. 7

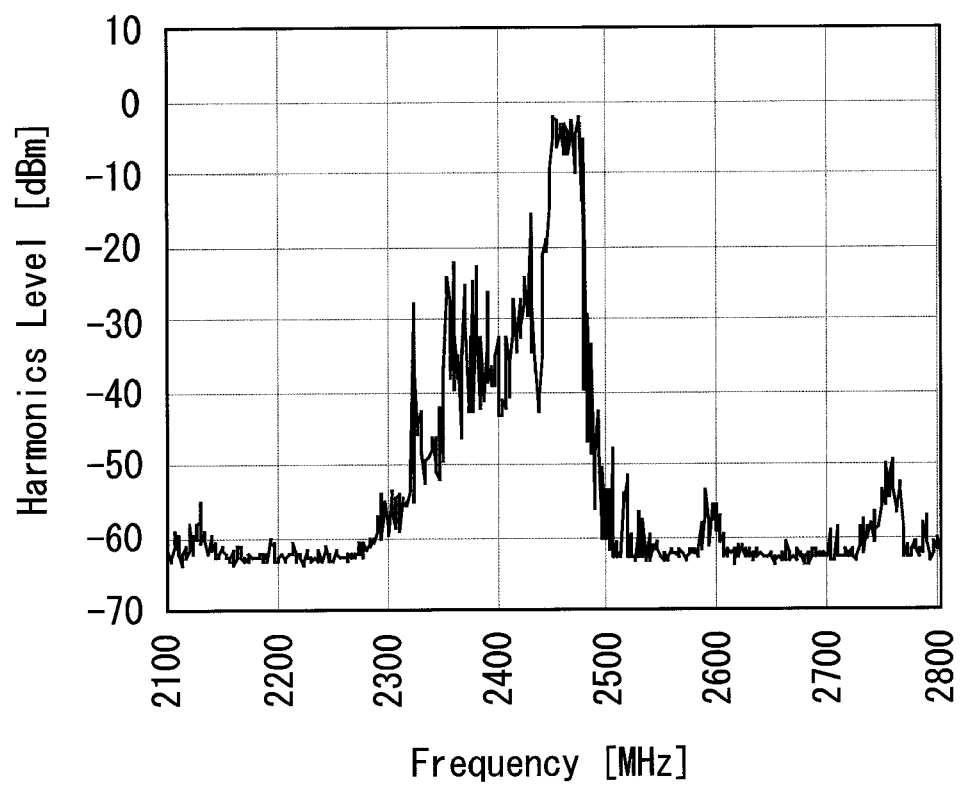


Fig. 8

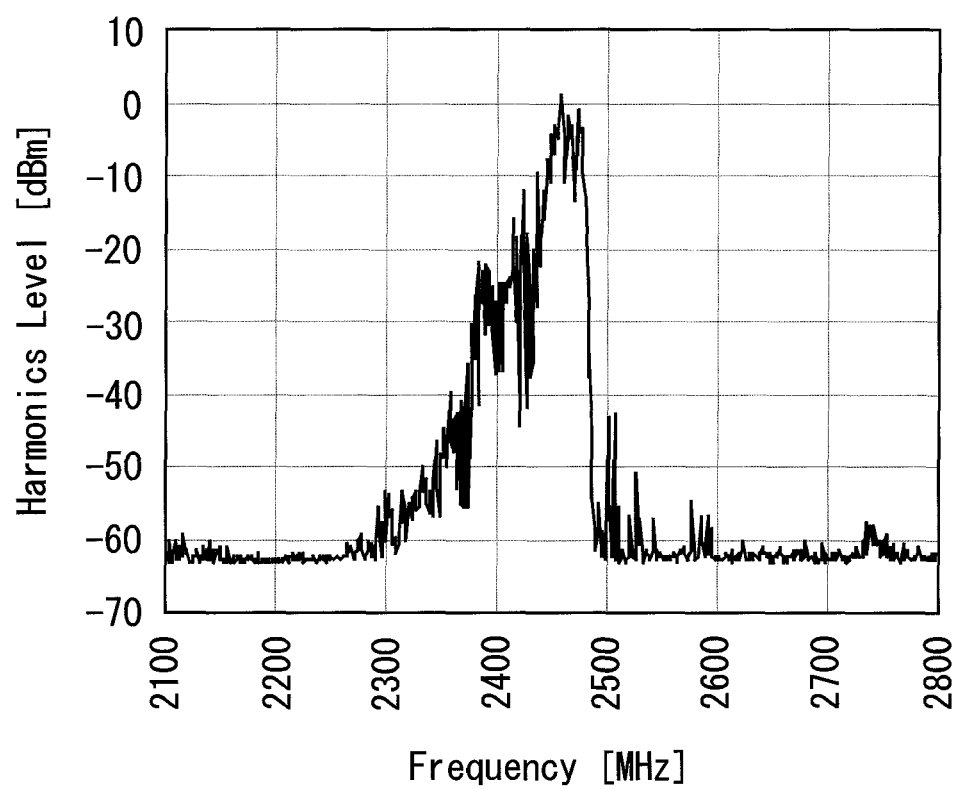


Fig. 9

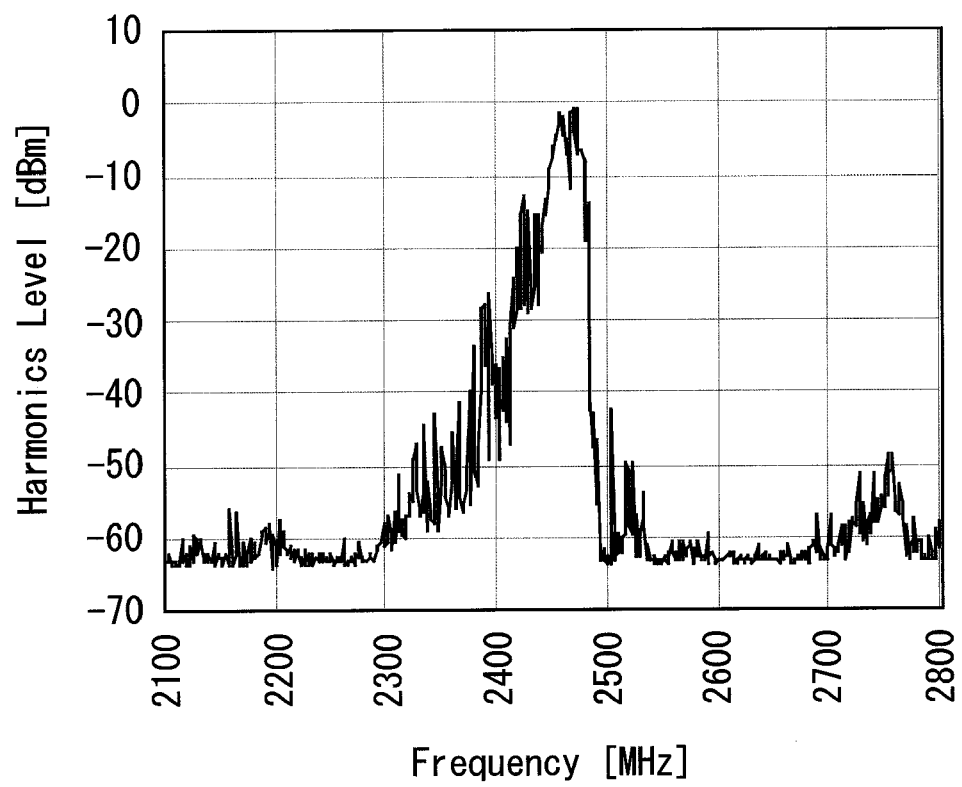


Fig. 10

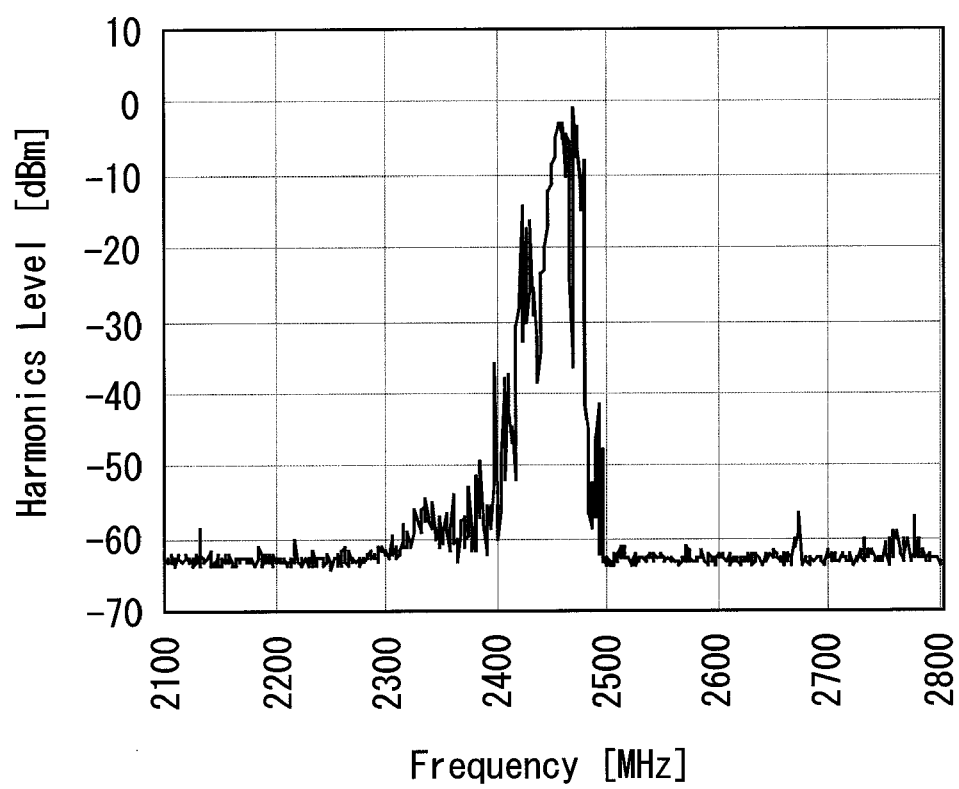


Fig.11

	Input side pole piece		Output side pole piece		Interval distance between Input side pole piece and Output side pole piece		Vaness		Filament		Presence or absence of unnecessary noises
	Diameter of Through-hole	Outer diameter of Internal surface	Diameter of Through-hole	Outer diameter of Internal surface	Outer annular portion	Inner annular portion	Diameter of Vane-inscribed cylindrical surface	Height	Outer diameter		
	IP1	IP2	OP1	OP2	D1	D2	B	H	F		
Example 1	8.7	15	8	12	22.5	11.2	8.1	8	3.7	few	
Example 2	8.7	16	8	12	22.5	11.2	8.1	8	3.7	few	
Example 3	9.0	16	8	12	22.5	11.2	8.1	8	3.7	few	
Comparative Example 1	8.4	12	8	12	22.5	11.2	8.1	8	3.7	presence	
Comparative Example 2	8.4	14	8	12	22.5	11.2	8.1	8	3.7	presence	
Comparative Example 3	8.7	14	8	12	22.5	11.2	8.1	8	3.7	presence	
Comparative Example 4	8.4	15	8	12	22.5	11.2	8.1	8	3.7	presence	
Comparative Example 5	8.4	16	8	12	22.5	11.2	8.1	8	3.7	presence	

(unit : mm)

Fig. 12

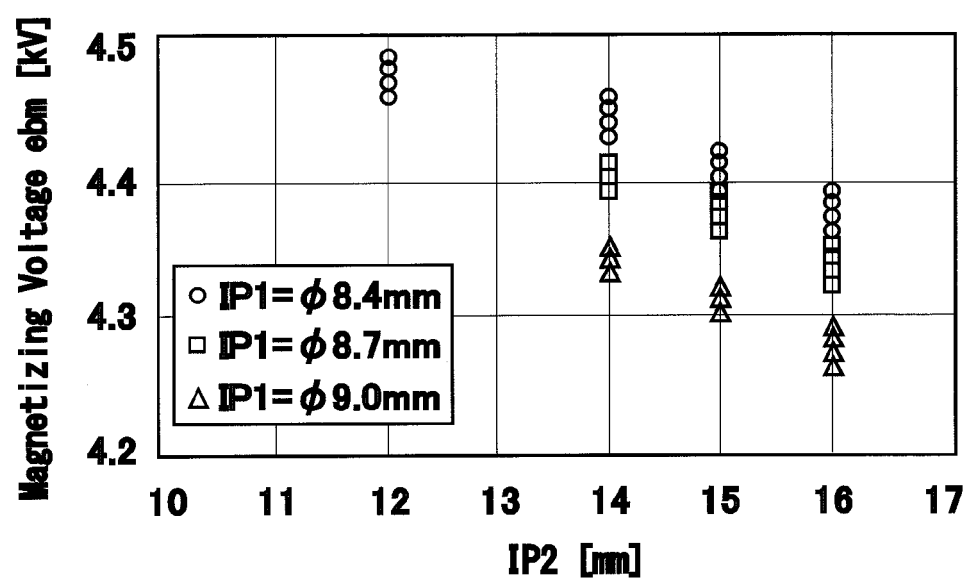
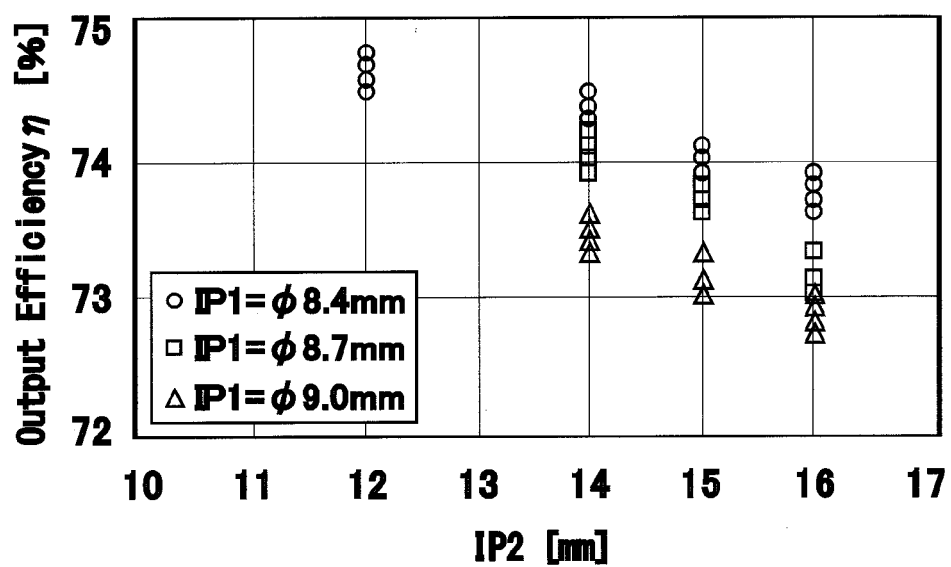


Fig. 13



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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