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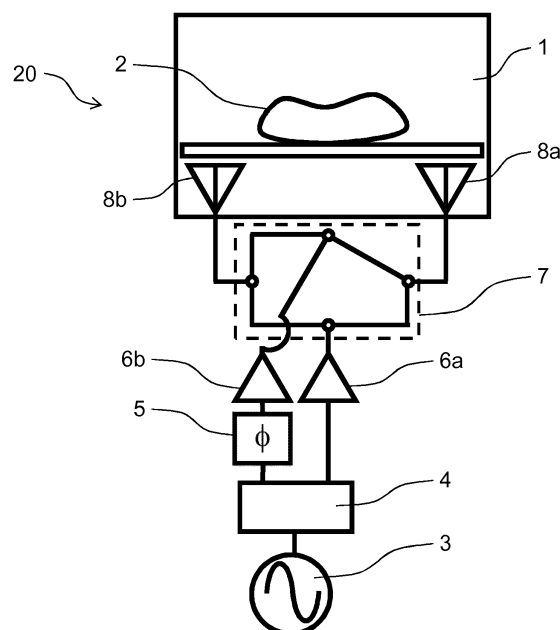
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(54) **MICROWAVE TREATMENT DEVICE**

(57) A microwave treatment device includes a heating chamber, a first and second antennas, a transmission line group, and a plurality of supply parts. The heating chamber accommodates an object to be heated. The first and second antennas radiate microwaves to the heating chamber. The transmission line group includes a plurality of transmission lines for supplying the first and second antennas with microwaves. The plurality of supply parts supplies the transmission line group with a microwave. The plurality of transmission lines includes first to fourth transmission lines coupled in a ring shape. The transmission line group further includes a first branch part between the first and third transmission lines, and a second branch part between the second and fourth transmission lines. The plurality of supply parts includes a first supply part between the first and second transmission line, and a second supply part between the third and fourth transmission lines. The first transmission line has the same phase length as that of each of the second and fourth transmission lines, and the third transmission line has a phase length different from that of each of the first, second, and third transmission lines. This aspect can carry out desired heating to objects to be heated having various shapes, types, and amounts for a short time.

FIG. 1



Description**TECHNICAL FIELD**

5 **[0001]** The present disclosure relates to a microwave treatment device including a microwave generator.

BACKGROUND ART

10 **[0002]** Conventionally, microwave treatment devices include those equipped with a plurality of rotating antennas for radiating microwaves (see, for example, PTL 1). This conventional technology can supply microwaves to a wide area of the inside of a heating chamber using a plurality of rotating antennas so as to suppress uneven heating.

[0003] Conventional technologies include a microwave treatment device that includes a plurality of antennas for radiating microwaves, and that is configured to control a phase difference of a plurality of microwaves (see, for example, PTL 2). This conventional technology can change microwave distribution by phase difference control so as to permit
15 uniform heating and intensive heating.

Citation List**Patent Literature**

20 **[0004]**

PTL 1: Japanese Patent Application Unexamined Publication No.2004-47322

PTL 2: Japanese Patent Application Unexamined Publication No. 2008-66292

SUMMARY OF THE INVENTION

30 **[0005]** However, with configurations in which microwaves are synthesized inside a heating chamber as in the above-mentioned conventional technologies, it is difficult to carry out desired heating to objects to be heated having various shapes, types, and amounts, as described below.

[0006] Even if a plurality of antennas is rotated, microwave distribution does not change much. Even if a standing wave is changed by phase difference control, the standing wave only moves half wavelength, and the microwave distribution does not change much.

35 **[0007]** Even if the microwave distribution inside the heating chamber is attempted to be changed by synthesizing a plurality of microwaves inside the heating chamber, the microwave distribution changes by the influence of an object to be heated accommodated in the heating chamber. Therefore, it is difficult to carry out heating as expected.

[0008] When a plurality of microwave radiation portions is intermittently driven, the microwave distribution greatly changes. However, the electric power supply decreases, so that cooking time increases.

40 **[0009]** The present disclosure solves the above-mentioned conventional problems and has an object to provide a microwave treatment device that carries out desired heating to objects to be heated having various shapes, types, and amounts for a short time.

[0010] A microwave treatment device in accordance with one aspect of the present disclosure includes a heating chamber, a first antenna, a second antenna, a transmission line group, and a plurality of supply parts.

45 **[0011]** The heating chamber is configured to accommodate an object to be heated. The first antenna and the second antenna are configured to radiate microwaves to the heating chamber. The transmission line group includes a plurality of transmission lines configured to supply the first antenna and the second antenna with a microwave. The plurality of supply parts is configured to supply the transmission line group with a microwave.

[0012] The plurality of transmission lines includes a first transmission line, a second transmission line, a third transmission line, and a fourth transmission line, all of which are coupled in a ring shape. The transmission line group further
50 includes a first branch part between the first transmission line and the third transmission line, and a second branch part between the second transmission line and the fourth transmission line.

[0013] The plurality of supply parts includes a first supply part between the first transmission line and the second transmission line, and a second supply part between the third transmission line and the fourth transmission line.

55 **[0014]** The first transmission line has the same phase length as that of each of the second transmission line and the fourth transmission line. The third transmission line has a phase length that is different from each phase length of the first transmission line, the second transmission line, and the fourth transmission line.

[0015] This aspect can carry out desired heating to objects to be heated having various shapes, types, and amounts for a short time.

BRIEF DESCRIPTION OF DRAWINGS

[0016]

FIG. 1 is a block diagram showing a basic configuration of a microwave treatment device in accordance with an exemplary embodiment of the present disclosure.

FIG. 2 is a diagram showing an arrangement of transmission lines included in a transmission line group in accordance with the exemplary embodiment.

FIG. 3 is a diagram for illustrating lengths of the transmission lines included in the transmission line group in accordance with the exemplary embodiment.

FIG. 4 is a perspective view showing a first configuration example of a transmission line group in accordance with the exemplary embodiment.

FIG. 5 is a perspective view showing a second configuration example of a transmission line group in accordance with the exemplary embodiment.

DESCRIPTION OF EMBODIMENTS

[0017] A microwave treatment device of a first aspect of the present disclosure includes a heating chamber, a first antenna, a second antenna, a transmission line group, and a plurality of supply parts.

[0018] The heating chamber is configured to accommodate an object to be heated. The first antenna and the second antenna are configured to radiate microwaves to the heating chamber. The transmission line group includes a plurality of transmission lines configured to supply the first antenna and the second antenna with a microwave. The plurality of supply parts is configured to supply the transmission line group with a microwave.

[0019] The plurality of transmission lines includes a first transmission line, a second transmission line, a third transmission line, and a fourth transmission line, all of which are coupled in a ring shape. The transmission line group further includes a first branch part between the first transmission line and the third transmission line, and a second branch part between the second transmission line and the fourth transmission line.

[0020] The plurality of supply parts includes a first supply part between the first transmission line and the second transmission line, and a second supply part between the third transmission line and the fourth transmission line.

[0021] The first transmission line has the same phase length as that of each of the second transmission line and the fourth transmission line. The third transmission line has a phase length that is different from each phase length of the first transmission line, the second transmission line, and the fourth transmission line.

[0022] In a microwave treatment device of a second aspect of the present disclosure, in addition to the first aspect, the third transmission line has a phase length that is different by $180 \text{ degrees} \pm 10\%$ from the phase length of the first transmission line.

[0023] In a microwave treatment device of a third aspect of the present disclosure, in addition to the first aspect, the transmission line group further includes a fifth transmission line connecting the first branch part to the first antenna, and a sixth transmission line connecting the second branch part to the second antenna.

[0024] In a microwave treatment device of a fourth aspect of the present disclosure, in addition to the first aspect, the transmission line group is formed of a microstrip line.

[0025] In a microwave treatment device of a fifth aspect of the present disclosure, in addition to the first aspect, the transmission line group is formed of a waveguide.

[0026] Hereinafter, the exemplary embodiments of the present disclosure are described with reference to drawings.

[Basic Configuration]

[0027] FIG. 1 is a block diagram showing a basic configuration of microwave treatment device 20 in accordance with an exemplary embodiment of the present disclosure.

[0028] As shown in FIG. 1, microwave treatment device 20 includes heating chamber 1, oscillation part 3, distributing part 4, phase variable part 5, amplifiers 6a and 6b, transmission line group 7, and antennas 8a and 8b.

[0029] Oscillation part 3 is a solid-state oscillation device formed of a semiconductor, and generates microwaves. Distributing part 4 distributes the microwaves generated by oscillation part 3 into amplifier 6a and phase variable part 5.

[0030] Phase variable part 5 receives an input of a microwave distributed by distributing part 4, and outputs a microwave whose phase is changed, in response to an instruction by a control section (not shown).

[0031] Amplifier 6a amplifies the microwave distributed by distributing part 4. Amplifier 6b amplifies the microwave output by phase variable part 5.

[0032] Transmission line group 7 includes a plurality of transmission lines, and allows antennas 8a and 8b to transmit the microwaves amplified by amplifiers 6a and 6b. Antennas 8a and 8b correspond to the first antenna and the second

antenna, respectively. Microwaves radiated by antennas 8a and 8b heat object to be heated 2 accommodated in heating chamber 1. Typically, object to be heated 2 is food.

[0033] Hereinafter, the effect of microwave treatment device 20 having the above-mentioned configuration is described.

[0034] FIG. 2 shows arrangement of transmission lines included in transmission line group 7. As shown in FIG. 2, transmission line group 7 includes transmission lines 7a, 7b, 7c, and 7d coupled in a ring shape. Transmission lines 7a, 7b, 7c, and 7d correspond to the first transmission line, the second transmission line, the third transmission line, and the fourth transmission line, respectively.

[0035] Microwaves from amplifiers 6a and 6b are supplied to transmission line group 7 through supply parts 9a and 9b. Supply parts 9a and 9b correspond to the first supply part and the second supply part, respectively.

[0036] Transmission line group 7 synthesizes the microwave supplied through supply part 9a with the microwave supplied through supply part 9b. The synthesized microwave is branched at branch part 10a. Transmission line 7e connects branch part 10a to antenna 8a, and propagates the synthesized microwave from branch part 10a to antenna 8a.

[0037] Transmission line group 7 synthesizes the microwave supplied through supply part 9a with the microwave supplied through supply part 9b. The synthesized microwave is branched at branch part 10b. Transmission line 7f connects branch part 10b to antenna 8b, and propagates the synthesized microwave from branch part 10b to antenna 8b. Branch parts 10a and 10b correspond to the first branch part and second branch part, respectively.

[0038] FIG. 3 is a diagram for illustrating lengths of the transmission lines forming transmission line group 7. The lengths of transmission lines 7a, 7b, 7c, and 7d are set to phase lengths PL1, PL2, PL3, and PL4, respectively. The phase length is a value obtained by substituting length L (mm) of a transmission line and wavelength λ (mm) of a microwave propagating in the transmission line into the following mathematical formula 1. The unit of the phase length is "degree".

$$\text{Phase length [deg.]} = \left(\frac{\text{Length L [mm]}}{\text{Wavelength } \lambda \text{ [mm]}} - \text{INT} \left(\frac{\text{Length L}}{\text{Wavelength } \lambda} \right) \right) \times 360$$

...(Formula 1)

(INT function rounds the argument to the nearest integer.)

[0039] Phase length PL1 is set to 0 degree at which a microwave that has passed through transmission line 7a has the same phase as that of the supplied microwave, at branch part 10a. Phase length PL2 is set to 0 degree at which a microwave that has passed through transmission line 7b has the same phase as that of the supplied microwave, at branch part 10b. Phase length PL4 is set to 0 degree at which a microwave that has passed through transmission line 7d has the same phase as that of the supplied microwave, at branch part 10b.

[0040] On the other hand, phase length PL3 is set to 180 degrees at which a microwave that has passed through transmission line 7c has a reverse phase to that of the supplied microwave, at branch part 10a.

[0041] That is to say, transmission line 7a has the same phase length as that of each of transmission lines 7b and 7d, and transmission line 7c has a phase length that is different by 180 degrees from the phase length of transmission line 7a. Thus, the microwave branched at branch part 10a has a reverse phase to that of the microwave branched at branch part 10b.

[0042] In this exemplary embodiment, phase length PL1 is the same as each of phase lengths PL2 and PL4. The difference between phase lengths PL1 and PL3 is 180 degrees. However, phase lengths PL1, PL2, and PL4 may not be completely identical. The difference between phase lengths PL1 and PL3 may not be strictly 180 degrees. The tolerance to the difference is, for example, $\pm 10\%$.

[0043] Table 1 shows the effect of transmission line group 7 in the case where two microwaves having the same phase are supplied to each of supply parts 9a and 9b.

[Table 1]

In the case of same phase at feeding parts 9a and	From feeding part 9a	From feeding part 9b	Synthesize results
To synthesizing part 10a	Through transmission line 7a	Through transmission line 7c	Cancel each other
To synthesizing part 10b	Through transmission line 7b	Through transmission line 7d	Overlap each other

[0044] As shown in FIGs. 2 and 3, transmission line 7a propagates the microwave supplied through supply part 9a to branch part 10a. Transmission line 7c propagates the microwave supplied through supply part 9b to branch part 10a.

[0045] As described above, the microwave that has passed through transmission line 7a has the same phase as that of the supplied microwave, at branch part 10a. At branch part 10a, the microwave that has passed through transmission line 7c has a reverse phase to that of the supplied microwave. Thus, at branch part 10a, two microwaves having the same phase at supply parts 9a and 9b cancel each other (see Table 1).

[0046] Transmission line 7b propagates the microwave supplied through supply part 9a to branch part 10b. Transmission line 7d propagates the microwave supplied through supply part 9b to branch part 10b.

[0047] As described above, the microwave that has passed through transmission line 7b has the same phase as that of the supplied microwave, at branch part 10b. The microwave that has passed through transmission line 7d has the same phase as that of the supplied microwave, at branch part 10b. Thus, at branch part 10b, two microwaves having the same phase at supply parts 9a and 9b overlap each other (see Table 1).

[0048] As a result, a microwave is not supplied to transmission line 7e. A microwave is supplied only to transmission line 7f, and a microwave is radiated by only antenna 8b.

[0049] Table 2 shows the effect of transmission line group 7 in the case where two microwaves having the reverse phases are supplied to each of supply parts 9a and 9b.

[Table 2]

In the case of reverse phase at feeding parts 9a and 9b	From feeding part 9a	From feeding part 9b	Synthesize results
To synthesizing part 10a	Through transmission line 7a	Through transmission line 7c	Overlap each other
To synthesizing part 10b	Through transmission line 7b	Through transmission line 7d	Cancel each other

[0050] As shown in FIGs. 2 and 3, transmission line 7a propagates the microwave supplied through supply part 9a to branch part 10a. Transmission line 7c propagates the microwave supplied through supply part 9b to branch part 10a.

[0051] As described above, the microwave that has passed through transmission line 7a has the same phase as that of the supplied microwave, at branch part 10a. The microwave that has passed through transmission line 7c has a reverse phase to that of the supplied microwave, at branch part 10a. Thus, at branch part 10a, two microwaves having the reverse phase at supply parts 9a and 9b overlap each other (see Table 2).

[0052] Transmission line 7b propagates the microwave supplied through supply part 9a to branch part 10b. Transmission line 7d propagates the microwave supplied through supply part 9b to branch part 10b.

[0053] As described above, the microwave that has passed through transmission line 7b has the same phase as that of the supplied microwave, at branch part 10b. The microwave that has passed through transmission line 7d has the same phase as that of the supplied microwave, at branch part 10b. Thus, at branch part 10b, two microwaves having the reverse phases at supply parts 9a and 9b cancel each other (see Table 2).

[0054] As a result, a microwave is not supplied to transmission line 7f. A microwave is supplied only to transmission line 7e, and a microwave is radiated by only antenna 8a.

[0055] As mentioned above, this exemplary embodiment can control the microwave distribution by operating the phase of microwaves supplied to supply parts 9a and 9b.

[0056] In this exemplary embodiment, oscillation part 3 is a solid-state oscillation device formed of a semiconductor. However, as oscillation part 3, magnetron may be used.

First Configuration Example

[0057] FIG. 4 is a perspective view showing a first configuration example of transmission line group 7. As shown in FIG. 4, in this configuration example, transmission lines 7a, 7b, 7c, 7d, 7e, and 7f are formed of a waveguide.

[0058] Supply parts 9a and 9b are formed of connector terminals protruding into the inside of the waveguide. Branch parts 10a and 10b are formed of a branched waveguide. Antennas 8a and 8b are connected to a waveguide, and protrude into the inside of the heating chamber 1.

Second Configuration Example

[0059] FIG. 5 is a perspective view showing a second configuration example of transmission line group 7. As shown in FIG. 5, in this configuration example, transmission lines 7a, 7b, 7c, 7d, 7e, and 7f are formed of microstrip lines

disposed in the vicinity of one wall surface of heating chamber 1.

[0060] Supply parts 9a and 9b are formed of a coaxial core wire that connects the wall surface of heating chamber 1 to the microstrip lines. Branch parts 10a and 10b are formed of branched microstrip lines. Antennas 8a and 8b are coupled to the microstrip lines and protrude to the inside of heating chamber 1.

[0061] In this configuration example, transmission lines 7e and 7f may be omitted. In this case, antennas 8a and 8b are disposed to branch parts 10a and 10b, respectively. Antennas 8a and 8b may be supplied with a microwave through branch parts 10a and 10b in a non-contact manner.

INDUSTRIAL APPLICABILITY

[0062] The present disclosure is applicable not only to microwave ovens and garbage disposers but also to the field of semiconductor manufacturing equipment.

REFERENCE MARKS IN THE DRAWINGS

[0063]

1	heating chamber
2	object to be heated
3	oscillation part
4	distributing part
5	phase variable part
6a, 6b	amplifier
7	transmission line group
7a-7f	transmission line
8a, 8b	antenna
9a, 9b	supply part
10a, 10b	branch part
20	microwave treatment device

Claims

1. A microwave treatment device comprising:

a heating chamber configured to accommodate an object to be heated;
 a first antenna and a second antenna configured to radiate a microwave to the heating chamber;
 a transmission line group including a plurality of transmission lines configured to supply the first antenna and the second antenna with the microwave; and
 a plurality of supply parts configured to supply the transmission line group with the microwave,

wherein the plurality of transmission lines includes a first transmission line, a second transmission line, a third transmission line, and a fourth transmission line, all of which are coupled in a ring shape,
 the transmission line group further includes a first branch part between the first transmission line and the third transmission line, and a second branch part between the second transmission line and the fourth transmission line,
 the plurality of supply parts includes a first supply part between the first transmission line and the second transmission line, and a second supply part between the third transmission line and the fourth transmission line,
 the first transmission line has a phase length identical to a phase length of each of the second transmission line and the fourth transmission line, and
 the third transmission line has a phase length that is different from each phase length of the first transmission line, the second transmission line, and the fourth transmission line.

2. The microwave treatment device according to claim 1, wherein the third transmission line has a phase length that is different by 180 degrees $\pm$ 10% from the phase length of the first transmission line.

3. The microwave treatment device according to claim 1, wherein the transmission line group further includes a fifth transmission line that connects the first branch part to the first antenna, and a sixth transmission line that connects the second branch part to the second antenna.

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4. The microwave treatment device according to claim 1, wherein the transmission line group is formed of a microstrip line.
5. The microwave treatment device according to claim 1, wherein the transmission line group is formed of a waveguide.

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FIG. 1

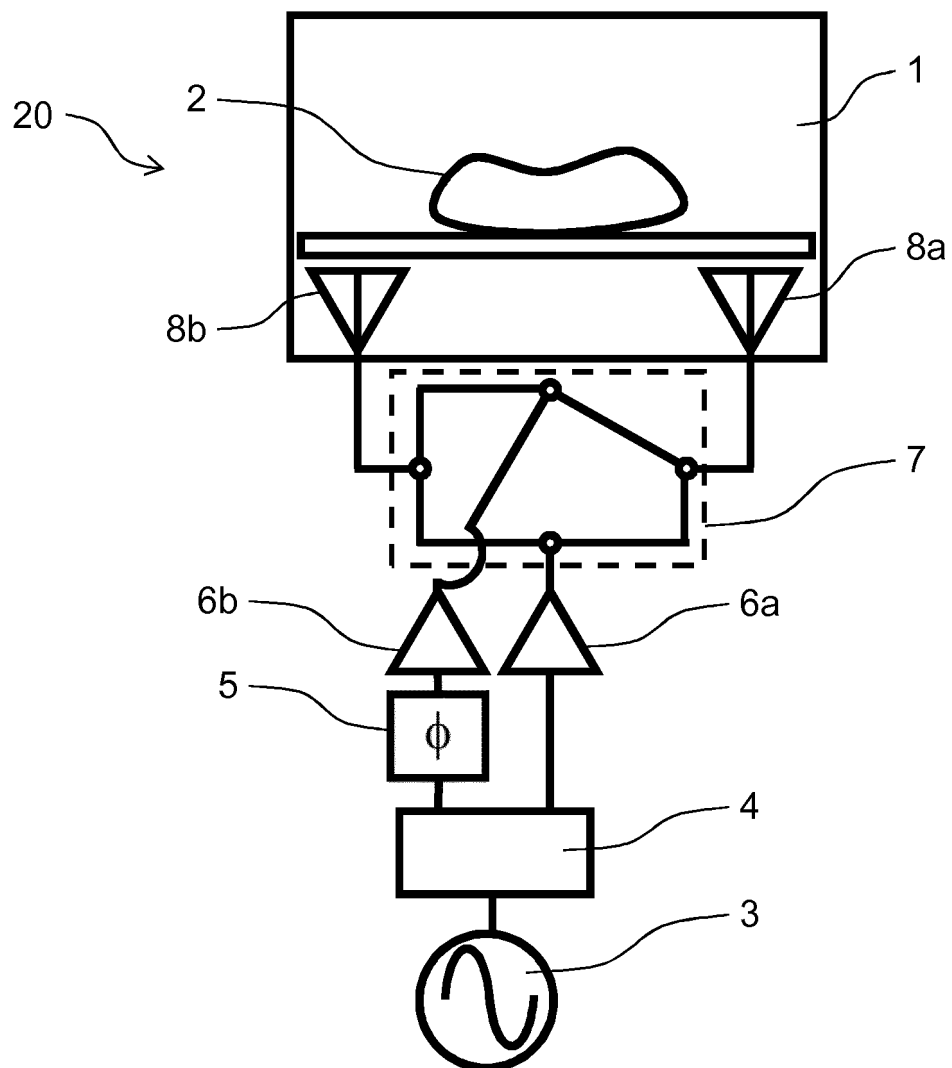


FIG. 2

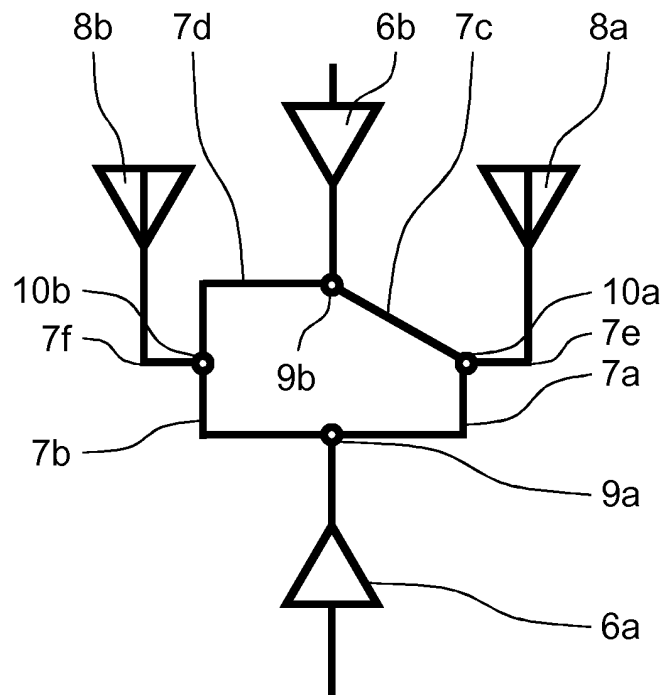


FIG. 3

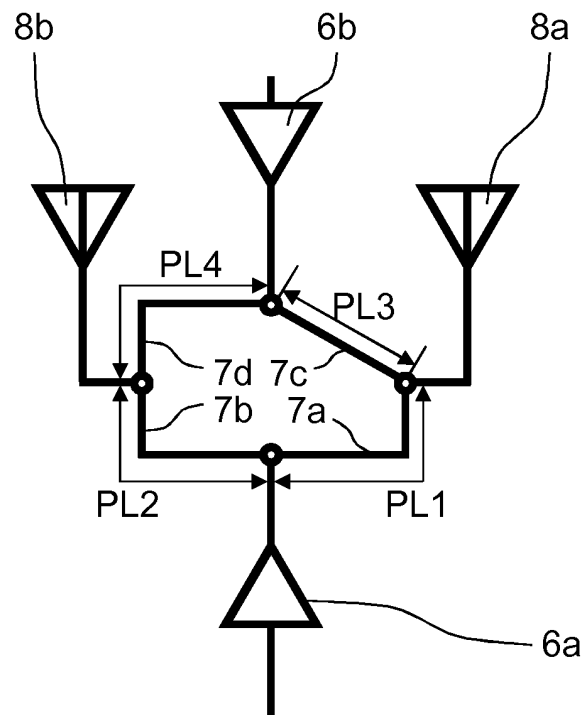


FIG. 4

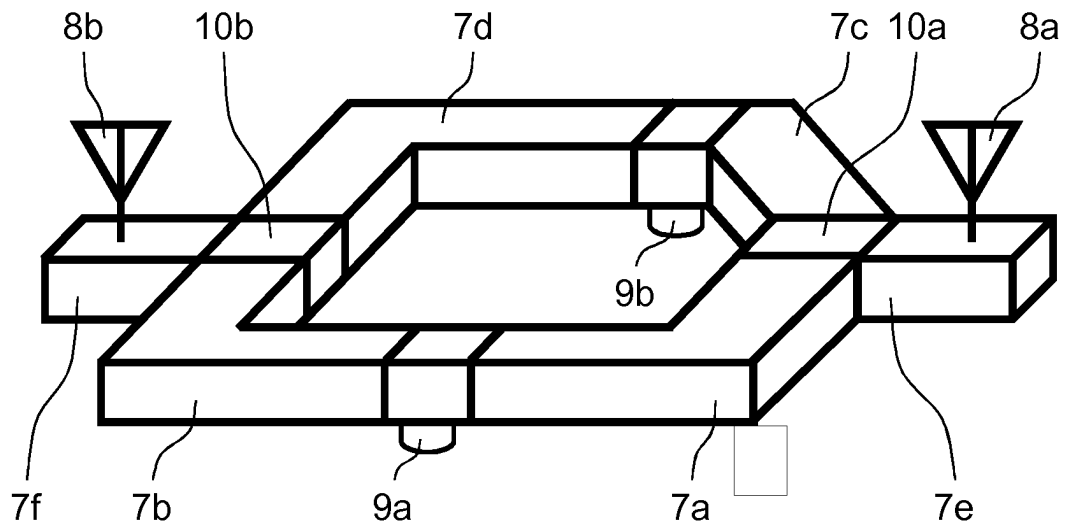
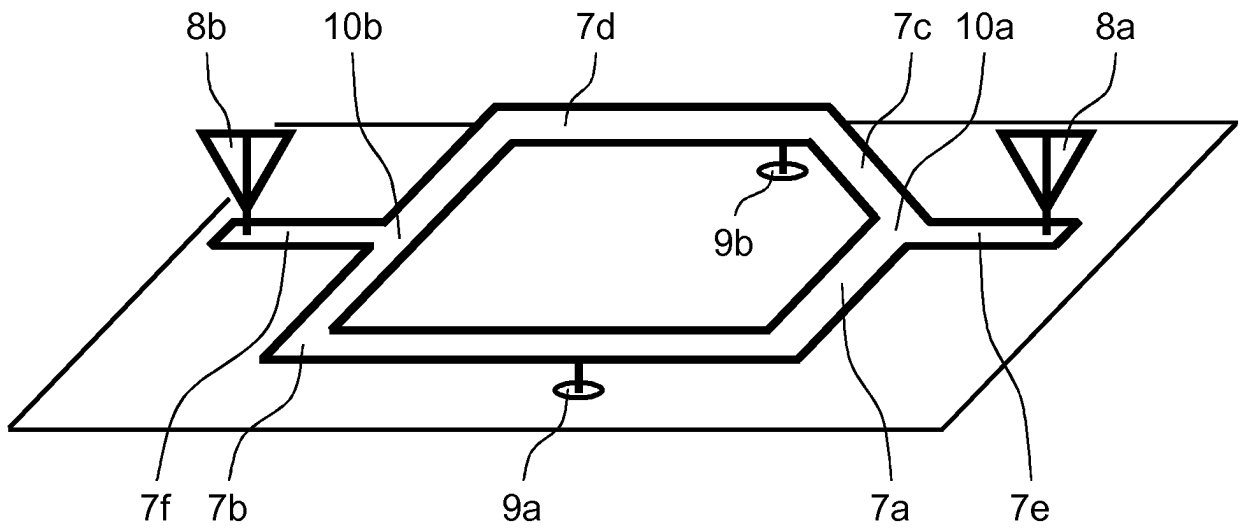


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/015930

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H05B6/70 (2006.01) i, F24C7/02 (2006.01) i, H05B6/66 (2006.01) i,
H05B6/72 (2006.01) i, H05B6/74 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H05B6/70, F24C7/02, H05B6/66, H05B6/72, H05B6/74

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 56-132793 A (HITACHI NETSUKIKU CORPORATION) 17 October 1981, specification, page 1, lower right column, line 15 to page 3, upper right column, line 12, fig. 2-5 (Family: none)	1-5
Y	US 2008/0191940 A1 (HASKELL, Philip, Edward) 14 August 2008, paragraph [0037], fig. 2 & WO 2006/120397 A1 & EP 1883994 A1	1-5
Y	WO 2009/050893 A1 (PANASONIC CORP.) 23 April 2009, paragraph [0107] & US 2010/0224623 A1, paragraph [0135] & EP 2205043 A1 & KR 10-2010-0068409 A & CN 101828427 A & RU 2010119699 A	4-5



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search
11 July 2018 (11.07.2018)

Date of mailing of the international search report
24 July 2018 (24.07.2018)

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Patent documents cited in the description

- JP 2004047322 A [0004]
- JP 2008066292 A [0004]