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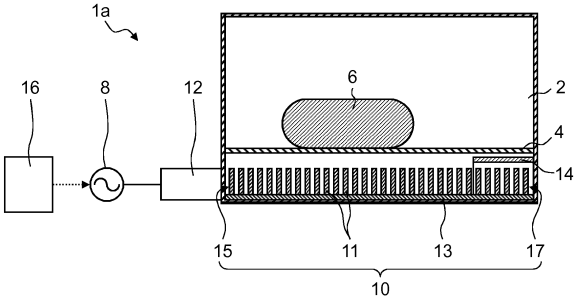
(54) HIGH-FREQUENCY HEATING DEVICE

(57) A high-frequency heating device (1a) includes a generation unit (8), a surface wave exciter (10), a first connecting unit (12), and a reuse unit (14). The generation unit (8) generates microwaves. The surface wave exciter (10) includes a periodic structure and heats a heating subject (6) by propagating the microwaves in a surface wave mode. The first connecting unit (12) is disposed at one end portion (15) of the surface wave exciter (10). The microwaves generated by the generation unit (8) are supplied to the surface wave exciter (10) through the first connecting unit (12). The reuse unit (14) reuses, for heating the heating subject (6), the microwaves that have reached another end portion (17) of the surface wave exciter (10) located in the propagation direction of the microwaves from one end portion (15) of the surface wave exciter (10). According to the present aspect, microwaves that have not been absorbed by the heating subject can be reused for heating the heating subject.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a high-frequency heating device such as a microwave oven.

BACKGROUND ART

[0002] Conventionally, high-frequency heating devices which heat heating subjects such as food products by supplying microwaves to surface wave transmission lines have been developed.

[0003] For example, Patent Literature (PTL 1) discloses a high-frequency heating device which thaws a frozen sushi placed in a surface wave transmission line by directly supplying microwaves to the surface wave transmission line.

Citation List

Patent Literature

[0004] PTL 1: Unexamined Japanese Patent Publication No. H08-166133

SUMMARY OF THE INVENTION

[0005] In the field of high-frequency heating devices, efficiently heating a heating subject has been a long-standing goal. An objective of the present disclosure is to provide a high-frequency heating device which contributes to achieving the aforementioned goal.

[0006] A high-frequency heating device according to one aspect of the present disclosure includes a generation unit, a surface wave exciter, a first connecting unit, and a reuse unit.

[0007] The generation unit generates microwaves. The surface wave exciter includes a periodic structure and heats a heating subject by propagating the microwaves in a surface wave mode. The first connecting unit is disposed at one end portion of the surface wave exciter. The microwaves generated by the generation unit are supplied to the surface wave exciter through the first connecting unit.

[0008] The reuse unit reuses, for heating the heating subject, the microwaves in the surface wave mode that have reached another end portion of the surface wave exciter located in a propagation direction of the microwaves from one end portion of the surface wave exciter.

[0009] According to the present embodiment, microwaves that have not been absorbed by the heating subject can be reused for heating a heating subject. As a result, the utilization efficiency of microwave energy can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a vertical cross-sectional view schematically illustrating a configuration of a high-frequency heating device according to Embodiment 1.

FIG. 2 is a horizontal cross-sectional view schematically illustrating a configuration of a high-frequency heating device according to Embodiment 1.

FIG. 3 is a horizontal cross-sectional view schematically illustrating a configuration of a high-frequency heating device according to Embodiment 2.

FIG. 4 is a horizontal cross-sectional view schematically illustrating a configuration of a high-frequency heating device according to Embodiment 3.

FIG. 5 is a perspective view illustrating a configuration of a surface wave exciter according to Embodiment 3.

FIG. 6 is a perspective view illustrating a configuration of a surface wave exciter according to Embodiment 3.

FIG. 7 is a horizontal cross-sectional view schematically illustrating a configuration of a high-frequency heating device according to Embodiment 4.

DESCRIPTION OF EMBODIMENTS

[0011] A high-frequency heating device according to the first aspect of the present disclosure includes a generation unit, a surface wave exciter, a first connecting unit, and a reuse unit.

[0012] The generation unit is configured to generate microwaves. The surface wave exciter includes a periodic structure and heats a heating subject by propagating the microwaves in a surface wave mode. The first connecting unit is disposed at one end portion of the surface wave exciter. The microwaves generated by the generation unit are supplied to the surface wave exciter through the first connecting unit.

[0013] The reuse unit is configured to reuse, for heating the heating subject, the microwaves in the surface wave mode that have reached another end portion of the surface wave exciter located in a propagation direction of the microwaves from one end portion of the surface wave exciter.

[0014] In the high-frequency heating device according to the second aspect of the present disclosure, the reuse unit in the first aspect includes a reflective unit disposed at another end portion of the surface wave exciter and configured to reflect the microwaves that have reached the other end portion of the surface wave exciter.

[0015] In the high-frequency heating device according to the third aspect of the present disclosure, the reflective unit in the second aspect is a waveguide which covers the other end portion of the surface wave exciter.

[0016] In the high-frequency heating device according to the fourth aspect of the present disclosure, the reuse

unit in the first aspect includes a matching unit disposed at the other end portion of the surface wave exciter and configured to carry out, by impedance matching, mode conversion of the microwaves in the surface wave mode that have reached the other end portion.

[0017] The high-frequency heating device according to the fifth aspect of the present disclosure further includes a power storage unit configured to store direct-current power in addition to those according to the fourth aspect. The reuse unit further includes a conversion unit configured to convert, into the direct-current power, the microwaves resulting from the mode conversion by the matching unit, and supply the direct-current power to the power storage unit.

[0018] In the high-frequency heating device according to the sixth aspect of the present disclosure, the reuse unit in the fourth aspect further includes: a second connecting unit disposed at one of end portions of the surface wave exciter; and a microwave transmission line which connects the matching unit and the second connecting unit.

[0019] In the high-frequency heating device according to the seventh aspect of the present disclosure, the surface wave exciter in the first aspect includes: a first portion which propagates surface waves obtained from the microwaves supplied through the first connecting unit; a second portion connected to the first portion and configured to change a propagation direction of the surface waves; and a third portion which is connected to the second portion and propagates the surface waves in the propagation direction that has been changed. In the present aspect, the reuse unit is the second portion and the third portion.

[0020] In the high-frequency heating device according to the eighth aspect of the present disclosure, the periodic structure in any one of the first to seventh aspects includes a plurality of columnar pins horizontally periodically arranged.

[0021] Hereinafter, preferred embodiments of the high-frequency heating device according to the present disclosure will be described with reference to the accompanying drawings. The high-frequency heating device according to the present disclosure is specifically a microwave oven. However, the high-frequency heating device according to the present disclosure is not limited to this and includes a heating device which uses dielectric heating, a garbage disposer, a semiconductor manufacturing device, and the like.

[0022] In the subsequent description, the same reference marks are given to the same or equivalent structural elements and redundant description thereof will be omitted.

EMBODIMENT 1

<Overall Configuration>

[0023] FIG. 1 and FIG. 2 are a vertical cross-sectional view and a horizontal cross-sectional view, respectively, which schematically illustrate a configuration of high-frequency heating device 1a according to Embodiment 1 of the present disclosure.

[0024] As illustrated in FIG. 1 and FIG. 2, high-frequency heating device 1a includes heating chamber 2, generation unit 8, surface wave exciter 10, connecting unit 12, reflective unit 14, and control unit 16. High-frequency heating device 1a is configured to heat heating subject 6 placed on tray 4 by microwaves which propagate on a surface of surface wave exciter 10 in a surface wave mode.

[0025] Note that FIG. 2 schematically illustrates a situation in which microwaves in the surface wave mode propagate on surface wave exciter 10 and also schematically illustrates a placement position of heating subject 6 on tray 4 (not illustrated in FIG. 2).

[0026] The structural elements will be described below.

<Generation Unit>

[0027] Generation unit 8 includes a magnetron and an inverter and is configured to generate microwaves under control of control unit 16. A solid-state oscillator and a power amplifier may constitute generation unit 8.

<Surface Wave Exciter>

[0028] Surface wave exciter 10 is disposed below tray 4. Surface wave exciter 10 heats heating subject 6 placed on tray 4 by propagating the microwaves in the surface wave mode.

[0029] Surface wave exciter 10 is a stub-type surface wave exciter which is a metallic periodic structure. Surface wave exciter 10 includes a plurality of metal plates 11 arranged on metal plate 13 at a predetermined interval.

[0030] Surface wave exciter 10 does not need to be the stub-type surface wave exciter and may be an interdigital surface wave exciter obtained by stamping a metal plate into an interdigitated pattern. Surface wave exciter 10 may be formed using a dielectric plate such as an alumna plate or a Bakelite plate instead of the metallic periodic structure.

[0031] The excitation frequency of surface wave exciter 10 depends on material, size, etc. In the case of the stub-type surface wave exciter, the excitation frequency can be set to a desired value by appropriately selecting the height, interval, etc., of metal plates 11. Generally, the excitation frequency of surface wave exciter 10 increases as the height of metal plates 11 is reduced and as the interval between metal plates 11 is reduced.

[0032] Metal plates 11 are arranged parallel to each other. Surface wave exciter 10 propagates the surface waves perpendicularly to metal plate 11, that is, along the alinement of metal plates 11. The propagation direction of the microwaves propagating on surface wave ex-

citer 10 in the surface wave mode matches the alinement direction of metal plates 11.

<Connecting Unit>

[0033] Connecting unit 12 is disposed on power supply edge 15 which is one end portion of surface wave exciter 10 (the left end of surface wave exciter 10 in FIG. 1 and FIG. 2). The microwaves generated by generation unit 8 are supplied from power supply edge 15 to surface wave exciter 10 through connecting unit 12. In the present exemplary embodiment, connecting unit 12 is a rectangular waveguide. Connecting unit 12 corresponds to the first connecting unit.

<Reflective Unit>

[0034] Reflective unit 14 is disposed so as to cover terminal edge 17. Terminal edge 17 is another end portion of surface wave exciter 10 that is located in propagation direction D1 from power supply edge 15 (the right end of surface wave exciter 10 in FIG. 1 and FIG. 2). Reflective unit 14 totally reflects, off terminal edge 17, microwaves in the surface wave mode that have propagated on the surface of surface wave exciter 10. In the present exemplary embodiment, reflective unit 14 is a rectangular waveguide.

<Effects of Surface Wave Exciter>

[0035] Effects of surface wave exciter 10 will be described with reference to FIG. 2.

[0036] As illustrated in FIG. 2, the microwaves generated by generation unit 8 are supplied from power supply edge 15 to surface wave exciter 10 through connecting unit 12.

[0037] When the microwaves are supplied, surface waves S1 which propagate on the surface of surface wave exciter 10 are generated. Surface waves S1 propagate in propagation direction D1 (in the figure, from the left to the right) and heats heating subject 6 from below.

[0038] Surface waves S2, which are part of surface waves S1, further propagate on the surface of surface wave exciter 10 in propagation direction D1 without being absorbed by heating subject 6, and reach terminal edge 17 of surface wave exciter 10. Reflective unit 14 reflects surface waves S2 off terminal edge 17, reversing the propagation direction of surface waves S2. The propagation direction of surface waves S2 is changed from propagation direction D1 to propagation direction D2 (in the figure, from the right to the left).

[0039] Surface waves S2 reflected by reflective unit 14 heat heating subject 6 from below by propagating on the surface of surface wave exciter 10 from terminal edge 17 toward power supply edge 15.

[0040] In a conventional high-frequency heating device, microwaves in the surface wave mode that have not been absorbed by heating subject 6 and have reached the terminal edge of the surface wave exciter are radiated to space. The microwaves that have been radiated to space do not contribute to heating of heating subject 6; thus, the utilization efficiency of microwave energy is reduced.

[0041] In the present exemplary embodiment, heating subject 6 is heated not only with surface waves S1, but also with surface waves S2 reflected by reflective unit 14. In this way, high-frequency heating device 1a is capable of reusing, for heating a heating subject, microwaves that have not been absorbed by the heating subject. As a result, the utilization efficiency of microwave energy can be improved.

[0042] In other words, in the present exemplary embodiment, reflective unit 14 corresponds to a reuse unit configured to reuse microwaves that have not been absorbed by heating subject 6 and have reached the terminal edge of the surface wave exciter.

EMBODIMENT 2

[0043] High-frequency heating device 1b according to Embodiment 2 of the present disclosure will be described focusing on differences from Embodiment 1.

[0044] FIG. 3 is a horizontal cross-sectional view schematically illustrating a configuration of high-frequency heating device 1b. FIG. 3 schematically illustrates a situation in which microwaves in the surface wave mode propagate on surface wave exciter 10 and also schematically illustrates a placement position of heating subject 6 on tray 4 (not illustrated in FIG. 3).

[0045] In Embodiment 1, surface waves S2 that have reached terminal edge 17 of surface wave exciter 10 are reflected so that the microwaves are reused. In contrast, in Embodiment 2, microwaves in the surface wave mode are converted into microwaves in another mode by impedance matching so that the microwaves are reused.

[0046] As illustrated in FIG. 3, high-frequency heating device 1b includes matching unit 22 and conversion unit 24 instead of reflective unit 14. In the present exemplary embodiment, matching unit 22 and conversion unit 24 correspond to the reuse unit. High-frequency heating device 1b further includes power storage unit 26.

[0047] Matching unit 22 is connected to terminal edge 17 of surface wave exciter 10. Conversion unit 24 is connected to matching unit 22 by microwave transmission line 23 and is connected to power storage unit 26 by direct-current power transmission line 25. Power storage unit 26 is connected to generation unit 8 and supplies power to generation unit 8.

[0048] Matching unit 22 is an impedance matching device configured to provide impedance matching for microwaves. Through the impedance matching, microwaves in the surface wave mode can be converted into microwaves in a co-axial mode or microwaves in a waveguide mode. Hereinafter, this will be referred to as mode conversion by impedance matching.

[0049] In the case of converting microwaves in the sur-

face wave mode into microwaves in the waveguide mode, matching unit 22 may have a stepped stub structure. In the case of converting microwaves in the surface wave mode into microwaves in the coaxial mode, matching unit 22 may have a two-step structure which converts microwaves in the surface wave mode into microwaves in the waveguide mode and then, converts the microwaves into microwaves in the coaxial mode. Matching unit 22 is not limited to these and may have various structures.

[0050] Microwave transmission line 23 may be formed of a co-axial line or a waveguide line, for example. According to the present exemplary embodiment, matching unit 22 converts microwaves in the surface wave mode into microwaves in the co-axial mode or the waveguide mode. Therefore, the microwaves can be transmitted to conversion unit 24, which is another structural element, by microwave transmission line 23.

[0051] Conversion unit 24 is a member which converts microwaves, which are alternating-current power, into direct-current power. For example, a rectifying antenna (rectenna) may be used for conversion unit 24.

[0052] In the above-described configuration, heating subject 6 is heated with surface waves S1 obtained from the microwaves supplied through connecting unit 12. Surface waves S2 that have propagated on surface wave exciter 10 without being absorbed by heating subject 6 reach terminal edge 17.

[0053] Matching unit 22 generates microwaves in the co-axial mode or the waveguide mode by carrying out, by impedance matching, mode conversion of the microwaves (surface waves S2) in the surface wave mode that have reached terminal edge 17. Matching unit 22 transmits the microwaves resulting from the mode conversion to conversion unit 24 by microwave transmission line 23.

[0054] Conversion unit 24 converts the microwaves into direct-current power and transmits the direct-current power to power storage unit 26 by direct-current power transmission line 25. Power storage unit 26 stores the direct-current power as power to be supplied to generation unit 8.

[0055] As described above, high-frequency heating device 1b converts the microwaves that have not been absorbed by heating subject 6 into the direct-current power using matching unit 22 and conversion unit 24. This direct-current power is stored in power storage unit 26 and, when required, is supplied to generation unit 8.

[0056] In this way, high-frequency heating device 1b is capable of reusing, for heating a heating subject, microwaves that have not been absorbed by the heating subject. As a result, the utilization efficiency of microwave energy can be improved.

EMBODIMENT 3

[0057] High-frequency heating device 1c according to Embodiment 3 of the present disclosure will be described focusing on differences from Embodiment 2. FIG. 4 is a horizontal cross-sectional view schematically illustrating a configuration of high-frequency heating device 1c. FIG. 4 schematically illustrates a situation in which microwaves in the surface wave mode propagate on surface wave exciter 20 and also schematically illustrates a placement position of heating subject 6 on tray 4 (not illustrated in FIG. 4).

[0058] As illustrated in FIG. 4, high-frequency heating device 1c does not include conversion unit 24 or power storage unit 26, but includes connecting unit 32 instead. High-frequency heating device 1c includes surface wave exciter 20 instead of surface wave exciter 10. Surface wave exciter 20 has a configuration different from the configuration of surface wave exciter 10 according to Embodiment 2. Connecting unit 32 corresponds to the second connecting unit.

[0059] High-frequency heating device 1c includes connecting unit 32 in addition to connecting unit 12. Connecting unit 32 is disposed on power supply edge 33 which is an end portion of surface wave exciter 20 different from power supply edge 15 and terminal edge 17. In the present exemplary embodiment, surface wave exciter 20 has the shape of an approximate square in plan view, and connecting unit 32 is disposed on power supply edge 33 orthogonal to power supply edge 15. Connecting unit 32 is connected to matching unit 22 by microwave transmission line 31.

[0060] In the above-described configuration, heating subject 6 is heated with surface waves S1 obtained from the microwaves supplied through connecting unit 12. Surface waves S2, which are part of surface waves S1, propagate on the surface of surface wave exciter 10 without being absorbed by heating subject 6, and reach terminal edge 17.

[0061] Matching unit 22 generates microwaves in the co-axial mode or the waveguide mode by carrying out, by impedance matching, mode conversion of the microwaves (surface waves S2) in the surface wave mode that have reached terminal edge 17. Matching unit 22 transmits the microwaves resulting from the mode conversion to connecting unit 32 by microwave transmission line 31.

[0062] The microwaves are supplied to surface wave exciter 20 through power supply edge 33 by way of connecting unit 32. With the microwaves, surface waves S3, which propagate in propagation direction D3 orthogonal to propagation direction D1 of surface waves S1 and S2, are generated. Heating subject 6 is heated also with surface waves S3. Thus, in the present exemplary embodiment, matching unit 22 and connecting unit 32 correspond to the reuse unit.

[0063] Surface wave exciter 20 according to the present exemplary embodiment has a pin-type stub structure. The pin-type stub structure is a periodic structure including a plurality of columnar pins horizontally periodically arranged.

[0064] FIG. 5 and FIG. 6 illustrate examples of the pin-type stub structure. Surface wave exciter 20 illustrated in FIG. 5 includes pins 20a each in the shape of a quad-

rangular prism. Surface wave exciter 20 illustrated in FIG. 6 includes pins 20b each in the shape of a circular cylinder. In surface wave exciter 20, the surface waves can propagate along in the alinement of the pins, that is, in an arbitrary direction parallel to the horizontal plane in which the pins are arranged.

[0065] As described above, in high-frequency heating device 1c, microwaves that have not been absorbed by heating subject 6 are re-supplied to surface wave exciter 20 through connecting unit 32. In this way, high-frequency heating device 1c is capable of reusing, for heating a heating subject, microwaves that have not been absorbed by the heating subject. As a result, the utilization efficiency of microwave energy can be improved.

EMBODIMENT 4

[0066] High-frequency heating device 1d according to Embodiment 4 of the present disclosure will be described focusing on differences from Embodiment 1. FIG. 7 is a horizontal cross-sectional view schematically illustrating a configuration of high-frequency heating device 1d. FIG. 7 schematically illustrates a situation in which microwaves in the surface wave mode propagate on surface wave exciter 30 and also schematically illustrates a placement position of heating subject 6 on tray 4 (not illustrated in FIG. 7).

[0067] High-frequency heating device 1d does not include reflective unit 14 which is the reuse unit, but includes surface wave exciter 30 which, because of its shape, can reuse microwaves that have not been absorbed by heating subject 6.

[0068] As illustrated in FIG. 7, surface wave exciter 30 is curved in a U-shape in plan view. Specifically, surface wave exciter 30 includes straight portion 30a, curved portion 30b, and straight portion 30c. Heating subject 6 is placed on tray 4 (not illustrated in the drawings), on and between straight portions 30a and 30c. Straight portion 30a, curved portion 30b, and straight portion 30c correspond to the first portion, the second portion, and the third portion, respectively.

[0069] Straight portion 30a extends in a straight line in plan view and propagates, in propagation direction D1, surface waves S1 obtained from the microwaves supplied through connecting unit 12. Surface waves S2, which are part of surface waves S1, further propagate on straight portion 30a without being absorbed by heating subject 6, and reach the terminal edge of straight portion 30a.

[0070] Curved portion 30b has the shape of a fan with a central angle of 180 degrees in plan view and connects straight portion 30a and straight portion 30c. Surface waves S2 that have propagated from straight portion 30a to curved portion 30b in propagation direction D1 propagate from curved portion 30b to straight portion 30c in propagation direction D2. In other words, curved portion 30b changes the propagation direction of surface waves S2. In the present exemplary embodiment, the propagation direction of surface waves S2 is reversed.

[0071] Straight portion 30c is connected to curved portion 30b and extends in a straight line in plan view. Straight portion 30c propagates, in propagation direction D2, surface waves S2 that have been reversed in the propagation direction by curved portion 30b.

[0072] With the above-described configuration, heating subject 6 is heated with surface waves S1 obtained as a result of propagation, on straight portion 30a, of microwaves supplied through connecting unit 12. In addition, heating subject 6 is also heated with surface waves S2 propagating on straight portion 30c in the propagation direction reversed by the curved portion 30b.

[0073] In the present exemplary embodiment, the reuse unit is not formed of other members such as reflective unit 14 and matching unit 22 unlike in Embodiments 1 and 2. Curved portion 30b and straight portion 30c included in surface wave exciter 30 function as the reuse unit.

[0074] As described above, high-frequency heating device 1d uses again, for heating heating subject 6, microwaves that have not been absorbed by heating subject 6. In this way, high-frequency heating device 1d is capable of reusing, for heating a heating subject, microwaves that have not been absorbed by the heating subject. As a result, the utilization efficiency of microwave energy can be improved.

[0075] Although Embodiments 1 to 4 have been described above, the present disclosure is not limited to these exemplary embodiments.

[0076] For example, in Embodiment 1, reflective unit 14 is disposed so as to cover terminal edge 17 of surface wave exciter 10. However, another configuration is also applicable as long as the surface waves can be reflected. For example, reflective unit 14 may completely cover surface wave exciter 10.

[0077] In Embodiment 1, all metal plates 11 included in surface wave exciter 10 are set to the same height. However, metal plates 11 covered by reflective unit 14 may be stepwise reduced in height toward terminal edge 17, for example. With this configuration, the surface waves can be more accurately reflected.

[0078] In Embodiment 2, the rectenna is given as an example of conversion unit 24. However, this is not limiting as long as the microwaves can be converted into direct-current power.

[0079] In Embodiment 3, connecting unit 32 is disposed on power supply edge 33 which is an end portion of surface wave exciter 20 different from power supply edge 15 and terminal edge 17. However, power supply edge 33 may be disposed on power supply edge 15 or terminal edge 17.

[0080] In the present disclosure, only surface wave exciter 20 according to Embodiment 3 has a pin-type stub structure. However, surface wave exciters 10 according to Embodiments 1 and 2 and surface wave exciter 30 according to Embodiment 4 may each have the pin-type stub structure.

[0081] In Embodiment 4, surface wave exciter 30 is U-shaped. However, the shape of surface wave exciter 30 is not limited to this as long as surface wave exciter 30 changes the propagation direction of surface waves S2 that have propagated on surface wave exciter 30.

INDUSTRIAL APPLICABILITY

[0082] The present disclosure is applicable to a microwave oven, a dehydrator, a heating device for pottery, a garbage disposer, a semiconductor manufacturing device, and the like.

REFERENCE MARKS IN THE DRAWINGS

[0083]

1a, 1b, 1c, 1d	high-frequency heating device
4	tray
6	heating subject
8	generation unit
10, 20, 30	surface wave exciter
12	connecting unit (first connecting unit)
14	reflective unit (reuse unit)
15	power supply edge (one end portion of surface wave exciter)
16	control unit
17	terminal edge (another end portion of surface wave exciter)
20a, 20b	pin
22	matching unit (reuse unit)
23, 31	microwave transmission line
24	conversion unit (reuse unit)
25	direct-current power transmission line
26	power storage unit
30a	straight portion (first portion)
30b	curved portion (second portion)
30c	straight portion (third portion)
32	connecting unit (second connecting unit and reuse unit)
33	power supply edge

Claims

1. A high-frequency heating device comprising:

a generation unit configured to generate microwaves;
a surface wave exciter including a periodic structure and configured to heat a heating subject by propagating the microwaves in a surface wave mode;
a first connecting unit which is disposed at one end portion of the surface wave exciter and through which the microwaves generated by the generation unit are supplied to the surface wave exciter; and
a reuse unit configured to reuse, for heating the heating subject, the microwaves in the surface wave mode that have reached an other end portion of the surface wave exciter, the other end portion being located in a propagation direction of the microwaves from the one end portion of the surface wave exciter.

2. The high-frequency heating device according to claim 1, wherein
the reuse unit includes a reflective unit disposed at the other end portion of the surface wave exciter and configured to reflect the microwaves that have reached the other end portion of the surface wave exciter.

3. The high-frequency heating device according to claim 2, wherein
the reflective unit is a waveguide which covers the other end portion of the surface wave exciter.

4. The high-frequency heating device according to claim 1, wherein
the reuse unit includes a matching unit disposed at the other end portion of the surface wave exciter and configured to carry out, by impedance matching, mode conversion of the microwaves in the surface wave mode that have reached the other end portion.

5. The high-frequency heating device according to claim 4, further comprising:

a power storage unit configured to store direct-current power, wherein
the reuse unit further includes a conversion unit configured to convert, into the direct-current power, the microwaves resulting from the mode conversion by the matching unit, and supply the direct-current power to the power storage unit.

6. The high-frequency heating device according to claim 4, wherein
the reuse unit further includes: a second connecting unit disposed at one of end portions of the surface wave exciter; and a microwave transmission line which connects the matching unit and the second connecting unit.

7. The high-frequency heating device according to claim 1, wherein
the surface wave exciter includes: a first portion which propagates surface waves obtained from the microwaves supplied through the first connecting unit; a second portion connected to the first portion and configured to change a propagation direction of the surface waves; and a third portion which is connected to the second portion and propagates the surface waves in the propagation direction that has

been changed, and
the reuse unit is the second portion and the third portion.

8. The high-frequency heating device according to claim 1, wherein
the periodic structure includes a plurality of columnar pins horizontally periodically arranged.

FIG. 1

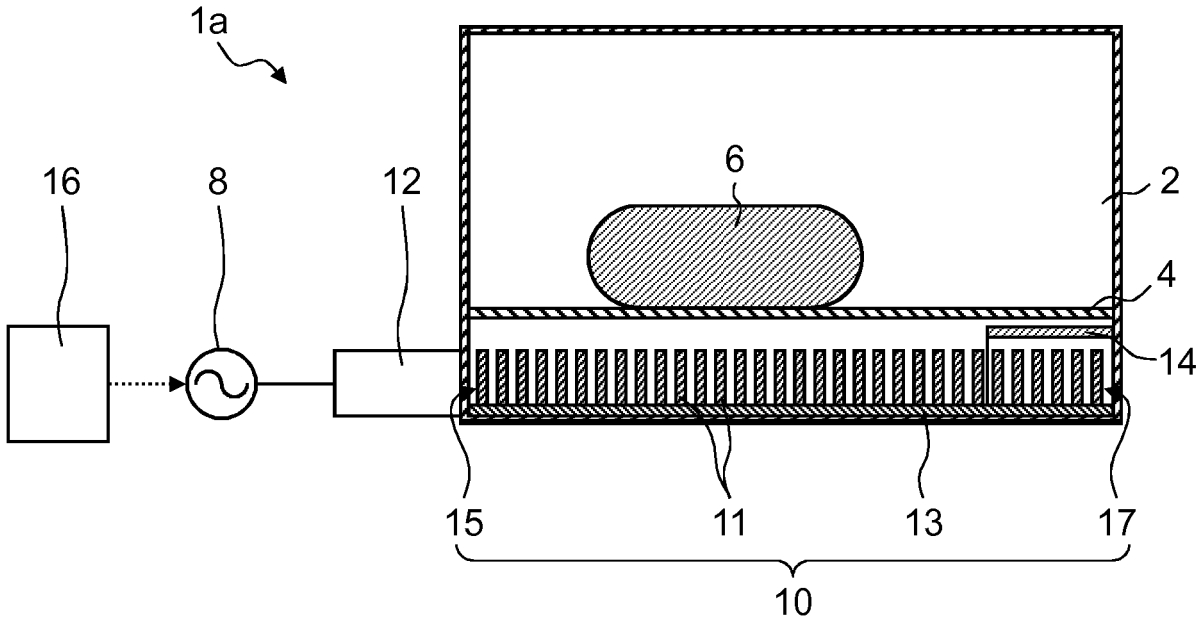
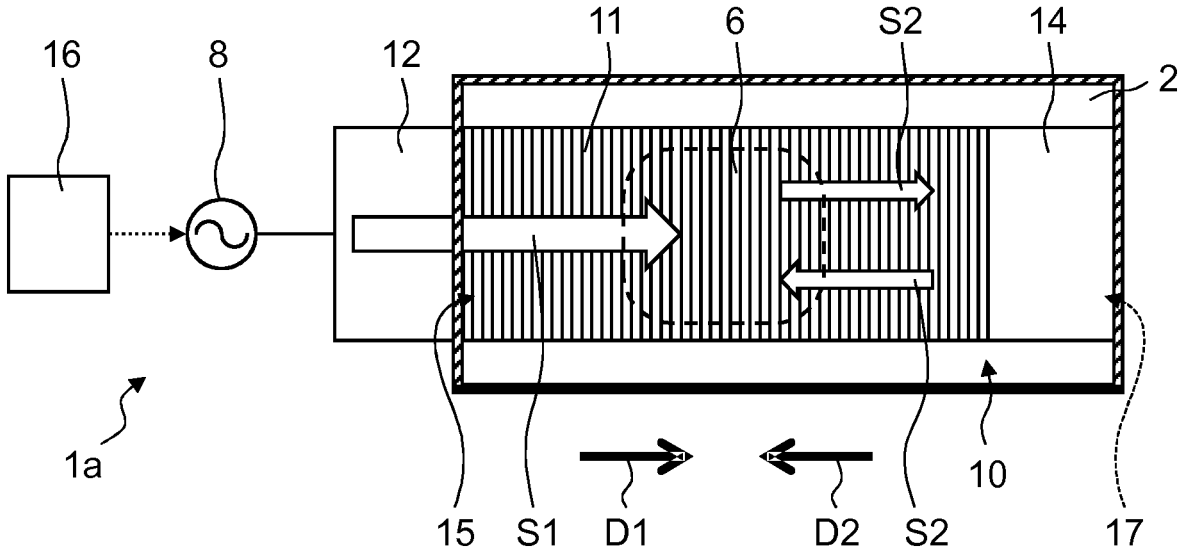

1a
16
8
12
6
2
4
14
15
11
13
17
10

FIG. 2


16
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11
6
S2
14
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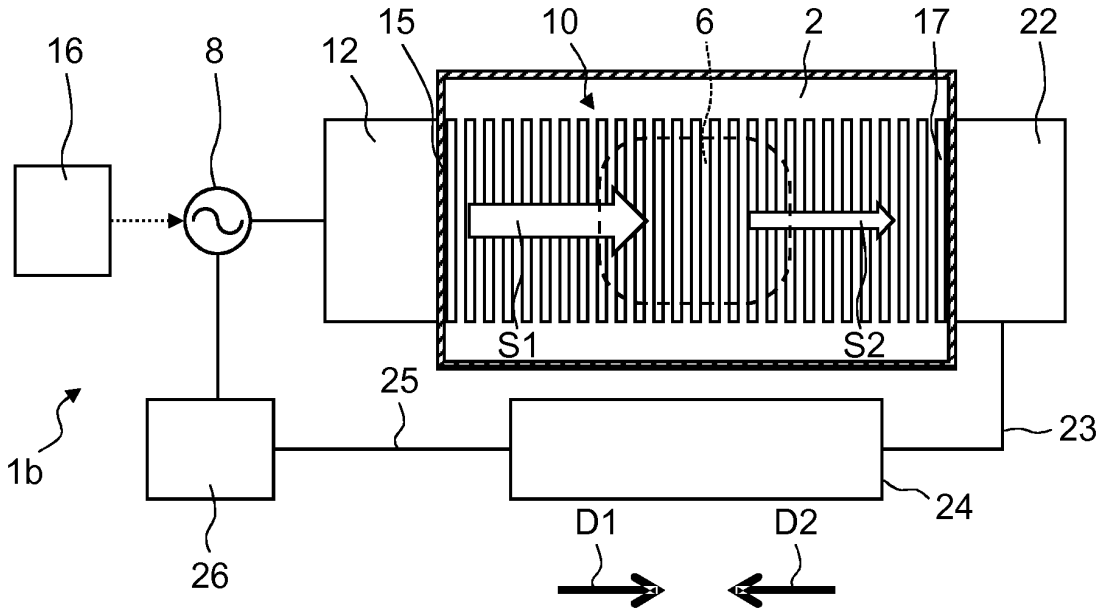
1a
15
S1
D1
D2
S2
10
17

FIG. 3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8
12
15
10
6
2
17
22
S1
S2
25
23
1b
24
26
D1
D2

FIG. 4

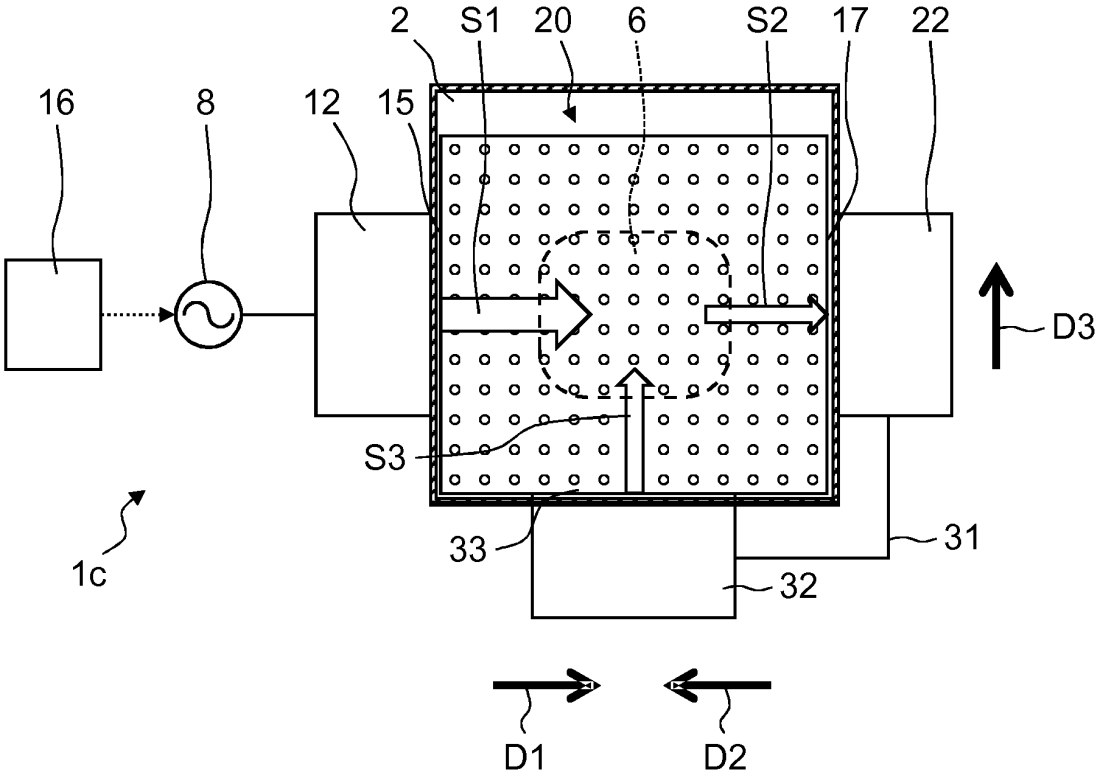

2
S1
20
6
S2
17
22
16
8
12
15
D3
S3
1c
33
31
32
D1
D2

FIG. 5

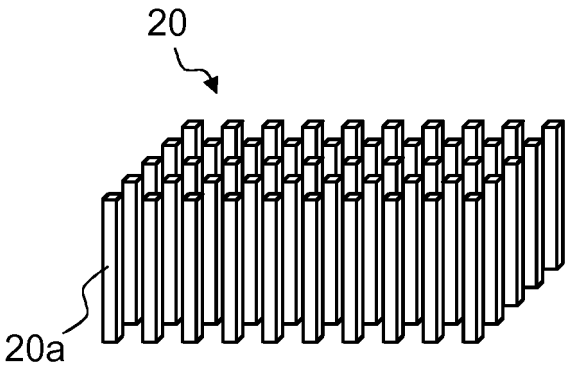


FIG. 6

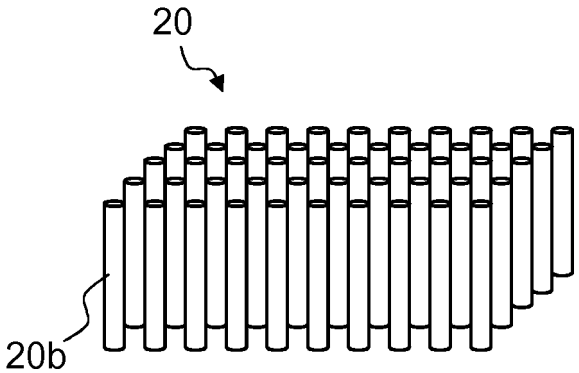
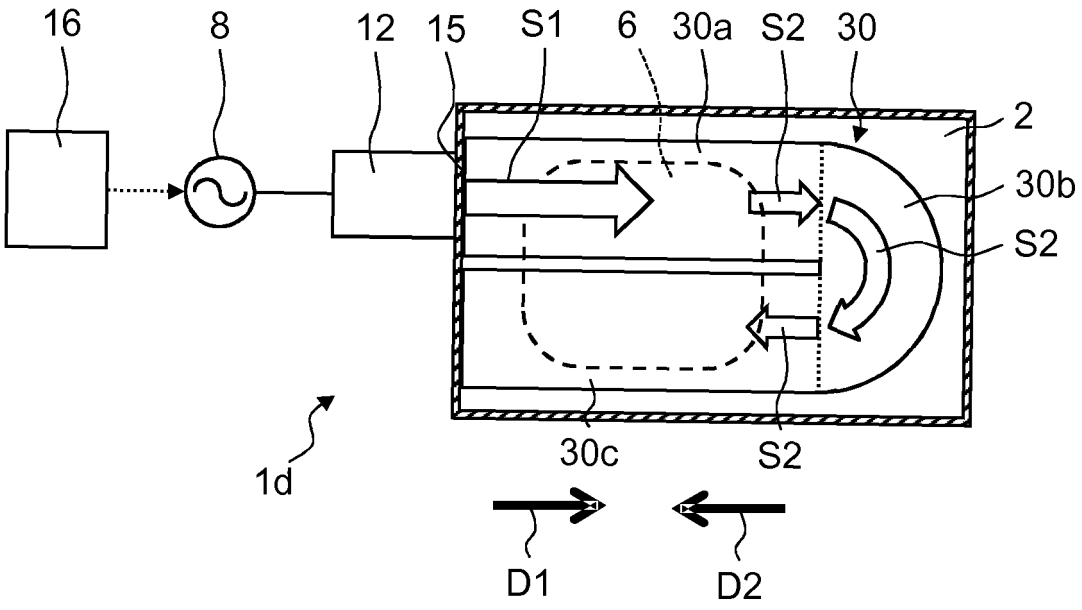


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/026620

A. CLASSIFICATION OF SUBJECT MATTER
H05B6/74(2006.01)i, *H05B6/70*(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)
H05B6/74, H05B6/70

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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.
X Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 141239/1981(Laid-open No. 078597/1982) (Matsushita Electric Industrial Co., Ltd.), 14 May 1982 (14.05.1982), specification, page 10, line 8 to page 11, line 5; fig. 13 (Family: none)	1,7,8 2,3 4-6
Y A	JP 57-124875 A (Sanyo Electric Co., Ltd.), 03 August 1982 (03.08.1982), claims; fig. 3 & GB 2088179 A fig. 8 & DE 3146045 A & NL 8105244 A	2,3 4-6

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 August 2017 (29.08.17)	05 September 2017 (05.09.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H08166133 B **[0004]**