

Description

The present invention generally relates to a stationary power transfer apparatus for transmitting or supplying electric energy through electromagnetic induction, and more particularly, to a technique and a high-frequency heating apparatus to which is applied the technique of electromagnetically shielding the power supply side of the stationary induction apparatus (primary side) from the power receiver side (secondary side), without impairing the electromagnetic induction function therebetween.

Because of the recent progress in inverter technology, inverter source systems are being put into practical use. In such inverter source systems, commercial frequencies are, before boosted by a boosting transformer and supplied to a magnetron, converted into high frequencies. Therefore, if the inverter source system is applied to an electronic oven, a power source of the magnetron of the electronic oven can be rendered compact in size, light in weight and low in manufacturing cost.

In the above-described development of the progress in technique, it has been tried to form such a microwave generating device for use in an electronic oven (a high frequency heating apparatus) that is light in weight and compact in size, wherein the primary side coil (power supply side induction element) of the boosting transformer (stationary induction apparatus) is positioned outside a shield casing, while the secondary side coil (power receiver side induction element) is placed inside the shield casing of the magnetron, so that the primary side coil and the secondary side coil are inductively coupled to each other to function as a transformer, whereas the primary side coil and the secondary side coil are separated from each other by the shield casing, thereby to maintain the shielding function of the shield casing.

In the electronic oven using the above-described system of the inverter power source, the high frequency waves of several tens kHz produced in the inverter circuit can be advantageously utilized as they are for induction heating. Therefore, if a heating coil for induction heating is added to the electronic oven employing the inverter power source, and the power is arranged to be supplied from the common inverter power source either to the heating coil or to the microwave generating device, an electronic oven equipped with the function of an electromagnetic cooking apparatus which can serve both as an electronic oven and as an electromagnetic cooking apparatus can be brought onto the market. In this case, although it may be possible to install the heating coil for electromagnetic cooking on the upper surface of the body of the electronic oven, it will be more convenient that the heating coil is placed at the bottom inside the heating chamber of the electronic oven, so that the room of the heating chamber can be a common space

for an object to be heated by the electronic oven and by the electromagnetic cooking apparatus. However, if the heating coil is placed within the heating chamber where the microwaves are irradiated, the exciting coil should be protected from damages caused by the microwaves, and for this purpose the exciting coil is necessary to be shielded from the microwaves, while the exciting coil which is an induction element at the power supply side is necessary to be inductively coupled to a metallic pan or the like (an object to be heated) which corresponds to an induction element at the power receiver side.

Both in the above-described microwave generating device and in the electronic oven functioning also as an electromagnetic cooking apparatus, the electromagnetic waves should be shielded between the power supply side and the power receiver side, but, the high-frequency power of several tens kHz should be transmitted through electromagnetic induction between the power supply side and the power receiver side. The above-described shielding and transmission of electromagnetic energy are contradictory facts from a physical viewpoint, and accordingly conventional techniques (as for instance described in JP-U-61/107 190) could not realize such ideas as the above microwave generating device or the electronic oven with the electromagnetic cooking apparatus. Those were only desk theories.

US-A 3,376,523 describes a power transfer apparatus, called magnetic transmission line, in which electric power is transferred by magnetic induction from a primary side of a transformer to the secondary side of the transformer. Between the primary side and the secondary side a shielding wall is provided to shield high frequency signals. However, if the distance between the electric power to be transmitted and the high frequencies to be shielded is low, the shielding measures are either not very effective, or the transmission of electric energy is affected.

An article in "Electronic Design", Vol. 31 (1983) February, No. 4, pages 165 - 174 discusses the theory of EMI/RFI shielding, and it is disclosed that wire mesh or metal foils can be used directly or in laminated form between plastic sheets to avoid EMI/RFI interferences. This article does not deal with the transfer of electric power by induction.

Accordingly, the invention concerns a power transfer apparatus comprising an induction element at the power supply side for supplying high frequency power through electromagnetic induction; an induction element at the power receiver side for receiving said high frequency power through electromagnetic induction; and a shielding wall formed by a metallic foil for shielding said induction elements from each other for frequencies higher than those of said high frequency power; as disclosed in US-A 3,376,523 mentioned above.

It is an object of the present invention to provide

such a power transfer apparatus having a good power transfer efficiency, and at the same time providing good high frequency shielding.

According to the invention, the power transfer apparatus is characterized by a shielding wall made of a metallic thin film having a thickness less than $1/10$ the depth of penetration with respect to the high frequency power to be transferred; and said metallic thin film being supported by a support member made of a dielectric material.

An alternative solution is characterized in that said shielding wall wall is made of a plurality of through hole cells each having a polygonal cross section and provided adjacent to each other as to have a common wall surface, the wall surface of each of said through hole cells being formed by a metallic foil in a thickness less than $1/10$ the depth of penetration with respect to the high frequency power, the size of the polygonal cross section of each of said through hole cells being such that their cut-off frequency, if regarded as a wave guide, is less than the frequency to be shielded.

Preferable embodiments of the power transfer apparatus are defined in the dependent claims, as well as a high frequency heating apparatus including such a power transfer apparatus.

The power transfer apparatus according to the present invention is applicable to those fields described at the beginning of the specification i.e. in a microwave generating device in a high frequency heating apparatus is one example. More specifically, in the microwave generating device, the secondary side of the boosting transformer (stationary induction apparatus) for supplying positive voltage (high voltage) and heater voltage (low voltage) to the magnetron is electromagnetically shielded from the primary side of the boosting transformer, through combination of the inverter power source, so that the leakage of electromagnetic waves from the cathode stem connected to the secondary side is prevented. Accordingly, the stationary induction apparatus of the present invention can achieve a highly efficient, light in weight and compact microwave generating device.

A second application example is an electronic oven which can serve also as an electromagnetic cooking apparatus, which has the heating coil placed in the bottom inside a heating chamber. According to the arrangement of this case, the heating coil which is an induction element at the power supply side is electromagnetically inductively coupled to a metallic pan (an object to be heated) which corresponds to an induction element at the power receiver side, while the heating coil including the plane facing the pan and the heating coil is electromagnetically shielded from the microwaves, so that the heating coil is not affected by the microwaves.

These and other objects and features of the present invention will become apparent from the following

description taken in conjunction with preferred embodiments thereof with reference to the accompanying drawings, throughout which like parts are designated by like reference numerals, and in which:

5 Fig. 1 is a cross sectional view of a conventionally proposed microwave generating device which is comprised of a magnetron using an inverter power source and its power circuit;

10 Fig. 2 is a cross sectional view of an example of a microwave generating device utilizing an inverter power source and provided with a stationary induction apparatus according to the present invention;

15 Figs. 3(a) and 3(b) are circuit diagrams of the microwave generating device of Fig. 2;

20 Fig. 4 is a graph showing shielding characteristic of metallic foils in the alternating magnetic field; Fig. 5 is a cross sectional view of a second example of a microwave generating device utilizing an inverter power source and installed with a stationary induction apparatus according to the present invention;

25 Figs. 6(a) and 6(b) are a perspective view and an enlarged plan view of a honeycomb core constituting an essential part of the microwave generating device of Fig. 5;

30 Figs. 7(a) to 7(c) are diagrams explaining the operation of the honeycomb core of Fig. 6;

35 Fig. 8 is a cross sectional view of an electronic oven with an electromagnetic cooking apparatus using the stationary induction apparatus according to the present invention;

40 Figs. 9(a) and 9(b) are enlarged views of an essential portion of the oven of Fig. 8;

45 Figs. 10(a) to 10(c) are diagrams showing the operation of the portion of Fig. 9; and

50 Fig. 11 is a circuit diagram of the electronic oven of Fig. 8.

Also, before starting the description of the present invention, it will be described first with reference to the disclosure in Japanese Utility Model Laid-Open Publication JP-U-61107190 (107190/1986) how the shielding of microwaves and the transmission of power through electromagnetic induction could not be technically achieved all together heretofore according to the conventional methods.

Generally, a filter circuit is formed for the magnetron by a choke coil provided within a shielding casing covering a cathode stem of the magnetron and a through capacitor, so as to prevent leakage of the electromagnetic waves from an input terminal side, namely, the cathode stem side. However, when an inverter power source using, for example, over 20 kHz frequency is used, the power which is converted into high-frequency waves by the inverter is unfavorably affected by the filter circuit and therefore, becomes difficult to be supplied to the magnetron. Fig. 1 shows a cross sectional view of an essential portion of a con-

ventional microwave generating device using the inverter power source disclosed in the above Japanese Utility Model Laid-Open Publication No. 61-107190 which device is proposed to solve the above-described disadvantage. In the microwave generating device of Fig. 1, an oscillator tube 14 has an antenna 19 at one end thereof, and a cathode stem 20 at the other end which has cathode terminals 21 and 22. The cathode stem 20 is surrounded by a shield casing 23 which is electrically connected to the oscillator tube 14 and formed by a non-magnetic conductive material. The shield casing 23 completely shields the inside from the outside of the casing electromagnetically. A primary side core 24 wound by a primary side winding 6a of a boosting transformer 6 is positioned outside the shield casing 23 opposite to a secondary side winding 6b and a low voltage secondary side winding 6c inside the shield casing 23, via wall surface 23a. In the instant reference, the primary side core 24 and the secondary side core 25 are so positioned via the wall surface 23a as to be electromagnetically coupled to each other through mutual induction. Accordingly, the high frequency waves can be prevented from leaking from the side of the input stem of the magnetron, and simultaneously the power converted into high frequency waves can be supplied to the magnetron. However, although it appears that the above-described arrangement functions as explained, but practically, the construction is merely a desk theory that is impossible to be achieved, the reason for which will be described hereinbelow.

According to the description of the abovementioned Japanese Utility Model Laid-Open Publication, the shield casing 23 surrounding the cathode stem 20 provided at one end of the oscillator tube 14 is formed by a non-magnetic conductive material, and the primary side and the secondary side of the boosting transformer are placed outside and inside the shield casing 23 via the wall surface 23a. In this case, it is true that the leakage of the high frequency waves from the cathode stem 20 can be prevented, but the primary side and the secondary side of the boosting transformer are shielded at the same time and therefore, the electromagnetic energy cannot be transmitted to the magnetron. Therefore, such position or arrangement of the primary side and the secondary side of the boosting transformer cannot be able to provide electromagnetic coupling therebetween through mutual induction. This is because, since the wall surface 23a of the shield casing 23 is formed by a conductive material, the magnetic field produced by the high frequency current running in the primary winding 6a of the boosting transformer 6 generates an induced eddy current in the wall surface 23a, and the electric energy of the magnetic field is consumed as Joule heat by this eddy current. As a result, the electric energy is never transmitted to the secondary side windings 6b and 6c of the boosting transformer

6, or is attenuated on a large scale. From another viewpoint, the shield casing 23 made of a conductive material is equivalent to a third secondary winding which is short-circuited and added to the boosting transformer 6. Therefore, it may be so considered that the electric energy of the magnetic field is almost all consumed by the short-circuited current flowing in the short-circuited secondary winding. In any case, it cannot be helped but the conventional arrangement is merely an imaginary idea because the shield casing 23 has a function impossible to be achieved physically by conventional means or measures.

In order to eliminate or solve the above-described disadvantages inherent in the prior art, the present invention provides a shielding technique to be applied to a high-frequency heating apparatus installed with a stationary induction apparatus, whereby the power supply side (the primary side) of the stationary induction apparatus can be shielded from the power receiver side (the secondary side) electromagnetically, without impairing the electromagnetic induction function therebetween.

Although various modes can be considered for practicing the present invention, some will be described one by one with reference to their embodiments.

A first embodiment is related to a magnetron and its boosting transformer, the construction and the operation of which will be described with reference to Figs. 2 to 5.

In Fig. 2, there is shown a cross sectional view of an essential portion of a high frequency heating apparatus which includes a stationary induction apparatus according to the first embodiment of the present invention. Fig. 3(a) is a circuit diagram schematically showing the circuit construction of the high frequency heating apparatus including the essential portion shown in Fig. 2.

Referring to Fig. 3(a), electric power at commercial frequencies supplied by a power source 1 is rectified by a rectifier circuit 3, and then supplied to an inverter circuit comprising a capacitor 8, a diode 9 and a transistor 10 as a switching element, through a low-pass filter composed of an inductance 5 and a capacitor 4. The transistor 10 is turned on or off by a high frequency pulse generated from a control circuit 11.

After the power is converted into a high frequency wave of approximately 20 kHz by the inverter circuit and supplied to a primary winding 7a of a boosting transformer 7, it is excited at a secondary winding 7b as the anode voltage of the magnetron and at a secondary winding 7c as the cathode voltage of the magnetron, respectively, to be inputted to the magnetron 13. In Fig. 2, an oscillator tube 14 is a main body of the magnetron, which has an antenna 19 at one end and a cathode stem 20 at the other end. A shield casing 28 covering the cathode stem 20 has a lid 28a which is a part of the wall surface of the casing and composed of a shield film 28b of a non-magnetic met-

allic thin film or a metallic evaporated film, and a support member 28c made of a dielectric material which supports the shield film 28b.

The boosting transformer 7 has its core divided by the lid 28a of the shield casing 28 to be positioned inside and outside of the casing 28. A primary side core 7p outside the shield casing 28 is wound with a primary winding 7a, and a secondary side core 7s inside the shield casing 28 is wound with secondary windings 7b and 7c. It is general that the material of the core is ferrite from the frequency viewpoint. As has been already mentioned above, the primary winding 7a is supplied with the voltage converted into high frequency by the inverter circuit, while the high voltage and the low voltage generated respectively in the secondary windings 7b and 7c are, through cathode terminals 20 and 21, inputted as the anode voltage and the cathode voltage to the magnetron, respectively.

The shielding effect of the shield casing 28 and the operation of the boosting transformer 7 will be explained hereinbelow.

Generally, when a conductive member which is represented by metal is applied with an alternating magnetic field whether it is magnetic or non-magnetic, an induced current is produced. The depth by which the induced current penetrates from the surface is limited, and the depth when the current density I becomes $1/e$ of the surface current density I_0 is called as the depth of penetration $\rho(m)$ which establishes an equation $\delta = \sqrt{\rho/\pi f \mu}$, wherein ρ is a specific resistance of the conductor (ohm-m), $f(\text{Hz})$ is frequency and μ is a specific magnetic permeability.

In general, the current density I in the conductor at a position spaced x from the surface is expressed by an equation, $I = I_0 \cdot e^{-x/\delta}$ wherein I_0 represents the current density on the surface. Attenuation of the magnetic field is proportional to the attenuation of the current, and the attenuation ratio A (dB) is expressed as follows,

$$A = 20 \log \frac{H_0}{H} = 20 \log \frac{I_0}{I} = 8.686x \frac{x}{\delta} \text{ dB}$$

Accordingly, for example, in the case of an aluminum plate, the depth of penetration δ is 0.6 mm or so in the frequency of 20 kHz. Even if the aluminum plate is so thin as about 0.6 mm, the attenuation ratio A is 8.686 dB. Thus, the alternating magnetic field added from one surface of the aluminum plate hardly penetrates to the opposite surface, and almost all of which is consumed as an ohmic loss by the induced current in the aluminum plate.

However, if an aluminum leaf or foil, not a plate, in the thickness of 20 μm is employed, this thickness of 20 μm is $1/30$ of $\delta=0.6$ mm (600 μm), which is the depth of penetration in 20 kHz frequency. The attenuation ratio A becomes 0.3 dB. Accordingly, contrary to the above case of the aluminum plate, the energy can

be transmitted to the opposite surface nearly to a full scale (97%).

Fig. 4 indicates how the shielding rate with respect to the alternating magnetic field of the metallic foil or the conductive coating film changes in accordance with the frequency. As is clear from the graph of Fig. 4 and also from the equation $\delta = \sqrt{\rho/\pi f \mu}$, the depth of penetration δ becomes smaller in accordance with the increment of the frequency f , thereby to increase the shielding effect of the metallic foil or the conductive coating film.

In the case where a metallic thin film, that is, non-magnetic stainless steel (SUS) having a thickness of 50 μm is employed for the shielding film 28b, it can be said that the metallic thin film displays no shielding effect at all with respect to the alternating magnetic field in the frequency less than 100 kHz. Consequently, the boosting transformer 7 perfectly serves as a transformer although the primary side and the secondary side thereof are divided by the lid 28a. In the meantime, noises generated by the magnetron spread widely into the low frequency region as well as to the basic frequency region of 2450 MHz. In the high frequency region over 10 MHz essentially necessary to be shielded, even if the shield film 28b is a metallic foil of non-magnetic stainless steel (SUS) of 50 μm , the shielding effect is achieved over 25 dB (magnetic field mode) and moreover, the shielding efficiency is more and more increased as the frequency becomes higher. It is to be noted here that the windings of the transformer are coupled to each other by the alternating magnetic field, and the data indicated in Fig. 4 is obtained in the magnetic field mode. However, it is made clear by experiments that, when the same 50 μm non-magnetic stainless steel (SUS) in the shape of a foil is employed in the electric field mode, a shielding effect having the attenuation ratio over 40 dB is achieved, including in the frequency region less than 10 MHz. Therefore, with respect to the electromagnetic waves leaking from the cathode stem 20 which should be prevented, actually effective shielding is exercised in the middle of the magnetic field mode and the electric field mode, and accordingly the non-magnetic stainless steel is sufficiently effective as the shield film for prevention of leakage of the high frequency waves.

Although the thickness of the shield film 28b is determined with consideration taken into the boosting transformer 7 and the shielding characteristic, etc., the loss in the shield film 28b should be also considered, and therefore a standard thickness of the shield film 28b is less than $1/10$ the depth of penetration δ .

In the case where the shield film 28b has the thickness of $1/10$ of the depth of penetration δ , the attenuation ratio A is approximately 10%, in accordance with the earlier-described equation $A = 8.686$

$\times \frac{X}{\delta}$ (dB), that is, $A = 0.8686$ dB.

On the contrary, the minimum thickness of the shield film is decided by the lowest frequency to be shielded and the shielding characteristic (attenuation ratio) required. Although radiation leaking from the cathode stem 20 of the magnetron 13 is spread all the way not only to the high frequency region around 2450 MHz, but also to the low frequency region, the lowest frequency for which is required high shielding effect of the shield casing is approximately 20 MHz. Supposing that the inverter frequency is 20 kHz, the above-mentioned lowest frequency 20 MHz is 1000 times the inverter frequency, and the depth of penetration is approximately 1/30. Accordingly, if the shield film is made of aluminum, the depth of penetration is 0.02 mm (20 μ m) in the 20 MHz frequency which is 1/30 the depth of penetration 0.6 mm in the 20 kHz frequency, which will be the standard thickness of the shield film. In practice, however, for controlling the transmission loss as low as possible in the stationary induction apparatus, the shielding characteristic may be sacrificed a little, and a thinner shielding film, namely, a shielding film having 1/100 or 1/200 the depth of penetration in the inverter frequency is employed in many cases.

As will be understood from the description above, according to the first embodiment of the present invention, the shield casing 28 is able to prevent leakage of the high frequency waves from the cathode stem of the magnetron, and at the same time, the boosting transformer 7, even though it is divided by the wall surface of the shielding casing 28, is able to perform its function as a transformer.

If a conventional boosting transformer is employed at the commercial frequency and a power of, for example, about 1 kW such a transformer would be almost an iron block having 4 kg in weight and 110x110x70 mm in outer dimension which is considerably heavier and bulkier than a magnetron having 1 kg in weight and 100x100x50 mm in outer dimension. Not only the whole power source circuit would become large in weight and size, but the boosting transformer is impossible to be integrally formed with the shield casing of the magnetron. On the contrary, according to the present invention, because the power is converted into high frequency waves of several tens kHz by the high frequency inverter circuit, and moreover, the material of the magnetic core is changed from plate-like silicon steel to ferrite, a light and compact structure of the boosting transformer, i.e., 400 g in weight and 70x70x40 mm in outer dimension, can be realized, so that the boosting transformer is able to be integrated with the shield casing of the magnetron.

If the shield film is made of a magnetic metal, the shield film unfavorably forms a branching circuit (shunt circuit) in the magnetic circuit of the boosting

transformer 7, resulting in reduction of magnetic property. Therefore, it is preferable to use a non-magnetic metal such as aluminum, etc. for the shield film as described above. However, if a non-magnetic material such as represented by copper (Cu) or aluminum (Al) is employed, the depth of penetration δ becomes small because of the small specific resistance (ohm-m) thereof, giving rise to troubles in processing. Therefore, the material of the shield film should be selected carefully with the above-described facts taken into consideration. For example, Monel (an alloy mainly composed of nickel and copper) can be said to be suitable for the material of the shield film since it is non-magnetic, but has relatively large specific resistance.

Further, in order to lessen the eddy current loss by the magnetism leaking from the boosting transformer, it is preferable that the other shield wall surface of the shield casing 28, except the shield film 28b, is made of, for example, aluminum which shows good electric conductivity, and is non-magnetic metal. The thickness of the wall surface is desirably over 0.6 mm which is the depth of penetration in the inverter frequency (20 kHz) of aluminum.

A ventilation hole 28d is formed in the overall surface of the shield casing 28 so as to cool the secondary side of the boosting transformer 7. The secondary side is forcibly cooled by a cooling fan 2 from outside of the shield casing 28.

Although it is so arranged in the present embodiment that the voltage at the secondary side of the boosting transformer is added to the magnetron as it is as an anode voltage, the voltage at the secondary side may be doubled and rectified by a diode and a capacitor, or subjected to full wave rectification by many diodes, and then added to the anode electrode. It is needless to say that various types of circuit constructions are possible. In the circuit constructions described above, such circuit elements as the diode, the capacitor, etc. are naturally placed inside the shield casing. Fig. 3(b) shows one example of such circuit construction as above, in which a diode 29 and a capacitor 30 constitute a voltage doubler circuit.

As is described hereinabove, the following effects can be achieved by the microwave generating device installed with the stationary induction apparatus of the present invention.

(1) The microwaves leaked from the cathode stem of the magnetron and the high frequency wave noises accompanied with the leakage of the microwaves are shielded within the shield casing, whereas the secondary side circuit of the boosting transformer inside the shield casing is able to be magnetically coupled to the primary side circuit outside the shield casing, thereby to fulfill the function as a transformer. As a result, the power which is converted into high frequency waves by the inverter can be effectively supplied to the

magnetron.

(2) When a conventional boosting transformer which steps up the power at the commercial frequency as it is employed to handle power of, for example, about 1 kW, the boosting transformer cannot be integrally formed with the magnetron since the boosting transformer is as heavy as over 4 kg, that is, four times the weight of the magnetron and, the outer dimension of the boosting transformer is very large. However, owing to the high frequency inverter employed, since the power is converted into high frequency waves of several tens kHz according to the present embodiment, and moreover, the magnetic core is changed from silicon steel plate to ferrite according to the present embodiment, the microwave generating device is realized in remarkably compact structure, 400 g weight and small dimension, wherein the boosting transformer and the magnetron are integrally formed.

(3) A filter circuit composed of an inductance and a capacitance (a through capacitor) which is provided in the prior art shield casing for avoiding leakage of high frequency wave noises is not necessary in the present embodiment. Accordingly, the voltage decrease and the power loss caused by the filter circuit are solved. At the same time, since the capacitance (through capacitor) and the inductance which are necessary to be high in voltage resisting property and accordingly expensive because the anode voltage is so high as about 4 kV can be solved, the manufacturing cost of the apparatus can be remarkably reduced.

Similarly to the first embodiment, a second embodiment is related to the magnetron and the boosting transformer. The difference is the structure of a shielding wall provided between the primary side (power supply side induction element) and the secondary side (power receiver side induction element) of the boosting transformer. With reference to Figs. 5 through 7, mainly the difference of the second embodiment from the first embodiment will be described.

Fig. 5 is a cross sectional view of an essential portion of a microwave generating device utilizing the inverter power source and installed with a stationary induction apparatus (boosting transformer) according to the second embodiment.

In the construction of Fig. 5, the lid 28a which is a part of the wall surface of the shield casing 28 covering the cathode stem 20 is constructed by a honeycomb core 28f made of aluminum foil and a supporter 28c made of dielectric material for supporting the honeycomb core 28f. The construction of the lid 28a of the second embodiment is different from that of the first embodiment shown in Fig. 2.

With reference to Fig. 6, the structure of the aluminum honeycomb core 28f will be described in de-

tail.

Fig. 6(a) is a perspective view of a part of the aluminum honeycomb core 28f cut out in general rectangular shape, and Fig. 6(b) is an enlarged view of one (unit structure) of cells composing the aluminum honeycomb core 28f. As seen from Fig. 6(b), the honeycomb core 28f is formed by many hexagonal cells through sticking of aluminum foils one after another. The honeycomb core 28f has relatively large mechanical strength in spite of its small weight, and therefore honeycomb cores are used in aircrafts. Moreover, the honeycomb core 28f shows shielding effects against electromagnetic waves while the gas permeability thereof is maintained. Accordingly, the honeycomb core is put into wide use, for example, in ventilation windows of a shield room for shielding electromagnetic waves, etc. According to the second embodiment, the aluminum foil thickness S of the honeycomb core 28f is, in the case where the inverter frequency is 20 kHz, below 1/10 of the depth of penetration 0.6 mm of the aluminum with respect to the above frequency. The cell size D and the core height T of the honeycomb core 28f are set on the basis of the largest frequency of the unwanted radiation to be shielded, and in the second embodiment, the core height T is 1.5 mm and the cell size D is approximately 3 mm.

Hereinafter, the operation of the microwave generating device having the above-described construction according to the second embodiment of the present invention will be described. First, the function of the boosting transformer will be explained with reference to Fig. 7.

Fig. 7(a) indicates the relation of the honeycomb core 28f made of the aluminum foil 32, the boosting transformer 6 which is separately arranged by the honeycomb core 28f outside and inside the shield casing 28, and the line 31 of magnetic flux in the high frequency magnetic field of 20 kHz which is generated when the boosting transformer 7 is driven. Fig. 7(b) is an enlarged view showing the relation between the honeycomb core 28f and the line of magnetic flux 31. The line of magnetic flux 31 is generally parallel to the axial direction of each cell (unit structure) forming the honeycomb core 28f.

As has been described in the first embodiment, generally, an electric conductor which is represented by metal, when applied with an alternating field, generates an induced current, whether the conductor is magnetic or non-magnetic. The induced current penetrates from the surface of a limited depth. The depth when the current density I becomes 1/e of the surface current density I₀ is called as the depth of penetration δ(m). And the depth of penetration δ(m) is expressed by an equation:

$$\delta = \sqrt{\rho / \pi f \mu}$$

wherein ρ(ohm-m) is a specific resistance of the conductor, f(Hz) is a frequency and μr is a specific per-

meability. The current density I in the conductor at a position x from the surface is expressed:

$$I = I_0 e^{-x/\delta} \quad (1)$$

wherein I_0 is the current density at the surface. By way of example, when the conductor is aluminum, the depth of penetration δ is approximately 0.6 mm when the frequency is 20 kHz. The direction of the induced current is vertical to the direction of the magnetic field (the line of magnetic flux 31).

Fig. 7(c) shows the relation of the aluminum foil 32 having the thickness S , the line of magnetic flux 31 in the alternating field added parallel to the aluminum foil 32, and the induced current produced in the aluminum foil 32. The current induced into the aluminum foil is exponentially and functionally decreased from the surface, as indicated by equation (1). The direction of the current induced in the aluminum foil 32 is vertical to the magnetic field, and moreover, the current density is I_a and I_b , opposite to each other, on the reverse and front surfaces of the aluminum foil, respectively. Meanwhile, if the thickness S of the aluminum foil composing the honeycomb core 28f is sufficiently smaller than the depth of penetration $\delta = 0.6$ mm, for example, if the thickness S is set to be 1/10 of the depth of penetration, the current densities I_a and I_b induced in the opposite directions on the reverse and front surfaces of the aluminum foil are opposite to each other, and accordingly, the actually running current density I is the difference between the current densities I_a and I_b . Therefore, the current induced in the aluminum foil placed parallel to the magnetic field is nearly neglectable if the thickness of the aluminum foil is less than 1/10 the depth of penetration δ , e.g., as small as 0.02 mm.

However, in the case where the honeycomb structure is gained by sticking of foils as in the present embodiment, the foils are piled up in double at two of the six sides of the hexagonal cell (unit structure). Therefore, the actual thickness of the aluminum foil at those two sides becomes double. This fact should be taken into consideration when the thickness of the aluminum foil is determined.

Thus, as described above, although the aluminum honeycomb core 28f is interposed between the primary side core 7p and the secondary side core 7s of the boosting transformer 7, energy loss is hardly produced in the high frequency magnetic field at 20 kHz, and accordingly the boosting transformer 7 can fully operate.

The operation and function of the shield casing 28 of the magnetron 13 will now be described.

The unwanted radiation leaking from the cathode stem 20 of the magnetron 13 is spread widely to the low frequency region as well as the 2450 MHz high frequency region. However, the shield casing 28 should do with the shielding effect only in the range about 20 MHz through 20 GHz at the widest.

In the case of the 20 MHz frequency, the depth

of the penetration δ of the aluminum foil composing the honeycomb core 28f is $1/\sqrt{1000}$ the value in the case of 20 kHz, that is, about 0.02 mm, which is equal to the foil thickness of the honeycomb core 28f according to the present embodiment. In other words, when the frequency is over 20 MHz, the thickness of the aluminum foil composing the honeycomb core 28f becomes equal to or larger than the depth of penetration. Therefore, when the frequency is over 20 MHz, the aluminum foil having the thickness 0.02 mm shows the characteristic of a usual aluminum plate. Thus, if each of the cells constituting the honeycomb core 28f is regarded as a wave guide which displays cut-off phenomenon to the leaked electromagnetic waves, the cell, showing the cut-off phenomenon, is said to have the shielding characteristic. On the other hand, in a higher frequency, according to the present embodiment, even when the largest frequency of the unwanted radiation extends to 20 GHz, the cell size D is 1/5 the wavelength $\lambda = 15$ mm since the cell size D is set to be 3 mm, which is completely within the shielding region. Therefore, the honeycomb core 28f can show high shielding effects.

As can be understood from the foregoing description, in the construction of the microwave generating device, not only the shield casing 28 is able to prevent the unnecessary radiation from leaking from the cathode stem 20 of the magnetron 13, but the boosting transformer 7 can fulfill its function as a transformer although it is separated by the wall surface of the shield casing 28.

The thickness of a metallic foil composing the honeycomb core 28f is decided, as is clear from the above description, depending on electric characteristics such as the inverter frequency (20 kHz in the present embodiment), the lowest frequency of the unnecessary radiation to be shielded, and the efficiency of the boosting transformer, etc. However, considering the mechanical strength of the honeycomb core 28f, the optimum thickness is about 1/10-1/100 the depth of penetration in the inverter frequency.

In the meantime, when a magnetic metal is employed for the honeycomb core 28f, the honeycomb core 28f generates a branching circuit (shunt circuit) in the magnetic circuit of the boosting transformer 7, resulting in decrease of magnetic efficiency. Therefore, the honeycomb core 28f is preferably formed by a non-magnetic metal such as aluminum employed in the present embodiment. However, if non-magnetic copper (Cu) or aluminum (Al) is used for the honeycomb core 28f, since the specific resistance (ohm-m) is small, the depth of penetration δ is small, giving rise to a processing problem. Therefore, the material of the honeycomb core 28f should be selected from the total viewpoint, with the above-described facts noted. For example, Monel metal, which is an alloy mainly composed of nickel and copper, is non-magnetic and,

at the same time, relatively large in the specific resistance, and accordingly, it can be said to be used suitably for the honeycomb core 28f.

In the above-described embodiment, the shielding wall is formed in the honeycomb structure, namely, by sticking metallic foils into hexagonal cells. However, the shielding wall for shielding electromagnetic waves is not restricted to be in the honeycomb structure.

In other words, a shielding wall is effective if many through holes (cells) each having a polygonal cross section, for example, a triangular cross section, a square cross section or a hexagonal cross section and passing through the shielding wall are placed adjacent to each other, with a wall surface in common. Such shielding walls as constructed in the above-described manner will function similarly as the shielding walls in the structure of the honeycomb.

Ventilation openings 28d and 28e are formed in the wall surface of the shielding casing 28 so as to cool the secondary side of the boosting transformer 7. It is so designed that the secondary side of the boosting transformer 7 is forcibly cooled by a cooling fan 2 from outside of the shield casing 28.

The microwave generating apparatus according to the second embodiment exhibits the same function and the same effects as the apparatus according to the first embodiment.

An electronic oven which is designed to act as an induction heating range will be described with reference to Figs. 8 through 11. The construction of a stationary induction apparatus according to a third embodiment of the present invention is applied to an exciting coil of the electronic oven referred to above.

Fig. 8 shows a cross sectional view of an electronic oven having an induction heating range with a heating coil portion in the structure of the stationary induction apparatus of the present invention. Fig. 9 shows an essential portion of Fig. 8, namely, the heating coil portion of Fig. 8, in detailed manner.

Referring to Fig. 8, microwaves (high frequency electromagnetic field) generated by a magnetron 71 are irradiated into a heating chamber 35 through a wave guide 72 and a rotary antenna 33. The rotary antenna 33, generally in a fan-like configuration, is rotated by a motor 34, so that microwave heating is uniformly carried out.

On the other hand, an exciting coil 38 is provided right over the rotary antenna 33, and a partition plate 39 made of a dielectric material such as a heat resisting ceramic plate or the like is so placed as to be almost in contact with the exciting coil 38. The partition plate 39 serves not only to protect the rotary antenna 33 and the exciting coil 38 in the bottom within the heating chamber 35, but to place an object 37 to be heated thereon.

The high frequency power is supplied to the boosting transformer for driving the magnetron 71

and to the exciting coil 38 by a circuit, e.g., shown in Fig. 11. The circuit of Fig. 11 includes a power source 42 of commercial frequencies, a smoothing circuit 48 comprised of a rectifier 47, an inductance 43 and a capacitor 44, an inverter circuit 49 comprised of a switching element 46 and a capacitor 45, and a controlling-driving circuit 50 which turns the switching element 46 on or off. The high frequency voltage at several tens kHz produced by the controlling-driving circuit 50 is delivered either to the exciting coil 38 for induction heating or to the boosting transformer 40 of the magnetron 71 which is a source of microwaves of the dielectric heating, in accordance with switching of a switch 41.

Fig. 9 is a detailed view showing the construction of the exciting coil 38 of Fig. 8; Fig. 9(a) being a broken view, and Fig. 9(b) being a plan view of Fig. 9(a). The exciting coil 38 in Fig. 9 is comprised of an exciting coil winding 38a having a winding wound into a flat board shape, a ferrite core 53 provided on the under surface of the exciting coil winding 38a for shielding of magnetism, aluminum honeycomb cores 51a and 51b in a perforated disc shape so provided as to hold both the exciting coil winding 38a and the ferrite core 53 from up and down and, shield rings 54a and 54b respectively in the inner peripheral side and the outer peripheral side of the aluminum honeycomb cores 51a and 51b. The shield rings 54a and 54b are made of non-magnetic metallic plates. Moreover, the shield rings 54a and 54b have many slit holes 55a and 55b formed in a radial direction, thereby to hinder the flow of the induced current in a circumferential direction generated on the shield rings 54a and 54b and to prevent the loss and the temperature rise resulting from the heat generation.

Although the structure of the aluminum honeycomb cores 51a and 51b is the same as already described with reference to the second embodiment, the cell size D and the core height T of the cores 51a and 51b should be determined so that the 2450 MHz microwaves employed for dielectric heating can be sufficiently shielded, and also the distance between the exciting coil winding 38a and the object 37 to be heated is within the range possible for induction heating. Accordingly, in the third embodiment of the present invention, the core height T for both the cores 51a and 51b is 1.5 mm, with the cell size D being set to be approximately 3 mm.

The operation of the electronic oven equipped with the function of the induction heating range as above will be described below with reference to Fig. 10.

In Fig. 10(a), there is indicated the mutual relationship among the exciting coil winding 38a, the line of magnetic flux 61 showing the high frequency magnetic field generated by the exciting coil winding 38a, the metallic object 37 to be heated which is heated by the current induced in the high frequency magnetic

field, the ferrite core 53 for shielding the leakage of the induced current below the high frequency magnetic field, and the aluminum honeycomb core 51a for preventing the exciting coil winding 38a from being heated by the high frequency waves, that is, 2450 MHz microwaves for dielectric heating, or from discharging. Now that the honeycomb core 51a interposed between the exciting coil winding 38a and the object 37 to be heated has the cell size D small enough with respect to the wavelength of the high frequency electromagnetic field (microwaves) at 2450 MHz, each of the cells of the honeycomb core 51a can be regarded as a wave guide, and therefore the honeycomb core 51a can display high shielding effects (with respect to 2450 MHz) owing to the similar effects as obtained by the cut-off phenomenon by the wave guide. The relation between the high frequency magnetic field 61 in the 20 kHz frequency used for induction heating and the honeycomb core 51a shown in Fig. 10(a) is enlarged in Fig. 10(b). The line 61 of magnetic force of the high frequency magnetic field is generally parallel to the axis direction of the cells composing the honeycomb core 51a.

Consequently, for the same reason as in the second embodiment, the honeycomb core 51a hardly produces any loss with respect to the 20 kHz high frequency magnetic field, although the honeycomb core 51a is intervened between the object 37 to be heated and the exciting coil winding 38a. The honeycomb core 51a works to shield (protect) the exciting coil winding 38a from the 2450 MHz high frequency electromagnetic field, i.e., microwaves.

Since the aluminum honeycomb core 51b completely covers the ferrite core 53, such disadvantage is solved that the ferrite core 53 absorbs the microwaves and generates heat.

Although the above description is made on the assumption that the honeycomb core is made of an aluminum foil, naturally, it is not restricted to the aluminum foil. However, a non-magnetic metal is better since a branching circuit is not formed in the non-magnetic metal in the high frequency magnetic field.

In addition, the aluminum honeycomb core is employed in the upper and lower surfaces of the exciting coil winding, and the inner and outer peripheral surfaces of the honeycomb core are constituted by a non-magnetic metal such as aluminum, but, the employment of the honeycomb core is not limited to the range of the present embodiment.

Moreover, such advantageous characteristics of the honeycomb structure as good gas permeability and light weight can be fully utilized. Particularly, the good gas permeability of the honeycomb structure is effective to control the temperature rise of the exciting coil winding 38a.

Accordingly, the application of the structure of the stationary induction apparatus of the present invention to the exciting coil will bring about the follow-

ing effects.

(1) Since the honeycomb coil winding is covered with the honeycomb core made of a metallic foil, the exciting coil winding can be prevented from generating heat or discharging by the influences of the microwaves, and at the same time, the high frequency magnetic field for induction heating generated by the exciting coil winding can reach the object to be heated without being attenuated, so that the generation of heat in the exciting coil at the induction heating time can be inhibited, while maintaining high heating efficiency.

(2) Furthermore, although it is natural, the honeycomb core has gas permeability, and accordingly, is effective to cool the exciting coil, so that the discharging of the heat can be effectively performed.

(3) The honeycomb core also covers the ferrite core below the exciting coil winding for shielding of the magnetism, and therefore, the ferrite core is prevented from absorbing the microwaves and generating heat.

Owing to the above-described advantages, a high frequency heating apparatus capable of induction heating and dielectric heating, which has been hardly believed to be practical, can be realized, with the exciting coil for induction heating provided within the heating chamber for dielectric heating, through application of the structure of the stationary induction apparatus according to the present invention to the induction heating coil of the apparatus.

Claims

1. Power transfer apparatus comprising
 - an induction element (7p, 7a) at the power supply side for supplying high frequency power through electromagnetic induction;
 - an induction element (7s, 7b, 7c) at the power receiver side for receiving said high frequency power through electromagnetic induction; and
 - a shielding wall (28b) formed by a metallic foil for shielding said induction elements from each other for frequencies higher than those of said high frequency power;
 characterized by
 - said shielding wall (28b) being made of a metallic thin film having a thickness less than 1/10 the depth of penetration with respect to the high frequency power to be transferred; and
 - said metallic thin film being supported by a support member (28c) made of a dielectric material.
2. Power transfer apparatus as claimed in claim 1, characterized in that the dielectric material is ceramic material.



field, the ferrite core 53 for shielding the leakage of the induced current below the high frequency magnetic field, and the aluminum honeycomb core 51a for preventing the exciting coil winding 38a from being heated by the high frequency waves, that is, 2450 MHz microwaves for dielectric heating, or from discharging. Now that the honeycomb core 51a interposed between the exciting coil winding 38a and the object 37 to be heated has the cell size D small enough with respect to the wavelength of the high frequency electromagnetic field (microwaves) at 2450 MHz, each of the cells of the honeycomb core 51a can be regarded as a wave guide, and therefore the honeycomb core 51a can display high shielding effects (with respect to 2450 MHz) owing to the similar effects as obtained by the cut-off phenomenon by the wave guide. The relation between the high frequency magnetic field 61 in the 20 kHz frequency used for induction heating and the honeycomb core 51a shown in Fig. 10(a) is enlarged in Fig. 10(b). The line 61 of magnetic force of the high frequency magnetic field is generally parallel to the axis direction of the cells composing the honeycomb core 51a.

Consequently, for the same reason as in the second embodiment, the honeycomb core 51a hardly produces any loss with respect to the 20 kHz high frequency magnetic field, although the honeycomb core 51a is intervened between the object 37 to be heated and the exciting coil winding 38a. The honeycomb core 51a works to shield (protect) the exciting coil winding 38a from the 2450 MHz high frequency electromagnetic field, i.e., microwaves.

Since the aluminum honeycomb core 51b completely covers the ferrite core 53, such disadvantage is solved that the ferrite core 53 absorbs the microwaves and generates heat.

Although the above description is made on the assumption that the honeycomb core is made of an aluminum foil, naturally, it is not restricted to the aluminum foil. However, a non-magnetic metal is better since a branching circuit is not formed in the non-magnetic metal in the high frequency magnetic field.

In addition, the aluminum honeycomb core is employed in the upper and lower surfaces of the exciting coil winding, and the inner and outer peripheral surfaces of the honeycomb core are constituted by a non-magnetic metal such as aluminum, but, the employment of the honeycomb core is not limited to the range of the present embodiment.

Moreover, such advantageous characteristics of the honeycomb structure as good gas permeability and light weight can be fully utilized. Particularly, the good gas permeability of the honeycomb structure is effective to control the temperature rise of the exciting coil winding 38a.

Accordingly, the application of the structure of the stationary induction apparatus of the present invention to the exciting coil will bring about the follow-

ing effects.

(1) Since the honeycomb coil winding is covered with the honeycomb core made of a metallic foil, the exciting coil winding can be prevented from generating heat or discharging by the influences of the microwaves, and at the same time, the high frequency magnetic field for induction heating generated by the exciting coil winding can reach the object to be heated without being attenuated, so that the generation of heat in the exciting coil at the induction heating time can be inhibited, while maintaining high heating efficiency.

(2) Furthermore, although it is natural, the honeycomb core has gas permeability, and accordingly, is effective to cool the exciting coil, so that the discharging of the heat can be effectively performed.

(3) The honeycomb core also covers the ferrite core below the exciting coil winding for shielding of the magnetism, and therefore, the ferrite core is prevented from absorbing the microwaves and generating heat.

Owing to the above-described advantages, a high frequency heating apparatus capable of induction heating and dielectric heating, which has been hardly believed to be practical, can be realized, with the exciting coil for induction heating provided within the heating chamber for dielectric heating, through application of the structure of the stationary induction apparatus according to the present invention to the induction heating coil of the apparatus.

Claims

1. Power transfer apparatus comprising an induction element (7p, 7a) at the power supply side for supplying high frequency power through electromagnetic induction; an induction element (7s, 7b, 7c) at the power receiver side for receiving said high frequency power through electromagnetic induction; and a shielding wall (28b) formed by a metallic foil for shielding said induction elements from each other for frequencies higher than those of said high frequency power; characterized by said shielding wall (28b) being made of a metallic thin film having a thickness less than 1/10 the depth of penetration with respect to the high frequency power to be transferred; and said metallic thin film being supported by a support member (28c) made of a dielectric material.
2. Power transfer apparatus as claimed in claim 1, characterized in that the dielectric material is ceramic material.



3. Power transfer apparatus comprising an induction element (7p, 7a) at the power supply side for supplying high frequency power through electromagnetic induction; an induction element (7s, 7b, 7c) at the power receiver side for receiving said high frequency power through electromagnetic induction; and a shielding wall (28f) formed by a metallic foil for shielding said induction elements from each other for frequencies higher than those of said high frequency power; characterized in that said shielding wall (28f) wall is made of a plurality of through hole cells each having a polygonal cross section and provided adjacent to each other as to have a common wall surface (32), the wall surface of each of said through hole cells being formed by a metallic foil in a thickness less than 1/10 the depth of penetration with respect to the high frequency power, the size of the polygonal cross section of each of said through hole cells being such that their cut-off frequency, if regarded as a wave guide, is less than the frequency to be shielded.
4. Power transfer apparatus as claimed in claim 3, characterized in that the through hole cells are of triangular, square or hexagonal cross section.
5. Power transfer apparatus as claimed in claim 3 or 4, characterized in that the wall surface of each through hole cell is formed from aluminum or copper foil.
6. Power transfer apparatus as claimed in claim 3, wherein said through hole cells are formed in a so-called honeycomb structure by sticking metallic foils (32) together.
7. Power transfer apparatus as claimed in any one of claims 1 to 6, where the metallic foil or the metallic thin film composing said wave shielding wall (28b, 28f) is made of a non-magnetic metallic material.
8. High frequency heating apparatus comprising a power transfer apparatus as claimed in any of claims 1 to 7, characterized by a magnetron (13) for generating microwaves, an inverter circuit for converting electric power of commercial frequencies into high frequency power of more than several tens kHz, a boosting transformer (7) for boosting and supplying said high frequency power to said magnetron (13), a primary winding (7a) of said transformer being part of the induction element (7p, 7a) at the power supply side, and a high voltage secondary winding (7b) for supplying anode voltage and a low voltage secondary

winding (7c) for supplying heater voltage being parts of the induction element (7s, 7b, 7c) at the power receiver side, the induction elements being at opposite sides of the wave shielding wall (28b, 28f) which is a part of the wall surface of a shielded casing for covering the portion of a cathode stem (20) of the magnetron (13) so as to prevent leakage of microwaves from the cathode stem portion to the outside.

9. High frequency heating apparatus which comprises a power transfer apparatus as claimed in any one of claims 1 to 7, characterized by a heating chamber where microwaves are radiated, a magnetron (13) for generating microwaves, a boosting transformer (7) for supplying electric power to said magnetron, an exciting coil (38) provided within said heating chamber for induction heating, and a high frequency inverter circuit for supplying electric power to said boosting transformer (7) and said exciting coil (38), the exciting coil (38) being used as the induction element at the power supply side, and the load of a pan (37) or the like to be heated being used as the induction element at the power receiver side, with the wave shielding wall (28b, 28f) interposed between the exciting coil (38) and the pan (37).
10. Power transfer apparatus as claimed in any one of claims 1 to 7, wherein an exciting coil (38) of an induction heating range, fed by a high frequency power over several tens kHz is used as the induction element at the power supply side, and the load of a pan (37) or the like to be heated is used as the induction element at the power receiver side, with the wave shielding wall (28b, 28f) interposed between the exciting coil (38) and the pan (37).

Patentansprüche

1. Einrichtung zum Übertragen elektrischer Leistung mit einem Induktionselement (7p, 7a) auf der die elektrische Leistung zuführenden Seite zum Zuführen elektrischer Leistung hoher Frequenz durch elektromagnetische Induktion; einem Induktionselement (7s, 7b, 7c) auf der die elektrische Leistung empfangenden Seite zum Empfangen der elektrischen Leistung hoher Frequenz durch elektromagnetische Induktion, und einer Abschirmwandung (28b) aus Metallfolie zum Abschirmen der Induktionselemente voneinander gegen Frequenzen, die höher sind als die der genannten elektrischen Leistung hoher Frequenz, dadurch gekennzeichnet, daß die Abschirmwandung (28b) aus einem metalli-



schen dünnen Film besteht, dessen Dicke geringer ist als 1/10 der Eindringungstiefe der zu übertragenden elektrischen Leistung hoher Frequenz, und
der metallische dünne Film von einem Halterungsglied (28c) gehalten wird, der aus einem dielektrischen Material besteht.

2. Einrichtung zum Übertragen elektrischer Leistung nach Anspruch 1, dadurch gekennzeichnet, daß das dielektrische Material Keramikmaterial ist.
3. Einrichtung zum Übertragen elektrischer Leistung mit einem Induktionselement (7p, 7a) auf der die elektrische Leistung zuführenden Seite zum Zuführen elektrischer Leistung hoher Frequenz durch elektromagnetische Induktion; einem Induktionselement (7s, 7b, 7c) auf der die elektrische Leistung empfangenden Seite zum Empfangen der elektrischen Leistung hoher Frequenz durch elektromagnetische Induktion und einer Abschirmwandung (28f) aus Metallfolie zum Abschirmen der Induktionselemente voneinander gegen Frequenzen, die höher sind als die der elektrischen Leistung hoher Frequenz, dadurch gekennzeichnet, daß die Abschirmwandung (28f) aus einer Mehrzahl von Zellen mit durchgehenden Öffnungen besteht, von denen jede einen polygonalen Querschnitt aufweist und die so aneinandergrenzend angeordnet sind, daß sie eine gemeinsame Wandfläche (32) haben, wobei die Wandfläche jeder der Zellen mit durchgehenden Öffnungen aus einer Metallfolie gebildet ist, deren Dicke geringer ist als 1/10 der Eindringungstiefe der elektrischen Leistung hoher Frequenz und die Größe des polygonalen Querschnitts jeder der Zellen mit durchgehenden Öffnungen so bemessen ist, daß ihre Grenzfrequenz, wenn als Hohlleiter betrachtet, niedriger ist als die abzuschirmende Frequenz.
4. Einrichtung zum Übertragen elektrischer Leistung nach Anspruch 3, dadurch gekennzeichnet, daß die Zellen mit durchgehenden Öffnungen von dreieckigem, rechteckigem oder sechseckigem Querschnitt sind.
5. Einrichtung zum Übertragen elektrischer Leistung nach Anspruch 3 oder 4, dadurch gekennzeichnet, daß die Wandfläche jeder Zelle mit durchgehenden Öffnungen aus Aluminium- oder Kupferfolie gebildet ist.
6. Einrichtung zum Übertragen elektrischer Leistung nach Anspruch 3, bei der die Zellen mit

durchgehenden Öffnungen durch Aneinanderkleben von Metallfolien (32) einen wabenförmigen Aufbau haben.

- 5 7. Einrichtung zum Übertragen elektrischer Leistung nach einem der Ansprüche 1 bis 6, bei der die die Wellenabschirmwandung (28b, 28f) darstellende Metallfolie oder der entsprechende metallische dünne Film aus einem nichtmagnetischen metallischen Material besteht.
- 10 8. Hochfrequenzheizvorrichtung mit einer Einrichtung zum Übertragen elektrischer Leistung nach einem der Ansprüche 1 bis 7, gekennzeichnet durch ein Magnetron (13) zum Erzeugen von Mikrowellen; eine Wechselrichterschaltung zum Umformen elektrischer Leistung mit einer Netzfrequenz in elektrische Leistung mit einer Frequenz von mehr als mehreren zehntausend Hz; einem Hochspannungstransformator (7) zum Erhöhen der Spannung und Zuführen der elektrischen Leistung hoher Frequenz an das Magnetron (13); eine Primärwicklung (7a) des Transformators, die Teil des auf der Zufuhrseite für elektrische Leistung angeordneten Induktionselementes (7p, 7a) ist, und eine Hochspannung-Sekundärwicklung (7b) zum Zuführen von Anodenspannung sowie eine Niederspannung-Sekundärwicklung (7c) zum Zuführen von Heizspannung, die Teil des auf der Empfangsseite für elektrische Leistung angeordneten Induktionselementes (7s, 7b, 7c) sind, wobei die Induktionselemente auf entgegengesetzten Seiten der Wellenabschirmwandung (28b, 28f) angeordnet sind, die ein Teil der Wandfläche eines abgeschirmten Gehäuses zum Abdecken des Kathodenstababschnittes (20) des Magnetrons (13) ist, um ein Streuen der Mikrowellen vom Kathodenstababschnitt nach außen zu verhindern.
- 15 9. Hochfrequenzheizvorrichtung mit einer Einrichtung zum Übertragen elektrischer Leistung nach einem der Ansprüche 1 bis 7, gekennzeichnet durch eine Heizkammer, in die Mikrowellen gestrahlt werden; ein Magnetron (13) zum Erzeugen von Mikrowellen; einen Hochspannungstransformator (7) zum Zuführen elektrischer Leistung an das Magnetron; eine Erregerspule (38), die in der Heizkammer zum induktiven Heizen angeordnet ist, und eine Hochfrequenz-Wechselrichterschaltung zum Zuführen elektrischer Leistung an den Hochspannungstransformator (7) und die Erregerspule (38), wobei die Erregerspule (38) als das Induktionselement auf der die elektrische Leistung zuführenden Seite und die Belastung durch einen zu erhitzenden Topf (37) oder dergleichen als Induktionselement auf der die elektrische Leistung
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empfangenden Seite benutzt wird und die Wellenabschirmwandung (28b, 28f) zwischen Erregerspule (38) und Topf (37) angeordnet ist.

10. Einrichtung zum Übertragen elektrischer Energie nach einem der Ansprüche 1 bis 7, bei der eine Erregerspule (38) eines Induktionsherdes, dem eine elektrische Leistung mit einer Frequenz von über mehreren zehntausend Hz zugeführt wird, als das Induktionselement auf der die elektrische Leistung zuführenden Seite verwendet wird, und die Belastung durch einen zu erhitzen den Topf (37) oder dergleichen als Induktionselement auf der die elektrische Leistung empfangenden Seite verwendet wird, wobei die Wellenabschirmwandung (28b, 28f) zwischen Erregerspule (38) und Topf (37) angeordnet ist.

Revendications

1. Appareil de transfert d'énergie comprenant :
 - un élément d'induction (7p, 7a) du côté de l'alimentation pour fournir de l'énergie à haute fréquence par induction électromagnétique;
 - un élément d'induction (7s, 7b, 7c) du côté de la réception d'énergie pour recevoir ladite énergie à haute fréquence par induction électromagnétique; et
 - une paroi de protection (28b) formée par un clinquant métallique pour protéger lesdits éléments d'induction l'un de l'autre pour des fréquences supérieures à celles de ladite énergie à haute fréquence;
 - caractérisé en ce que :
 - ladite paroi de protection (28b) est constituée d'un fin film métallique ayant une épaisseur inférieure au dixième de la profondeur de pénétration en ce qui concerne l'énergie de haute fréquence devant être transférée; et
 - ledit fin film métallique est maintenu par un élément de support (28c) en matériau diélectrique.
2. Appareil de transfert d'énergie selon la revendication 1, caractérisé en ce que le matériau diélectrique est un matériau céramique.
3. Appareil de transfert d'énergie comprenant :
 - un élément d'induction (7p, 7a) du côté de l'alimentation pour fournir de l'énergie à haute fréquence par induction électromagnétique;
 - un élément d'induction (7s, 7b, 7c) du côté de la réception d'énergie afin de recevoir ladite énergie à haute fréquence par induction électromagnétique; et
 - une paroi de protection (28f) formée par un clinquant métallique pour protéger lesdits éléments

d'induction l'un de l'autre pour des fréquences supérieures à celles de ladite énergie à haute fréquence;

caractérisé en ce que :

ladite paroi de protection (28f) est constituée d'une multitude de cellules à trou traversant, chacune ayant une section transversale polygonale et étant prévue en étant contiguës les unes aux autres de manière à avoir une surface de paroi commune (32), la surface de la paroi de chacune desdites cellules à trou traversant étant formée par un clinquant métallique ayant une épaisseur inférieure au dixième de la profondeur de pénétration en ce qui concerne l'énergie à haute fréquence, les dimensions de la section transversale polygonale de chacune desdites cellules à trou traversant étant telles que leur fréquence de coupure, si on les considère comme un guide d'ondes, est inférieure à la fréquence devant être protégée.

4. Appareil de transfert d'énergie selon la revendication 3, caractérisé en ce que les cellules à trou traversant ont une section transversale triangulaire, carrée ou hexagonale.
5. Appareil de transfert d'énergie selon la revendication 3 ou la revendication 4, caractérisé en ce que la surface de la paroi de chaque cellule à trou traversant est constituée d'un clinquant d'aluminium ou de cuivre.
6. Appareil de transfert d'énergie selon la revendication 3, dans lequel lesdites cellules à trou traversant sont formées d'une structure dite à nid d'abeilles en collant ensemble des clinquants métalliques (32).
7. Appareil de transfert d'énergie selon l'une quelconque des revendications 1 à 6, dans lequel le clinquant métallique ou le fin film métallique constituant ladite paroi de protection contre les ondes (28b, 28f) est constitué d'un matériau métallique amagnétique.
8. Appareil de chauffage à haute fréquence comprenant un appareil de transfert d'énergie selon l'une quelconque des revendications 1 à 7, caractérisé par un magnétron (13) pour produire des micro-ondes, un circuit convertisseur pour transformer l'énergie électrique de fréquences industrielles en énergie à haute fréquence supérieure à plusieurs dizaines de kHz, un transformateur élévateur (7) pour élever ladite énergie à haute fréquence et la fournir audit magnétron (13), un enroulement primaire (7a) dudit transformateur faisant parti de l'élément d'induction (7p, 7a) du côté de l'alimentation, et un en-



roulement secondaire à haute tension (7b) pour fournir une tension d'anode et un enroulement secondaire à basse tension (7c) pour fournir la tension d'un élément chauffant, faisant partie de l'élément d'induction (7s, 7b, 7c) du côté de la réception de l'énergie, les éléments d'induction se trouvant aux côtés opposés de la paroi de protection contre les ondes (28b, 28f) qui fait partie de la surface de la paroi d'un boîtier protégé afin de recouvrir la partie d'une tige de cathode (20) du magnétron (13) de façon à éviter la fuite des micro-ondes vers l'extérieur à partir de la portion tige de la cathode.

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9. Appareil de chauffage à haute fréquence qui comprenant un appareil de transfert d'énergie selon l'une quelconque des revendications 1 à 7, caractérisé par une chambre de chauffage dans laquelle des micro-ondes sont rayonnées, un magnétron (13) pour produire des micro-ondes, un transformateur élévateur (7) pour fournir de l'énergie électrique audit magnétron, une bobine d'excitation (38) montée dans ladite chambre de chauffage pour chauffage par induction, et un circuit convertisseur à haute fréquence pour fournir de l'énergie électrique audit transformateur élévateur (7) et à ladite bobine d'excitation (38), la bobine d'excitation (38) étant utilisée comme l'élément d'induction du côté de l'alimentation en énergie, et la charge d'un ustensile de cuisine (37) ou analogue devant être chauffée étant utilisée comme l'élément d'induction du côté de la réception d'énergie, avec la paroi de protection contre les ondes (28b, 28f) interposée entre la bobine d'excitation (38) et l'ustensile (37).

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10. Appareil de transfert d'énergie selon l'une quelconque des revendications 1 à 7, dans lequel une bobine d'excitation (38) d'une gamme de chauffage par induction, alimentée par une énergie à haute fréquence supérieure à plusieurs dizaines de kHz est utilisée comme l'élément d'induction du côté de l'alimentation en énergie, et la charge d'un ustensile de cuisine (37) ou analogue devant être chauffée est employée comme l'élément d'induction du côté de la réception d'énergie, avec la paroi de protection contre les ondes (28b, 28f) interposée entre la bobine d'excitation (38) et l'ustensile (37).

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