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(54) **TRANSMISSION APPARATUS**

(57) The present invention is to provide a transmission device for efficiency transfer power obtained from a solar cell and the like to a load. The present invention has a core and, a transmission line 4 having first and second lines #1 and #2, which are separated from each other and disposed approximately in parallel with each other, a third curved line #3, which is alternately entangled with and wound around the first and second lines from one direction thereof so as to form a plurality of

entangling portions in the longitudinal direction of the first and second lines, respectively, and a fourth curved line #4, which is alternately entangled with and wound around the first and second lines from one direction thereof so as to form a plurality of entangling portions P1 to Pn and a plurality of intersecting portions C1 to Cn so as to intersect with the third curved line inside the first and second lines in the longitudinal direction of the first and second lines, respectively, and the transmission line 4 is wound around the magnetic body.

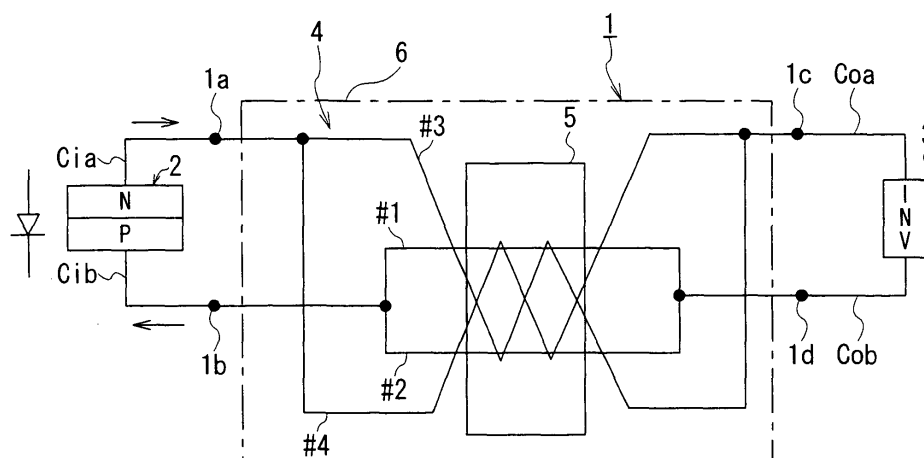


FIG. 1

Description

Technical Field

[0001] The present invention relates to a transmission device, and more particularly, to a transmission device having a very small phase delay and amplitude attenuation (voltage drop) at a time when power obtained from a solar cell is transmitted.

Background Art

[0002] In general, when a signal and power are transmitted through a transmission path, it is unavoidable that transmission characteristics are deteriorated in that the voltages of a signal and power received on a signal receiving side and on a power receiving side drop (amplitudes are attenuated) with respect to a transmitted signal (input) or the phase of them are delayed due to a resistance component and an inductance component of a transmission path. It is an important matter to design a structure of the transmission path so as to minimize the phase delay and the voltage drop and to thereby optimize the transmission characteristics.

[0003] In particular, when a high-frequency signal is transmitted, the signal is deteriorated remarkably by being greatly affected by a floating capacitance and an inductance existing in the transmission path, a loss due to a skin effect, a dielectric loss, frequency dispersion and the like, and accordingly, when a signal is transmitted in a long distance, it is necessary to locate a relay for amplifying the signal on the way thereof.

[0004] To improve the problem due to the signal deterioration, by previously taking the deterioration of a waveform into consideration, an arrangement for providing an equalizer has come into practical use for arranging a signal waveform on a transfer side as a waveform in which a deteriorated waveform is compensated for. However, such practical use involves a problem in that provision of the equalizer increase a cost and makes the arrangement complex.

[0005] Further, it is also proposed to cope with the above problem by separating a high-frequency component whose signal is greatly deteriorated from a low-frequency component whose signal is less deteriorated. For example, a transmitted signal is separated to a low-frequency component and a high-frequency component by a waveform deterioration compensation unit having a plane pattern formed in a flat C-shape. More specifically, a high-frequency transmission path, which makes use of an inter-wiring capacitance, is formed making use of the fact that the impedance of the high-frequency component is small with respect to a capacitance, and the high-frequency component is separated by the high-frequency transmission path.

On the other hand, the low-frequency component is separated using a low-frequency transmission path which is composed of a C-shaped conducting path, and the low-

frequency component is caused to pass on the low-frequency transmission path side longer than the high-frequency transmission path by a predetermined amount. According to such arrangement, a transmission time difference is set between the low-frequency transmission path and the high-frequency transmission path, and the high-frequency component is transmitted faster than the low-frequency component to thereby compensate for waveform deterioration (a delay of the high-frequency component whose transmission speed is slower than that of the low-frequency component is compensated for by a difference of distance). By synthesizing this result, the signal waveform deterioration compensated for. A waveform deterioration compensation transmission path arranged as described above is disclosed in Patent Document 1.

[0006] The signal deterioration also occurs in wirings of an integrated circuit likewise. For example, an integrated circuit, which operates at a clock frequency equal to or larger than gigahertz, is greatly affected by the ground as a return current path in addition to an inductance component of wirings. That is, since a floating capacitance and inductance, which are not disadvantageous in a low-frequency region, causes a serious problem in a high frequency region, a return current strongly depends on the frequency characteristics of the wirings and does not necessarily pass through the ground. As a result, when a high frequency signal is transmitted through a transmission path, transmission characteristics are deteriorated, and a voltage level drops and a phase delays further at an output end.

[0007] As described above, the quality of a signal transmitted in a signal transmission path is affected by a resistance component, a capacitance component and an inductance component of the transmission path itself. In particular, in a high-frequency transmission, since the floating components of these components greatly affect the signal, a signal amplitude is greatly attenuated (voltage is dropped) as well as a phase is greatly delayed, and thus an eye pattern as a parameter for evaluating transmission characteristics is greatly collapsed, providing the most significant problem in the signal transmission.

[0008] Further, in order to cope with amplitude deterioration (voltage drop) caused mainly by the resistance component in the transmission path, there is provided, for example, a method of amplifying the amplitude by an amplifier accommodated in a relay on the way of transmission.

[0009] As, for example, a conventional power transfer system, there is known a system of disposing a series compensation apparatus, which generates a voltage having a phase offset by 90° in terms of an electric angle, in an electric power cable, the system generating a voltage for equivalently compensating a voltage drop due to reactance (refer to, for example, Patent Document 2).

Patent Document 1: Japanese Unexamined Patent

Application Publication No. 2004-297538
 Patent Document 2: Japanese Unexamined Patent
 Application Publication No. 11-299104

Disclosure of the Invention

[0010] However, in the conventional power transmission system disclosed in Patent Document 2, since it is necessary to provide the series compensation apparatus for generating the voltage having the phase offset by about 90° to a current flowing in an electric power cable, a cost is increased and an external power is required, which is contrary to energy saving.

[0011] Although there is conventionally known a power cable such as a strand cable and a coaxial cable as a transmission medium for transferring power obtained by a solar cell, the power cable has a problem in that the conversion efficiency of the power of the solar cell is greatly reduced due to the structure of the solar cell, the internal resistance thereof, the resistance component of the power cable itself, and the inductance component thereof.

[0012] In particular, since diode oscillation is generated in the solar cell by a diode as a semiconductor, the conventional power cable is disadvantageous in that when power of a high-frequency component is transmitted, a signal is remarkably deteriorated by an increase of influence of a floating capacitance and inductance existing in an internal resistance of the solar cell and in a transmission path, a loss due to a skin effect, a dielectric loss, frequency dispersion and the like.

[0013] An object of the present invention, which was made in consideration of the above circumstances, is to provide a transmission device capable of effectively transmit power obtained from a solar cell and the like to a load.

[0014] A transmission device of the present invention includes: a magnetic body; and a transmission medium having first and second conducting wires, which are separated from each other and disposed approximately in parallel with each other, a third conducting wire, which is alternately entangled with and wound around the first and second conducting wires from one direction thereof so as to form a plurality of entangling portions in a longitudinal direction of the first and second conducting wires, respectively, and a fourth conducting wire, which is alternately entangled with and wound around the first and second conducting wires from one direction thereof so as to form a plurality of entangling portions and a plurality of intersecting portions so as to intersect with the third conducting wire inside the first and second conducting wires in the longitudinal direction of the first and second conducting wires, respectively, the transmission medium being wound around the magnetic body.

[0015] According to the transmission device of the present invention, when a signal and power are transmitted, the phase delay and the amplitude attenuation (voltage drop) of the signal and the power can be signif-

icantly reduced.

[0016] In the present invention of the characters mentioned above, it is preferable that the respective entangling portions of the third and fourth conducting wires are alternately arranged in the longitudinal direction of the first and second conducting wires, respectively, the third and fourth conducting wires are entangled with one of the first and second conducting wires in a same direction in the respective entangling portions, respectively, the first and second conducting wires are entangled with each other at entangling portions in opposing directions, and the third and fourth conducting wires are overlapped with each other in directions opposite to the directions of the first and second conducting wires in the longitudinal direction thereof at the respective intersecting portions.

[0017] With this arrangement, even if an external force such as tension and the like is applied to the transmission medium in a longitudinal direction, since the overall shape thereof can be suppressed from being changed, the phase delay and the reduction of the amplitude attenuation can be suppressed.

[0018] In the present invention, it may be desired that the first to fourth conducting wires are disposed within a range in which an electromagnetic interaction is caused by a current flowing in the conducting wires.

[0019] In the present invention, the third and fourth conducting wires may be formed in a sine wave shape or a chevron shape so as to be entangled with the first and second conducting wires.

[0020] In the present invention, it is preferable that the first conducting wire and the second conducting wire are commonly connected to on input end sides and output end sides, respectively, such that the common input end side is connected to one of a pair of electrodes of a solar cell and the common output end side is connected to one end of a load, and wherein the third and fourth conducting wires are commonly connected to the input and output end sides, respectively, and the common input end side is connected to another one of the pair of electrodes of the solar cell, and the common output end side is connected to another end of the load.

[0021] Furthermore, in the present invention, it is preferable that the first conducting wire and the second conducting wire are commonly connected to the input end sides and the output end sides, respectively, the common input end side is connected to one of a pair of electrodes of a solar cell, the common output end side is connected to one end of a load, the third conducting wire and the fourth conducting wire are commonly connected to the input end side and the output end side, respectively, the common input end side is connected to another one of the pair of electrodes of the solar cell, and the common output end side is connected to another end of the load.

[0022] In the present invention, it is preferable that the transmission device has a vessel having an electric insulation property, in which the transmission medium and the magnetic body are accommodated and that an input terminal and an output terminal, which are electrically

connected to an input side and an output side of the transmission medium, are disposed on an outer surface of the vessel.

[0023] Furthermore, in the present invention, it is preferable that a plurality of the transmission mediums is electrically connected in parallel with each other.

[0024] Still furthermore, in the present invention, it is preferable that the solar cell is composed of either one of a crystal solar cell, a thin film solar cell and a compound solar cell.

[0025] Still furthermore, in the present invention, it is also preferable that the load is composed of an inverter for converting a direct current from the solar cell to an alternating current. However, the load need not be the inverter and may be an electric load including at least any one of L, C and R.

[0026] Still furthermore, in the present invention, it is preferable that the magnetic body and the transmission medium are arranged so as to be resonated in series to an oscillating frequency of the solar cell.

Brief Description of the Drawings

[0027]

[Fig. 1] Fig. 1 is a schematic view showing an example of arrangement of a transmission device according to one embodiment of the present invention and an example of a method of connecting the transmission device to a solar cell.

[Fig. 2] Fig. 2(A) is a plan view of a portion of a transmission line used for the transmission device, and Fig. 2(B) is a schematic view showing a principle of the transmission line.

[Fig. 3] Fig. 3 is a schematic plan view showing an example of a connecting method on an input end side and an output end side of the transmission line shown in the Fig. 2(A).

[Fig. 4] Fig. 4 is a schematic view showing a distribution of electric field intensity at a time when power is supplied through the transmission line as shown in Fig. 1 and Fig. 2(A).

[Fig. 5] Fig. 5 is a schematic view showing moving directions when a loop antenna is moved in three directions (X, Y, Z) of the transmission line in an experiment for measuring the distribution of the electric field intensity to collect the electric field intensity distribution data shown in Fig. 4.

[Fig. 6] Fig. 6 is shows angles between the antenna surface of the loop antenna and the transmission line in the experiment for measuring the distribution of the electric field intensity shown in Fig. 4, and a right column represents perspective views of the loop antenna at the respective angles.

[Fig. 7] Fig. 7 is a graph showing a variation of transmitted power in a day when the power generated by a 110 W spherical solar cell is transmitted to a load through the transmission device shown in Fig. 1.

[Fig. 8] Fig. 8 is a graph showing a variation of transmitted power in a day when the power generated by a 110 W single-crystal solar cell is transmitted to a load through the transmission device shown in Fig. 1.

[Fig. 9] Fig. 9 is a plan view of a portion of another transmission line used for the transmission device shown in Fig. 1.

Best Mode for Carrying Out the Invention

[0028] An embodiment of the present invention will be explained below with reference to a plurality of accompanying drawings. Further, it is to be noted that the same portions or corresponding portions are denoted by the same reference numerals in the plurality of accompanying drawings.

[0029] Fig. 1 is a schematic view showing an example of an arrangement of a transmission device 1 according to the embodiment of the present invention and a method of connecting the transmission device 1 to a solar cell.

[0030] As shown in Fig. 1, in the transmission device 1, a pair of input terminals 1a, 1b are electrically connected to the solar cell 2 through a pair of two-wire input side cables Cia, Cib, whereas a pair of output terminals 1c, 1d are electrically connected to an inverter 3 as an example of a load through a pair of two-wire output side cables Coa, Cob. The respective pairs of input side cables Cia, Cib and pairs of output side cables Coa, Cob are a kind of a conventional power cable, for example, AWG, KIV, or the like.

[0031] In the transmission device 1, a transmission line 4 as an example of a transmission medium shown in Fig. 2(A) is wound around the outer peripheral surface of a cylindrical or columnar core 5 made of ferrite as an example of a magnetic body by a required number of turns (for example, 10 turns). The core 5 is arranged so as to provide such permeability that the transmission device 1 generates series resonance to the frequency oscillated by the solar cell 2. The core 5 and the transmission line 4 are accommodated in an accommodation box 6 as an example of a vessel made of, for example, a synthetic resin and the like having electric insulation. The accommodation box 6 has the input terminals 1a and 1b and the output terminals 1c and 1d disposed on the outer surface thereof, respectively. The accommodation box 6 may be arranged as a closed vessel having a waterproof structure and a magnetic shield structure or may be arranged so as to be forcibly cooled.

[0032] As shown in Fig. 2(A), the transmission line 4 includes first and second lines # 1 and #2 as first and second linear conducting wires, which are disposed approximately in parallel with each other at a predetermined interval W, and third and fourth curved lines #3 and #4 as third and fourth conducting wires, which are wound by many turns between the first and second lines # 1 and #2 in a longitudinal direction of the first and second lines # 1 and #2 in an approximate 8-shape in a phase different by approximately 180°.

[0033] Conducting wire surfaces of the respective lines # 1 to #4 are covered with insulation films. However, it is not necessarily to be covered with the insulation films if the conducting wires of the lines # 1 and #4 are not contacting each other. The respective lines # 1 to #4 may be composed of an ordinary conductive wire, and any type of conductive materials such as copper, aluminum and the like may be employed. The distance of the interval W between the first and second lines # 1 and #2 is, for example, about 4 mm, and the interval S of the position at which the third and fourth curved line lines #3 and #4 are entangled with the first and second lines # 1 and #2 is about 5 mm. However, these intervals may be appropriately selected according to a using condition of the transmission line 4. Further, the first and second lines # 1 and #2 are not necessarily straight lines and may be curved lines as far as being disposed approximately in parallel with each other.

[0034] The transmission line 4 has a significant feature in, for example, an entangling portion in which the third and fourth curved lines #3 and #4 are entangled with the first and second lines # 1 and #2, and in a knit structure. More specifically, as shown in Fig. 2(A), as to the chevron-shaped or sine wave-shaped third and fourth curved lines #3 and # 4, at the entangled position P1, the third curved line #3 is entangled with the second line #2 positioned below the second line #2 in the figure in such a manner of being bent so as to run round from a front (i.e., upper) side to a distal (i.e., lower) side in the figure, and at the adjacent entangled position P2, the third line #3 is entangled with the first line # 1 in the figure in such a manner of being bent so as to run round from a lower side of the line # 1 toward the upper side thereof.

[0035] Further, the third curved line #3 is entangled with the second line #2 so as to be bent from the upper side thereof to the lower side thereof at an adjacent entangling position P3, is entangled with the first line # 1 located at an upper position in the figure from the lower side thereof to the upper side thereof at an entangling position P4, and is entangled with the second line #2 from the upper side thereof to the lower side thereof at an entangling position P5, and thereafter, the third curved line #3 is entangled and knitted likewise. Accordingly, the entangling positions (entangling portions) P1 to P5 of the curved line #3 are repeatedly wound in the longitudinal direction of the first and second lines # 1 and #2.

[0036] In contrast, in Fig. 2(A), the fourth curved line #4 is entangled with the first line # 1 located at the upper position in the figure in such a manner of being bent so as to run round from the lower side thereof to the upper side thereof at the entangling position P1 and is entangled with the second line #2 so as to be bent from the upper side thereof to the lower side thereof at the entangling position P2. Further, the fourth curved line #4 is entangled with the first line # 1 so as to be bent from the lower side thereof to the upper side thereof at the adjacent entangling position P3, is entangled with the second line #2 so as to be bent from the upper side thereof to

the lower side thereof at entangling position P4, and is entangled with the first line # 1 so as to be bent from the lower side thereof to the upper side thereof at the entangling position P5, and thereafter, the fourth curved line #4 is entangled and knitted likewise. Accordingly, the entangling positions P1 to P5 of the fourth curved line #4 repeatedly appear in the longitudinal direction of the first and second lines # 1 and #2.

[0037] At the entangling positions P1 to P5, the third and fourth curved lines #3 and #4 are entangled so as to be bent round from the lower side to the upper side of the first line # 1 on the first line # 1 side. In contrast, on the second line #2 side, the third and fourth curved lines #3 and #4 are tangled so as to be bent round from the upper side to the lower side of the second line #2, and thus, the run-round direction thereof, i.e. the winding direction of the first line # 1, is reversed from that the second line #2.

[0038] More specifically, as shown in Fig. 2(A), at the respective entangling portions P0 to Pn of the first line # 1 located at the upper position in the figure, the straight third and fourth curved lines #3 and #4 run round from the lower (distal) side to the upper (front) side of the first line # 1 in the figure and are wound by being bent at a required angle such as right angles and the like.

[0039] In contrast, in Fig. 2(A), at the entangling portions P0 to Pn of the second line #2 located at a lower position, the curved third and fourth curved lines #3 and #4 run round from the upper (front) side to the lower (distal) side of the second line #2 in the figure as well as wound at a required angle, substantially, right angles, and the winding direction thereof opposites to that of the first line # 1. Accordingly, it is supposed that a horizontal center line, not shown, which travels in parallel with the first and second lines # 1 and #2, is made as a symmetric axis at the intermediate points in the separating direction of the first and second lines # 1 and #2, the winding directions in the entangling portions P0 to Pn of the first and second lines # 1 and #2 are made asymmetric.

[0040] Intersecting portions C1, C2, ..., Cn, at which the third curved line #3 intersects with the fourth curved line #4 at a required angle such as right angles, are formed at the respective intermediate portions in the longitudinal direction of the respective entangling portions P0 to Pn of the respective lines #1 to #4. At the intersecting portions C1, C2, ..., Cn, one of the third and fourth curved lines #3 and #4 passes (i.e., extends) on the upper (front or proximal) side of the other curved line, and the third and fourth curved lines #3 and #4 intersect with each other so that the overlapping direction thereof is sequentially reversed in the longitudinal direction of the first and second lines # 1 and #2.

[0041] For example, at the left intersecting point C1 in Fig. 2(A), the fourth curved line #4 passes on the upper side of the third curved line #3, and at the next intersecting point C2, the third curved line #3 passes on the upper side of the fourth curved line #4, and, at the subsequent intersecting portions C3 to Cn, a line passing on the upper

side thereof is sequentially reversed to the fourth curved line #4, the third curved line #3,

[0042] As shown in Fig. 2(B), when a current i is supplied to the transmission line 4 shown in Fig. 2(A) from an input (in) on the entangling portion PO side to an output (out) side, variable vertical magnetic fields N of an N-pole, for example, are formed to the respective approximately triangular spaces ma , ma , ... , ma formed by being surrounded by the first line #1, and the third and fourth curved lines #3 and #4, respectively.

[0043] Further, variable vertical magnetic fields S of an S-pole, for example, are formed, respectively, to the respective approximately triangular spaces mb , mb , ... , mb formed by the second line #2, and the third and fourth curved lines #3 and #4, respectively. The N- and S-pole variable vertical magnetic fields sequentially move along the longitudinal direction of the first and second lines #1 and #2.

[0044] Accordingly, it will be understood that the transmission line 4 achieves a so-called self-exciting electron accelerating operation for accelerating the electrons of the current passing in the respective lines #1 to #4 by the variable vertical magnetic fields N and S . More specifically, it will be said that the transmission device 1 is a self-exciting electron accelerator. Note that the arrangement of the multi-transmission line 4 is approximately the same as the transmission medium having substantially the same structure as that previously applied by the same applicant (PCT/JP2008/066426), and the mathematical consideration and theoretical consideration of the operation/working effect of the multi-transmission line 4 is the same as those of the transmission medium.

[0045] As also shown in Fig. 3, the transmission line 4 constitutes one approach path by coupling the input ends (IN) of the third and fourth curved lines #3 and #4 with each other and the output ends (OUT) thereof with each other, and further constitutes one return path by coupling the input ends (IN) of the first and second curved lines #1 and #2 with each other and the output ends (OUT) thereof with each other.

[0046] As shown in Fig. 1, in the transmission line 4 arranged as described above, the respective input ends "IN" of the approach paths (#3, #4) and the return paths (#1, #2) are electrically connected to the internal ends of a pair of input terminals 1a and 1b, and the respective output ends "OUT" thereof are electrically connected to the internal ends of a pair of output terminals 1c and 1d.

[0047] Further, in the transmission line 4, the input terminal 1a of the approach paths (#3, #4) is connected to, for example, a plus (positive) electrode of the solar cell 2 through the input side cable Cia, and the input terminal 1b of the return paths (#1, #2) is electrically connected to a minus (negative) electrode of the solar cell 2 through the input side cable Cia. However, the positive and negative polarities of the electrodes of the solar cell 2 to which the pair of input terminals 1a and 1b are connected may be reversed.

[0048] Further, a plurality of the transmission lines 4

may be connected in parallel with each other and wound around the outer periphery of the core 5. According to this arrangement, the amount of a current flowing in the transmission line 4 may be increased by the number of the parallel transmission lines. Further, the current capacity of the respective conducting wires #1 to #4 of the transmission line 4 can be increased by increasing the diameter thereof. However, since when the respective conducting wires #1 to #4 are knitted, a large amount of power is required due to the increase of the diameter thereof, and since the knitting becomes difficult, so that the connection of a plurality of the transmission lines 4 composed of thin conducting wires in parallel with each other can easily increase the power.

[0049] Fig. 4 shows a schematic mode representing a result of experiment in a case when distribution of intensity of radiated electromagnetic wave of the transmission line 4 was measured, wherein R1 to R5 are regions showing radiated intensities (V_{pp} (mv)), in which R1 is strongest in intensities and the intensities are gradually weakened toward R5. However, it is to be noted that the intensity distribution is only tentatively shown by the 5 steps (R1 to R5) for the sake of convenience of explanation, and in an actual phenomenon, the intensity distribution continuously changes.

[0050] The an experiment method mentioned above will be explained hereunder.

[0051] First, a signal source was connected to the input side "IN" of the transmission line 4, and a resistor of 50 Ω was connected to the output side "OUT" thereof as a load. A balance connection without grounding was employed as the connection method assuming a use in the solar cell 2.

[0052] Next, a required signal of, for example, a sine wave having 10 V and 15 to 80 MHz was applied from the signal source, and the intensity of the electromagnetic wave radiated from the transmission line 4 was measured by a small loop antenna connected to an oscilloscope.

[0053] The loop antenna was automatically controlled as to the angle θ between the three directions X, Y, Z of the transmission line 4 shown in Fig. 5 and the antenna surface of the loop antenna ANT shown in Fig. 6, in which a signal transmitting direction was shown by X, a line width direction was shown by Y, and an antenna height was shown by Z.

[0054] Further, the measurement range of X, Y was set to $0 \leq X \leq 130$ mm, and the antenna height Z was visually set to about 1 to 2 mm from the upper surface of the transmission line 4. The antenna angle θ was set to 0° when an antenna surface is in parallel with the X-direction, and the intensity of the electromagnetic wave was measured at 45° , 90° and 135° , respectively. Further, in Fig. 6, the right end column in the columns showing the respective antenna angles shows the perspective shapes of the loop antenna at the respective angles.

[0055] As shown in Fig. 4, it was found in the experiment that the electromagnetic wave intensity was strongest at the centers of the respective intersecting portions

C1 to C5, Cn of the transmission line 4 and gradually weakened toward the centrifugal external direction.

[0056] It was also found that the external peripheries of the intensity regions R5 in the central portions of the intersecting portions C 1 to Cn, in which the radiation intensity was strongest, were approximately concentrically surrounded, and for example, the regions R5 were surrounded double by both the regions R3 and R4 which are weaker than the regions R5 by two stages and coupled with each other, respectively, in the longitudinal direction of the transmission line 4 of both the regions R3, R4, i.e., in the signal transmitting direction.

[0057] It was also found that the electromagnetic wave intensities distributed just above the first and second lines # 1 and #2 and in the peripheries thereof were region R4, which was as weak as almost zero, and that the regions R1 to R3 stronger than the region R4 were not distributed. Further, since the electromagnetic wave energies outside of the first and second lines # 1 and #2 were almost zero, the strongest electromagnetic wave energy generated in the respective intersecting portions C 1 to Cn did not diffuse outward, that is, did not leak and was substantially entirely transmitted in the transmitting direction X on the Cn side from the intersecting point C1 side, i.e., from the input side of the transmission line 4 to the output side thereof.

[0058] Accordingly, the variable vertical magnetic fields N, S generated above and below the respective intersecting portions C1 to Cn shown in Fig. 2 are strong, and the electron accelerating operation for accelerating the electrons of the current flowing in the respective lines # 1 to #4 is also improved.

[0059] Incidentally, the solar cell 2 may use any one of a crystal solar cell such as a single and polycrystal silicon solar cell, a thin film solar cell, a hybrid solar cell thereof, a compound solar cell of CIGS (Cu-In-Ga-Se), CdFe, and the like as long as having a photoelectric conversion function.

[0060] The inverter 3 is of a type converting the electricity obtained from the solar cell 2 from a direct current to an alternating current and may be accommodated in a power conditioner added with a function for keeping power quality to a predetermined level and for associating systems.

[0061] The solar cell 2 is not a simply direct current source and oscillates (diode oscillation) a high-frequency of, for example, the order of 10 MHz such as 13.5 MHz and outputs the high-frequency component after it is superimposed to a direct current component as a ripple.

[0062] Since the high-frequency component flows on the surface sides of the respective lines 1 to 4 due to the skin effect, an electronic acceleration effect is further improved by the variable vertical magnetic fields N and S. Accordingly, the amplitude attenuation (voltage drop) and the phase delay of the transmitted power are reduced together, and the transmitting efficiency thereof can be improved.

[0063] That is, when a power cable having high imped-

ance is connected to the solar cell 2 as in a conventional case, since the high-frequency component of the power obtained by the solar cell 2 is almost entirely converted to heat by the internal resistance of the solar cell 2 itself, the transmitting efficiency of the power is not available.

[0064] However, the transmission device 1 of the present invention is arranged to execute the series resonance by selecting the inductance L and the capacitance C of the transmission line 4 and the core 5 so that the transmission device 1 resonates the oscillating frequency of the solar cell 2. The inductance L of the transmission device 1 can be adjusted by, for example, the magnetic permeability of the core 5. Accordingly, the impedance of the transmission device 1 can be applied to the inverter 3 of the load after it is reduced to almost zero with respect to the high-frequency component of the oscillating frequency in the power from the solar cell 2.

[0065] Further, since the high-frequency component generated in the solar cell 2 can be more efficiently transmitted to the load 3 by the transmission device 1, the amount of heat, which is obtained by converting the high-frequency component to heat by the internal resistance of the solar cell 2, can be reduced. Accordingly, since the amount of heat generated by the solar cell 2 can be suppressed, deterioration of a power generation performance due to an increase of temperature of the solar cell can be suppressed.

[0066] Figs. 7 and 8 show the data of an experiment executed by the inventor on October 28, 2008 in Saku City, Nagano Prefecture, Japan to measure the power transmission characteristics of the transmission device 1. Fig. 7 shows graphs of the variation of the power transmitted to the inverter 3 in one day in a case in which one panel of the 110 W spherical solar cell 2 was used as the solar cell 2 and the transmission device 1 was assembled thereto (shown by a curve (A)) and in a case in which the transmission device 1 was removed and the input and output side cables Cia and Coa, and Cib and Cob were directly coupled with each other (shown by a curve (B)). In Figs. 7 and 8, an illuminance curve (C) is a graph showing the variation of illuminance in one day when sunlight was radiated to the solar cell 2.

[0067] As shown in the curve A of Fig. 7, the transmitted power when the transmission device 1 was inserted in series between the solar cell 2 and the inverter 3 exceeds the power represented by the characteristic curve B when the transmission device 1 was removed in the entire time interval of daily sunlight time. Further, as shown in Fig. 8, it was found that the transmitted power per hour was, for example, about 469 [wh] in the case of A in which the transmission device 1 was provided (A) and about 369 [wh] in the case of B in which the transmission device 1 was removed, and that in the former case A, the transmitted power was increased by about 25% as compared with the latter case B. Accordingly, it is considered to be possible to achieve further improvement of the transmitted power, that is, to improve the transmitted power, for example, by about 75% by appro-

privately connecting a plurality of the panels of the solar cells 2 in series and in parallel with each other.

[0068] Fig. 8 shows graphs for comparing a characteristic curve "a", which shows the variation of the transmitted power in one day when one sheet of a single crystal panel (110W) was used as the solar cell 2 with a characteristic curve "b" when the transmission device 1 being removed. As shown in Fig. 8, the characteristic curve "a" in the case of being provided with the transmission device 1 exceeds the characteristic curve "b" in almost all the time region of the sun-shining. Furthermore, it was found that the transmitted power per hour was about 183 [Wh] in the case of "a" in which the transmission device 1 was provided and was improved about 11% as compared with about 164 [Wh] in the case of "b" in which the transmission device 1 was not provided.

[0069] That is, according to the transmission device 1 of the present invention, the power generation efficiency of the solar cell 2 can itself be improved, and in addition, the power obtained by the solar cell 2 can be efficiently transmitted to the load such as the inverter 3.

[0070] Further, the transmission line 4 (refer to Fig. 4) of the transmission device 1 may be replaced with a transmission line 4A shown in Fig. 9. This transmission line 4A has a feature in that when the third and fourth curved lines #3 and #4 are entangled with the first and second linear lines # 1 and #2, the third curved line #3 and the fourth curved line #4 always intersect with each other after they run round the first and second lines # 1 and #2 from the lower sides (back surface sides of Fig. 9) to the upper sides (front surface sides in Fig. 9), and the other arrangement of the transmission line 4A is approximately the same as the transmission line 4 shown in Fig. 2.

[0071] In such transmission line 4A, the variable vertical magnetic fields N and S are formed to approximately triangular space portions "ma" and "mb", which are formed by the intersecting portions C1 to Cn of the third and fourth curved line #3 and #4 and the first and second lines # 1 and #2, respectively, as like as in the transmission line 4. Accordingly, the transmission line 4A has so-called a self-exciting electron accelerating function. Thus, substantially the same power transfer efficiency as that in the transmission line 4 can be achieved. Particularly, the power generation efficiency of the solar cell 2 can itself be improved as well as the transmission efficiency of the power obtained by the solar cell 2 can be remarkably improved.

[0072] Further, although in the embodiment described above, there is described the case in which the solar cell 2 is used as the signal source and the power source of the transmission device 1, the present invention is not limited thereto, and the transmission device 1 may be used simply for a power transmission without using as signal source and power source other than the solar cell 2.

[0073] Further, although in the embodiment described above, there is described the case in which the solar cell 2 is used as the signal source and the power source of

the transmission device 1, the present invention is not limited thereto, and the transmission device 1 may be used simply for a power transmission without using as signal source and power source other than the solar cell 2.

Industrial Applicability

[0074] According to the present invention, there can be achieved an effect of reducing both the amplitude (voltage) attenuation and the phase delay of the power caused by the power transmission. In addition, the power generation efficiency of the solar cell itself can be improved as well as the transmission characteristics can be improved in the case where the power obtained by the solar cell is transmitted to the load such as the inverter.

Claims

1. A transmission medium comprising:

a magnetic body; and

a transmission medium having first and second conducting wires, which are separated from each other and disposed approximately in parallel with each other, a third conducting wire, which is alternately entangled with and wound around the first and second conducting wires from one direction thereof so as to form a plurality of entangling portions in a longitudinal direction of the first and second conducting wires, respectively, and a fourth conducting wire, which is alternately entangled with and wound around the first and second conducting wires from one direction thereof so as to form a plurality of entangling portions and a plurality of intersecting portions so as to intersect with the third conducting wire inside the first and second conducting wires in the longitudinal direction of the first and second conducting wires, respectively, the transmission medium being wound around the magnetic body.

2. The transmission device according to claim 1, wherein the respective entangling portions of the third and fourth conducting wires are alternately arranged in the longitudinal direction of the first and second conducting wires, respectively, the third and fourth conducting wires are entangled with one of the first and second conducting wires in a same direction in the respective entangling portions, respectively, the first and second conducting wires are entangled with each other at entangling portions in opposing directions, and the third and fourth conducting wires are overlapped with each other in directions opposite to the directions of the first and second con-

ducting wires in the longitudinal direction thereof at the respective intersecting portions.

3. The transmission device according to claim 1, wherein the first to fourth conducting wires are disposed within a range in which an electromagnetic interaction is carried out by a current flowing in the respective conducting wires. 5

4. The transmission device according to claim 1, wherein the third and fourth conducting wires are formed in a sine wave shape or a chevron shape so as to be entangled with the first and second conducting wires. 10

5. The transmission device according to claim 1, wherein the first and second conducting wires are commonly connected to each other on input end sides and output end sides thereof, respectively, such that the common input end side is connected to one of a pair of electrodes of a solar cell and the common output end side is connected to one end of a load, and wherein the third and fourth conducting wires are commonly connected to each other on input end sides and output end sides thereof, respectively, such that the common input end side is connected to another one of the pair of electrodes of the solar cell and the common output end side is connected to another end of the load. 15
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6. The transmission device according to claim 5, further comprising a vessel having an electric insulation property, in which the transmission medium and the magnetic body are accommodated, wherein an input terminal and an output terminal, which are electrically connected to an input side and an output side of the transmission medium, are disposed on an outer surface of the vessel. 30
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7. The transmission device according to claim 5, wherein a plurality of the transmission mediums are electrically connected in parallel with each other. 40

8. The transmission device according to claim 5, wherein the solar cell is at least one of a crystal solar cell, a thin film solar cell and a compound solar cell. 45

9. The transmission device according to claim 5, wherein the load is an inverter for converting a direct current from the solar cell to an alternating current. 50

10. The transmission device according to claim 5, wherein the magnetic body and the transmission medium are arranged so as to be resonated in series to an oscillating frequency of the solar cell. 55

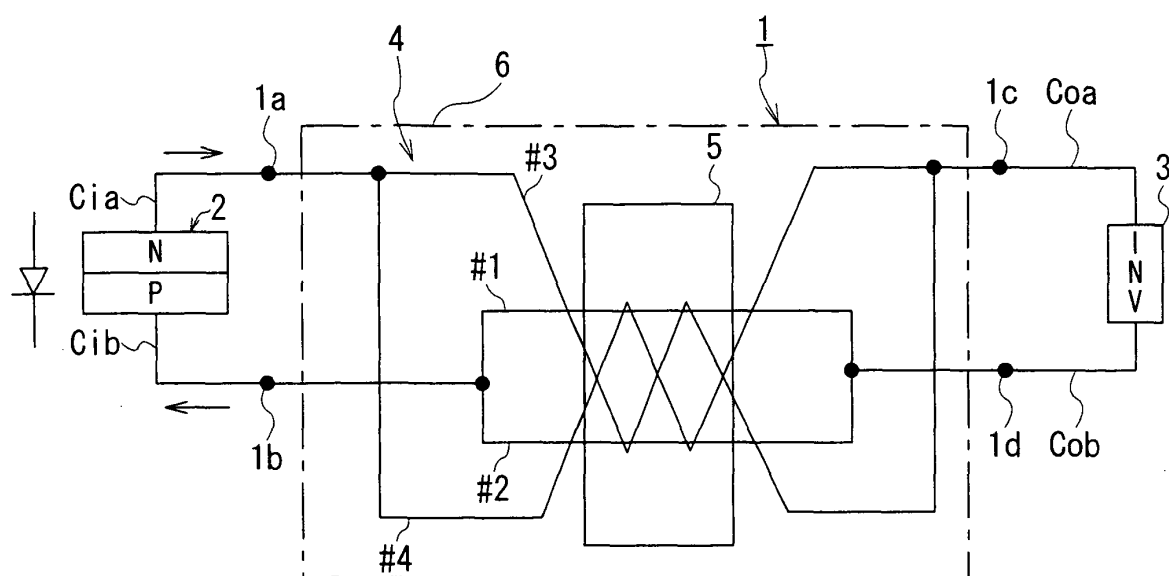


FIG. 1

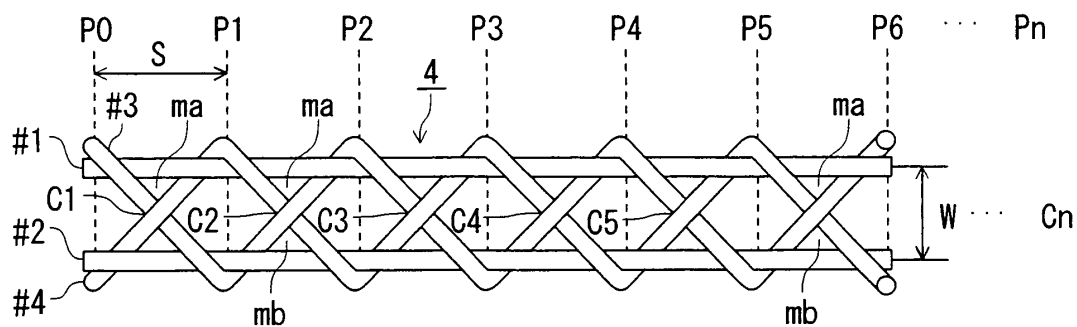


FIG. 2(A)

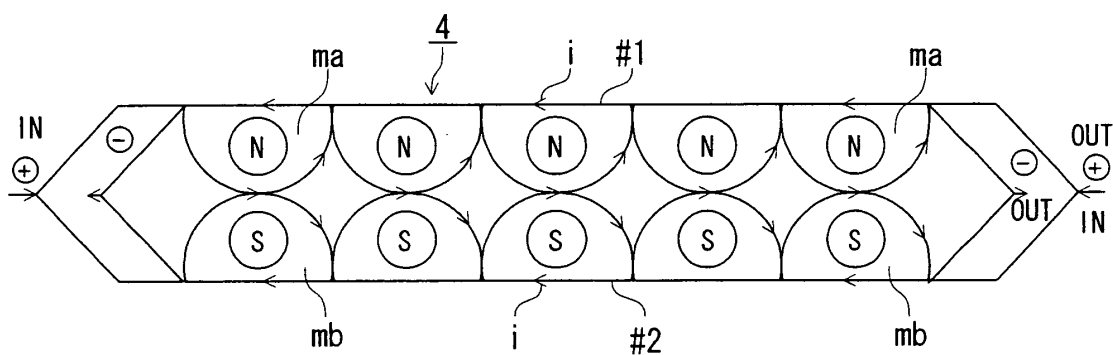


FIG. 2(B)

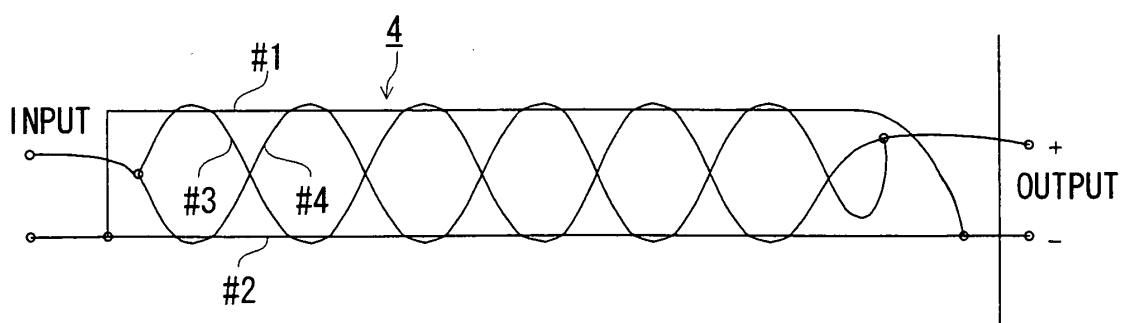


FIG. 3

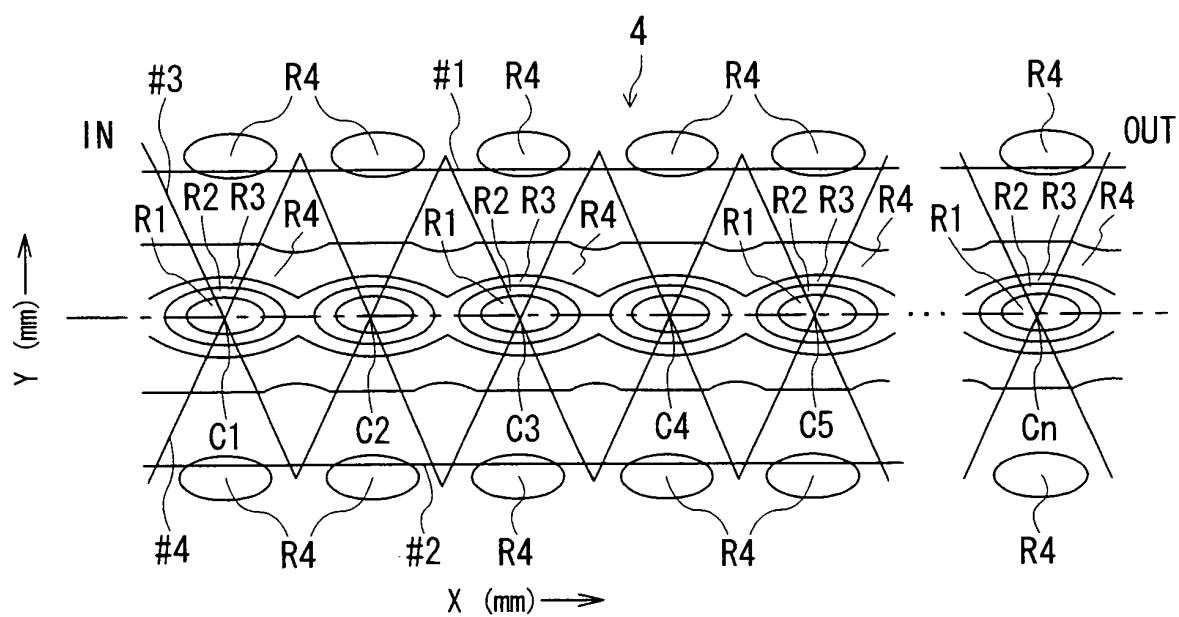


FIG. 4

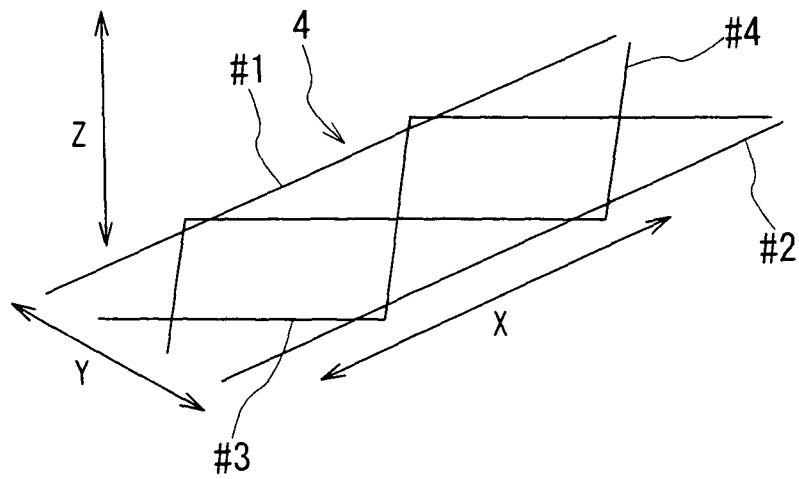


FIG. 5

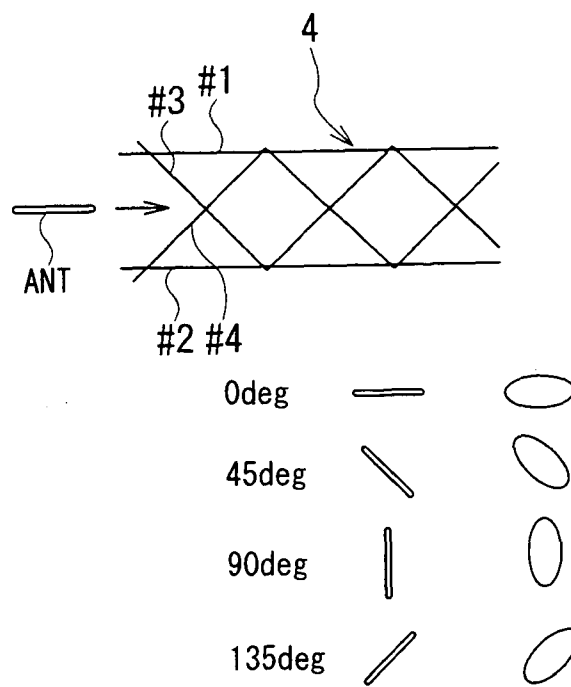


FIG. 6

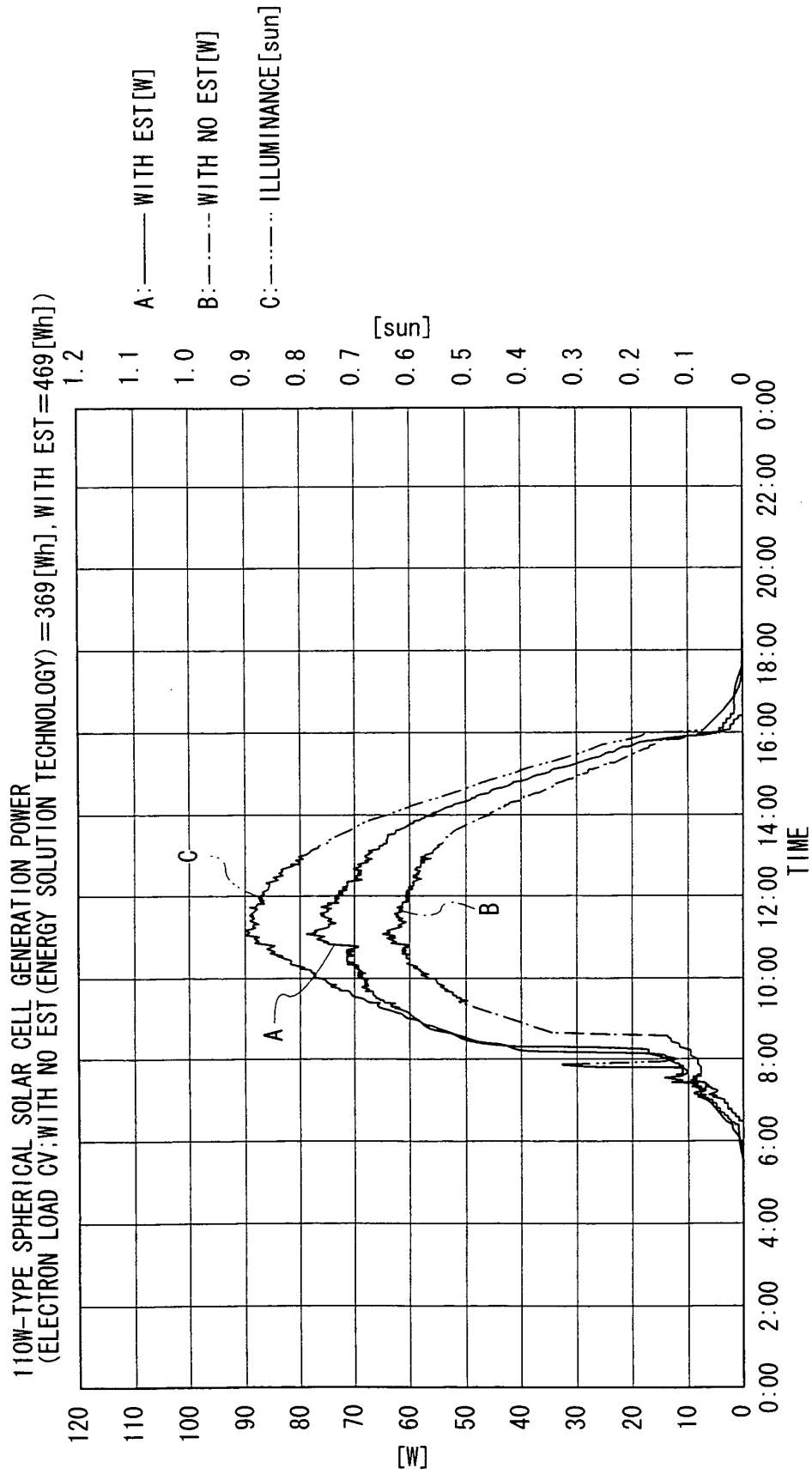


FIG. 7

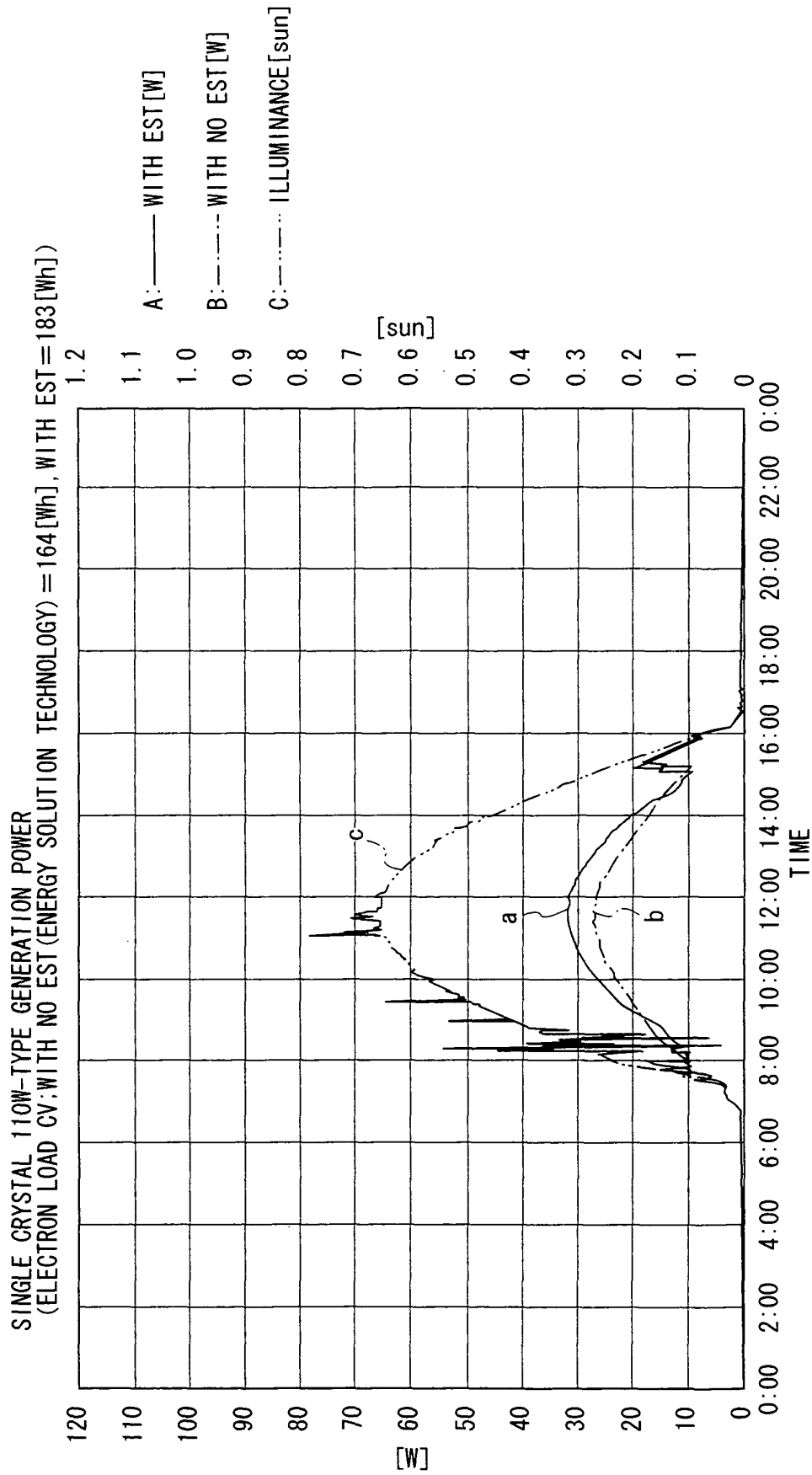


FIG. 8

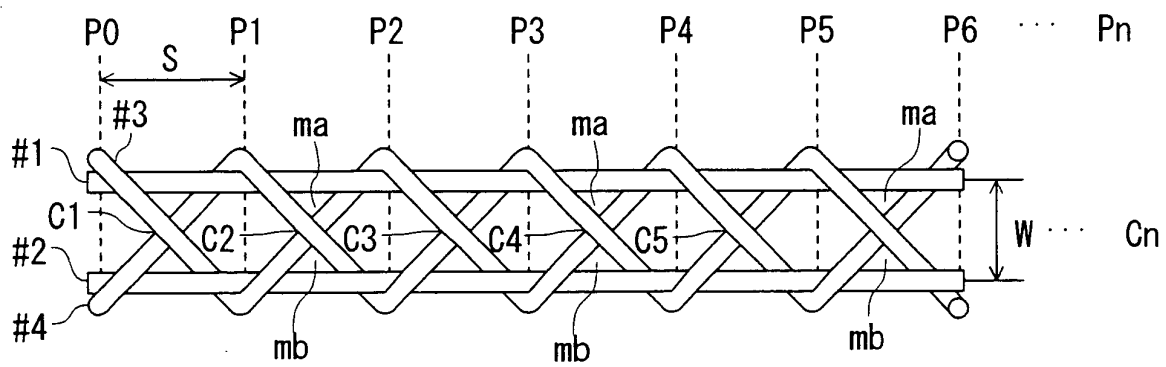


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/073388

A. CLASSIFICATION OF SUBJECT MATTER

H01B11/00 (2006.01) i, H02G1/06 (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)

H01B11/00, H02G1/06

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	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2008-226774 A (Toru KANMA, Rie KANMA), 25 September, 2008 (25.09.08), Par. Nos. [0001] to [0049]; Figs. 1 to 9 (Family: none)	1-10
Y	JP 10-269854 A (Hosiden Corp.), 09 October, 1998 (09.10.98), Par. Nos. [0010] to [0014]; Fig. 1 (Family: none)	1-10
Y	JP 2000-166124 A (Toshiba Corp.), 16 June, 2000 (16.06.00), Par. Nos. [0014] to [0018]; Fig. 1 (Family: none)	5-10

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

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Date of the actual completion of the international search
16 April, 2009 (16.04.09)Date of mailing of the international search report
28 April, 2009 (28.04.09)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/073388

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-272639 A (Kyocera Corp.), 18 October, 2007 (18.10.07), Par. No. [0023]; Fig. 2 (Family: none)	8

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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- JP 11299104 A [0009]
- JP 2008066426 W [0044]