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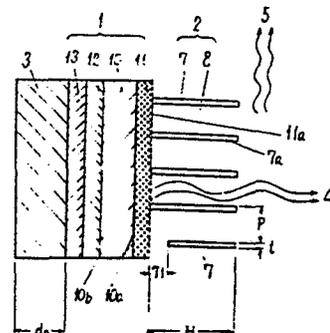
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54 An infrared radiant heater.

57 Described is an infrared radiant heater comprising a heat generator (1) with an infrared radiative layer (11) standing for the nearly vertical direction and an infrared transparent and low thermal conductive body (2) arranged near or on the infrared radiative layer (11). The infrared transparent and low thermal conductive body (2) typically comprises thin protruded plates (7) arranged near or on the infrared radiative layer (11) and spaces (8) limited by the thin protruded plates (7) and the infrared radiative layer (11). Thermal energy dissipated by convection can be decreased and, as a result, emission of radiant energy with a high radiation efficiency can be obtained.

Fig.2



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An infrared radiant heater

The present invention relates to an infrared radiant heater having a high radiation efficiency, which is defined as the ratio of the radiant energy to the applied energy to the heater. This heater is mainly used
5 for spot heating.

Various types of spot heating apparatus have been used. One such apparatus comprises a heat generator provided with a flat surface having a comparatively large area which surface is disposed substantially vertically. This heater is called a panel heater
10 and usually uses a metal body within which electric heating wires are arranged, said electric heating wires being electrically insulated from said metal body. When said metal body consists essentially of a metal such as
15 Al with a low emissivity, an infrared radiative layer comprising metal oxides with a high emissivity such as ZrO_2 , SiO_2 or TiO_2 is formed on the surface of said metal body. Needless to say, this fact indicates that the infrared layer is not required to be formed when
20 a heavily oxidized metal is used as said metal body. There is also used another heater whose heat generator comprises a metal plate, on whose surface a resistive film is formed instead of said metal body described hereinbefore.

When electric power is applied to said electric wires or said resistive film, the surface temperature of said metal body increases and is saturated at a higher temperature than an atmospheric temperature. Then the infrared radiation emitted from the surface is obtained. However, the convectional heater has the disadvantage that the radiation efficiency is low in the range of 40-50%. This low radiation efficiency is attributed to the fact that the applied electric power is dissipated not only by radiation, but also by convection. In the other words, more than half amounts of the applied electric power are unavailably dissipated by convection. Accordingly, the conventional heater has the another disadvantage that the unavailable thermal energy dissipated by convection increases nearly linearly with an increase of the radiant energy, because higher radiant energy can be obtained mainly by means of increasing the surface temperature when said heat generator have a given emissive surface.

The heater has the further disadvantage that amounts of the radiant energy available for heating is also low in comparison with that of the total radiant energy. When occupants receive the radiant energy from the heater, the radiant energy available for heating is considered to be usually limited to the radiant energy emitted for the particular available space, which is defined as the space viewed from the heater at the angle

of elevation less than 20-30 degrees for the vertical direction and at the wide angle for the horizontal direction.

However, since the infrared radiative layer has the nearly perfect diffused surface, comparatively large amounts of the radiant energy are emitted for the unavail-
5 able space for heating. This fact is attributed to the conventional radiation characteristic that the radiant energy emitted from the nearly perfect diffused surface does not decrease steeply with increase of the angle of
10 elevation because the radiant energy varies with the angle in accordance with Lambert's cosine law.

There has been also known an another type of heater which is possible to be used as such a particular spot heating apparatus as described hereinafter.

15 This heater comprises a heat generator arranged horizontally with a flat surface and a collimator arranged on the flat surface of said heat generator. Said collimator consists of many plates which extend for the normal direction to the flat surface and are crossed each other in the
20 form of a lattice and the like. Said plates are preferably composed of metal plates having a highly reflective surface. This heater was disclosed in West Germany Patent No. DE 2619622.

As described in the referenced Patent, this
25 heater is availably used for industrial applications such as firing organic materials with a small limited surface

at a position aparted slightly from the heater. When this heater is used as the infrared radiant heater for heating occupants indoor, this heater is situated at a high position near a ceiling and the radiant energy is emitted downward from near the ceiling. In this heating process, the heater has the advantage of high radiation efficiency because air is prevented from moving upward by said crossed plates and the resultant thermal energy dissipated by convection decreases greatly. However, as for the radiant energy emitted downward from near the ceiling, vertical radiant energy density decreases steeply with the height, therefore, local warm discomfort occurs at the head, and/or cold discomfort at the feet.

On the other hand, when said heat generator is arranged vertically, this heater has the disadvantage that the radiation efficiency is lower than that of the conventional panel heater. Since said collimator consisting highly reflective metal plates is highly thermal conductive, said collimator increases the thermal energy dissipated by convection and decreases that dissipated by radiation.

This heater has the further disadvantage that the radiant energy is limited to too local space to be emitted over the available space for heating. Since said collimator consists of many plates crossed each other in the form of the lattice and the like, the radiant energy emitted for the normal direction to the flat surface of

said heat generator at the center position is high. However, the radiant energy emitted for the different direction at the aperted position from the center decreases steeply. This fact indicates that the radiant energy is emitted only for the normal direction to said flat surface of said heat generator. Considering that the available space for heating is spreaded widely for the horizontal direction, the too limited radiant energy for the horizontal direction is not available for comfortable heating.

10 The other of the infrared radiant heating apparatus except for the panel heater comprises a long and slender heat generator. One of this heater is called an electric stove. Said long and slender heat generator is arranged horizontally or vertically. This heater has the advantage of a high radiation efficiency by means of selecting the suitable form of said heat generator. However, the heater has the disadvantage that the more radiant energy is dissipated for the unavailable space for heating.

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SUMMARY OF THE INVENTION

An object of this invention is to provide an infrared radiant heater with a high radiation efficiency when said radiant heater is situated vertically.

Another object of the present invention is to provide an infrared radiant heater with a particular angular dependence of the radiant energy, which is charac-

terized in that the radiant energy for the space available for heating is higher than that for the space unavailable for heating.

5 A further object of the present invention is to provide an infrared radiant heater which can decrease hot discomfort when fingers or other human body touch the warmed surface of said radiant heater.

10 Other objects of the present invention will be obvious from the contents of the detailed description disclosed hereinafter.

According to one aspect of the present invention, there is provided an infrared radiant heater comprising a heat generator with an infrared radiative surface standing for the nearly vertical direction and both an infrared
15 transparent and low thermal conductive body arranged near the surface of said heat generator.

Infrared rays emitted from the surface of said infrared radiative surface pass through said infrared transparent and low thermal conductive body almost without
20 absorption loss because of nearly perfect infrared transparency thereof and then infrared radiations available for heating are obtained. On the other hand, since said infrared transparent and low thermal conductive body is also a superior thermal insulator, the surface temperature
25 thereof is considerably lower than that of said infrared radiative surface. This fact indicates that the heater

according to the present invention has a high radiation efficiency because convective thermal energy owing to air flow decreases with decrease of temperature difference between said infrared radiative surface temperature of the heater and a surrounding temperature. Needless to say, the heater dissipates thermal energy almost only by both convection and radiation, and heat transfer by conduction is possible to be neglected because there exists no thermal conductive material except for electric wires for applying electric power to the heater and the electric wires have a high heat resistance owing to be small in section and long in length.

BRIEF DESCRIPTOIN OF THE DRAWINGS

Fig. 1 is a cross-sectional view showing a fundamental construction of an infrared radiant heater according to the present invention.

Fig. 2 is a cross-sectional view showing a construction of the infrared radiant heater according to the present invention wherein an infrared transparent and low thermal conductive body comprises both thin protruded plates and spaces limited by said thin protruded plates and an infrared radiative surface of the heater.

Fig. 3 shows schematically a measuring method of a radiant energy.

Fig. 4 shows vertical angular dependences of the

radiant energy.

Fig. 5 shows horizontal angular dependences of the radiant energy.

Fig. 6 shows surface temperatures as a function of applied electric powers.

Fig. 7 is a cross-sectional view showing a construction of the infrared radiant heater according to the invention wherein said thin protruded plates are inclined for the downward direction to said infrared radiant layer.

Fig. 8 shows the vertical angular dependence of the radiant energy of the heater shown in Fig. 7.

Fig. 9 is a cross-sectional view showing a construction of the heater according to the invention wherein infrared reflective films are formed on the surface of said thin protruded plates.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Fig. 1, there is shown a fundamental construction of an infrared radiant heater according to the invention. The heater according to the invention comprises a heat generator (1) with an infrared radiative surface (1a) standing for the nearly vertical direction and an infrared transparent and low thermal conductive body (2) arranged near or on the surface (1a) of said heat generator (1). A thermal insulating body (3) is arranged in order to decrease the thermal energy

dissipated from the other surface (1b) of said heat generator (1).

Infrared rays emitted from the infrared radiative surface (1a) pass through said infrared transparent and low thermal conductive body (2) almost without absorption loss because of high infrared transparency thereof and infrared radiations (4) available for heating are obtained. On the other hand, since said infrared transparent and low thermal conductive body (2) is also a superior insulator in thermal conduction, the surface (1a) temperature thereof is considerably lower than the surface (1a) temperature of said heat generator (1). Considering that an applied energy to said heat generator (1) is almost dissipated both convection (5) owing to air flow and infrared radiations (4) if said thermal insulating body (3) is perfect, a high radiation efficiency can be achieved because thermal energy dissipated by convection (5) decreases with decrease of temperature difference between the surface (2a) temperature and a surrounding temperature.

It is obvious from the contents described hereinbefore that the high radiation efficiency can be achieved by two characteristics of said infrared transparent and low thermal conductive body (2); (1) high infrared transparency thereof which causes the infrared radiations (4) to be emitted from the surface (1a) of said heat generator (1) to an outer space, and (2) low thermal

conductivity thereof which causes the decrease of the surface (2a) temperature.

Needless to say, when said heat generator (1) has the poor infrared radiative surface (1a), an infrared radiative layer is formed on the surface (1a). A fired film comprising metal oxides such as ZrO_2 , SiO_2 , Fe_2O_3 , Cr_2O_3 , TiO_2 and the like is frequently used as said infrared radiative layer.

Referring to Fig. 2, there is shown an embodiment of the heater according to the invention. Said heat generator (1) consisted essentially of a metal substrate (10), said infrared radiative layer (11) formed on one surface (10a) of said metal substrate (10), an electric insulating film (12) fixed to the another surface (10b) of said metal substrate (10) and a planar resistive film (13) formed on said electric insulating film (12). Al, Fe and the other metal plates were used as said metal substrate (10). A polymer film was used as said electric insulating film (12). A fired film of a mixture of fine carbon particles and polymer was used as said planar resistive film (13). A fired film of metal oxides described hereinbefore was used as said infrared radiative layer (11).

Said infrared transparent and low thermal conductive body (2) consisted essentially of both thin protruded plates (7) for the normal direction to the

surface (11a) of said infrared radiative layer (11),
said thin protruded plates (7) being arranged horizontally
near or on the surface (11a) in such a way that said thin
protruded plates (7) of H(cm) in height and t(cm) in
5 thickness were separated each other at a given interval
P(cm), and spaces (8) limited by said thin protruded
plates (7) and said infrared radiative layer (11).
Thin poly-ethylene terephthalate films of 0.3 mm in
thickness were typically used as said thin protruded
10 plates (7).

Said thermal insulating body (3) is arranged
on said planar resistive film (13). A polyurethane foam
of 15 mm in thickness da was typically used as said
thermal insulating body (3). Needless to say, said
15 thermal insulating body (3) is required when infrared
radiations from one surface (11a) of the heater is avail-
able for heating. Accordingly, it is obvious that the
same construction as that including said infrared
radiative layer (11) and said infrared transparent and
20 low thermal conductive body (2) is arranged instead of
said thermal insulating body (3) when infrared radiations
from both the surface (11a) of said infrared radiative
layer (11) and the surface (13a) of said planar resistive
film (13) is required.

25 Said thin protruded plates (7) prevent air from
flowing upward along said infrared radiative layer (11)

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when the surface (11a) temperature is increased by applying an electric power to said planar resistive film (13). In addition, air is an excellent thermal insulator. These facts indicate that thermal energy dissipated by convection (5) owing to air flow is decreased by arranging said thin protruded plates (7). On the other hand, since air is also very transparent in the region of infrared wavelengthes, infrared radiations (4) emitted from the heated surface (11a) of said infrared radiative layer (11) passes through said spaces (8) almost without being absorbed by said spaces (8) and then is radiated outside the heater. It is obvious from the contents described hereinbefore that the construction comprising said thin protruded plates (7) and said spaces (8) is an excellent infrared transparent and low thermal conductive body (2).

In addition to say, it is obvious that the existence of an interval (71) between said infrared radiative layer (11) and all or parts of said thin protruded plates (7) is not harmful to decrease of convective thermal dissipation under the conditions that the interval (71) is less than several millimeters. This fact is due to an existence of a large resistance to air flow when the interval (71) is small.

Radiation characteristics will be described in detail hereinafter when said planar resistive film (13) has a very low positive temperature coefficient of resistance.

Referring to Fig. 3, there is schematically shown a measuring method of the radiant energy. The radiant energy was detected by a radiation detector (9) along boundary lines of a circle whereof the center agreed with the center of the heater. Two types of an angular dependence of the radiant energy were typically measured. One angular dependence was a vertical angular dependence, which showed a variation of the radiant energy incident to said radiation detector (9) as a function of a vertical angle θ under the conditions of a given radius r and a particular horizontal angle $\phi=0$ degree. Another angular dependence was a horizontal angular dependence, which showed a variation of the radiant energy incident to said radiation detector (9) as a function of a horizontal angle ϕ under the conditions of the given radius r and the particular vertical angle $\theta=0$ degree.

Since the radiant energy in a given and comparatively large solid angle (~ 2.5 radian) around the normal to a small sensing surface of said radiation detector (9) was incident to said radiation detector (9), the incident radiant energy contained not only the radiant energy emitted from the heater, but also a radiant energy emitted from a surrounding under the particular conditions depending on the heater size (L_1, L_2) and the radius r . In the following description, when the measured total energy included the radiant energy emitted from both the heater

and the surrounding, the former radiant energy was used.

A hemispherical radiant energy, designating a whole radiant energy emitted for all directions of the enclosing hemisphere, was determined by integrating the angular radiant energy over all directions.

In this experiment, the heater in the rectangular form of $L_1=L_2=45$ cm and $dh=2$ mm was used. The radiant energy was typically measured at the conditions of the radius $r=100$ cm and the applied power of 630 W/m². As described hereinbefore, the thickness da of said thermal insulating body ③ was typically 15 mm. However, the radiation efficiency varies with the thickness da because the thermal energy dissipated from the surface of said thermal insulating body ③ varies with the heat resistance determined by the thickness da . In order to evaluate exactly the effect of said infrared transparent and low thermal conductive body ② comprising said thin protruded plates ⑦ and spaces ⑧, the radiation efficiency was also measured under the conditions that the thickness da was thick enough for the thermal energy dissipated from the surface of said thermal insulating body ④ to be neglected. The radiation efficiency measured in such a way is defined as the elemental radiation efficiency. On the other hand, the radiation efficiency measured under the conditions of the suitable thickness da for practical uses is defined as the practical radiation efficiency.

The elemental and practical radiation efficiencies of the conventional heater without said thin protruded plates ⑦ and spaces ⑧ were about 50% and 42%, respectively. On the other hand, the elemental and practical efficiencies of the heater having said thin protruded plates ⑦ and spaces ⑧ increased greatly. Typical efficiencies in the various forms of said thin protruded plates ⑦ and spaces ⑧ are shown in Tab. 1 together with those of the conventional heater.

10 Referring to Fig. 4, there are shown various vertical angular dependences of the radiant energy. In Fig. 4, the ratios of the radiant energy emitted from the heater according to the present invention with a given thickness $da=15$ mm and various values of H and P to that
15 emitted from the conventional heater whereof the size L_1, L_2 is the same as that of the present heater are shown when the radiant energy from the conventional heater was measured at the given conditions of $r=100$ cm and $\theta=\phi=0$ degree. The vertical angular dependences with regard to
20 the conventional heater are also shown in Fig. 4 by the same ratio as that described hereinbefore. The conventional heater showed the vertical angular dependence of the radiant energy which decreased slowly with the vertical angle θ , as shown by curve A1 in Fig. 4. This charac-
25 teristic agreed nearly with Lambert's cosine law.

On the other hand, the heater according to the

TAB. 1 Elemental and practical efficiency

Thin Plates *1)		Elemental Efficiency (%) *2)		Practical Efficiency (%) *3)	
H (mm)	P (mm)	Radiation η_{rF}	Convection $\eta_{cF} (=1-\eta_{rF})$	Radiation η_r	Convection η_c
50	17.5	71	29	55	22
50	25	65	35	51	29
30	10	67	33	52	26
30	15	61	39	49	32
30	20	58	42	47	35
15	7.5	63	37	50	30
9	5	65	35	52	28
5	2.5	58	42	47	36
0 *4)	-	52	48	45	41

*1) Thickness $t=0.3$ mm

*2) Measured under the conditions of the thickness $d_a=100$ mm

*3) Measured under the conditions of the thickness $d_a=15$ mm

*4) Conventional heater

present invention showed unique characteristics, as shown by curve B1 and C1 in Fig. 4, in that the radiant energy decreased very sharply with the vertical angle θ in comparison with that of the conventional heater, as shown by curve A1 in Fig. 4. Curve B1 and C1 were obtained with regard to the heater construction of $t=0.3$ mm, $P=10$ mm, $H=30$ mm and $t=0.3$ mm, $p=7.5$ mm, $H=15$ mm, respectively. The radiant energy (curve B1 and C1) emitted for the direction of the vertical angle θ less than about 20 degree increased greatly in comparison with that of the conventional heater (curve A1). In particular, heater wherein said thin protruded plates (7) of $t=0.3$ mm and $H=30$ mm were arranged at the interval $P=10$ mm emitted the radiant energy for the direction of the vertical angle $\theta=0$ which was about 1.3 times greater in intensity than that of the conventional heater. On the contrary, the radiant energy emitted for the direction of the vertical angle θ larger than about 20 degrees decreased greatly in comparison with that of the convectional heater.

Referring to Fig. 5, there are shown various horizontal angular dependences of the radiant energy. The ratio, described in Fig. 4, is shown as a function of the horizontal angle ϕ . These measurements were carried out at the same conditions as those in Fig. 4. The radiant energy (curve B2 and C2) of the heater according to the present invention for all the directions of the measured

horizontal angle ϕ increased greatly in comparison with that of the conventional heater (curve A2).

As disclosed hereinbefore, the heater according to the present invention has a useful angular dependence of the radiant energy in that the radiant energy for the directions of both all the horizontal angle ϕ and the vertical angle θ less than about 20 degree increased greatly in comparison with that of the conventional heater. Since the available space for heating by infrared radiations is considered to be the space viewed from the heater at the angle of elevation less than 20~30 degree, this angular dependence of the radiant energy indicates that the heater according to the present invention is mostly suitable for heating by infrared radiations.

The reason why the useful angular dependence of the radiant was obtained is considered as followings.

When the electric power was applied to said resistive film (13), the surface temperature T_s of said infrared radiative layer (11) at the center increased as shown in Fig. 6. The surface temperature T_s (curve B3 and C3) of the heater according to the present invention increased greatly in comparison with that of the conventional heater (curve A3) under the conditions of a given applied electric power. Curve A3, B3 and C3 were measured at the same conditions except for the applied electric power as those whereat curve A1, B1 and C1 were measured

in Fig. 4. The heater construction of $t=0.3$ mm, $P=15$ mm, $H=30$ mm and $t=0.3$ mm, $p=7.5$ mm, $H=15$ mm showed the surface temperatures T_s which were about 30°C and 19°C higher than that of the conventional heater, respectively, when the electric power of 630 W/m^2 was applied to the heater. The surface temperature T_s depended mainly on the height H and the interval P . The higher the height H became, the higher the surface temperature T_s became under the conditions of the given interval P . And the shorter the interval P became, the higher the surface temperature T_s became under the conditions of the given height H . This increase in the surface temperature T_s is considered to be the origin of increase in the radiant energy.

On the other hand, the radiant energy from the heater comprises both the radiant energy emitted from the surface (11a) and that emitted from the surface (7a) of said thin protruded plates (7). Temperature of the surface (11a) was higher than that of the surface (7a). When said radiation detector (9) viewed the heater according to the present invention along the boundary line of the vertical circle, the viewed area of the surface (11a) by said radiation detector (9) decreased rapidly with increase of the vertical angle θ and, on the contrary, the viewed area of the surface (7a) increased rapidly with increase of the vertical angle θ . This vertical angular dependence of the viewed area of the surface (11a), which can emit

higher radiant energy than the surface (7a), is considered to be the origin of the vertical angular dependence of the radiant energy. In the other words, the rapid increase of the viewed area of the surface (7a) with increase of the vertical angle θ are considered to be the origin of the vertical angular dependence of the radiant energy.

When said radiation detector (9) viewed the heater according to the present invention along the boundary line of the horizontal circle, the viewed area of the surface (11a) and (7a) by said radiation detector (9) decreased slowly with increase of the horizontal angle ϕ nearly in accordance with the Lambert's cosine law. This horizontal angular dependence of the viewed area of the surface (11a) and (7a) is considered to be the origin of the horizontal angular dependence of the radiant energy, which is similar to that of the conventional heater.

Considering the facts: (1) the surface (2a) temperature T_s is determined from the relation that the total energy applied to the heater, which consists of the applied electric power and the incident thermal energy to the heater from a surrounding, is equivalent to the total thermal energy dissipated by radiation and convection under the conditions of conduction being neglected, and (2) the thermal energy dissipated by radiation increased by means of the heater construction according to the present invention, it is suggested that the thermal energy dissipated

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by convection decreased and, as a result, the surface (11a) temperature increased. In addition, there may exist the possibility that the amount of the decreased radiant energy emitted for the direction larger than 20~30 degree in the vertical angle θ in comparison with that of the conventional heater, the decreased radiant energy being unavailable for heating, contributed also the increase in the surface (11a) temperature.

The reason why the convective thermal energy decreased is considered to be due to the facts that air fulfilled in said spaces (8) is difficult to be heated up because of its low thermal conductivity and is limited to flow upward by said thin protruded plates (7) even if air is heated up. This fact indicates that said thin protruded plates (7) are preferably composed of a low thermal conductive material because its low thermal conductivity does not increase the surface (7a) temperature, whereon air temperature in said spaces (8) depends, greatly, and, as a result, the convective thermal energy decreases.

Considering both radiation characteristics and the size of the heater suitable for practical uses, it is preferable that said thin protruded plates (7) have the form of 0.05~1.0 mm in thickness and 5~50 mm in height H, and are arranged at the interval P of 2.5~50 mm.

Since said thin protruded plates (7) are arranged on the surface (11a) of said heat generator (1), there

decreases the possibility that fingers or other human body touch directly the surface (11a) kept at high temperature.

There exists the possibility that fingers or other human body touch the top of said thin protruded plates (7).

5 However, since the top temperature is very lower than the surface (11a) temperature, hot discomfort does not arise. Accordingly, the heater according to the invention is safe and can decrease hot discomfort.

Referring to Fig. 7, there is shown an another
10 embodiment of the heater according to the invention, wherein said thin protruded plates (7) were inclined for the downward direction to the surface (11a) of said infrared radiative layer (2). This heater construction was characterized in the vertical angular dependence of the
15 radiant energy, as shown in Fig. 8. Fig. 8 shows the vertical angular dependence B4 of the radiant energy when the angle θ^1 between said thin protruded plates (7) and the surface (11a) was selected at 60 degrees in comparison with that A4 of the conventional heater. Since the viewed
20 area of the surface (11a) by said radiation detector (9) had the maximum value at the vertical angle of $(90-\theta^1)$ degrees, the radiant energy had the maximum value at this vertical angle. It is obvious that the horizontal angular dependence of the radiant energy had also a similar tendency.
25 Since this angular dependence indicates that the high radiant energy is emitted for the downward direction

determined by the angle θ^1 , this heater construction is much available for local heating such as that of one's feet. It is preferable that the angle θ^1 between said thin protruded plates (7) and the surface (11a) is ranged from 45 to 90 degrees because the radiation for the downward direction of the angle θ^1 less than 45 degree is not available in practical heatings.

Referring to Fig. 9, there is shown another embodiment of the heater according to the invention, further comprising infrared reflective films (72) formed on the surface (7a) of said thin protruded plates (7). Metal films such as Al, Ni, Zn, Ag, Sn and the like are used as said reflective films (72). Since said reflective films (72) have a very low emissivity, the radiant energy emitted from said reflective films (72) is negligible small. On the other hand, parts of infrared rays emitted from the surface (11a) of said heat generator (1) are incident to said reflective films (72) and then reflected many times. As a result, nearly all of infrared rays emitted from the surface (11a) are radiated outside the heater. These facts indicate that the radiant energy from the heater comprises nearly only the radiant energy from the surface (11a). Moreover, the vertical angular dependence of the radiant energy such as those shown by curve B1, C1 in Fig. 4 disappears mostly because the viewed area of the surface (11a) by said radiation detector (9) does not decrease with increase

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of the vertical angle θ . When a comparatively large spot heating is required with the radiant energy, the heater is available because the heater can emit the radiant energy for a comparative large area with a high radiation efficiency.

5 It is preferable that said reflective films (72) have a low thermal conductivity owing to the same reason as that described in the low thermal conductivity of said thin protruded plates (7). The low thermal conductivity can be obtained by means of a very thin metal films in
10 thickness without decreasing the reflectivity.

When the radiant energy emitted from the heater is required to be stronger for the upward or downward direction, it is obvious that said reflective films (72) are preferably formed on one upward or downward surface of
15 each of said thin protruded plates (7), respectively.

Radiation characteristics described in detail hereinbefore were obtained when said planar resistive film (13) shown in Fig. 2 had a very low positive temperature coefficient of resistance. On the other hand, when said
20 resistive film (13) has a steeply sloped positive temperature coefficient of resistance at a selected temperature, different characteristics from those described hereinbefore were obtained.

When the electric power was initially applied to
25 said resistive film (13), a high electric power was dissipated because the resistance at the temperature range

less than the selected temperature was determined to have a low value. However, as the temperature of said resistive film (13) increased and approached to the selected temperature, the applied electric power decreased steeply and then the temperature was saturated near the selected temperature in the stationary state because the resistance increased steeply near the selected temperature. These facts cause different characteristics from those described hereinbefore to be obtained.

10 When the heater was constructed as shown in Fig. 2 and said resistive film (13) had the steeply sloped PTC, the vertical angular dependence of the radiant energy showed the similar characteristics as those shown by curves B1 and C1 in Fig. 4 except for the fact that the radiant
15 energy for the normal direction of $\theta=0$ and $\phi=0$ degree was nearly equivalent to that of the conventional heater. The horizontal dependence of the radiant energy showed the similar characteristics as that of the conventional heater, shown by curve A2 in Fig. 5. However, the dissipated
20 electric power decreased to about 70~80% of the dissipated power in the conventional heater. These facts indicate that the heater according to the invention has the advantage of being possible to save the dissipated electric power without decreasing the radiant energy available for heating.

25 When a long and slender electric heat generator standing for the vertical direction was used as said heat

generator ①, said thin protruded plates ⑦ were arranged around said long and slender heat generator. This heater showed the similar vertical angular dependence of the radiant energy as those obtained with the heater comprising said resistive film ⑬ having the steeply sloped PTC. On the other hand, the dissipated electric power also decreased to about 90~80% of that in the conventional heater. These facts indicate that the heater according to the invention has the advantage of being possible to save the dissipated electric power without decreasing the radiant energy available for heating.

While several embodiments of the invention have been illustrated and described in detail, it is particularly understood that the invention is not limited thereto or thereby. For example, the invention can be also applied to gas-firing or oil-firing infrared radiator and the like.

CLAIMS:

1. An infrared radiant heater comprising a heat generator with an infrared radiative surface standing for the nearly vertical direction; and an infrared transparent and low thermal conductive body arranged near or on said infrared radiative surface.

2. An infrared radiant heater claimed in Claim 1, wherein said infrared transparent and low thermal conductive body comprises thin protruded plates for the normal direction to said infrared radiative surface, said thin protruded plates being arranged horizontally near or on said infrared radiative surface in such a way that said thin protruded plates are separated each other at an interval, and spaces limited by said thin protruded plates and said infrared radiative surface.

3. An infrared radiant heater claimed in Claim 2, wherein said thin protruded plates are composed of a low thermal conductive materials.

4. An infrared radiant heater claimed in Claim 2 or 3, wherein said thin protruded plates have the form of 0.05~1.0 mm in thickness and 5~50 mm in height, and are arranged at an interval of 2.5~50 mm.

5. An infrared radiant heater claimed in Claim 2, wherein the angle between said thin protruded plates and said infrared radiative surface is ranged from 45 to 90 degrees.

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6. An infrared radiant heater claimed in Claim 2, further comprising infrared reflective films formed on the surface of said thin protruded plates.

7. An infrared radiant heater claimed in Claim 6, wherein said infrared reflective films have a low thermal conductivity.

8. An infrared radiant heater claimed in Claim 6, wherein said reflective films are formed on one upward or downward surface of each of said thin protruded plates.

9. An infrared radiant heater claimed in Claim 2, wherein said heat generator comprises a resistor having a steeply sloped positive temperature coefficient of resistance.

10. An infrared radiant heater claimed in Claim 2, wherein said heat generator has a long and slender form and said thin protruded plates are arranged around said heat generator.

Fig. 1

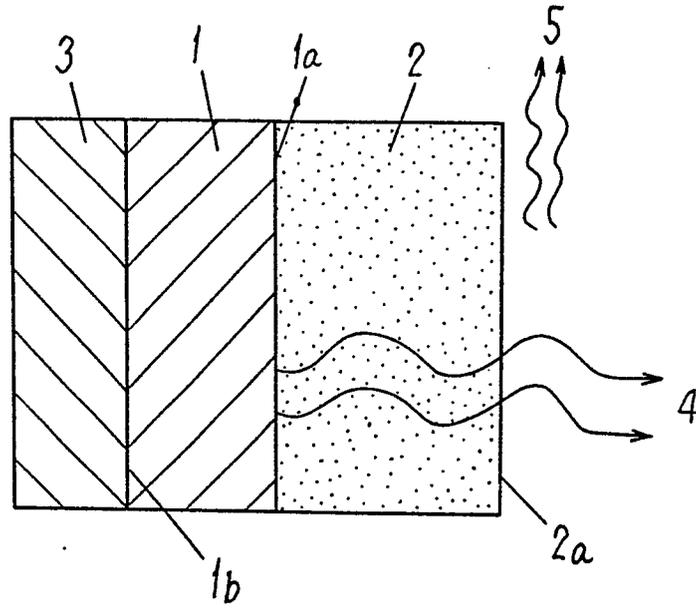


Fig. 2

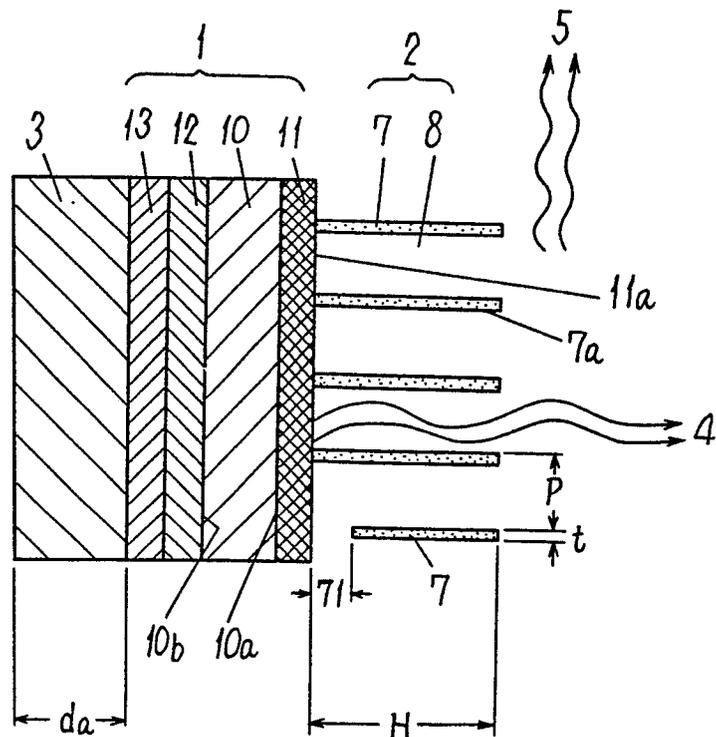


Fig. 3

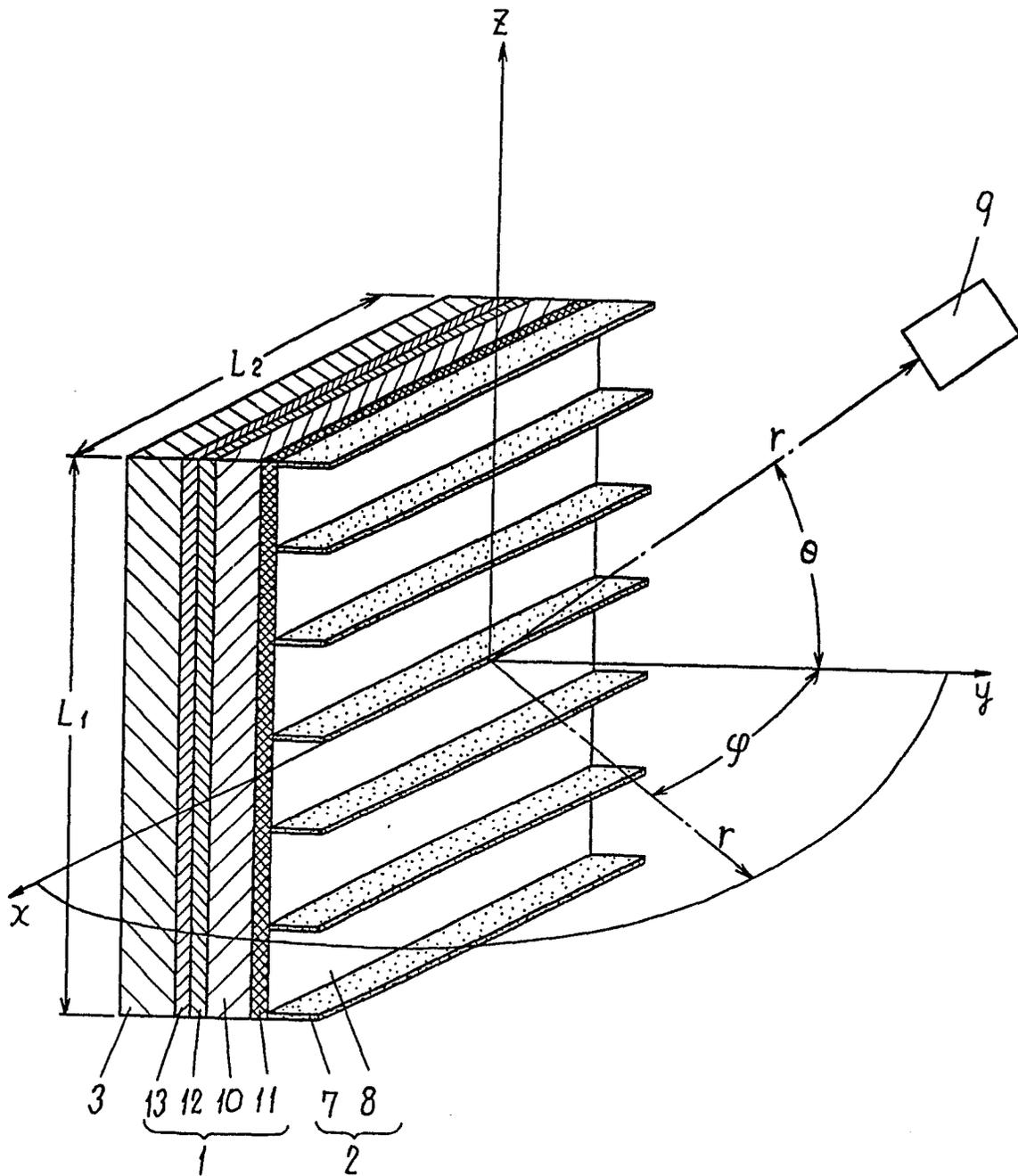


Fig. 4

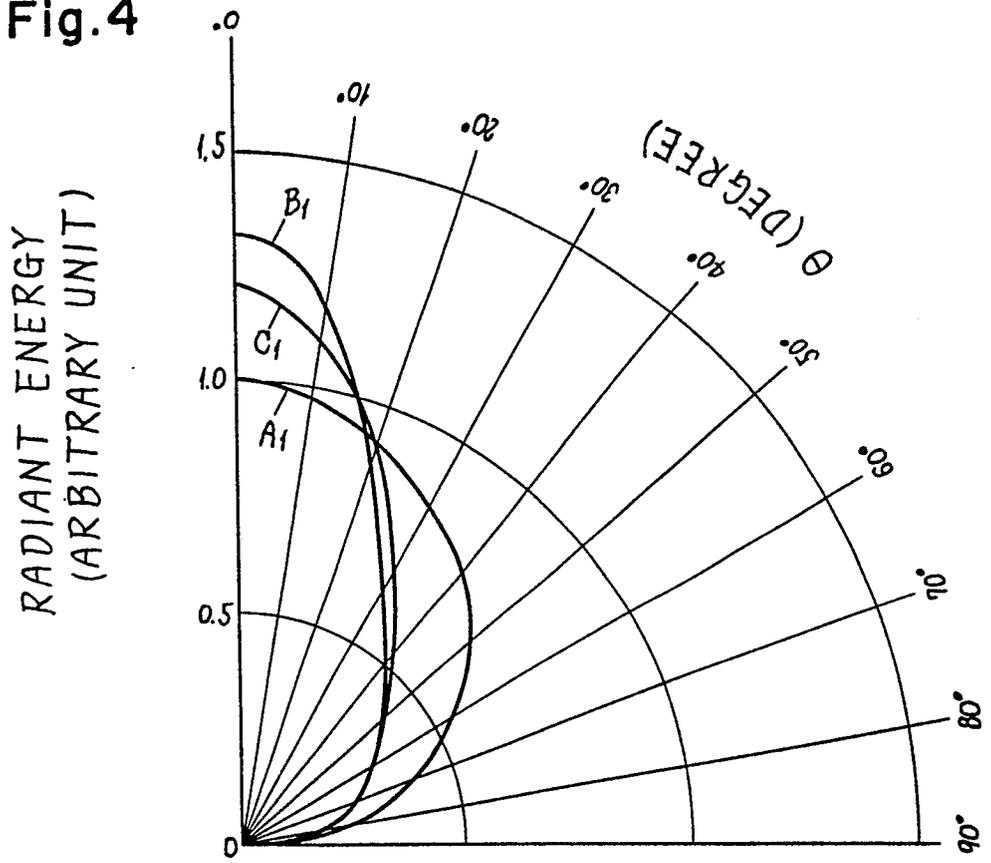


Fig. 5

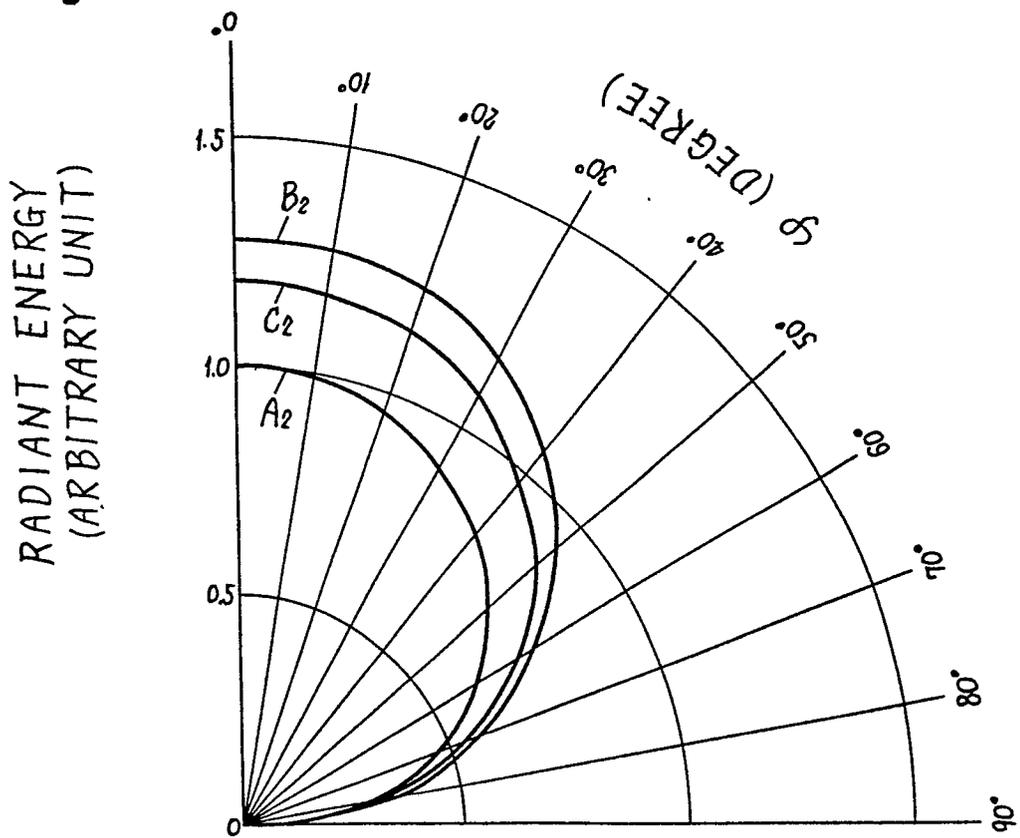


Fig.6

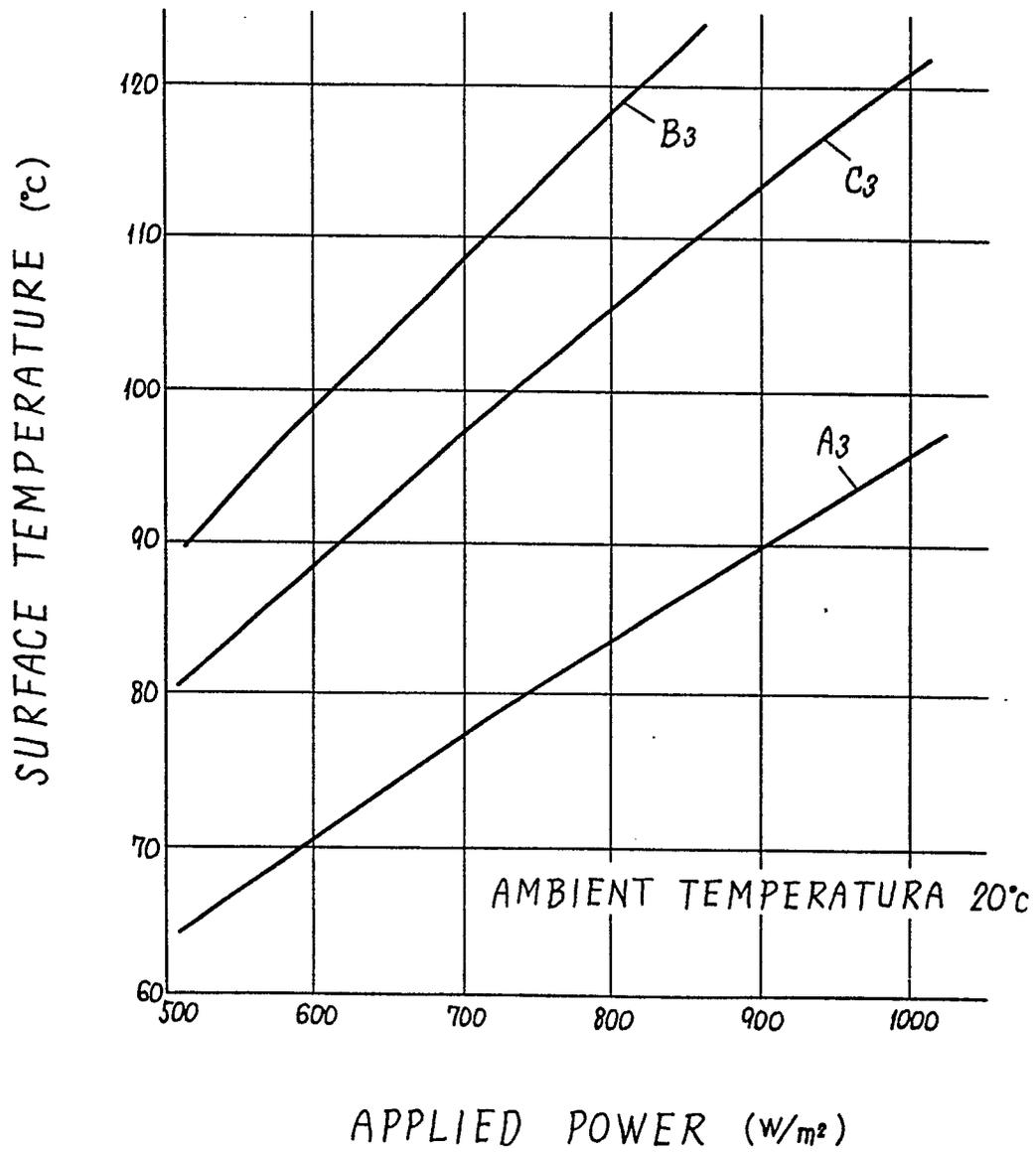


Fig.7

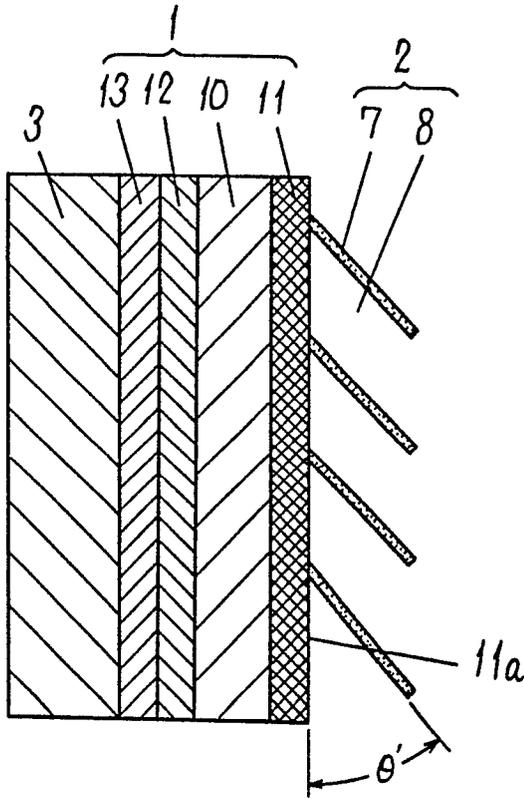


Fig.8

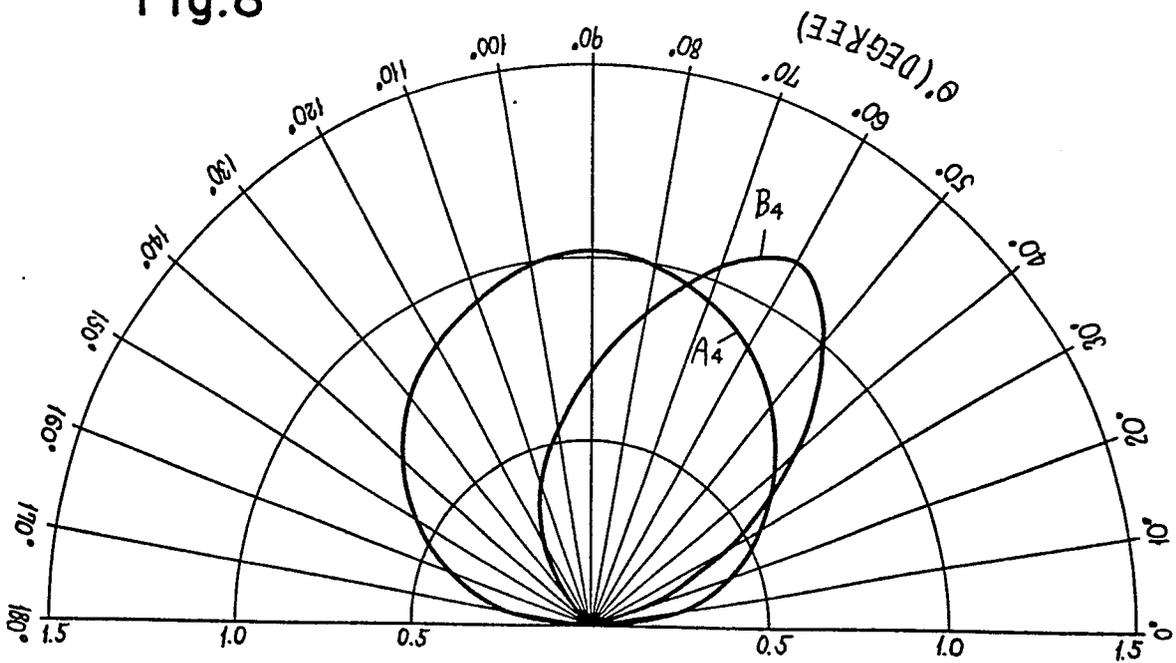
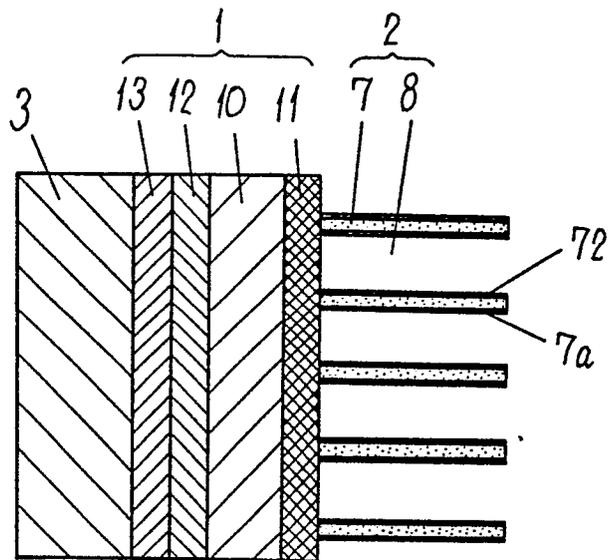


Fig. 9





EP 83300322.1

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 7)
X	<u>US - A - 3 045 100</u> (C.A. MILLS) * Totality * --	1	H 05 B 3/20 H 05 B 3/10
A	<u>DE - A1 - 2 442 892</u> (HEWLETT- PACKARD) * Totality * --	1	
A	<u>US - A - 3 493 724</u> (H.D. WELLS) * Totality * --	1,2	
A	PATENT ABSTRACTS OF JAPAN, unexamined applications, section M, vol. 1, no. 65, June 24, 1977 THE PATENT OFFICE JAPANESE GOVERNMENT page 879 M 77 * Kokai-No. 52-13 146 * --		TECHNICAL FIELDS SEARCHED (Int. Cl. 7) H 05 B 3/00 F 24 C 7/00 H 01 K 1/00
A	<u>DE - A1 - 2 407 619</u> (BLACK BODY CORPORATION) --		
A	<u>FR - A - 1 230 450</u> (EMILE BIGEAULT) --		
D,A	<u>DE - B2 - 2 619 622</u> (STEINMETZ MANFRIED) ----		
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 28-04-1983	Examiner TSILIDIS
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			