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(54) **Electric stove with limited-power heating circuits**

(57) An electric stove, herein termed "Herna stove", comprising a metal footing (1), vertical walls (6) which are rigidly coupled to the footing and to each other, a top surface (10) for closing the stove which is fixed to the side walls, a heating cavity (5) which is delimited between the footing (1), the side walls and the top (10) of the stove, intake means (11) for aspirating air from the surrounding space into the stove, said means being arranged with an upward and downward orientation, a

complex ventilation system (4) for aspirating/delivering ambient air through the air intake and discharge means, the ventilation system being arranged inside the heating chamber, possibly on the internal surface of the top structure with downward and upward flow directions, electric air heating means (7) arranged on the side walls toward the inside of the stove, means (3) for the forced evacuation of the air from the inside of the stove toward the surrounding space which are arranged in the footing.

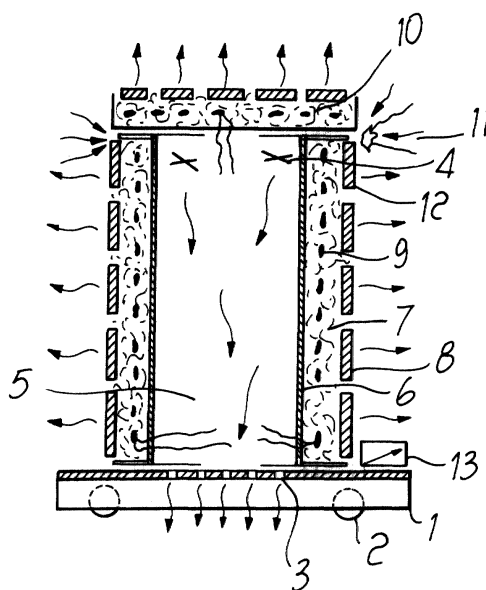


Fig. 1

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Description

[0001] The present invention relates to a stove which is supplied with electric power by means of limited-power heating circuits, for the ecological heating of civil spaces.

[0002] The stove according to the present invention, termed "Herna stove", is an innovation with respect to the classic ancient wood-burning stove, which is known as "Pigna" in the Alps, i.e., the typical stove of mountainous regions or of European regions that have a cold climate (such as, in Italy, the Alpine range or other European regions, such as the Slavic, German and Swiss regions).

[0003] The origin of the so-called "stove" is Latin and dates back to the Roman period. The Romans in fact already used vertical tubular heating systems made of fired clay or terra-cotta.

[0004] The classic "stove" usually substantially consists of a vertical masonry structure in which the outer walls are usually clad with tiles or, in order to improve the aesthetic and functional effect, majolica, owing to its higher heat conductivity and higher ability to retain stored heat. The masonry footing of the classic "stove" is rigidly coupled to the floor of the room in which it is installed, and sometimes two of the four vertical surfaces are rigidly coupled to the walls of the room.

[0005] The "stove" is internally hollow, forming the so-called hearth, in order to be able to accommodate the firewood and therefore the fire, whose tongues rise through channels formed along the cavities of the internal walls of the stove, transmitting heat to the outer surface and therefore to the surrounding room.

[0006] The inside of the classic stove, i.e., the cavity that acts as a hearth, is connected to a so-called flue pipe in order to evacuate the fumes toward the stack and is also connected to an opening arranged on the base in order to allow the inflow of combustion air and allow so-called "draft".

[0007] The classic stove has drawbacks. It requires the use of wood which, in modern times, is increasingly unavailable even in mountainous or wooded regions, due to the modern lifestyle of people.

[0008] The classic stove dissipates much of its heat through the stack, and therefore its efficiency is reduced considerably; it uses a fuel (wood) which has a very low calorific value (approximately 3000 kcal/kg at the most) and has an average consumption of 100-140 kg of wood in 24 hours, with an average cost of approximately 34,000 Italian lire in order to maintain 18 °C in a room measuring 5 m x 5 m x 3 m in height (75 m³) when the outside temperature is between -5 °C and +5 °C.

[0009] The classic stove must be tended, since the fire must be constantly controlled and ash must be removed; this can entail a problem and a cost for disposal if the "stove" is operating in urban areas.

[0010] The aim of the present invention is to provide a device which, although replicating the appearance of the classic stove, overcomes its drawbacks, does not require wood or other fuel, but has a high efficiency, a surface of the radiating walls at 149 °C with protective spacers, uniform heat distribution, no heat loss at the stack, no maintenance and no fire to be tended or residue to be disposed.

[0011] This aim and these and other objects which will become better apparent from the description that follows are achieved by an electric stove, hereinafter termed "Herna stove", which comprises a metal footing, vertical walls which are rigidly coupled to the footing and to each other, a top surface for closing the stove which is fixed to the side walls, a heating chamber which is delimited between the footing, the side walls and the top of the stove, means for drawing air from the surrounding space into the stove which are arranged with upward and downward orientations, a complex ventilation system for aspirating/discharging ambient air through the air intake and discharge means, said ventilation system being arranged inside the heating chamber, possibly on the internal surface of said top structure with downward and upward flow directions, electric air heating means arranged on the side walls toward the inside of said stove, means for the forced evacuation of the air from the inside of the stove toward the surrounding space, said means being arranged in said footing.

[0012] In one embodiment of the stove according to the present invention, the air evacuation means are arranged on the side walls, on the bottom and on the top, with an individual-independent supply which is differentiated both as pressure and as flow-rate.

[0013] Figure 1 shows a sectional view of the stove of the present invention;

[0014] Figure 2 shows a curve of minimum dissipation per meter of an applied heat-regulating conductor.

[0015] The stove according to the present invention is described in greater detail with reference to Figure 1.

[0016] The metal footing 1 can be constituted for example by stainless steel plate or iron coated by means of processes using thermosetting powders baked in an oven at temperatures of 180 °C and up to 240 °C.

[0017] The indicative dimensions of the footing can be comprised between 40 cm x 40 cm x 10 cm of thickness up to 200 cm x 200 cm x 30 cm of thickness and over.

[0018] Larger dimensions are also possible, since the electric stove according to the invention can be assembled at the user for which it is meant and therefore does not impose dimensional and weight constraints for transport and for passing through doors or stairways.

[0019] Other shapes of the footing, for example circular, oval or polygonal ones, are possible.

[0020] The footing can be provided with casters or swiveling wheels 2, for example four, six or eight wheels, so that the stove is not constrained to a fixed position, as instead occurs with the conventional stove. The wheels can be provided with a locking assembly on bearings and can be of the swiveling type.

[0021] The larger surface, i.e., the level surface that is parallel to the floor, of the footing comprises means 3 for the forced evacuation of the hot air toward the space to be heated (downward circuit). These means can be constituted by a number of holes whose diameter, quantity and arrangement are variable according to the dimensions and heating capacity of the stove.

[0022] The flow of hot air through the stove is promoted by an adequate ventilation assembly 4 which is arranged inside the stove, in the heating cavity 5 delimited inside the stove which replaces the hearth of the classic stove.

[0023] The lateral and vertical walls, which are preferably at least four, are composed of supporting structures 6 which are for example made of iron plate coated with powders baked in an oven at 180 °C and are shaped for example like a rectangular tray whose depth, i.e., the third dimension which determines its volume, is such as to accommodate the heating means 7 and the outer cladding 8.

[0024] The outer surface 12 of the walls, i.e., the exposed surface, which constitutes a radiating heating surface, can be formed by majolica tiles both to give a decorative appearance and to improve thermal efficiency.

[0025] The heating means 7 of the stove according to the present invention are preferably constituted by a mass which constitutes a thermosetting structure which comprises a material previously known generically as feldspar and a chemical bonding agent which undergoes thermosetting with an exothermic reaction; said mass surrounds an electrical heating cable 9.

[0026] Said material is particularly preferred if it is constituted by quartzitic silicate (SiO_2) or by trigonal silicon dioxide (assuredly mica-free), since one of the characteristics of this derivative of metamorphic rock is that it diffuses heat uniformly when it is compacted and homogenized without forming cracks and/or air pockets in order to surround a heating cable which is supplied with electric power. The microcrystals that compose it, if stimulated by a heat source included therein, can be compared to an electrical network composed of infinite microswitches which close, distributing the current uniformly throughout the system. Completeness is achieved by means of vibration during production and by preheating the heating cable.

[0027] The chemical bonding agent used is a thermosetting bonding agent which can be constituted for example by a mixture which gives rise to an exothermic reaction, aggregated with epoxy resin and amine resin, in order to obtain a thermosetting mix.

[0028] A preferred material comprises 88.5% sand and 11.5% epoxy resin.

[0029] The epoxy resin can be chosen from the group constituted by epoxy resins derived from the reaction of bisphenol-A and epichlorohydrine with an equivalent epoxy weight of 185-196, a viscosity at 25 °C of 12,000-16,000 cP, a 25/25 relative density of 1.16, an open-cup flash point of 249 °C, and a maximum Gardner color 3.

[0030] The material can also comprise a hardening or maturing agent such as an amide-amine.

[0031] An example of said material usable to provide the present invention is a siliceous product which comprises 82.8-83.8% by weight of a mineral aggregate, 12-13% by weight of epoxy resin, 3.7-4.7% by weight of maturing agents, and 0.03-0.09% by weight of a pigment, said mineral aggregate containing washed sand and quartzarenite.

[0032] The same mass, consisting of a thermosetting structure, can be used for the application and anchoring of the majolica tiles to the surface of the stove when they are applied to the mass of thermosetting feldspar prior to the exothermic reaction thereof during manufacture, i.e., before its final and permanent setting; the majolica tiles are also partially penetrated by said mass.

[0033] The heating cable 9 can be a self-regulating limited-power heating element, with a parallel-connected resistor, which emits temperatures up to 149 °C and can withstand a maximum temperature of up to 260 °C, being operational already at a minimum temperature of minus 40 °C.

[0034] The preferred type is the self-limiting one with a cable matrix for process temperature up to 150 °C and with a preferred power of 66 W/meter, provided with a nickel-plated sheath without fluoropolymer protection (to allow better grounding).

[0035] The characteristics of the matrix of the chosen heating cable, of the explosion-proof type, must be such as to allow a minimal starting overcurrent.

[0036] The self-limiting heating cable is cut to such a length as to have the wattage assumed for the power of the intended heating system.

[0037] The self-limiting heating cable is coupled at one end so as to perfectly insulate the electrically conducting part with respect to the sheath which acts as a ground conductor and with respect to the thermosetting structure of the heating means in order to avoid a short circuit.

[0038] The heating element can be supplied by the electrical mains at 220/240 V, approximately 50/60 Hz; it can operate continuously and uninterruptedly and from a power of 66 W/m (at 10 °C) with an initial starting current of approximately 0.3 A/m which may decrease by as much as 40% when the steady state is reached, by virtue of the structural composition of the chosen feldspar.

[0039] A fundamental characteristic of this heating element is that electrical consumption decreases as the temperature of the heating cable and of the particular silica feldspar-quartzitic environment that contains it rises and therefore it is possible to obtain extensive surfaces heated to temperatures around 120-140 °C with a consumption between a few tens of watts up to a few hundred watts without having to distribute with a particular pitch density the chosen heating cable, which is of the self-limiting and explosionproof type.

[0040] Table 1 lists, merely as a non-limitative illustration of the invention, examples of parameters related to typical heating panels, i.e., walls of the Herna stove, provided by means of majolica, a hardened and homogeneous siliceous mass, a limited-power heating element, a metallic containment tray whose surface lies opposite the one to which the majolica is applied and whose surface directed toward the inside of the cavity of the Herna stove forms the radiating surface.

Table 1

Example of characteristic data of a basic model suitable for environments measuring 70 m ³ to 150 m ³	
Vertical radiating surface of each wall	60 x 150 cm
Thickness of radiating surface with majolica	Approximately 7 cm
Thickness of radiating surface without majolica	Approximately 3 cm
Supporting structure of the radiating surface (tray)	Fe coated with powders in an oven at 180 °C
Structure of footing	Stainless steel and/or iron coated with powders in an oven at 180 °C
No. of vertical radiating surfaces	four (60 x 150 cm)
No. of horizontal radiating surfaces	1 (70 x 70 cm)
Power applied to each vertical radiating surface	(0.066 x 12) kW = approximately 0.792 kW
Total power applied to the vertical radiating surfaces	(0.792 x 4) kW = approximately 3.2 kW
Steady-state consumption of each surface	0.560 kW/h (0.792 x 0.7) (*)
Delta between starting consumption (applied power) and steady-state consumption according to the indicative dissipation curve (ref. Table 3)	on average 30-40% lower (*)
Circuit engagement	Not simultaneous but by means of electronic sequencing unit
Starting current absorption for each vertical radiating surface	3.6 A
Steady-state current absorption of each vertical radiating surface	2.52 - 2.16 A
Total power absorbed by the four vertical walls in the steady state	Approximately 10 A max
Total steady-state consumption of the four vertical walls if all four circuits are engaged	2.20 kW/h (0.560 x 4)
Total steady-state consumption of radiating surface placed at the top (top covering)	(66 W/m x 6 m x 0.7) 0.28 kWh
Total hourly consumption of the system in the steady state	2.2 + 0.28 = 2.48 kWh
Total average hourly cost	2.48 kWh x 302 ITL/kWh = approximately 749 lire
Total average cost for 24 hours	749 ITL/h x 24 = approximately 17,980 lire
Possible temperature on radiating surfaces	120-140 °C
Ventilation system at the maximum pressure of 30 Pa for flow-rates variable from	200 to 300 m ³ /h
Hourly consumption of ventilation system	0.002-0.003 kWh

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Table 1 (continued)

Example of characteristic data of a basic model suitable for environments measuring 70 m ³ to 150 m ³	
Dimensions of wheel-mounted device	70 cm x 70 cm x 190 cm height
Placement options	Anywhere, even in the center of the room
Power supply voltage	220/240 V DC - 50/60 Hz, single-phase, with ground
Indicative weight	approximately 350 to 450 kg

[0041] The heating element can be provided by one or more separate circuits, so as to allow electrical supply of the individual circuits by means of a single switch or by means of a sequencing system programmed to eliminate an excessive electrical starting peak and also to allow use of the "Herna stove" even in households fitted with a meter with a power limit of 3 kW. A box 13 for the electrical controls is arranged on the outside of the stove.

[0042] The vertical walls of the stove according to the present invention can be rigidly coupled to the footing and to each other by means of appropriate and functional mechanical couplings provided in compliance with all applicable statutory provisions.

[0043] The top 10 of the stove according to the present invention is closed by means of a structure which is identical to the structure of the walls or even merely similar to the structure of the walls when it is provided only with the majolica tile, without the heating system.

[0044] An adequate ventilation system, which draws the air from the room by virtue of the air intake means 11, is arranged inside the stove, in the heating cavity or on the internal surface of the structure that closes the top of the stove, with downward and upward flow withdrawal.

[0045] The air intake means can be constituted by upper-lateral peripheral passages and/or lower-lateral peripheral passages and/or both, controlled by air locks, and propel the air inside the heating chamber of the stove according to the invention toward the footing and the means for forced evacuation of the air, making it flow out through said means provided in the footing, in the walls and in the top.

[0046] This solution allows to remove the cold and damp air that tends to stagnate on the floor of the room and allows correct and uniform distribution of temperature/humidity, without removing dust and rapidly reduces the difference between the temperature of the aspirated air with respect to the colder and heavier air that would tend to stagnate on the floor.

[0047] The finish of the outer surface, such as the edges, et cetera, can be as appropriate as possible in order to harmonize with the surrounding space that contains the Herna stove according to the invention and/or with the most disparate architectural requirements.

[0048] The advantages of the stove according to the present invention with respect to a conventional wood-burning stove are also shown in Table 2.

Table 2

Advantages of the Herna stove with respect to a conventional wood-burning stove			
ASPECTS		HERNA STOVE	CONVENTIONAL STOVE
Fuel		electricity	Wood
Fuel management		none	Indispensable
Residues of fuel to be managed		no	yes, ash
Standards to be met for residue disposal		no	Yes
Combustion tending		no	Yes
Combustion dust and pollution		no	Yes
Programmable temperature		yes	No
Uniform heat distribution		yes	No
Loss of heat in stack		no	Yes
Remote ignition of stove (option)		yes	No
Programming of ignition without operator		yes	No
Placement requires permanent fixing to floor		no	Yes

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Table 2 (continued)

Advantages of the Herna stove with respect to a conventional wood-burning stove			
ASPECTS		HERNA STOVE	CONVENTIONAL STOVE
Placement is constrained by containment room		no	Yes
<u>Consumption and energy costs</u> Amount of wood in 24 hours for a 75-m ³ room, at the temperature of 18 °C (room measuring 5 m x 5 m x 3 m height) - outside temperature between -5 and +5 °C		=====	approximately 140 kg or more
Average price of 100 kg of wood		=====	23-26,000 lire
Total cost for 24 hours with wood-burning stove after reaching the steady state		=====	34,000 lire
Time required to reach steady state		=====	1h 15 m
Electrical consumption in 24 hours in equal conditions with a Herna stove system in the steady state		57 kW max	=====
Cost, kW/h = 243 lire + 24 lire for tax + 35 lire for fees		302 lire per kW/h	=====
Time required to reach steady state		40 minutes	=====
<u>NOTE</u> Costs and prices taken from invoices and bills in Italy dated November/December 1999			
Total cost for 24 hours (302 ITL/kWh x 57 kW)		17,214 lire	=====
Extra cost with respect to wood-burning stove		=====	16.786 lire
Saving allowed by Herna stove		16,786 lire	=====
Constancy of maximum temperature over 24 hours		yes	No*
<u>*NOTE</u> In the case of the wood-burning stove, wood must be placed periodically in the hearth, involving the operator; accordingly, the thermal behavior of the wood-burning system is not constant at its maximum value.			
Possibility of placement in any room, including buildings in historical centers		yes	No
Request for authorizations to build stacks required for the stove		no	Yes
Building costs for installing the stove		no	Yes
Space required to store fuel		no	Yes
Additional costs for insurance policies according to the room where the stove is placed		no	Yes
Utilization of generated heat		100%	max 50-70%
Wood consumption per hour	approx	=====	5-6 kg/h
Electric power consumption per hour with system in the steady state	approx	2.4 kW/h	=====
Cost of wood per hour (average)	approx	=====	1,348 lire/h
<u>NOTE</u> In order to compensate for the difference, the electrical system would			

Table 2 (continued)

Advantages of the Herna stove with respect to a conventional wood-burning stove			
ASPECTS		HERNA STOVE	CONVENTIONAL STOVE
have to consume twice as much, or for an equal running cost one could heat a room with approximately twice the volume, other conditions being equal.			
Average cost per hour of electricity	approx	725 lire/h	=====

[0049] The stove according to the invention is highly efficient and has low energy consumption.

[0050] For each meter of heating conductor applied to the stove, the starting current is approximately 0.3 A. In the steady state, the consumption of the cable alone is reduced by 27% and by as much as 40% according to the placement and controlled intervention of the air flows.

[0051] In the presence of the heating element, as used in the present invention, and by keeping the radiating surface at an actual temperature of approximately 140 °C, the operating current and therefore the consumption are reduced by 40-42% with respect to the initial starting value and therefore with respect to the first-start absorption (supply voltage approximately 220 volts single-phase with ground, 50/60 Hz).

[0052] An indicative curve of the minimum dissipation per meter of applied heat-regulating conductor is plotted in Figure 2.

[0053] These results are not achieved even by using so-called classic "adhesive cement mortars", which are specific for bonding ceramics, tiles, mosaics et cetera. (Example: MAPEI Keracolor product and the like).

[0054] The stove according to the present invention was devised with attention to environmental problems and to energy saving with respect to conventional solutions.

[0055] Although electric power is admittedly generated to a large extent by thermoelectric power stations, at least in Italy, it is also true that these thermoelectric power stations are currently run very well and that every parameter (such as CO, CO₂, SO₂, NO, NO₂, O₂, dust, particulate, et cetera) is continuously monitored, thus achieving better environmental and energy compliance by reducing the countless small thermal units fired by fossil fuel, plant-derived, wood-derived and gaseous fuel. The small and medium domestic units are in fact not monitored constantly and therefore they certainly are sources of pollution and of consequent energy waste.

[0056] Moreover, by contributing to the reduction of wood combustion, the stove according to the present invention also contributes to the preservation of trees, which are essential for health, but also for soil containment and for a more natural control of water runoff.

[0057] Moreover, the manufacture of the Herna stove according to the present invention does not produce, due to its processes, any kind of pollution, including noise pollution, except for the normal noise pollution generated by a quiet well-run workshop.

[0058] The disclosures in Italian Patent Application No. MI2000A000792 from which this application claims priority are incorporated herein by reference.

[0059] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. An electric stove, comprising:

- (1) a metal footing (1);
- (2) side walls (6) which are rigidly coupled to the footing and to each other;
- (3) a top structure (10) for closing the stove which is fixed to the side walls;
- (4) a heating cavity (5) delimited between said footing, said side walls and said top structure;
- (5) intake means (11) for introducing air at an adjustable pressure and flow rate from the surrounding space into the heating cavity, said intake means being arranged vertically in the structure of the walls and in the top structure;
- (6) a ventilation system (4) for aspirating air from the surrounding space, through said air intake means, said

ventilation system being arranged in the heating cavity;
 (7) electric air heating means (7) of the type with temperature self-adjustment, arranged on said side walls;
 (8) means (3) for the forced evacuation of the air, with adjustable pressure and flow-rate, from said heating
 cavity toward the surrounding space, said means (3) being provided in said footing.

2. The stove according to claim 1, **characterized in that** said air evacuation means (3) are also arranged on the side walls (6).
3. The stove according to claim 1 or 2, **characterized in that** said air evacuation means (3) are constituted by holes.
4. The stove according to one of the preceding claims, **characterized in that** said air heating means (7) comprise a heating element (9) with temperature self-adjustment.
5. The stove according to claim 5, **characterized in that** said self-adjusting heating element (9) is enclosed within a mass which contains feldspar and a chemical bonding agent.
6. The stove according to claim 5, **characterized in that** the feldspar is constituted by trigonal silicon dioxide.
7. The stove according to claim 6, wherein the chemical bonding agent is constituted by a mixture of epoxy resin and amine resin.
8. The stove according to one or more of the preceding claims, **characterized in that** the side walls (6) are clad with majolica tiles.

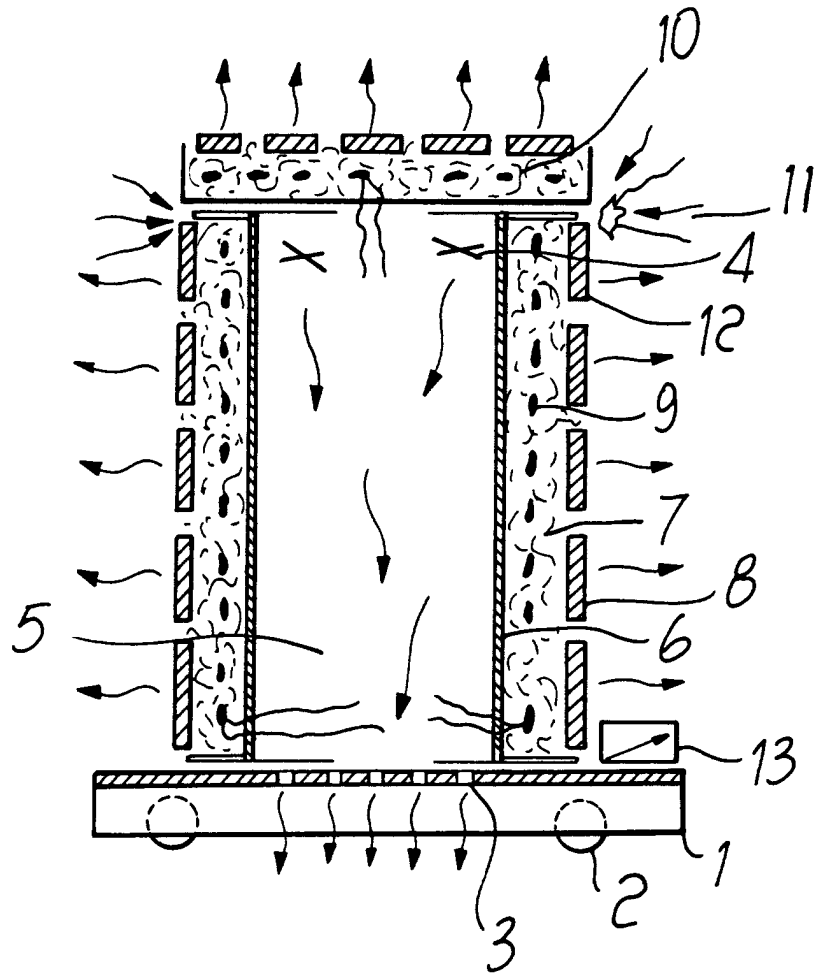


Fig. 1

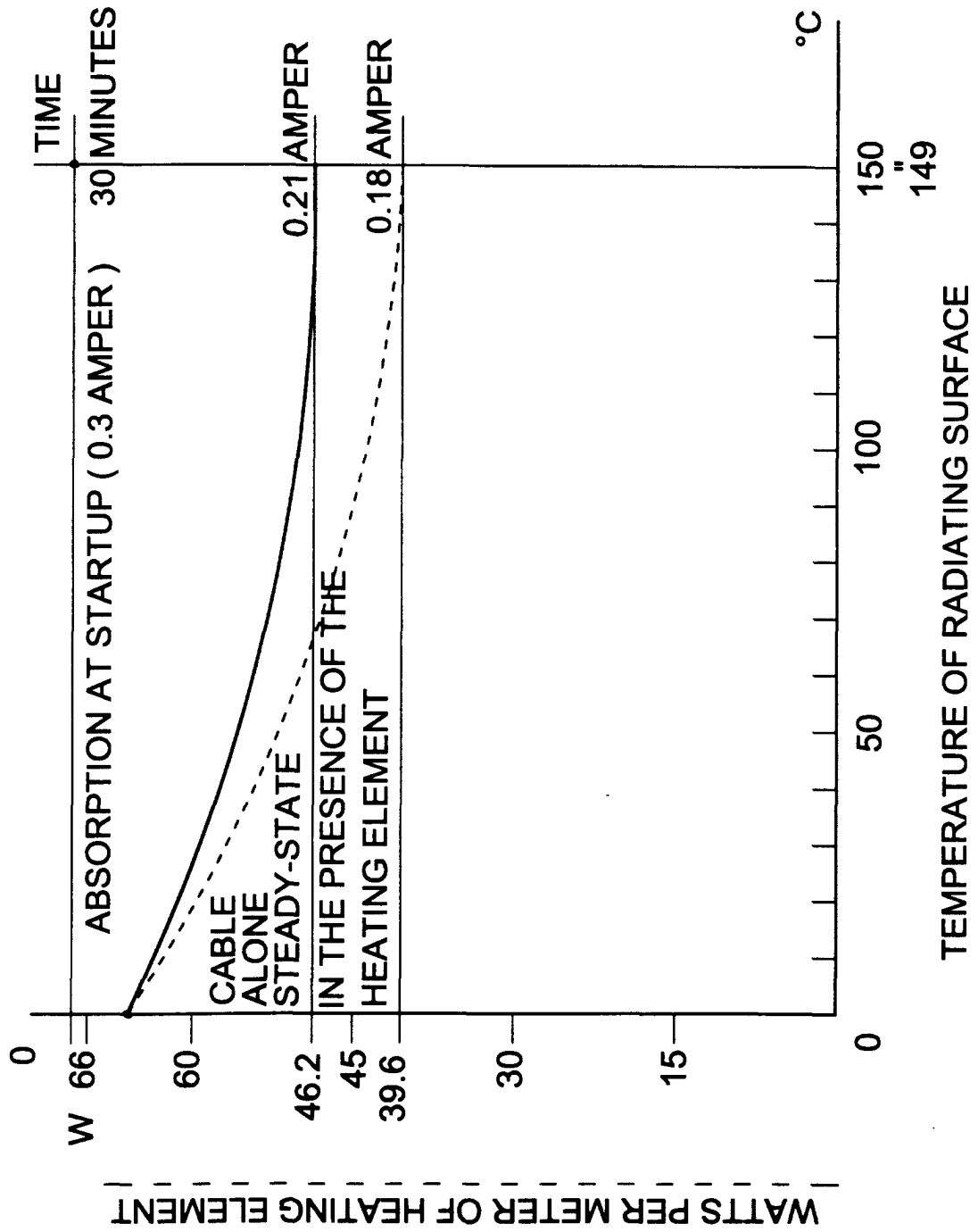


FIG. 2