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(54) **Method and device for homogeneously heating materials by means of high-frequency electromagnetic radiation**

(57) The invention provides for a method for heating materials being capable of absorbing high-frequency electromagnetic radiation, in particular microwaves, by means of irradiating said materials with high-frequency electromagnetic radiation. In order to achieve an essentially consistent heating of the material and, in particular, to avoid hot spots in the material, the high frequency electromagnetic radiation is coupled into said material at a plurality of radiation areas by means of a plurality of in-coupling means, the centres of said radiation areas being

spaced apart from each other. The temperature of the material is measured in each of said plurality of radiation areas, and the radiation dose of said plurality of in-coupling means is controlled, dependent on the respective temperature, in such a way that a substantially uniform temperature of the material is obtained in all of said plurality of radiation areas. The method is particularly useful for curing or crosslinking polymers or resins. Moreover, a device for carrying out such method is proposed.

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Description

[0001] The present invention relates to a method for heating materials being capable of absorbing high-frequency electromagnetic radiation, in particular microwaves, by means of irradiating said materials with high-frequency electromagnetic radiation. Moreover, the present invention is directed to a device for heating materials being capable of absorbing high-frequency electromagnetic radiation, the device being capable of carrying out such process and comprising at least one source of radiation capable of generating high-frequency electromagnetic radiation, in particular microwaves, said source of radiation being connected to at least one incoupling means being capable of incoupling the high-frequency electromagnetic radiation generated by said source of radiation into the material to be heated.

[0002] Devices for the generation of high-frequency electromagnetic radiation of the type mentioned above are well-known in the art in order to heat different types of materials, e.g. meals and drinks (microwave ovens), polymers which are to be plastified (thermoplastics) or cured/cross-linked (thermosetting plastics, elastomers), etc.. Usually, the frequency and wavelength of the generated radiation are in the range of microwaves, i.e. between approximately 300 MHz and 300 GHz and between approximately 1 mm and 1 m, respectively, although said parameters may vary in a broader range dependent on the material to be heated.

[0003] One basic problem of the heating by means of high-frequency electromagnetic radiation, in particular microwaves, consists in that a rather inhomogeneous temperature distribution is achieved in the material being heated as conventional incoupling means, e.g. microwave antennas in the form of substantially rectangular or cylindrical wave guides and the like, usually emit a rather acute "jet", in the centre thereof the material tends to get overheated whereas in the circumferential area of this "jet" no significant heating occurs. Furthermore, the radiation field itself generated by an incoupling means, e.g. a microwave antenna, of a source of radiation being capable of generating microwaves, e.g. a magnetron, klystron or the like, tends to be rather inhomogeneous. Moreover, as heating of a material by means of high-frequency electromagnetic radiation is dependent on its material properties, e.g. density, water content, material type and especially absorption capacity for high-frequency electromagnetic radiation, it is practically impossible to provide for a substantially homogeneous heating of the material by means of high-frequency electromagnetic radiation, which not only applies in connection with materials to be heated itself being not very homogenous.

[0004] Conventional microwave ovens try to cope with this problem by rotating the material to be heated in order to obtain on the one hand a broader area being exposed to the microwaves and on the other hand to prevent discrete areas of the material from being overheated due to being exposed to the microwaves over a too long pe-

riod of time. As far as the use of high-frequency electromagnetic radiation in the field of plastics procession is concerned, e.g. in order to cure or cross-link curable or cross-linkable resins or polymers, the problem above is conventionally also addressed by moving or rotating a mould being filled with the resin or polymer relative to one or more microwave incoupling means or antennas or vice versa.

[0005] However, while merely moving the material to be heated relative to a microwave radiation field being generated by appropriate incoupling means of a microwave radiation source might largely prevent the material from being overheated in certain areas being most exposed to the radiation field, it is obvious that a substantially homogeneous heating of the material cannot be achieved in doing so, even if microwave absorbing additives are added to the material to be heated in order to enhance its microwave absorbance.

[0006] In addition, in particular in the field of plastics procession, especially in connection with curing or cross-linking resins or polymers or, generally speaking, monomers, dimers, oligomers or polymers, it is often required to observe very strict processing conditions due to the need of having a reproducible curing, cross-linking or polymerisation which can even make it necessary to formulate the resin batch-wise by manual preparation, as the case may be together with fibrous material for reinforcement purposes. As conventional microwave incoupling means cannot provide for a substantially homogenous and reproducible heating on the occasion of subsequent curing or cross-linking the resin, the latter is usually heated convectively.

[0007] In the case of rather large-scale components or products such as boats or hulls, blades of windmills, pipes and the like which are usually manufactured by resin infusion using an appropriate form tool or mould, the formulation often even has to be cured at ambient temperature over a long period of time, because there is no economical and environmental friendly solution for a homogeneous and reproducible heating-technology. Therefore, the manufacturer of such parts has to tailor a resin formulation for the processing (mixing of the resin components, additives, reinforcement fibres etc.) as well as for the curing at ambient temperature. However, while for the processing a rather low viscosity of the resin is beneficial (small molecules, short chain length, substantially no cross-linking) in order to provide for a homogeneous mixture and for a complete impregnation of reinforcement fibres, for the subsequent curing or cross-linking a fast polymerisation of the resin is advantageous which induces a strong increase of the viscosity, and therefore impregnation properties as well as mixing properties decrease drastically. Accordingly, if no change in boundary conditions, e.g. temperature, between the filling process of the mould and the curing or cross-linking process can be performed, the resin formulation has to fulfil conflicting conditions.

[0008] It is therefore an object of the present invention

to provide a method and a device for heating materials being capable of absorbing high-frequency electromagnetic radiation by means of such radiation of the type mentioned by way of introduction, where the above drawbacks are wholly or at least partially eliminated and which are preferably applicable for substantially homogeneously and reproducibly heating and curing or cross-linking resins or polymers.

[0009] On the one hand, this object is achieved by a method as defined by way of introduction, the method being characterised in that the high-frequency electromagnetic radiation is coupled into said material at a plurality of radiation areas by means of a plurality of incoupling means, the centres of said radiation areas being spaced apart from each other, wherein the temperature of the material is measured in each of said plurality of radiation areas, and the radiation dose of said plurality of incoupling means is controlled, dependent on the respective temperature, in such a way that a substantially uniform temperature of the material is obtained in all of said plurality of radiation areas.

[0010] On the other hand, the above object is achieved by a device as defined by way of introduction, the device being characterised in that it is provided with a plurality of incoupling means, said incoupling means are arranged in such a way that radiation areas are obtained the centres thereof being spaced apart from each other, wherein a temperature measuring means is assigned to each incoupling means being capable of measuring the temperature of each radiation area, and wherein the radiation dose of each incoupling means is controllable, dependent on the temperature of its radiation area measured by the respective temperature measuring means, in such a way that a substantially uniform temperature of the material to be heated is obtained in the radiation areas of all incoupling means, respectively.

[0011] The invention combines the main advantage of conventionally heating of materials by means of high-frequency electromagnetic radiation being comparatively fast and economical due to a comparatively high effectiveness with the essential further advantage of being able to provide for a substantially homogeneous and reproducible heating of the material in an effective and inexpensive manner due to the possibility of controlling the radiation dose of each of the plurality of incoupling means being spaced apart from each other dependent on the temperature of the respective radiation area of the material being radiated from the respective incoupling means. In this manner, a local overheating of the material ("hot spots") as well as more or less important temperature gradients in the material are reliably avoided which enables the invention to be particularly applied to plastics procession processes, e.g. curing or cross-linking of curable or cross-linkable resins or polymers for shaped parts of any size and especially also for relatively large-scaled shaped parts as described below in more detail. However, it is obvious for one skilled in the art that the present invention may be useful for heating any material being

capable of absorbing high-frequency electromagnetic radiation at least partially and, therefore, the invention must not be regarded as being restricted to the heating of plastics materials.

5 **[0012]** In an embodiment of the invention, the temperature of the material being heated is measured at least in the central region of each area being radiated, e.g. in the central point of the radiation field being emitted from the respective incoupling means. For this reason, the
10 temperature measuring means can be arranged in such a way that it is capable of measuring the temperature of at least the central region of the radiation area of the respective incoupling means, e.g. in alignment with the focus of the latter.

15 **[0013]** In order to provide for a substantially continuous control of the temperature profile in the material to be heated by the plurality of incoupling means, the temperature is preferably measured substantially continuously, especially in real-time and in time intervals of, e.g., 0,01
20 s to 1 s, respectively. In this case, the temperature measuring means is adapted to measure the temperature of the respective radiation area substantially continuously, wherein a data processing means as a central processing unit (CPU) or the like may be provided for processing the
25 temperature data being supplied from all of the temperature measuring means and for controlling the radiation dose being emitted from the respective incoupling means dependent on the actual temperature, respectively.

[0014] Although the temperature of the material being
30 radiated by the plurality of incoupling means may be basically measured by any suitable temperature measuring means, measurement of the temperature preferably takes place without contact of the measuring means with the material to be heated, in particular by means of infrared sensors.
35

[0015] With regard to the control of the radiation dose of each incoupling means in dependence on the temperature of the respective radiation area of the material to be heated, it can be preferable for each incoupling means
40 to be connected to an individual source of radiation capable of generating high-frequency electromagnetic radiation, e.g. a magnetron, klystron, maser or the like. In this case, the radiation dose of each incoupling means can be controlled by means of individually controlling the
45 radiation efficiency, in particular the amplitude of the high-frequency electromagnetic radiation, of its respective source of radiation. Alternatively or additionally, the radiation dose of each incoupling means can be controlled by means of individually controlling the duration of
50 generating radiation of its respective source of radiation, e.g. the source of radiation can be pulsed in order to generate discrete pulses of radiation being transmitted to the respective incoupling means, the duration and/or the frequency of the pulses being controlled dependent
55 on the temperature measured in the respective radiation area. In this manner, the radiation efficiency, in particular the amplitude of the high-frequency electromagnetic radiation, of each source of radiation can be held on a sub-

stantially constant level, preferably on an adjustable level or can, of course, be varied additionally.

[0016] As an alternative or in addition to controlling the radiation dose of the incoupling means by modifying the radiation efficiency or "power" of their respective source of radiation, it is, of course, also possible to modify the radiation dose of each incoupling means by directly affecting its emission properties. This provides the possibility to reduce the number of radiation sources such as magnetrons, klystrons etc. as all or at least some - controllable - incoupling means may be connected to one and the same source of radiation. To this end, according to an embodiment of the invention, the radiation dose of each incoupling means is controlled by means of individually influencing the emission properties of the respective incoupling means, wherein the radiation dose of each incoupling means preferably is controlled by means of varying a magnetic field affecting the respective incoupling means.

[0017] Accordingly, an embodiment of a device according to the invention can be designed in such a way that the radiation dose of each incoupling means is controllable by means of individual interference of the emission properties of the respective incoupling means. Preferably, a magnet having a variable magnetic field, in particular an electromagnet, is assigned to each incoupling means, wherein the magnet is arranged in such a way that its magnetic field is allowed to affect the radiation efficiency of the high-frequency electromagnetic radiation emitted from the respective incoupling means. The electromagnet is suitably in the form of a coil whose windings surround the respective incoupling means, e.g. a waveguide or antenna, wherein the coil is connected to a power supply unit such as a voltage or current generator, the power of which is controlled dependent on the temperature measured by the respective temperature measuring means, e.g., by means of a CPU as indicated above.

[0018] According to a preferred embodiment of the present invention, the plurality of incoupling means may be arranged in such a way that the radiation areas thereof overlap partially so that the circumferential areas of each radiation area generated by the plurality of incoupling means (in which the radiation dose is decreased compared to their central area and, therefore, an inferior heating capacity is obtained) can be radiated by more than one incoupling means, e.g. by two incoupling means being positioned adjacently. This may contribute to a very homogenous heating of the material avoiding any serious temperature gradients therein.

[0019] The plurality of incoupling means may be, e.g., arranged in an array, wherein such array preferably can comprise several rows of incoupling means, the rows being arranged substantially in parallel relationship. In order to provide for a homogenous overall radiation field as possible and, preferably, for a peripheral overlapping of the individual radiation fields being emitted from each incoupling means, the incoupling means of at least some

rows, in particular of adjacent rows, can be arranged in a staggered relationship, wherein the offset of different or adjacent rows may correspond to the reciprocal value of the number of rows multiplied by the distance of incoupling means or their radiation area in a row, respectively.

[0020] In an embodiment of the invention, the plurality of incoupling means is arranged on a carrier means, wherein the incoupling means are movable relative to said carrier means and/or said carrier means is movably mountable on the ground. The displacement of the array of incoupling means in respect of the carrier means or the displacement of the latter in respect to the ground may be, e.g., ensured through the provision of guide rails, portal cranes, robots or the like. By this means, it is for example possible to move the array of incoupling means along a shaped part or along a mould being filled with a curable resin in order to provide for a substantially homogenous curing or cross-linking thereof being initiated by the heating by means of high-frequency electromagnetic radiation.

[0021] A method as claimed in any one of claims 1 to 13, wherein the material being heated is selected from a group comprising curable and/or cross-linkable monomers, dimers, oligomers and polymers.

[0022] As indicated above, the invention is especially applicable to a thermally initiatable curing of resins or a cross-linking of polymers or, generally speaking, to the curing and/or cross-linking of curable and/or cross-linkable monomers, dimers, oligomers and/or polymers which can be heated to a sufficient temperature in order to substantially homogeneously cure and/or cross-link said monomers, dimers, oligomers and polymers at least partially, wherein the curing/cross-linking process can, of course, be influenced by previously known measures such as the provision of additives in the form of cross-linking agents, accelerators, promoters, hardeners (e.g., substances being capable to be decomposed to radicals such as peroxides etc.), additives being capable of enhancing the microwave absorbance (such as glycols, phthalates, amines etc.) and so on.

[0023] In practice, the curable and/or cross-linkable monomers, dimers, oligomers and polymers will be arranged in a mould, wherein the incoupling means are moved over substantially the entire mould in order to achieve a substantially homogenous curing and/or cross-linking of the curable and/or cross-linkable monomers, dimers, oligomers and/or polymers thereby obtaining a cured and/or cross-linked moulding. For this reason, the device according to the present invention may further comprise a mould being capable of accommodating curable and/or cross-linkable monomers, dimers, oligomers and/or polymers, the incoupling means being movable over substantially the entire mould in order to achieve a substantially homogenous curing and/or cross-linking of the curable and/or cross-linkable monomers, dimers, oligomers and/or polymers thereby obtaining a cured and/or cross-linked moulding or shaped part.

[0024] The invention will now be described in more detail by way of a preferred embodiment of a device for heating materials being capable of absorbing high-frequency electromagnetic radiation according to the present invention and with reference to the accompanying drawings, in which

fig. 1 is a perspective view of an embodiment of a device for heating materials by means of microwaves according to the present invention; and

fig. 2 is a schematic top plan view of an array of microwave antennas of the device as shown in fig. 1.

[0025] Referring to fig. 1, an embodiment of a device 1 for heating materials being capable of absorbing high-frequency electromagnetic radiation such as microwaves comprises a plurality of incoupling means 2 in the form of microwave antennas which may, e.g., be composed of hollow waveguides, coaxial waveguides or the like. Each incoupling means 2 is connected to an individual source of radiation 3 being capable of generating microwaves such as magnetrons. The incoupling means 2 are arranged in an array which, in the present embodiment, comprises two parallel rows R_1 , R_2 of microwave antennas 2 being positioned equidistantly and in a staggered relationship, wherein the offset of the antennas 2 of the first row R_1 and the ones of the second row R_2 is approximately half the distance of the antennas 2 in the first and second rows R_1 , R_2 , respectively, in order to provide for a substantially homogenous overall radiation field, the radiation field of the individual antennas 2 overlapping each other peripherally (see also fig. 2).

[0026] Referring again to fig. 1, the array of incoupling means or microwave antennas 2 and their sources of radiation or magnetrons 3 are arranged on a carrier means 4 in the form of a frame, wherein the array of microwave antennas 2 is movable in respect of the frame 4. For this reason, the array can, for example, be positioned on a slide 5 which is guidably mounted on guide rails 6 being fixedly mounted on the frame 4 in order to be able to be displaced a least translationally along the guides 6. Of course, the array of antennas 2 or the slide 5 can further be displaceable in a direction substantially perpendicular to that of the guides, and/or can be mounted rotatable around a vertical axis (not shown), if need be.

[0027] As shown in fig. 2, a temperature measuring means, e.g. an infrared sensor preferably being adapted to deliver measurement signals with regard to the temperature substantially continuously or in real-time, is assigned to each microwave antenna 2 in order to measure the temperature of the material to be heated (not shown) in a radiation area of the material being radiated from the respective antenna 2. The infrared sensors 7 can be arranged in the central region of each antenna 2 or its radiation area, respectively although, of course, more than one sensor may be assigned to each of the antennas 2

in order to measure the temperature of the radiated material in more than one point of the respective radiation area. A control means such as a CPU unit (also not shown) is provided in order to receive the information in regard to the temperature of all infrared sensors 7, and to control the microwave antennas 2, dependent on the respective temperature, in such a way that a substantially uniform temperature of the material to be heated is obtained in the radiation areas of all antennas 2. To this end, the radiation efficiency (i.e. the amplitude or "power" of the microwaves) of the radiation of the respective magnetrons 2 and/or the duration/frequency of discrete pulses of radiation being generated by the respective magnetrons 3 may be controllable dependent on the temperature measured in the respective radiation area.

[0028] In a particularly preferred embodiment, the device 1 is further provided with a mould (not shown) being positioned beneath the slide 5 carrying the array of microwave antennas 2 so that the microwaves can be incoupled directly in the mould. The width of the mould should correspond approximately to the width of the array of microwave antennas 2, whereas the length of the mould should not exceed the length of the guide rails 6 so that it is possible for the mould to be radiated substantially over the whole projection thereof by means of the moving the array of microwave antennas 2 along the guide rails 6. In any case, the mould should be positionable relative to the microwave antennas 2 in such a way that it is enabled to be radiated by the array of microwave antennas 2 substantially completely, e.g. beneath the array being mounted on the slide 5 which is movably mounted on the guide rails 6. The mould serves to accommodate curable and/or cross-linkable polymer or resins systems such as di or multifunctional acids, anhydrides, alcohols, isocyanates etc., if need be together with suitable additives, reinforcement fibres and so on, the resin system being curable or cross-linkable by means of radiating it with microwaves.

[0029] In this manner, mouldings or shaped parts, in particular also large-scale and/or rather complex mouldings such as blades of windmills, hulls etc. can be produced under pre-adjustable, reproducible and homogeneous curing conditions and in an inexpensive and time-saving manner, e.g. compared to a curing at ambient temperature or a curing employing convective heating.

Claims

1. A method for heating materials being capable of absorbing high-frequency electromagnetic radiation, in particular microwaves, by means of irradiating said materials with high-frequency electromagnetic radiation, **characterised in that** the high-frequency electromagnetic radiation is coupled into said material at a plurality of radiation areas by means of a plurality of incoupling means (2), the centres of said radiation areas being spaced apart from each other,

- wherein the temperature of the material is measured in each of said plurality of radiation areas, and the radiation dose of said plurality of incoupling means (2) is controlled, dependent on the respective temperature, in such a way that a substantially uniform temperature of the material is obtained in all of said plurality of radiation areas.
2. A method as claimed in claim 1, wherein the temperature of the material being heated is measured at least in the central region of each area being radiated.
 3. A method as claimed in claim 1 or 2, wherein the temperature is measured substantially continuously.
 4. A method as claimed in any one of claims 1 to 3, wherein the temperature is measured by means of infrared sensors.
 5. A method as claimed in any one of claims 1 to 4, wherein each incoupling means (2) is connected to an individual source of radiation (3) capable of generating high-frequency electromagnetic radiation.
 6. A method as claimed in claim 5, wherein the radiation dose of each incoupling means (2) is controlled by means of individually controlling the radiation efficiency, in particular the amplitude of the high-frequency electromagnetic radiation, of its source of radiation (3).
 7. A method as claimed in claim 5, wherein the radiation dose of each incoupling means (2) is controlled by means of individually controlling the duration of generating radiation of its source of radiation (3).
 8. A method as claimed in claim 7, wherein the radiation efficiency, in particular the amplitude of the high-frequency electromagnetic radiation, of each source of radiation (3) is held on a substantially constant level.
 9. A method as claimed in any one of claims 1 to 8, wherein the radiation dose of each incoupling means (2) is controlled by means of individually influencing the emission properties of the respective incoupling means (2).
 10. A method as claimed in claim 9, wherein the radiation dose of the incoupling means (2) is controlled by means of varying a magnetic field affecting the respective incoupling means (2).
 11. A method as claimed in any one of claims 1 to 10, wherein the plurality of incoupling means (2) is arranged in such a way that the radiation areas thereof overlap partially.
 12. A method as claimed in any one of claims 1 to 11, wherein the plurality of incoupling means (2) is arranged in an array.
 13. A method as claimed in claim 12, wherein the array comprises several rows (R_1 , R_2) of incoupling means (2), the rows (R_1 , R_2) being arranged substantially in parallel relationship.
 14. A method as claimed in claim 13, wherein the incoupling means (2) of at least some rows (R_1 , R_2), in particular of adjacent rows (R_1 , R_2), are arranged in a staggered relationship.
 15. A method as claimed in any one of claims 1 to 14, wherein the plurality of incoupling means (2) is arranged on a carrier means (4), wherein the incoupling means (2) are movable relative to said carrier means (4) and/or said carrier means (4) is movably mountable on the ground.
 16. A method as claimed in any one of claims 1 to 15, wherein the material being heated is selected from a group comprising curable and/or cross-linkable resins, monomers, dimers, oligomers and polymers.
 17. A method as claimed in claim 16, wherein the curable and/or cross-linkable resins, monomers, dimers, oligomers and/or polymers are heated to a sufficient temperature in order to substantially homogeneously cure and/or cross-link said resins, monomers, dimers, oligomers and polymers at least partially.
 18. A method as claimed in claim 16 or 17, wherein the curable and/or cross-linkable resins, monomers, dimers, oligomers and polymers are arranged in a mould, wherein the incoupling means (2) are moved over substantially the entire mould in order to achieve a substantially homogenous curing and/or cross-linking of the curable and/or cross-linkable resins, monomers, dimers, oligomers and/or polymers thereby obtaining a cured and/or cross-linked moulding.
 19. A device (1) for heating materials being capable of absorbing high-frequency electromagnetic radiation, the device (1) comprising at least one source of radiation (3) capable of generating high-frequency electromagnetic radiation, in particular microwaves, said source of radiation (3) being connected to at least one incoupling means (2) being capable of incoupling the high-frequency electromagnetic radiation generated by said source of radiation (3) into the material to be heated, **characterised in that** the device (1) is provided with a plurality of incoupling means (2), said incoupling means (2) are arranged in such a way that radiation areas are obtained the centres thereof being spaced apart from each other,

- wherein a temperature measuring means (7) is assigned to each incoupling means (2) being capable of measuring the temperature of each radiation area, and wherein the radiation dose of each incoupling means (2) is controllable, dependent on the temperature of its radiation area measured by the respective temperature measuring means (7), in such a way that a substantially uniform temperature of the material to be heated is obtained in the radiation areas of all incoupling means (2), respectively.
20. A device as claimed in claim 19, wherein the temperature measuring means (7) is arranged in such a way that it is capable of measuring the temperature of at least the central region of the radiation area of the respective incoupling means (2).
21. A device as claimed in claim 19 or 20, wherein the temperature measuring means (7) is adapted to measure the temperature of the respective radiation area substantially continuously.
22. A device as claimed in any one of claims 19 to 21, wherein the temperature measuring means (7) is composed of an infrared sensor.
23. A device as claimed in any one of claims 19 to 22, wherein the device (1) comprises a plurality of sources of radiation (3) capable of generating high-frequency electromagnetic radiation, each source of radiation (3) being connected to an individual incoupling means (2).
24. A device as claimed in claim 23, wherein the radiation dose of each incoupling means (2) is controllable by means of individual controllability of the radiation efficiency, in particular the amplitude of the high-frequency electromagnetic radiation, of its source of radiation (3).
25. A device as claimed in claim 23, wherein the radiation dose of each incoupling means (2) is controllable by means of individual controllability of the duration of generating radiation of its source of radiation (3).
26. A device as claimed in claim 25, wherein the radiation efficiency, in particular the amplitude of the high-frequency electromagnetic radiation, of each source of radiation (3) is substantially constant, in particular on an adjustable level.
27. A device as claimed in any one of claims 19 to 26, wherein the radiation dose of each incoupling means (2) is controllable by means of individual interference of the emission properties of the respective incoupling means (2).
28. A device as claimed in claim 27, wherein a magnet having a variable magnetic field, in particular an electromagnet, is assigned to each incoupling means (2), wherein the magnet is arranged in such a way that its magnetic field is allowed to affect the radiation efficiency of the high-frequency electromagnetic radiation emitted from the respective incoupling means (2).
29. A device as claimed in any one of claims 19 to 28, wherein the plurality of incoupling means (2) is arranged in such a way that the radiation areas thereof overlap partially.
30. A device as claimed in any one of claims 19 to 29, wherein the plurality of incoupling means (2) is arranged in an array.
31. A device as claimed in claim 30, wherein the array comprises several rows (R_1 , R_2) of incoupling means (2), the rows (R_1 , R_2) being arranged in a substantially parallel relationship.
32. A device as claimed in claim 31, wherein the incoupling means (2) of at least some rows (R_1 , R_2), in particular of adjacent rows, are arranged in a staggered relationship.
33. A device as claimed in any one of claims 19 to 32, wherein the plurality of incoupling means (2) is arranged on a carrier means (4), wherein the incoupling means (2) are movable relative to said carrier means (4) and/or said carrier means (4) is movably mountable on the ground.
34. A device as claimed in any one of claims 19 to 33, wherein it further comprises a mould being capable of accommodating curable and/or cross-linkable resins, monomers, dimers, oligomers and/or polymers, the incoupling means (2) being movable over substantially the entire mould in order to achieve a substantially homogenous curing and/or cross-linking of the curable and/or cross-linkable resins, monomers, dimers, oligomers and/or polymers thereby obtaining a cured and/or cross-linked moulding.

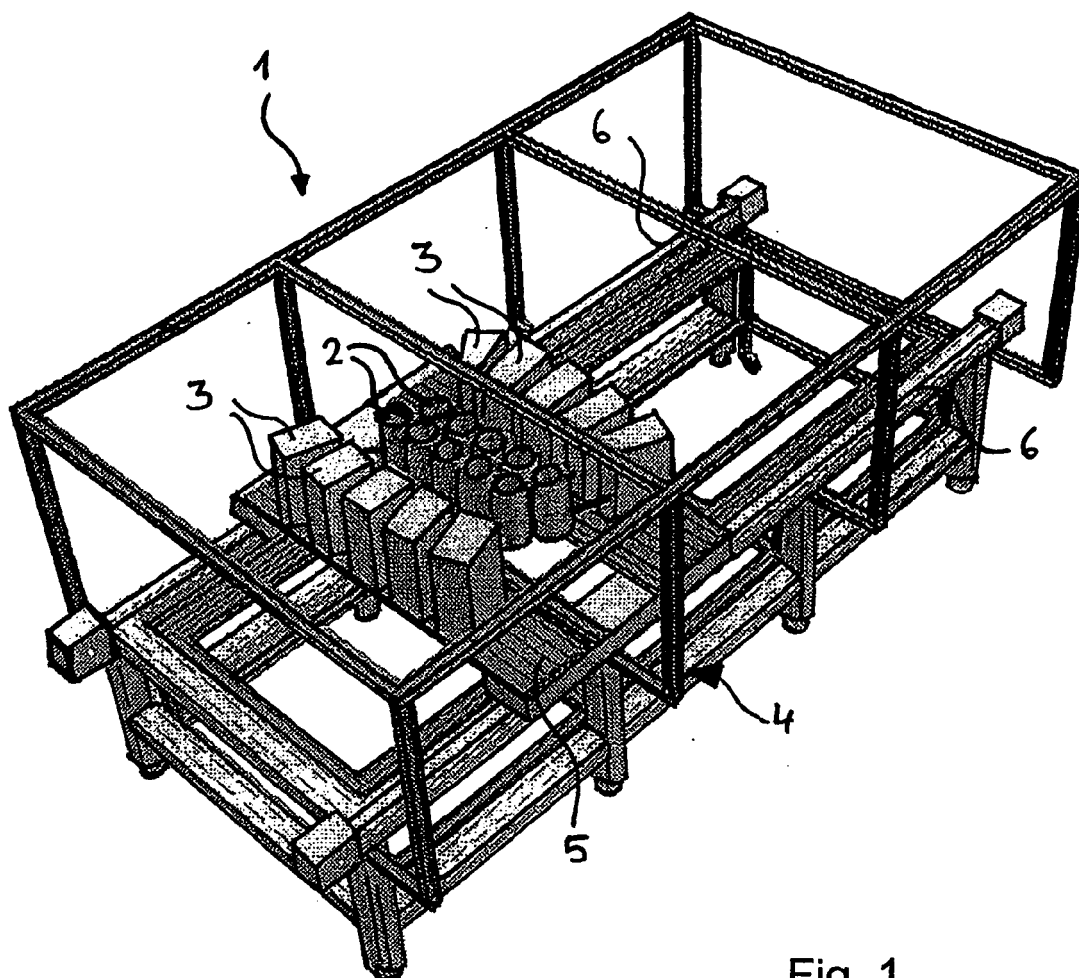


Fig. 1

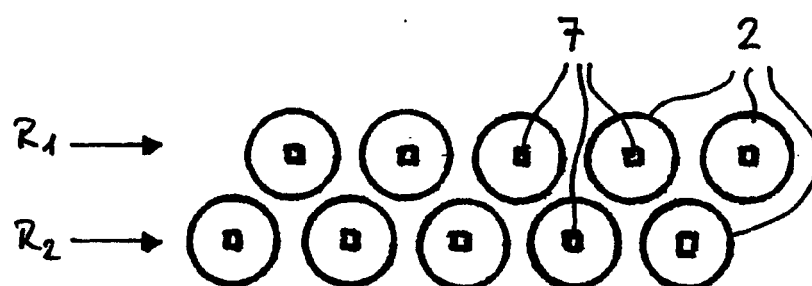


Fig. 2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 01 9535

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 97/13136 A (CEM CORP [US]; JENNINGS WILLIAM EDWARD [US]; MANCHESTER DENNIS PALMER) 10 April 1997 (1997-04-10) * figures 2-4 * -----	1-4,9, 10,12, 16-22, 24,27, 28,30	INV. H05B6/68 H05B6/80 B01J19/12
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			TECHNICAL FIELDS SEARCHED (IPC)
			H05B B01J
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 March 2008	Examiner Tasiaux, Baudouin
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			

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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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