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(54) **CURING WATER-BASED PAINT FILMS**

(57) A technique of curing a target film (6), comprising: controlling the operation of one or more of:
(i) one or more first radiation sources (10) for primarily heating the target film within a chamber (2),
(ii) one or more second radiation sources (11) for primarily evaporating water from the target film, and (iii) one or more extraction devices (14) for extracting water vapour from the chamber, at least partly on the basis of one or more indicators (12) of the concentration of water vapour at one or more locations within the chamber.

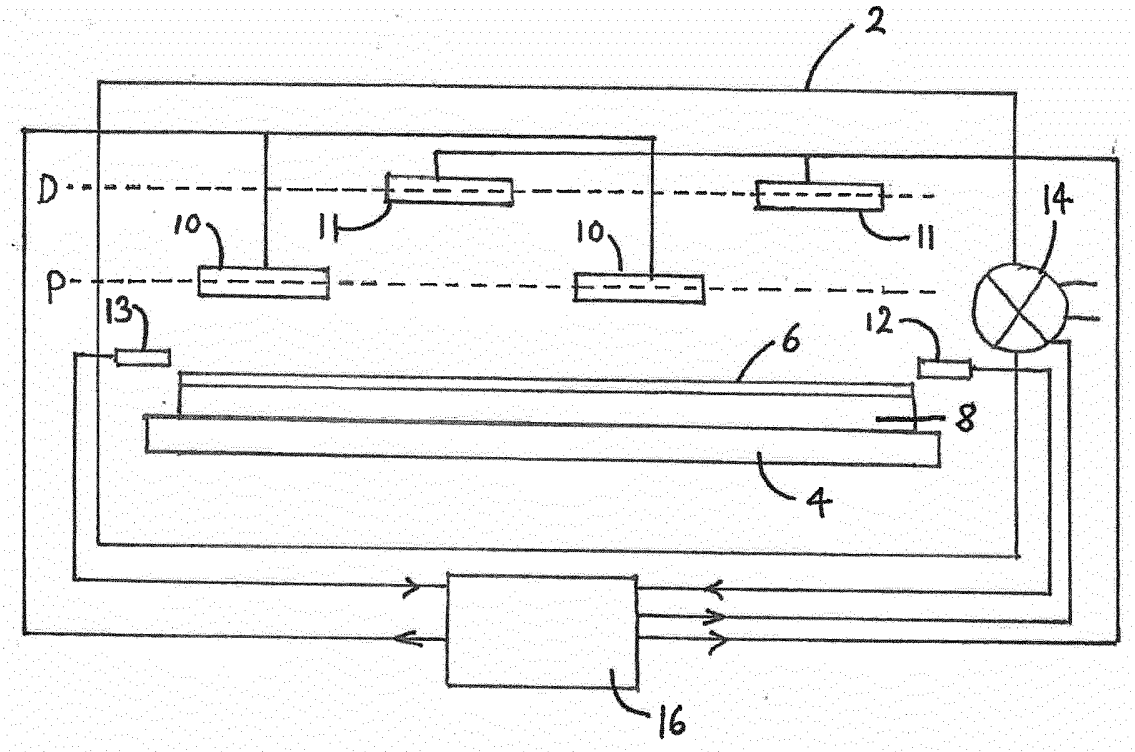

Figure 1

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Description

Technical Field

[0001] The present invention relates to curing wet water-based paint films, using heating radiation.

Background

[0002] A water-based paint may comprise any water-based composition that can be applied as a thin film to a supporting substrate. A water-based paint may comprise one or more pigments and/or other additives dissolved and/or suspended in water. Some water-based paints are curable by heating, whereby the solid film remaining on the substrate is rendered more resistant to water.

[0003] Curing of wet water-based paint films supported on a substrate may be carried out by using an irradiative technique according to which at least part of the radiation is absorbed by the substrate. This technique can achieve good uniform heating and curing of the water-based paint film. However, the inventor for the present application has identified the problem that such an irradiative technique can produce surface defects in the target film. One aim of the research work carried out by the inventor for the present application is to provide a curing technique for which there is less risk of producing surface defects.

[0004] As discussed below, one embodiment of the curing technique developed by the inventor for the present application comprises operating one or more radiation sources having an emission spectrum characterised by a peak wavelength in the medium infrared range in combination with one or more radiation sources having an emission spectrum characterised by a peak wavelength in the short infrared range. US2002/0034594 happens to describe a technique using a range of IR lamps at different wavelengths, but there is no mention in US2002/0034594 of the problem identified by the inventor for the present application, nor any mention of technical solution developed by the inventor for the present application.

Summary

[0005] There is hereby provided a method of curing a target film, comprising: controlling the operation of one or more of: (i) one or more first radiation sources for primarily heating the target film within a chamber, (ii) one or more second radiation sources for primarily evaporating water from the target film, and (iii) one or more extraction devices for extracting water vapour from the chamber, at least partly on the basis of one or more indicators of the concentration of water vapour at one or more locations within the chamber.

[0006] According to one embodiment, controlling the operation of one or more of (i) said one or more first radiation sources, (ii) said one or second radiation sources, and (iii) said one or more extraction devices is also based on one or more indicators of the temperature at the surface of the target film at one or more locations within the chamber.

[0007] According to one embodiment, the method comprises operating the one or more second radiation sources at an emission spectrum characterised by a peak wavelength within the infrared range longer than the peak wavelength of the emission spectrum of the one or more first radiation sources.

[0008] According to one embodiment, controlling the operation of one or more second radiation sources comprises switching between supplying and cutting power to the one or more second radiation sources.

[0009] According to one embodiment, controlling the one or more first radiation sources comprises controlling the distance of the one or more first radiation sources from the target film.

[0010] According to one embodiment, the method further comprises triggering an alert in response to detecting that a rate of evaporation of water from the target film exceeds a predetermined upper threshold or is lower than a predetermined lower threshold.

[0011] According to one embodiment, the method further comprises conveying the target film along a route through the chamber, locating said first and second radiation sources at a plurality of locations along the route, and providing heating radiation reflectors between said locations.

[0012] According to one embodiment, heating of the target film by radiation from the one or more first radiation sources occurs at least partly via absorption of radiation from the one or more first radiation sources by a substrate in thermal contact with the target film.

[0013] There is also hereby provided an apparatus for curing a target film, comprising: a chamber; one or more first radiation sources for primarily heating the target film within the chamber; one or more second radiation sources for primarily evaporating water from the target film; one or more extraction devices for extracting water vapour from the chamber; and a controller configured to control operation of one or more of (i) said one or more first radiation sources, (ii) said one or more second radiation sources, and (iii) said one or more extraction devices at least partly on the basis of one or more indicators of the concentration of water vapour at one or more locations within the chamber.

[0014] According to one embodiment, the controller is configured to control the operation of one or more of (i) said one or more first radiation sources, (ii) said one or second radiation sources, and (iii) said one or more extraction devices also on the basis of one or more indicators of the temperature of the surface of the target film at one or more locations within the chamber.

[0015] According to one embodiment, the controller is configured to operate the one or more second radiation sources at an emission spectrum characterised by a peak wavelength within the infrared range longer than the peak

wavelength of the emission spectrum of the one or more first radiation sources.

[0016] According to one embodiment, controlling operation of the one or more second radiation sources comprises switching between supplying and cutting power to the one or more second radiation sources.

[0017] According to one embodiment, controlling the one or more first radiation sources comprises controlling the distance of the one or more first radiation sources from the target film.

[0018] According to one embodiment, the controller is configured to trigger an alert in response to detecting that a rate of evaporation of water from the target film exceeds a predetermined upper threshold or is lower than a predetermined lower threshold.

[0019] According to one embodiment, the apparatus further comprises a conveyor for conveying the target film along a route through the chamber; said first and second radiation sources are located at a plurality of locations along the route; and wherein the apparatus further comprises heating radiation reflectors between said locations.

[0020] According to one embodiment, heating of the target film by radiation from the one or more first radiation sources occurs at least partly via absorption of radiation from the one or more first radiation sources by a substrate in thermal contact with the target film..

Brief Description of the Drawings

[0021] To assist understanding of the present disclosure and to show how embodiments may be put into effect, reference is made by way of example to the accompanying drawings in which:

Figure 1 illustrates one example of apparatus according to an embodiment of the present invention;
Figure 2 illustrates a first operation mode of the apparatus of Figure 1 in accordance with an embodiment of the present invention;
Figure 3 illustrates a second operation mode of the apparatus of Figure 1 in accordance with an embodiment of the present invention;
Figure 4 illustrates a third operation mode of the apparatus of Figure 1 in accordance with an embodiment of the present invention; and
Figure 5 illustrates one example of a set of operations at a controller processor according to an embodiment of the present invention.

Detailed Description

[0022] With reference to Figure 1 of the present invention, a curing apparatus according to an example embodiment of the present invention comprises a substantially longitudinal curing chamber (oven) 2 housing. Figure 1 shows the arrangement of elements within the housing at one stage along the route of a target object through the oven - the same or similar arrangement of some or all of these same elements also exists within the housing at other stages (at different distances from the oven entrance) of the route of a target object through the oven. The elements shown in Figure 1 comprise: a conveyor 4 to support and transport a target object comprising a wet water-based paint film 6 supported by a substrate 8 along a route through the oven from the oven entrance to the oven exit; short-wave IR lamps 10 (having an emission spectrum characterised by a peak wavelength in the range of about 0.75 to about 3 microns) moveable between at least proximal (P) and distal (D) positions relative to the target object; medium-wave IR lamps 11 having an emission spectrum characterised by a peak wavelength in the range of about 3 to about 8 microns; a humidity sensor 12 (one example of an absolute humidity sensor is a thermal hygrometer, which measures changes in the thermal conductivity of air). to measure the concentration of water vapour above the target object; and a temperature sensor 13 (one example of a temperature sensor is a remote-sensing thermometer such as a pyrometer or a radiometric thermometer which determines the temperature at the surface of the target object from the spectrum of the thermal radiation that it emits)) to measure the temperature at the surface of the target object.

[0023] The curing apparatus also comprises extraction fans 14 on one or both sides of the conveyor 4 to remove gaseous material including water vapour from inside the curing chamber 2.

[0024] The short-wave IR lamps 10, medium-wave IR lamps 11 and extraction fans 14 at different stages along the route of the target object through the oven are independently controllable, such that e.g. medium-wave IR lamps 11 at one stage may be on while medium-wave IR lamps at one or more other stages may be off, and the same applies to the short-wave IR lamps 10 and the extraction fans 14.

[0025] The curing apparatus may also comprise infrared reflectors between IR lamps 10, 11 at different stages, to better isolate IR lamps 10, 11 at one stage from IR lamps 10, 11 at adjacent stage(s) (i.e. to better avoid IR lamps 10, 11 at one stage heating the target object at another stage served by other IR lamps 10, 11), and thereby facilitate better independent control of the IR lamps 10, 11 at different stages.

[0026] The curing apparatus also includes a controller 16 configured to receive input signals from at least the humidity sensors 12 and the temperature sensors 13 at the plurality of stages and output control signals to control the following: supply power to the short-wave IR lamps 10; movement supply of power to the medium-wave IR lamps 11; and operation of the extraction fans 14.

[0027] The short-wave IR lamps 10 have an emission spectrum that is better suited than that of the medium-wave IR lamps 11 to penetration of radiation through the water-based paint film 6 and absorption by the substrate 8. The medium-wave IR lamps 11 have an emission

spectrum that is better suited than that of the short-wave IR lamps 10 to the evaporation of water from an outer surface portion of the water-based paint film 6.

[0028] In use, a target object including an uncured water-based paint film 6 in thermal contact with a substrate 8 is placed on the conveyor 4 for transport through the oven. The controller 16 monitors input signals from the humidity sensors 12 and temperature sensors 13 at different stages along the route (STEP 500 of Figure 5), and determines one or more operating parameters for the short-wave IR lamps, medium-wave IR lamps and extraction fans at the plurality of stages along the route to achieve the desired curing rate without causing excessive surface heating and surface defects (STEP 502 of Figure 5). This cycle of feedback-based control is repeated throughout the passage of the target object through the oven to achieve good control of the curing process during the whole passage of the target object through the oven 2.

[0029] Examples of different modes of operation at an example stage along the route are shown in Figures 2 to 4, in which diagonal shading is used to indicate the lamps that are in operation, i.e. on.

[0030] In the mode of operation shown in Figure 2, the controller operates the short-wave IR lamps 10 in the proximal position (P) relative to the conveyor 4, and supplies power to the medium-wave IR lamps 11 and the extraction fan(s) 14.

[0031] In the mode of operation shown in Figure 3, the controller 16 again operates the short-wave IR lamps 10 in the proximal position, but cuts the supply of power to the medium-wave IR lamps 11 and the extraction fan(s) 14.

[0032] In the mode of operation shown in Figure 4, the controller operates the short-wave IR lamps 10 in the distal position (D) and cuts the supply of power to the medium-wave IR lamps 11 and the extraction fans 14.

[0033] A relatively high concentration of water (high water content) in the water-based paint film 6 leads to a relatively high concentration of water vapour above the water-based paint film 6, which water vapour attenuates the radiation from the short-wave IR lamps 10, reducing the intensity of radiation absorbed by the substrate 8, and thereby reducing the heating of the water-based paint film 6 by the substrate 8. When the water content in the water-based paint film 6 is high (and the concentration of the water vapour above the water-based paint film is high), the medium IR lamps 11 and extraction fan 14 can be operated (to increase the rate of water removal from the water-based paint film 6) and the short-wave IR lamps 10 can be operated in the proximal position, without any significant risk of excessive heating of the water-based paint film 6 by the short-wave IR lamps 10 and causing defects in the surface of the water-based paint film 6. As the water content in the water-based paint film 6 decreases (and the concentration of water vapour above the water-based paint film 6 decreases), switching off the medium-wave IR lamps 11 and the extraction fan 9 reduces the rate of removal of water from the water-based paint film 6 and reduces the risk of excessive heating of the water-based paint film 6 by the short-wave IR lamps 10. Moving the short-wave IR lamps 10 from the proximal position to the distal position further reduces the risk of excessive heating of the water-based paint film 6 by the short-wave IR lamps 10.

[0034] The humidity sensors 12 may also be used to evaluate the performance of the system. The controller 16 may be configured to trigger an alert if the humidity sensors indicate an excessively low or excessively high rate of evaporation of water from the target film.

[0035] With the above-described technique, there is no need to use different ovens with different lamp configurations etc. according to the starting content of water in the water-based paint film and/or the thickness of the water-based paint film. The above-mentioned control based on at least an indicator of the concentration of water vapour at one or more locations within the curing chamber ensures efficient operation of the curing apparatus without any significant risk of excessive surface heating and surface defects.

[0036] The examples described herein are to be understood as illustrative examples of embodiments of the invention. Further embodiments and examples are envisaged. Any feature described in relation to any one example or embodiment may be used alone or in combination with other features. In addition, any feature described in relation to any one example or embodiment may also be used in combination with one or more features of any other of the examples or embodiments, or any combination of any other of the examples or embodiments. Furthermore, equivalents and modifications not described herein may also be employed within the scope of the invention, which is defined in the claims.

Claims

1. A method of curing a target film, comprising: controlling the operation of one or more of: (i) one or more first radiation sources for primarily heating the target film within a chamber, (ii) one or more second radiation sources for primarily evaporating water from the target film, and (iii) one or more extraction devices for extracting water vapour from the chamber, at least partly on the basis of one or more indicators of the concentration of water vapour at one or more locations within the chamber.

2. A method according to claim 1, wherein: controlling the operation of one or more of (i) said one or more first radiation sources, (ii) said one or second radiation sources, and (iii) said one or more extraction devices is also based on one or more indicators of the temperature at the surface of the target film at one or more locations within the chamber.

3. A method according to claim 1 or claim 2, comprising operating the one or more second radiation sources at an emission spectrum **characterised by** a peak wavelength within the infrared range longer than the peak wavelength of the emission spectrum of the one or more first radiation sources.

4. A method according to any preceding claim, wherein controlling the operation of one or more second radiation sources comprises switching between supplying and cutting power to the one or more second radiation sources.

5. A method according to any preceding claim, wherein controlling the one or more first radiation sources comprises controlling the distance of the one or more first radiation sources from the target film.

6. A method according to any preceding claim, comprising triggering an alert in response to detecting that a rate of evaporation of water from the target film exceeds a predetermined upper threshold or is lower than a predetermined lower threshold.

7. A method according to any preceding claim, comprising conveying the target film along a route through the chamber, and locating said first and second radiation sources at a plurality of locations along the route, and providing heating radiation reflectors between said locations.

8. A method according to any preceding claim, wherein heating of the target film by radiation from the one or more first radiation sources occurs at least partly via absorption of radiation from the one or more first radiation sources by a substrate in thermal contact with the target film.

9. An apparatus for curing a target film, comprising: a chamber; one or more first radiation sources for primarily heating the target film within the chamber; one or more second radiation sources for primarily evaporating water from the target film; one or more extraction devices for extracting water vapour from the chamber; and a controller configured to control operation of one or more of (i) said one or more first radiation sources, (ii) said one or more second radiation sources, and (iii) said one or more extraction devices at least partly on the basis of one or more indicators of the concentration of water vapour at one or more locations within the chamber.

10. An apparatus according to claim 9, wherein the controller is configured to control the operation of one or more of (i) said one or more first radiation sources, (ii) said one or second radiation sources, and (iii) said one or more extraction devices also on the basis of one or more indicators of the temperature of the surface of the target film at one or more locations within the chamber.

11. An apparatus according to claim 9 or claim 10, wherein the controller is configured to operate the one or more second radiation sources at an emission spectrum **characterised by** a peak wavelength within the infrared range longer than the peak wavelength of the emission spectrum of the one or more first radiation sources.

12. An apparatus according to any of claims 9 to 11, wherein controlling operation of the one or more second radiation sources comprises switching between supplying and cutting power to the one or more second radiation sources, and/or controlling the one or more first radiation sources comprises controlling the distance of the one or more first radiation sources from the target film.

13. An apparatus according to any of claims 9 to 12, wherein the controller is configured to trigger an alert in response to detecting that a rate of evaporation of water from the target film exceeds a predetermined upper threshold or is lower than a predetermined lower threshold.

14. An apparatus according to any of claims 9 to 13, wherein the apparatus further comprises a conveyor for conveying the target film along a route through the chamber; said first and second radiation sources are located at a plurality of locations along the route; and wherein the apparatus further comprises heating radiation reflectors between said locations.

15. An apparatus according to any of claims 9 to 14, wherein heating of the target film by radiation from the one or more first radiation sources occurs at least partly via absorption of radiation from the one or more first radiation sources by a substrate in thermal contact with the target film.

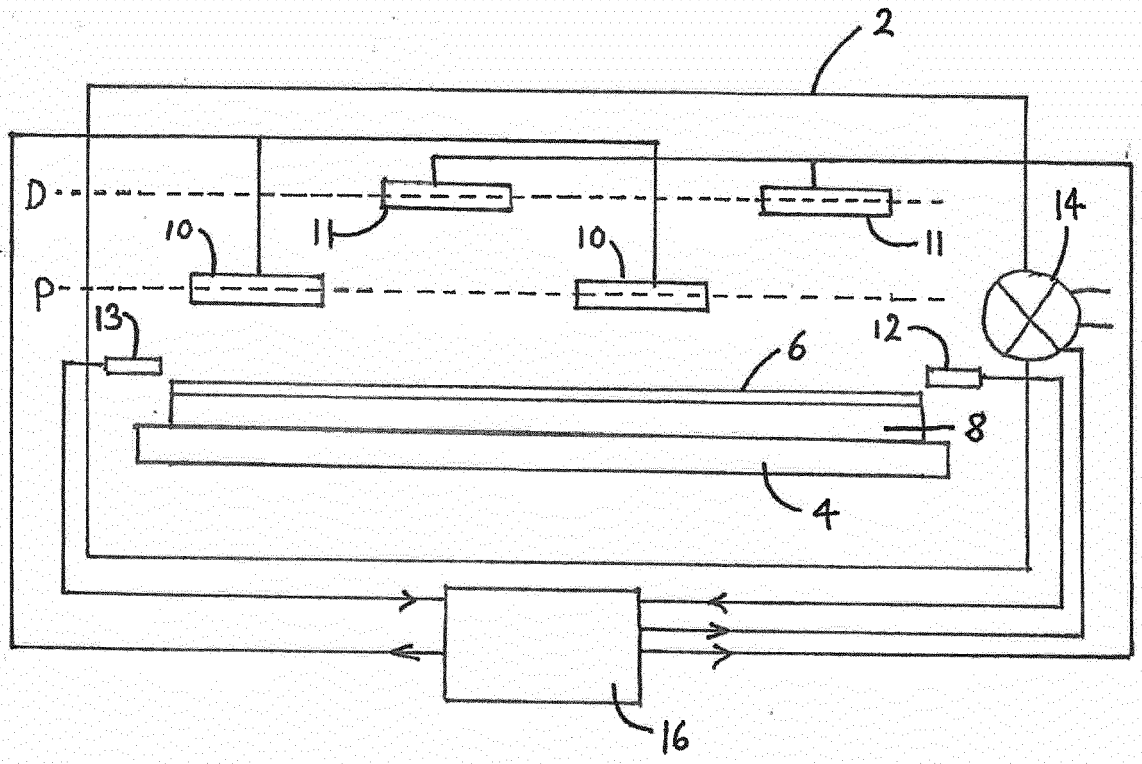

Figure 1

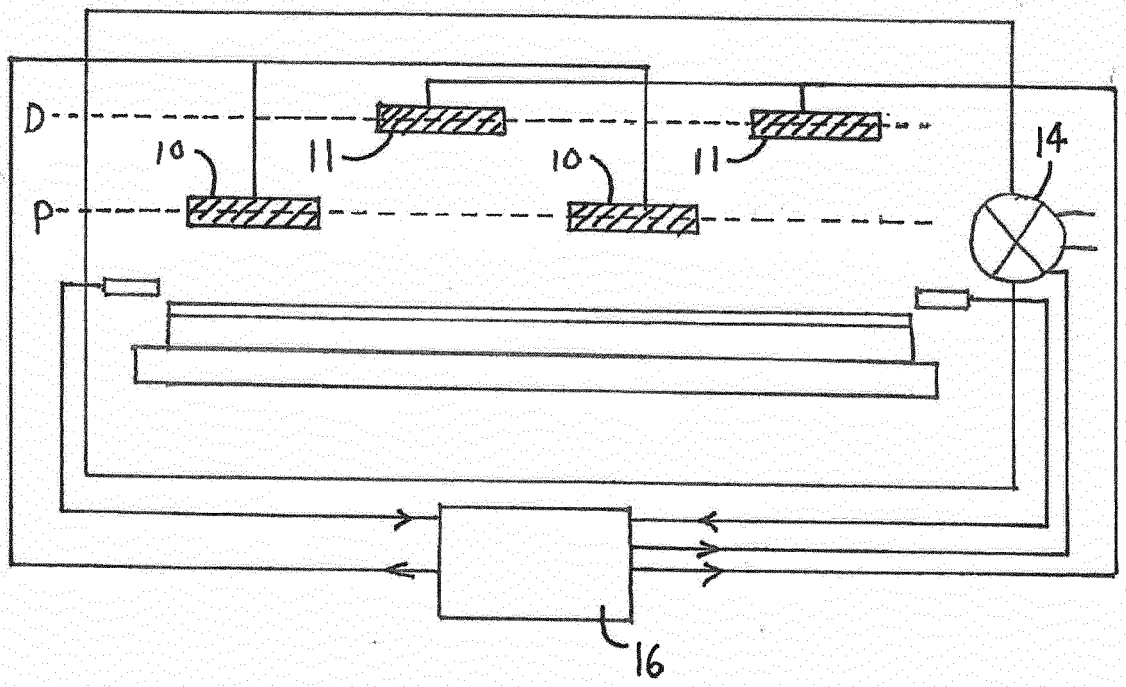

Figure 2

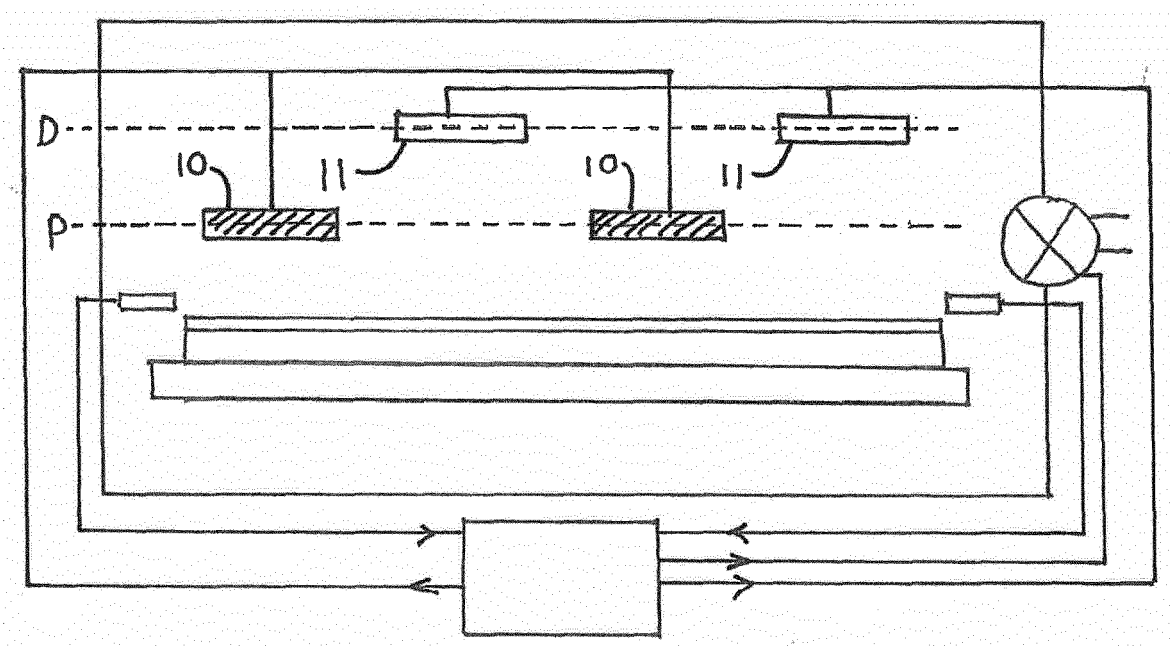

Figure 3

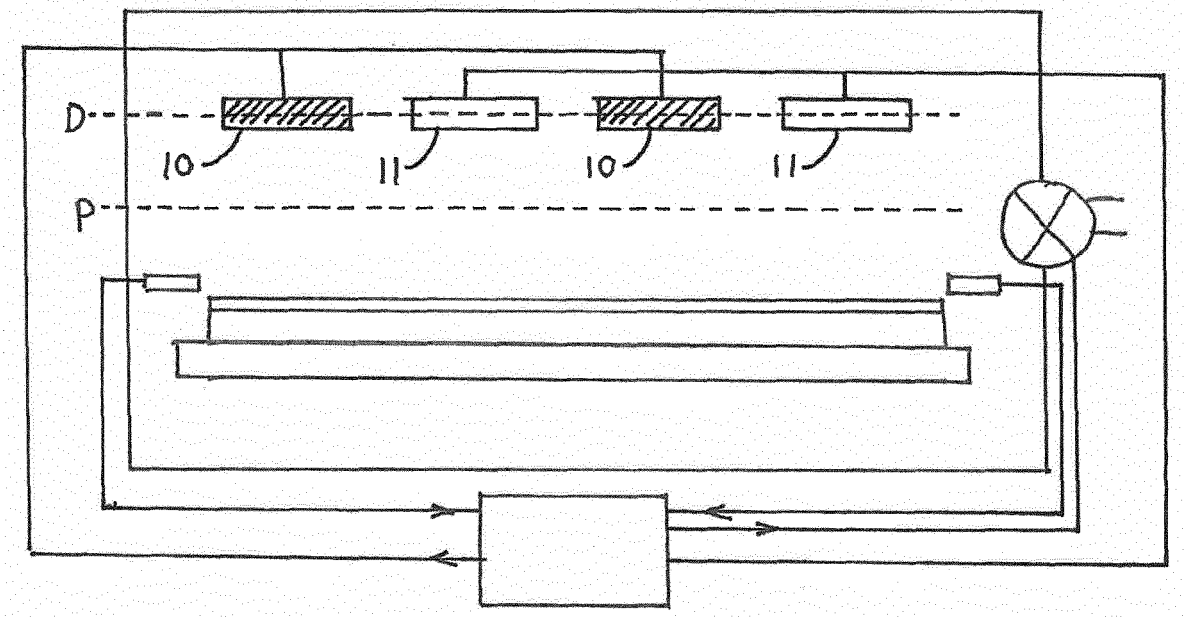

Figure 4

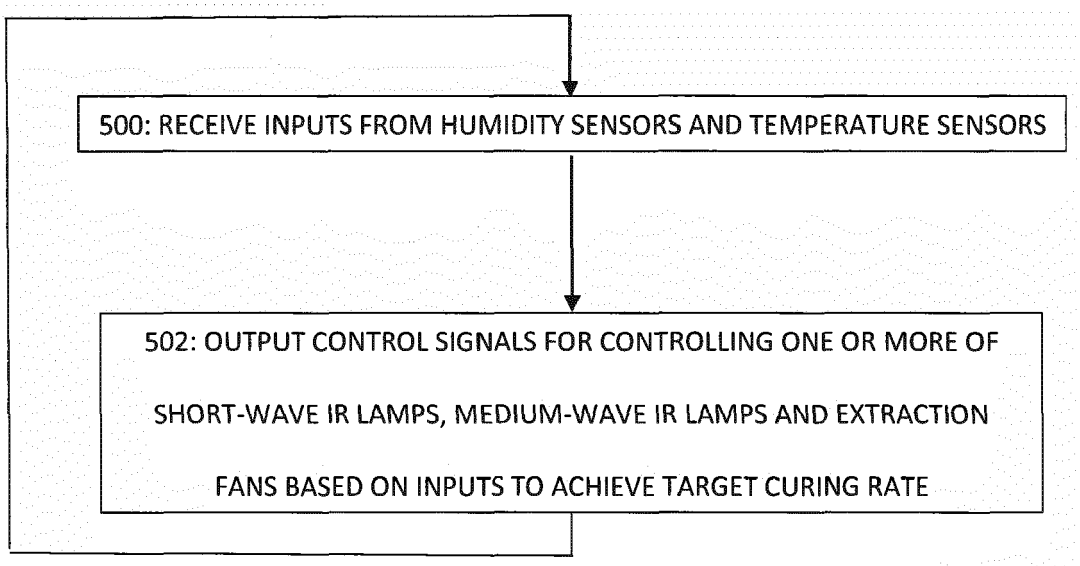
500: RECEIVE INPUTS FROM HUMIDITY SENSORS AND TEMPERATURE SENSORS
502: OUTPUT CONTROL SIGNALS FOR CONTROLLING ONE OR MORE OF SHORT-WAVE IR LAMPS, MEDIUM-WAVE IR LAMPS AND EXTRACTION FANS BASED ON INPUTS TO ACHIEVE TARGET CURING RATE

Figure 5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 16 4161

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 September 2017	Grave, Christian

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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