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(54) ELECTRIC HEATING ELEMENTS, ELECTRIC HEATED KILN CARS, CONTINUOUS KILNS AND METHODS

(57) The present disclosure relates to electric heating assemblies for kiln cars and kilns, to electric heated kiln cars for kilns, to electric continuous kilns and methods. An electric heating assembly comprises a U-shaped electric heating element and a first insulation surrounding an end part of a first side portion of the heating element and a second insulation surrounding an end part of a second side portion of the heating element. The first and second side portions are of a same length or shorter than a top portion of the U-shaped electric heating element.

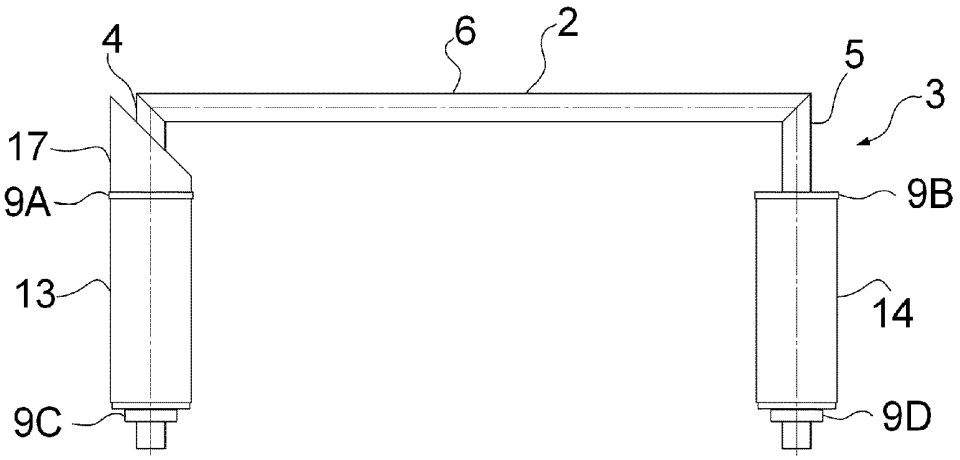

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to heating assemblies for kiln cars and kilns and to electric heated kiln cars, particularly for continuous kilns. The present disclosure further relates to electric continuous kilns and methods for heating a load on an electric heated kiln car or on a non-electric heated kiln car being transported through a continuous kiln.

BACKGROUND

[0002] A kiln is a type of oven that produces temperatures sufficient to complete some process, such as hardening, sintering or drying. For example, kilns are used for "firing" clay based ceramic ware. In the firing process, the ware (which may be glazed) is to be heated for a prolonged period of time according to a specific temperature profile. The temperature profile may be designed to ensure vitrifying of the ware. The use of kilns is known e.g. in the manufacture of sanitary ware, dishes and porcelain, roofing tiles, bricks, technical ceramics and other.

[0003] Different types of kilns are known. In continuous kilns, kiln cars are loaded with the ware to be fired and are moved for heating the ware when traveling through the kiln. Kiln cars may be moved "continuously" through the kiln using e.g. rails. Continuous kilns may also be called tunnel kilns.

[0004] In these kilns, heating elements are usually arranged on the internal walls of the continuous kiln such that the temperature of the ware can be controlled along the whole length of the kiln. For example, gas burners may be provided such that the load of the kiln is heated when the kiln car goes through the continuous kiln. At the entrance, the ware is cold, and as it is slowly transported through the kiln, its temperature increases as it approaches the central, usually hottest part of the kiln. As the ware continues to move through the kiln, the temperature of the ware may be lowered. Along sections of the continuous kiln, cold air may be injected to ensure that the ware undergoes a specifically designed temperature profile.

[0005] In intermittent kilns, on the contrary, the ware to be fired is first loaded into the kiln. The kiln is then sealed, and the internal temperature is then increased according to a specific temperature profile. After the firing process is completed, both the kiln and the ware are cooled. Intermittent kilns may also rely on the use kiln cars. In intermittent kilns, heating elements are arranged on the internal walls of the kiln. The kiln car moves or is transported into the kiln, the kiln car stops, and the electric heating elements heat the load of the kiln car. After the heat treatment is completed, both the kiln and the load may be cooled. The load may be removed from the intermittent kiln, the kiln may be cleaned and the next heating cycle may begin. Different types of heating elements may be used.

[0006] CH216256 discloses a tunnel kiln with kiln cars that incorporate electric heating. Electric power is provided to the electric heating devices through a conductive rail arranged along the floor of the tunnel. DE 1 558 062A also discloses kiln cars incorporating electric heating. More modern tunnel kilns generally rely on gas burners rather than electric heating in spite of the benefits of CO_2 reduction when avoiding LPG (liquefied petroleum gas) or natural gas for heating. One reason is that heating with gas may be easier due to the large dimensions of the kilns and the amount of heating power required. Moreover, electric heating may be less efficient than gas heating in terms of heat transfer. The heat transfer of electric heating is mostly thermal radiation, whereas the heat transfer of conventional gas burners is mostly heat convection. There is still a need to provide electric heating solutions for ceramic ware which provide effective electrical heating and are both efficient and cost-effective.

SUMMARY

[0007] In an aspect of the present disclosure, an electric heating assembly is provided. The electric heating assembly comprises a substantially U-shaped electric heating element including a first side portion, a second side portion and a top portion connecting the first side portion with the second side portion, the top portion extending along a longitudinal direction and configured to heating ware. The electric heating element is mounted at end parts of the first and second side portions. The electric heating assembly further comprises a first insulation surrounding the end part of the first side portion and a second insulation surrounding the end part of the second side portion, wherein the first and second end parts of the two side portions can move along the longitudinal direction. The first and second side portions have a length which is equal to or shorter than a length of the top portion of the U-shaped electric heating element.

[0008] In accordance with this aspect, an effective electric heating solution is provided for ceramic ware in kilns. A kiln car can support the ware. In some examples, electric heating may be provided on individual kiln cars such that the heating can be adapted to the ware provided on each individual kiln car. In these or other examples, electric heating may also be provided on the floor of the kiln.

[0009] U-shaped heating elements are generally known in the art, but usually the side portions of the U are significantly longer than the bottom of the U (or "top" portion when inverted). In the present disclosure, in order to provide effective heating, the portion connecting the two side portions is at least as long as or significantly longer than the side portions.

[0010] When electric current is circulated through the electric heating element, thermal expansion of the heating element may be absorbed by allowing movement in the longitudinal direction of the U-shaped electric heating

element. Damage, e.g. fracture, of the U-shaped electric heating element may be avoided. At the same time, the kiln car and ceramic ware are protected since the electric heating element is (electrically) insulated.

[0011] Throughout this disclosure, an electric heating element may refer to an element which heats up when an electric current is circulated through it. As previously indicated, the electric heating element has a U-shape.

[0012] When the first and second side portions of the electric heating element are shorter than the top portion of the electric heating element, a more efficient and safer heating may be achieved, as more heat may be released upwardly due to a longer top portion and less electric heating elements are needed in the kiln car body and/or in the kiln floor body.

[0013] The electrical resistance of the side portions of the U-shaped electric heating element may be different from the electrical resistance of the top portion, for example due to the introduction of different densities of the material as well as different conductive cross sections such as hollow sleeves. In particular, the electrical resistance of the top portion may be higher than the electrical resistance of the side portions. For a given current level, the top portion will heat up more, providing more efficient heating for the ware. The electrical resistance of the two side portions may be the same or similar. Also, the electrical resistance of the two side portions may be low or very low for heating these side portions as little as possible.

[0014] In some examples, the first and second insulation may be resilient and configured to be compressed radially outwards as the electric heating element expands.

[0015] The first and the second insulation may comprise hollow sleeves in some examples. The sleeves may be configured to compress radially outwards when the side portions of the U-shaped electric heating element exert a radially outward force, in particular along the longitudinal direction of the U-shaped electric heating element. In some examples, the sleeves may be tightly fitted around the side portions. I.e., initially, when the heating element is cold, the inner walls of the sleeves may touch the outer surface of the side portions.

[0016] In some examples, a first gap may be provided between the first insulation and the first side portion along the longitudinal direction, and a second gap may be provided between the second insulation and the second side portion along the longitudinal direction to allow for longitudinal movement of the side portions. The gap or hole may be elongated. The first and second insulation may have an oval or an oblong cross-section, e.g. substantially elliptical of racetrack shaped, in order to retain the electric heating element in one direction, and allow movement in another direction.

[0017] The first and the second insulations may comprise hollow sleeves or rings. An inner diameter of the hollow sleeves or rings may be larger than an outer diameter of the side portions of the U-shaped electric heating element along the longitudinal direction of the U-shaped electric heating element, and the first and second side portions may move radially outwards, in particular along the longitudinal direction, when a current is circulated through the heating element and therefore heated. The initial outer diameter of the side portions when they are cold, i.e. before current circulation through them, may be increased. The inner diameter of the hollow sleeves or rings may limit the radial expansion of the side portions along the longitudinal direction. I.e., the hollow rings may be rigid. The hole may for example be oval or oblong, as indicated in the previous paragraph.

[0018] The U-shaped electric heating element may comprise, and in particular may be made of, silicon carbide (SiC). Silicon carbide is a semiconductor material which has a high thermal conductivity and is able to withstand harsh environments. In kilns for firing ceramics such as sanitary ware, temperatures of e.g. 1200°C or higher may be reached.

[0019] Additional U-shaped electric heating element assemblies like the ones described herein may be arranged on a kiln car body or on a kiln floor body. The provided heating element assemblies may be arranged forming for example two (or more) rows on the kiln car body or one row on the kiln floor body.

[0020] In a further aspect of the disclosure, a kiln car for a kiln is provided. The kiln car comprises a kiln car body, a supporting base for supporting a load to be fired and the electric heating assembly of the previous aspect arranged below the supporting base. End parts of the two side portions of the U-shaped electric heating elements are mounted on the kiln car body and the top portion is arranged above the kiln car body such that the U-shaped electric heating element is configured to heat the load on the support base. The one or more electric heating assemblies further comprise a first insulation surrounding the end part of the first side portion and a second insulation surrounding the end part of the second side portion, wherein the first and second end parts of the two side portions are mounted in the kiln car body such that the first and second end parts can move along the longitudinal direction.

[0021] In a further aspect of the disclosure, an electric continuous kiln is provided. The electric continuous kiln comprises a tunnel, one or more electric heated kiln cars according to any of the examples described herein and one or more rails for guiding the electric heated kiln cars. An electric continuous kiln may heat a load on a kiln car by using electric heating elements, for example a load on an electric heated kiln car as disclosed herein, when the electric heated kiln car moves along the kiln. It should be noted that an electric continuous kiln may also be configured to partially heat a load on a kiln car in additional ways. For example, in some examples, in addition to electric heating elements, the continuous kiln may use additional gas burners. Also, as mentioned below, an electric continuous kiln may be configured to heat a load on a kiln car (electric heated or non-electric heated) when

the kiln car moves along the kiln, the electric heating elements being arranged in a floor body of the kiln.

[0022] Different kiln cars may be used such that different loads can be heated and cooled simultaneously in different parts of the kiln. For example, a load on one or more kiln cars is being heated in a first region of the continuous kiln, whereas another load one or more other kiln cars is being cooled in a subsequent region of the continuous kiln at a same time. The treated loads may be continuously removed from the kiln and replaced by loads in another part of the kiln which are then heated.

[0023] The term "load" herein refers to the products that are being heated. These products may be e.g. sanitary products such as toilet bowls, sinks or other. The terms "ware" and "load" may be used interchangeably herein.

[0024] In a further aspect of the disclosure, an electric continuous kiln is provided. The kiln comprises a tunnel, one or more rails for guiding one or more kiln cars and a kiln floor body comprising an electric heating assembly as described herein. The end parts of the two side portions are mounted on the floor body and the top portion is arranged above the floor body such that the U-shaped electric heating element is configured to heat a load on a kiln car.

[0025] In a further aspect of the disclosure, a method for heating a load arranged on an electric heated kiln car, e.g. on an electric heated kiln car as described throughout this disclosure, in a continuous kiln is provided. The method comprises moving the kiln car through the continuous kiln, and simultaneously circulating an electric current through the U-shaped electric heating element as described herein for heating the load.

[0026] Therefore, while the kiln car is being moved through the kiln, electric current may be introduced in the electric heating element through the free end of one of its side portions, circulated through its top portion and then removed through the free end of the other of its side portions. The heat released by the electric heating element, and in particular through its top portion, may be used to heat a load above the electric heating element.

[0027] In this manner, the load on an electric heated kiln car can be heated when the kiln car travels through the continuous kiln. The load on a non-electric heated kiln car may also be heated when the kiln travels through the continuous kiln by mounting the heating elements on the floor body. In some examples, electric heating assemblies as described herein may be mounted both on the kiln cars and on a kiln floor body.

[0028] In some examples, the load may be a ceramic load. In other examples, the load may be any other suitable load.

[0029] Particular aspects, examples and elements of aspects or examples disclosed herein can be combined together in any number and order to form new aspects and examples that form part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

Figure 1 schematically illustrates a front view of an example of an electric heating assembly comprising a U-shaped electric heating element.

Figure 2 schematically illustrates an exploded view of the assembly of figure 1.

Figure 3 schematically illustrates a cross-sectional enlarged view of the assembly of figure 1.

Figure 4 schematically illustrates a cross-sectional view of another example of an electric heating assembly.

Figures 5, 6 and 7 schematically illustrate a front view, a perspective view and a side view of an example of an electric heated kiln car comprising a plurality of U-shaped electric heating elements.

Figure 8 schematically illustrates a top view of the electric heated kiln car of figures 5-7.

Figures 9 and 10 schematically illustrate two cross-sections of an example of a kiln. The cross-section of figure 9 is perpendicular to the direction of travel of the kiln cars. The cross-section of figure 9 is a longitudinal cross-section of the kiln.

Figure 11 shows a flow chart of a method for heating a load arranged on a kiln car, optionally on an electric heated kiln car, in an electric continuous kiln.

DETAILED DESCRIPTION OF EXAMPLES

[0031] Reference will now be made in detail to embodiments of the present disclosure, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation only, not as a limitation. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present disclosure. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present disclosure covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0032] Figure 1 schematically illustrates a front view of an electric heating assembly 3. An exploded view of this assembly 3 can be seen in figure 2, and a cross-section of the left portion of the assembly can be seen in figure 3. An electric heating assembly 3 comprises a U-shaped electric heating element 2. The U-shaped electric heating element 2 comprises a first side portion 4, a second side portion 5 and a top portion 6 connecting the first side

portion 4 with the second side portion 5. As such, the heating element 2 thus forms an inverted U. The top portion 6 extends along a longitudinal direction of the U-shaped electric heating element.

[0033] The electric heating assembly 3 further comprises a first insulation 8A surrounding an end part of the first side portion 4 and a second insulation 8B surrounding an end part of the second side portion 5, see figures 2 and 3. The first and second end parts are mounted such that the first and second end parts can move along the longitudinal direction when the first 4 and the second 5 side portions are mounted to a body 7 of a kiln car 1 or to a floor of a kiln. As can be seen in figure 1 and in figure 5, the first 4 and second 5 side portions have a length which is equal to or shorter than a length of the top portion 6 of the U-shaped electric heating element 2.

[0034] In this manner, thermal expansion of the U-shaped electric heating element 2 may be controlled. In particular, damage to the heating element 2 and to the kiln car body 7 may be avoided or at least reduced.

[0035] The U-shaped electric heating element 2 may comprise, and in particular may be made of, silicon carbide (SiC). An electrical resistance of the top portion 6 of the heating element 2 may be higher than an electrical resistance of the side portions 4, 5 of the heating element 2 to generate most heat in the top portion.

[0036] The first insulation 8A and the second insulation 8B may be resilient and configured to be compressed radially outwards under a radially outwards force of the first side portion 4 and the second portion 5, respectively (see figures 2 and 3). Compression may in particular be along the longitudinal direction of the U-shaped electric heating element.

[0037] The first insulation 8A and the second insulation 8B may completely surround, in a tangential direction of a side portion 4, 5, an end part of the corresponding side portion 4, 5 of the heating element 2.

[0038] The first insulation 8A and the second insulation 8B may or may not reach an end of the side portion 4, 5 which is to be mounted on a kiln car body or on a kiln floor body. The first 8A and second 8A insulation will in general not reach the opposite end of the side portion 4, 5, i.e. the end that touches the top portion 6 of the U-shaped electric heating element 2.

[0039] The heating assembly may further comprise a first stopper 9A and optionally a second stopper 9B configured to limit a movement of the first and second end parts along the longitudinal direction of the electric heating element 2 respectively. For example, a first radial gap 10 may be provided between the first stopper 9A and the first side portion 4 (see figure 3), and a second radial gap 10 may be provided between the second stopper and the second side portion 5. Additional stoppers 9C, 9D may further be provided.

[0040] In some examples, the first insulation 8A and the second insulation 9A may be hollow sleeves 8A, 8B, see figures 2 and 3. The sleeves may be resilient and configured to compress along an outwardly radial direction when the side portions 4, 5 expand radially outward and exert a radial force on the sleeves 8A, 9A. The force and the compression may in particular be along the longitudinal direction of the U-shaped electric heating element. The sleeves may comprise a ceramic material.

[0041] The electric heating assembly 3 may further comprise a first outer rigid sleeve 13 and a second outer rigid sleeve 14, see figures 1-3. The rigid sleeves 13, 14 may tangentially surround the compressible sleeves 8A, 8B. An inner wall of the rigid sleeves 13,14 may radially limit the compressible sleeves 8A, 8B and keep them in an appropriate position. The rigid sleeves 13, 14 may comprise or may be made of a ceramic material. The rigid sleeves 13, 14 may also protect an inside of a kiln car body 7 or a floor body of a kiln from the heat absorbed by the compressible sleeves 8A, 8B.

[0042] In some examples, the compressible sleeves 8A, 8B and the outer rigid sleeves 13, 14 may be arranged between a top stopper 9A, 9B and a bottom stopper 9C, 9D. In the example of these figures, the top stoppers and the bottom stoppers are configured as rigid hollow elements having a radial gap with respect to the corresponding side portion 4, 5 of the heating element 2 when the heating element is cold. The bottom stoppers may help to support the compressible sleeves 8A, 8B and the rigid sleeves 13, 14. A washer 15 may be arranged between the bottom stopper and the supported sleeves 8A, 8B, 13, 14. The washer 15 may be made of stainless steel.

[0043] One or more pins 16, see figure 2, may be provided for keeping the electric heating element 2 at a desired height with respect to the other components of the assembly 3. Alternative or additional retaining elements may be provided.

[0044] In some examples, a first gap may be provided between the first insulation and the first side portion along the longitudinal direction, and a second gap may be provided between the second insulation and the second side portion along the longitudinal direction. Therefore, the first 4 and second 5 side portions may have room for moving along the longitudinal direction of the U-shaped heating element, and in particular outwardly, when the U-shaped heating element is electrically heated. Also, the first insulation and the second insulation may be rigid, i.e. non-resilient. Therefore, when the side portions 4, 5 of the U-shaped electric heating element exert a force along the longitudinal direction of the heating element against the rigid insulations, the insulations may prevent the side portions 4, 5 to advance further in the direction along which they are pushing.

[0045] Figure 4 schematically illustrates a cross-sectional view of another example of an electric heating assembly 3. The electric heating assembly 3 is like the assembly 3 of figures 1-3, but the radii of the first insulation 8A and the second insulation 8B are bigger along the longitudinal direction of the U-shaped electric heating element 2 than along the other directions. The inner and outer perimeters of the first 8A and second 8B insulation are for example oval in cross-section, see

the example of figure 4. In general, the first insulation and the second insulation may have an oval cross-section or an oblong cross-section. In the case of an oblong cross-section, a central section may have a constant width between two rounded portions with a constant radius. Also, in the example of figure 4, a first gap 27 and a second gap 28 between the side portions 4, 5 of the U-shaped heating element 3 and the first 8A and second 8B insulations are provided along the longitudinal direction of the U-shaped heating element 3.

[0046] The first insulation 8A and the second insulation 8B may be sleeves or hollow rings in some examples. The first and second insulations may be elongated (e.g. in a radial direction of the sleeve or ring, and in particular in a longitudinal direction of the U-shaped electric heating element). An elongated inner diameter may reduce the probability of breakage of the U-shaped electric heating element 2 as well as may help to keep the electric heating element 2 in place by retaining it along a direction perpendicular to the largest diameter of the hole. An inner diameter of the insulations, e.g. of the sleeves or hollow rings, may have a racetrack shape or an oval shape in some examples.

[0047] In the examples including the first 27 and second 28 gaps, one or more retaining elements 16 (e.g. pins, similar as in figure 2) may also be provided. In the examples where the first gap and the second gap are provided, as well as in the examples where the first and second insulations are resilient, the first insulation and the second insulation may be made from ceramic materials.

[0048] According to another aspect of the disclosure, a kiln car is provided. Figure 5 schematically illustrates a front view of an example of a kiln car 1 comprising an electric heating element assembly 3, and in particular a plurality of electric heating element assemblies 3.

[0049] Figure 6 shows the same example of the kiln car in a perspective view. The electric heating assemblies 3 in these examples are assemblies as illustrated in figures 1-3, but in other examples electric heating assemblies comprising the first gap and the second gap between the U-shaped electric heating element 2 and the first and second insulations for allowing longitudinal movement may be used.

[0050] Two of the electric heating assemblies 3 of the kiln car can be seen in figure 5. A portion of the body 7 of the kiln car 1 has been removed such that the arrangement of an assembly 3 within the kiln car body 7 may be seen. When an electric heating assembly 3 is mounted to the kiln car 1, the first insulation 8A and the second insulation 8B are arranged inside the kiln car body 7, i.e. the insulations are not in contact with air above the kiln car body.

[0051] A plurality of kiln cars may be moved along a tunnel kiln. A tunnel kiln may have a length of e.g. 60 meters, 100 meters or more. Suitable rails may be arranged along the length of the tunnel kiln. In other examples, other guiding systems may be provided. A width of the tunnel may be e.g. 3-5 meters in some examples.

[0052] In examples where a kiln car 1 comprises a plurality of electric heating assemblies 3, electric power may be provided from the bottom of the kiln car using one or more conductive tracks. The kiln car may include one or more contact shoes which contact with the conductive track. The kiln car may include suitable power converter systems and controls to continuously or intermittently supply current through the electric heating assemblies.

[0053] A control system may comprise one or more processors and one or more memories for storing instructions which the processors can execute. The control system may be configured to set a temperature profile along the continuous kiln. The control system may be arranged outside the kiln, separate from the kiln car(s).

[0054] For example, three temperature regions may be set in the continuous kiln: a first region in which the temperature increases from an initial temperature to an intermediate temperature, a second region in which the intermediate temperature is maintained, and a third region in which the temperature is decreased from the intermediate temperature. The intermediate temperature may be the highest temperature reached, and may be above 1000 °C.

[0055] The continuous kiln may comprise sensors for monitoring the heating process. For example, temperature sensors, pressure sensors and others may be arranged within the kiln. The continuous kiln may also comprise insulation. For example, the inner walls of the continuous kiln may comprise a thermal insulation coating or layer.

[0056] The continuous kiln may comprise a suitable cooling system. For example, a plurality of fans for air injection may be provided in the kiln. In some examples, the air injection may be controlled by pulses, which may give higher air speeds. Outputs such as pipes for exhausting waste air may also be provided. One or more fans may also be used to exhaust waste air.

[0057] The electric heated kiln car 1 may further comprise a supporting base 11 arranged above the kiln car body 7 which is configured to support the load to be heated or fired in the kiln. The U-shaped electric heating element assemblies 3 may be arranged below the supporting base 11, but without touching the supporting base 11. The supporting base 11 may include a platform in some examples. The platform may be supported by a structure of beams or rods.

[0058] The supporting base 11 may have a same or similar shape and horizontal dimensions similar to the shape and horizontal dimensions of the kiln car body 7. The supporting base 11 may extend over the whole or the majority of the top surface of the kiln car body 7, see figures 1 and 2.

[0059] The supporting base 11 may be joined to the kiln car body 7 by one or more vertical supports 12. A structure of beams or roads supporting the platform of the base 11 extends between the supports 12 in this example.

[0060] For a load or ware to be fired on the kiln car, a specific temperature profile may be established. The kiln car and/or the tunnel may comprise a plurality of temperature sensors, e.g. thermocouples. Based on the temperature measurements, the current supplied to the electric heating assemblies may be determined such that the ware is heated according to the predetermined temperature profile.

[0061] Along the tunnel, additional heating elements (electric heaters, gas burners or other) and/or additional cooling elements (e.g. cooling air injectors) may be provided to ensure that the predetermined temperature profile is followed as closely as possible.

[0062] In some examples, a scale or other weighing system may be provided at the entrance of the tunnel. From the weight of the kiln car, the (amount of) ware may be determined which may also be used as input for the control of the electric heating assemblies.

[0063] The electric heated kiln car 1 further comprises a kiln car body 7, see figures 5 and 6. The kiln car body 7 may be a, or comprise a, platform or frame. The platform may be flat or have a flat top surface. The kiln car body 7 is configured to support the elements arranged on it. The two side portions 4, 5 of the electric heating element 2, in particular the end parts of the two side portions, are mounted to the kiln car body, 7 and the top portion 6 of the U-shaped heating element is arranged above the kiln car body 7 such that the U-shaped electric heating element 2 heats a load (not shown) above the U-shaped electric heating element 2 while the kiln car 7 is in use and an electric current is circulated through the U-shaped electric heating element 2.

[0064] As can be seen in figure 5, the top portion 6 of the heating element 2 is separated from a top surface of the kiln car body 7. The top portion 6 may be in direct contact with surrounding air. That is to say, the top portion 6 may be uncoated or uncovered such that a covering element does not touch the top portion 6. The electric heating element 2 may therefore efficiently heat a load above the kiln car body 7.

[0065] Electric connectors 25, 26 for circulating an electric current through the electric heating element 2 may be seen in figures 2 and 3.

[0066] The first side portion 4 of the U-shaped electric heating element may be closer to a side edge of the kiln car 1 than the second side portion 5, see for example figure 5. In such examples, the first electric heating element assembly 3 may further comprise a protective element 17 configured to protect an outer region of the first side portion 4. The protective element 17 may be provided on top of the top stopper in some examples, see figures 1 and 3.

[0067] The protective elements 17 at least partially surround the side portions of the U-shaped heating element. The protective elements 17 may be arranged to avoid cooling air impinging directly on the heating elements, and thereby potentially affecting the temperature of the electric heating element. A height of the protective element 17 may decrease towards an inside of the kiln car 1, see figure 5. The protective element 17 may be arranged above the kiln car body 7. In this manner, the affected region of the first side portion 4 may be protected from a cooling fluid delivered from an inner wall of the continuous kiln.

[0068] As can be seen in figure 3, a radial gap 18 may be provided between an inner wall of the protective element 17 and an outer wall of the side portions 4, 5 of the electric heating element 2. This gap may be present already when the heating element 2 is still cold. Such gap may help to direct the heat generated by the side portions 4, 5 upwards, towards the load. In other examples, a protective element 17 with such a radial gap may be provided, but a height of the protective element 17 may not vary, or may vary in a different manner from what is shown in figure 3.

[0069] Protective elements 17 may also be provided in the examples where a first gap 27 and a second gap 28 are provided between the side portions 4, 5 of the U-shaped electric heating element 2.

[0070] All or the majority of the components of the electric heating element assembly 3, except the electric heating element, may be electrically insulating. The components surrounding the electric heating element 2 may have a thermal conductivity lower than the thermal conductivity of the electric heating element. A safer process may be performed in this manner.

[0071] In some examples, the first insulation and the second insulation may be entirely arranged within the kiln car body 7. In the example of figure 5, the compressible sleeves 8A, 8B and at least the bottom stoppers are entirely arranged within the kiln car body 7.

[0072] Figures 7 and 8 schematically illustrate a side view and a top view of the electric heated kiln car of figure 1, respectively. The kiln car body 7 may be configured to move on rails. The kiln car 1 may for example comprise a plurality of wheels connected to the kiln car body 7 to this end.

[0073] As can be seen in figures 5 and 6, the side portions 4, 5 of the U-shaped electric heating elements may extend vertically. The top portion 6 of the electric heating elements may extend substantially horizontally. A stable, simple and effective way of arranging the heating elements with respect to the kiln car body 7, the load and the continuous kiln is provided in this example.

[0074] The kiln car 1 may further comprise a plurality of additional assemblies including U-shaped electric heating elements. The U-shaped heating element assemblies of the kiln car 1 may be arranged in at least one row 19, e.g. in two rows 19, see figures 5, 6 and 8. The rows 19 may extend along a longitudinal direction of the kiln car 1 at least in some examples. The longitudinal direction of the kiln car may be the same as the longitudinal direction of the electric continuous kiln on which the kiln car is to move. Two longitudinal rows may be a suitable compromise between having large top portions 6 of the electric heating elements 2 and having resistant

and durable heating elements.

[0075] The side portions of the heating elements 2 which are closest to the side edges of the kiln car 1, and therefore of the kiln, may be provided with protective elements 17.

[0076] A kiln car 1 may further comprise one or more sensors. For example, the kiln car may comprise one or more sensors for measuring the temperature of the U-shaped electric heating elements 12. A kiln car 1 may further comprise a cooling system. For example, a fan may be provided at the bottom surface of the kiln car body 7. The kiln car may be configured to be actively cooled in some examples.

[0077] In a further aspect, a continuous electric kiln is provided. The kiln comprises a tunnel, one or more electric heated kiln cars 1 as described herein, e.g. with respect to figures 5-8, and one or more rails for guiding the electric heated kiln cars 1. The kiln car(s) can therefore move or be moved along the continuous kiln. In some examples, an electrical line may be arranged with an electric rail such that an electrical current drives the motors which cause the wheels of the kiln car to turn. Transformers may be provided between the electric line and the wheels. One or more electrical lines or rails for electrically feeding the U-shaped electric heating elements may also be provided.

[0078] Electric current can flow to these heating elements via contacts arranged, for example, on the underside of the kiln platform, which are arranged in the longitudinal direction of the kiln channel next to or between the kiln rails.

[0079] The continuous kiln may comprise a control system for controlling the U-shaped electric heating elements 2 of the electric heated kiln cars 1.

[0080] The rails may be arranged on a kiln floor in some examples. In other examples, the rails may be arranged below a kiln floor, e.g. in a kiln floor body.

[0081] In a further aspect of the disclosure, another continuous kiln using electric heating is provided. The kiln comprises a tunnel, one or more rails for guiding one or more kiln cars and a floor body comprising an electric heating assembly as described herein. The end parts of the two side portions are mounted on the floor body, and the top portion is arranged above the floor body such that the U-shaped electric heating element is configured to heat a load on a kiln car.

[0082] In these examples, a kiln car does not include electric heating assemblies as described in other examples.

[0083] An example of a kiln according to this aspect is schematically illustrated in figures 9 and 10. The kiln 30 comprises a floor body 31, a top wall and two side walls 33, 34. A first electric heating assembly 3 is mounted to the floor body 31, see figure 9. The top portion 6 of the U-shaped heating element 2 is parallel to a horizontal transverse direction of the kiln 30, and in particular to a direction in which the width of the kiln is measured.

[0084] The floor body 31 may comprise more than one electric heating assembly 3. For example, a row comprising a plurality of electric heating assemblies may be provided. As the plurality of electric heating assemblies is provided along a longitudinal direction of the kiln, the U-shaped electric heating elements may release heat when the kiln car travels over the corresponding portion of the floor body of the kiln. The electric heating assemblies may be sized and arranged such that a vertical gap may be provided between the top portion 6 of the U-shaped heating elements 2 and a bottom of a body of a kiln car when the body of the kiln car is over the heating assemblies. In general, the first insulation 8A and the second insulation 8B will be arranged inside the floor body 31.

[0085] The electric heating assembly 3 may be arranged between two rails 35 of the kiln 30. That is to say, a length of the heating assemblies 3 may be shorter than a distance between the two rails. In this manner, the kiln car body may travel over the heating assemblies when advancing on the rails. The floor body 31 may comprise a top portion 36 and a bottom portion 37. The electric heating assemblies may be arranged in the portion 36, and the rails 35 may be arranged in the bottom portion 37. The bottom portion 37 may further comprise electrical components, e.g. wires, for circulating an electric current through the U-shaped heating elements 2.

[0086] The kiln 30 may further comprise additional electric heating assemblies. For example, additional electric heating assemblies similar to heating assembly 3 described herein may be arranged on the floor body 31, for example towards the sides of the kiln, e.g. between a corresponding rail 35 and a side wall 33, 34 of the kiln. In some examples, there may therefore be at least three rows of electric heating assemblies 3 or similar arranged on the floor body 31. Providing additional electric heating assemblies, e.g. on the floor body, may help to better heat the load.

[0087] Additionally or alternatively, other types of electric heating elements may be provided. For example, instead of arranging electric heating assemblies between a rail 35 and a side wall 33, 34, other U-shaped electric heating elements 38 may be arranged. In the example of figure 9 it may be seen that U-shaped electric heating elements 38 are arranged on the side walls 33, 34 of the kiln. Some of them extend below a kiln car body 7 whereas others extend above the load for heating the load from above. The ones arranged on a bottom portion of the side walls 33, 34 may be supported on the kiln floor body 31, and the ones arranged on a top portion of the side walls 33, 34 may be supported on the kiln top wall 32. Suitable supports 39 are provided for this.

[0088] The U-shaped electric heating elements 38 may have side portions 40 (i.e. legs) configured to heat up when an electric current is circulated through them. A connecting portion joins the side portions of a heating element 38. The connecting portion may for example be a bridge made of a low resistance SiC. In the example of figure 9, only one leg 40 of these elements 38 is seen, as

the connecting portions extend in a longitudinal direction of the kiln. These elements 38 may therefore heat up for helping to heat the load on a kiln car. The connecting portion of these heating elements 38 may be shorter than its side portions in some examples.

[0089] The legs 40 may go through a side wall 33, 34 of the kiln and be supported in the side wall. An electrical connection may be made at the side of the kiln.

[0090] In a further aspect, a method 20 for heating a load arranged on a kiln car, optionally on an electric heated kiln car 1 as described herein, in an electric continuous kiln is provided. The method is illustrated in the flow chart of figure 11. Previous details and explanations of the kiln car and the kiln are applicable to this method and *vice versa.* The method comprises, at block 21, continuously moving the kiln car 1 through the continuous kiln. The method further comprises, at block 22, simultaneously circulating an electric current through the U-shaped electric heating element 2 of an electric heating assembly 3 as described herein for heating the load.

[0091] The electric heating assembly 3 may be arranged on the kiln car body 7 in some examples. In other examples, the electric heating assembly 3 may be arranged on the kiln floor body 31.

[0092] In some examples, the kiln car body 7 and/or the kiln floor body may comprise a plurality of electric heating assemblies 3.

[0093] The load may be a ceramic load in some examples. In some of these examples, the load may be sanitary ware.

[0094] In examples where the kiln car comprises a plurality of electric heating element assemblies 3, some of the heating elements 2 may be heated at different times than others. For example, alternating heating elements 2 of a row of heating elements may be heated at a first time, and the remaining heating elements 2 of the row may be heated at a second time after the first time. The life time of the electric heating assemblies and of the kiln car may be extended. In this regard, the electric heating elements may be heating using pulses of current. Pulses of current may also be used even if all the electric heating elements 2 are heated at a same time.

[0095] This written description uses examples to disclose a teaching, including the preferred embodiments, and also to enable any person skilled in the art to put the teaching into practice, including making and using any devices or systems and performing any incorporated methods. The patentable scope is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims. Aspects from the various embodiments described, as well as other known equivalents for each such aspects, can be mixed and matched by one of ordinary skill in the art to construct additional embodiments and techniques within the scope of this disclosure. If reference signs related to drawings are placed in parentheses in a claim, they are solely for attempting to increase the intelligibility of the claim, and shall not be construed as limiting the scope of the claim.

Claims

1. An electric heating assembly for a kiln comprising:

   a substantially U-shaped electric heating element comprising a first side portion, a second side portion and a top portion connecting the first side portion with the second side portion and extending along a longitudinal direction, wherein
   the first and second side portions have a length which is equal to or shorter than a length of the top portion of the U-shaped electric heating element; and wherein
   the electric heating element is mounted at end parts of the two side portions and the top portion is arranged such that the U-shaped electric heating element is configured to heat a load; and
   a first insulation surrounding the end part of the first side portion and a second insulation surrounding the end part of the second side portion, wherein the first and second end parts are mounted such that the first and second end parts can move along the longitudinal direction.

2. The electric heating assembly according to claim 1, wherein the first insulation and the second insulation are resilient and configured to be compressed radially outwards.

3. The electric heating assembly according to claim 2, further comprising a stopper configured to limit a movement of the first and second end parts along the longitudinal direction respectively.

4. The electric heating assembly according to claim 1, wherein a first gap is provided between the first insulation and the first side portion along the longitudinal direction, and a second gap is provided between the second insulation and the second side portion along the longitudinal direction.

5. The electric heating assembly according to any of claims 1 - 4, wherein the first and the second insulation have an oval cross-section or an oblong cross-section.

6. The electric heating assembly of any of claims 1-5, wherein the U-shaped electric heating element comprises, and in particular is made of, silicon carbide.

7. The electric heating assembly of any of claims 1 - 6, wherein the first and second insulation are made from ceramic materials.

8. A kiln car comprising:

a kiln car body;
a supporting base for supporting a load to be fired; and
the electric heating assembly according to any of claims 1 - 7 arranged below the supporting base; wherein
the end parts of the two side portions are mounted on the kiln car body and the top portion is arranged above the kiln car body such that the U-shaped electric heating element is configured to heat the load on the support base.

9. The kiln car of claim 8, wherein the first side portion is closer to a side edge of the kiln car than the second side portion, the first electric heating element assembly further comprising a protective element configured to protect an outer region of the first side portion.

10. The kiln car of claim 9, wherein a height of the protective element decreases towards an inside of the kiln car.

11. The kiln car of any of claims 8-10, comprising a plurality of electric heating assemblies, wherein the U-shaped heating elements of the heating assemblies are arranged in one or more rows.

12. An electric continuous kiln comprising a tunnel, one or more electric heated kiln cars of any of claims 8-11 and one or more rails for guiding the electric heated kiln cars.

13. An electric continuous kiln comprising a tunnel, one or more rails for guiding one or more kiln cars and a kiln floor body comprising the electric heating assembly according to any of claims 1-7;
wherein the end parts of the two side portions are mounted on the floor body and the top portion is arranged above the floor body such that the U-shaped electric heating element is configured to heat a load on a kiln car.

14. A method for heating a load arranged on a kiln car, in particular on the kiln car of any of claims 8 - 11, in an electric continuous kiln, the method comprising:

continuously moving the kiln car through the continuous kiln; and
simultaneously circulating an electric current through the U-shaped electric heating element of the electric heating assembly of any of claims 1 - 7 for heating the load.

15. The method of claim 14, wherein the load is a ceramic load.

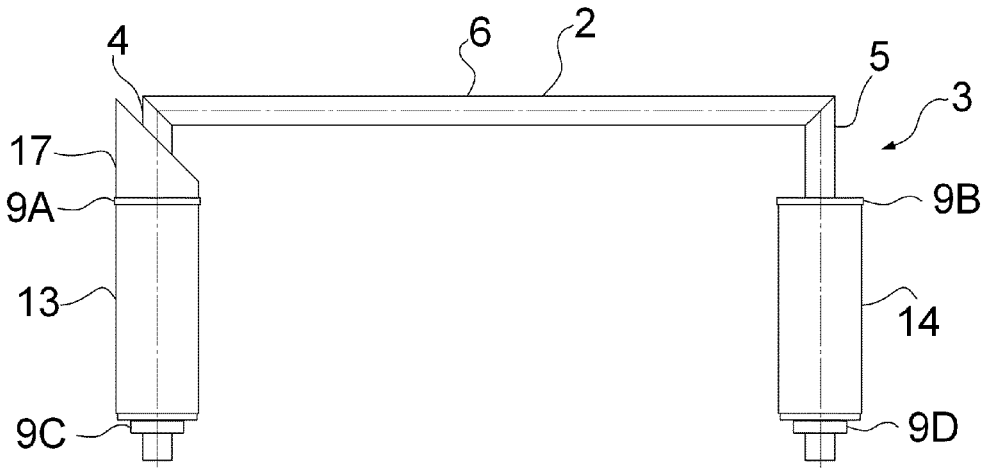

Fig. 1

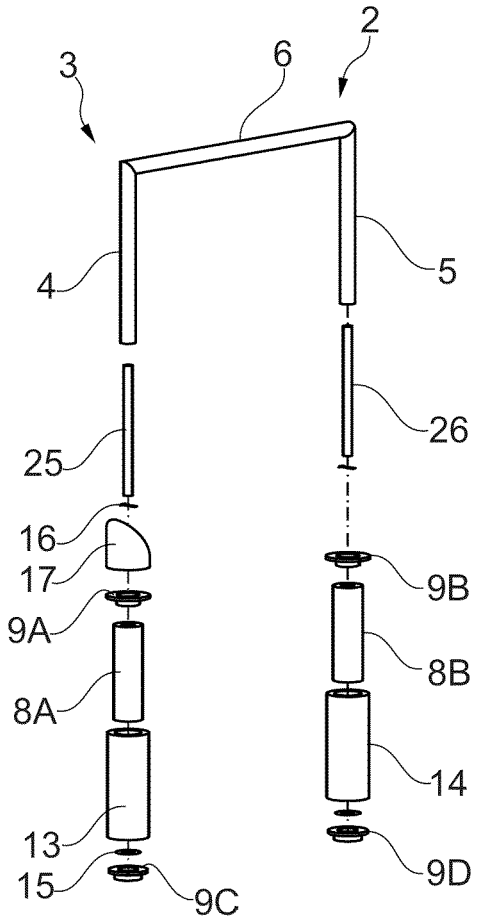

Fig. 2

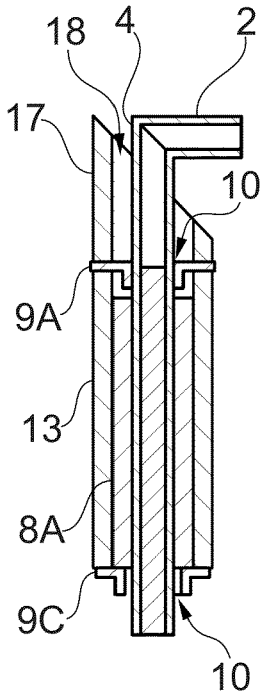

Fig. 3

Fig. 4

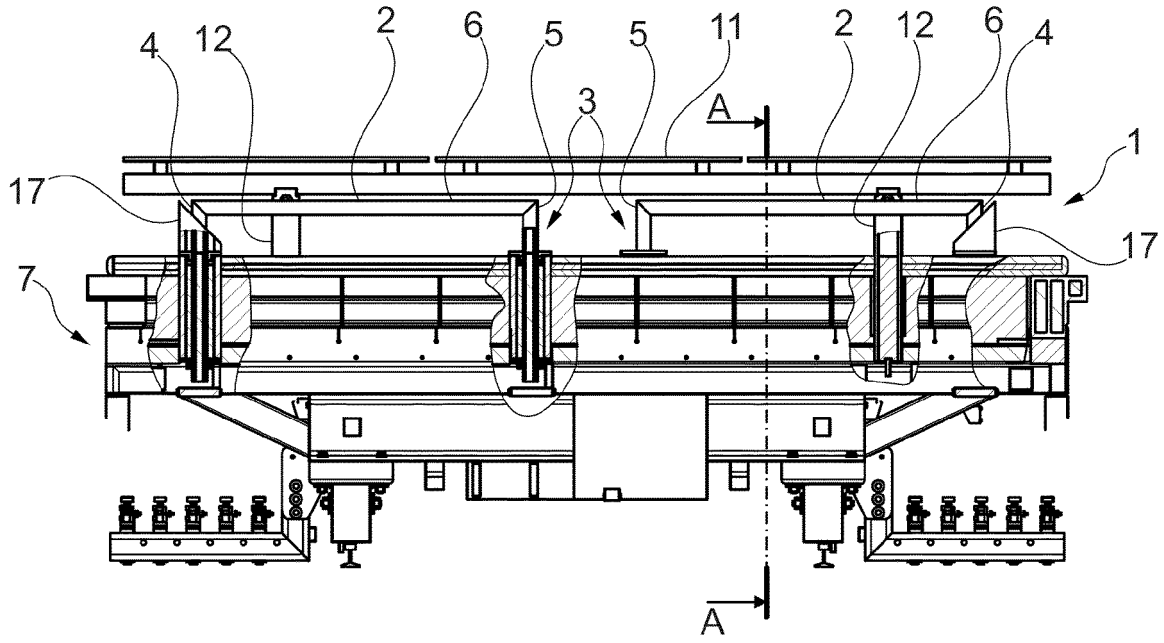

Fig. 5

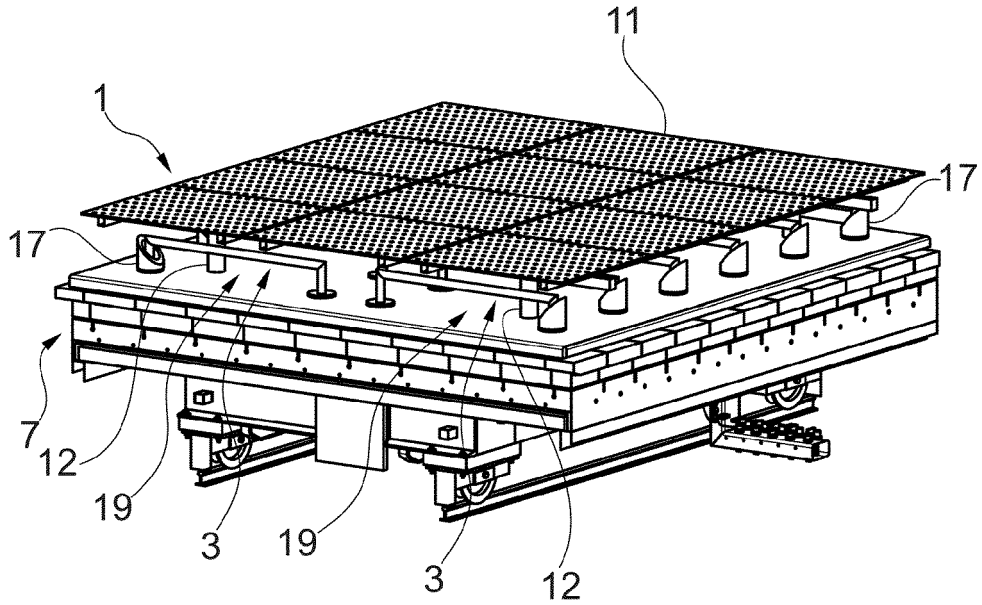

Fig. 6

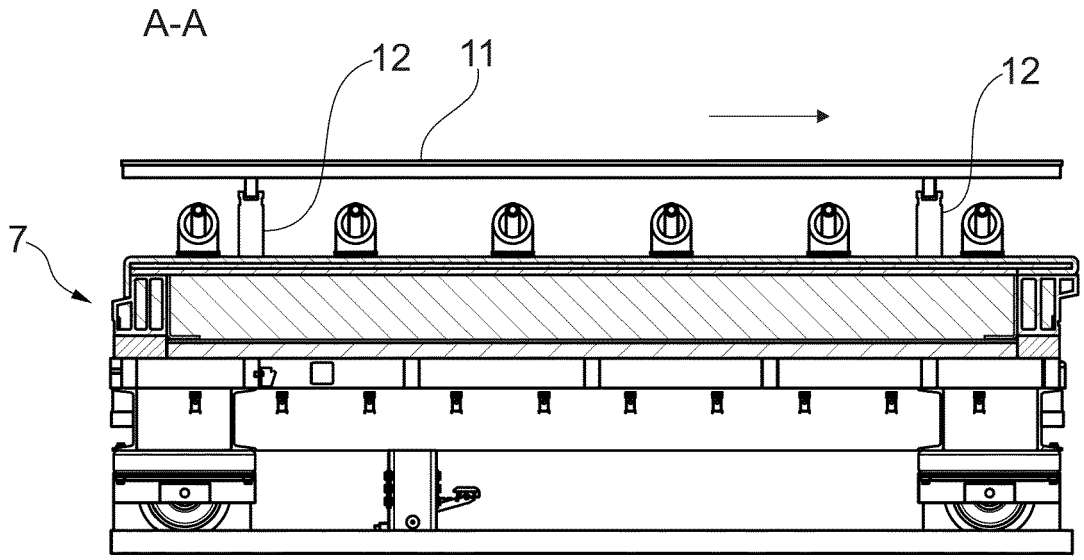

Fig. 7

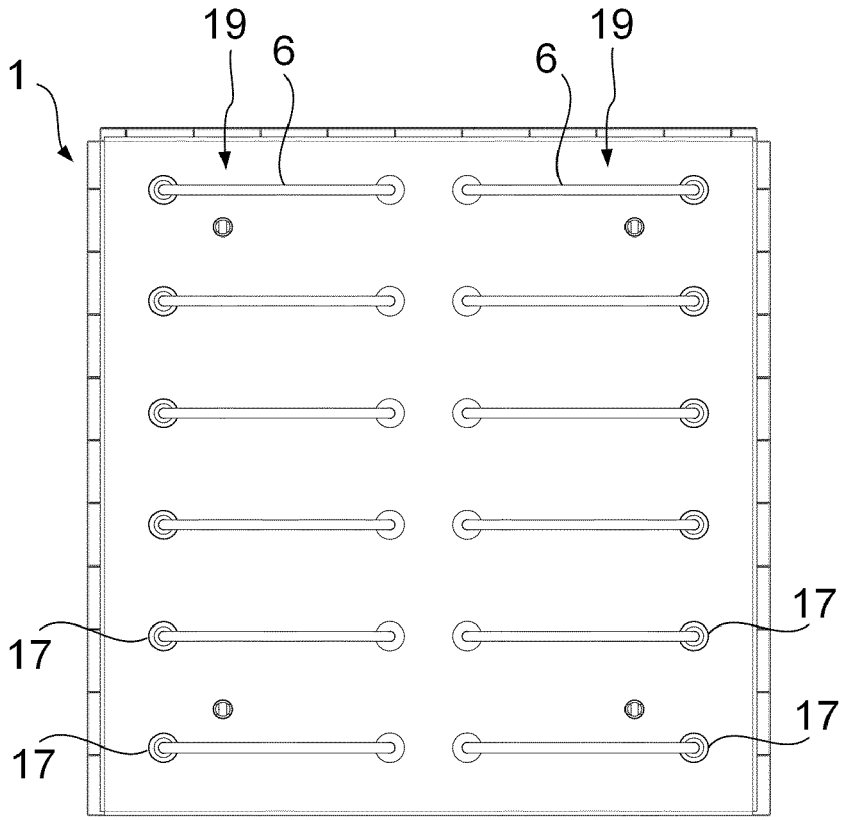

Fig. 8

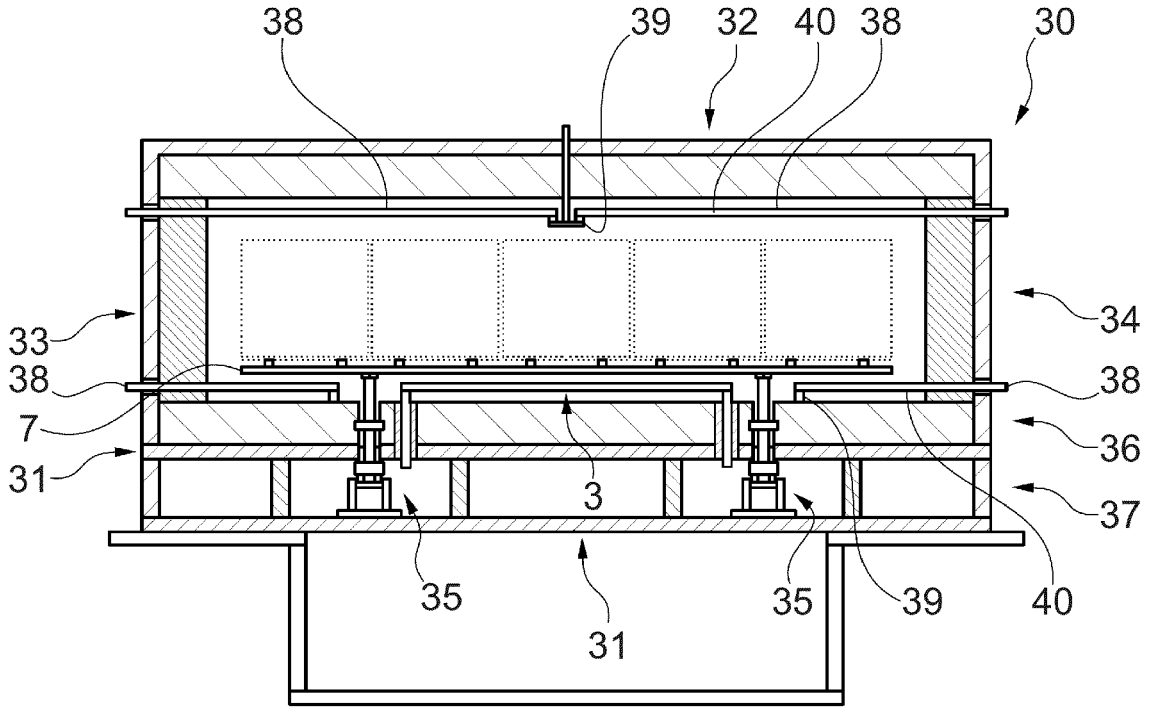

Fig. 9

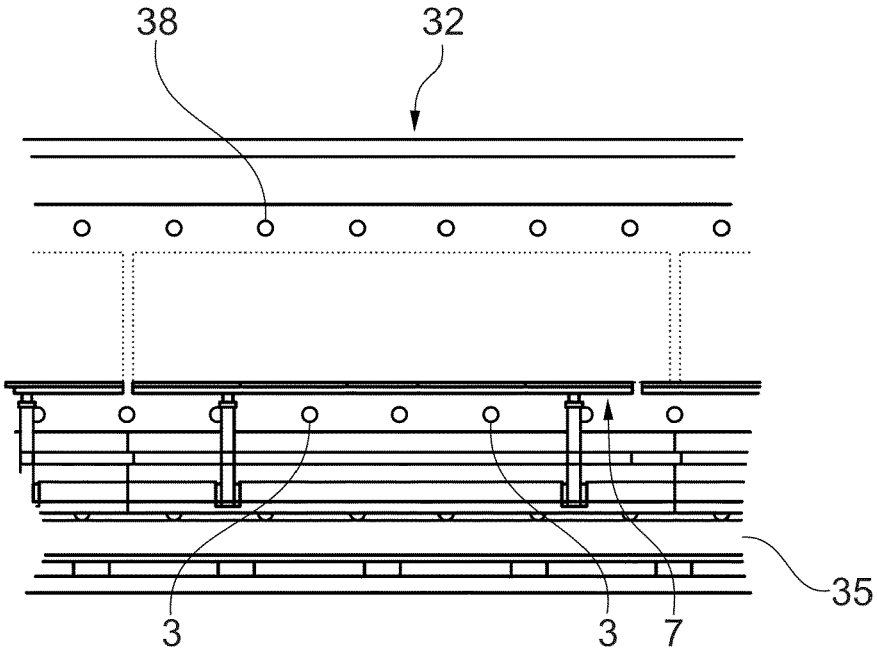

Fig. 10

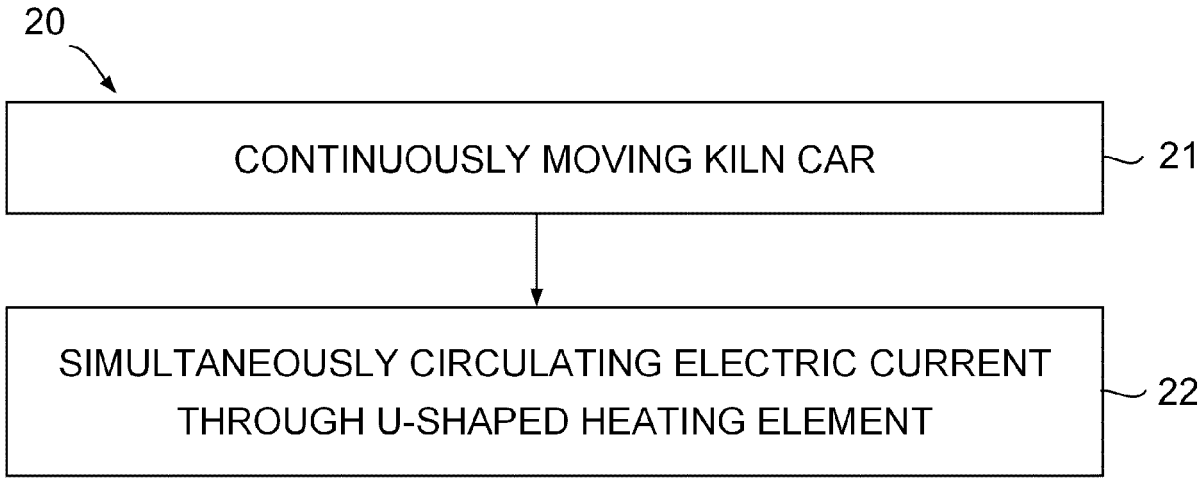
20
CONTINUOUSLY MOVING KILN CAR
21
SIMULTANEOUSLY CIRCULATING ELECTRIC CURRENT THROUGH U-SHAPED HEATING ELEMENT
22

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 5661

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	US 2012/106934 A1 (YU MING-HUI [TW] ET AL) 3 May 2012 (2012-05-03)	1	INV. F27B9/06
A	* figures 2,4 * * paragraph [0019] - paragraph [0020] *	8-15	F27B9/24 F27B9/26 F27B9/30 F27B9/36 F27D3/12 F27D11/02 F27D99/00 H05B3/62 H05B3/64 H05B3/66
A,D	CH 216 256 A (KERAMISCHE IND BEDARFS KOMM GE [DE]) 15 August 1941 (1941-08-15) * figures 1-3 *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

F27B
H05B
F27D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	2 May 2024	Peis, Stefano

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 20 5661

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02-05-2024

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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