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(54) **Vertical-shaft type kiln provided with means for transporting goods therethrough.**

(57) A kiln comprises a vertical shaft for pallets on which goods to be heat treated are placed and means for lowering the pallets intermittently or continuously down the shaft from a loading station at the top of the shaft to an unloading station at its base. Air at ambient temperature or preheated air is introduced in a controlled manner at the base of the shaft and heating means are provided in the shaft intermediate its ends.

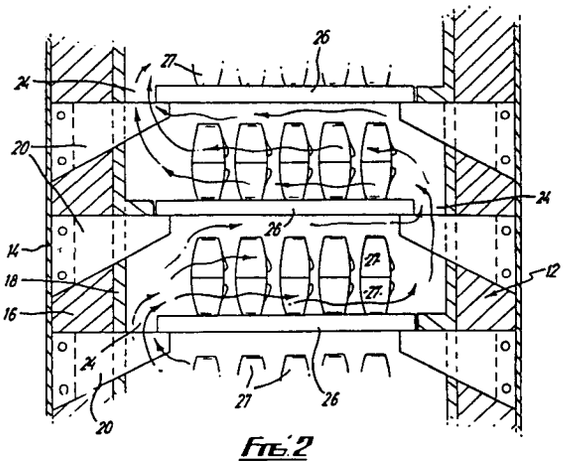

Fig.2

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TITLE MODIFIED
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Improvements in or relating to kilns

The invention concerns improvements in or relating to kilns, particularly but not exclusively kilns for firing ceramic materials. The invention may apply also to kilns for the heat treatment of metal products and products of other materials.

It is an object of the present invention to provide a kiln which is thermodynamically more efficient than prior kilns.

According to the present invention there is provided a kiln comprising a substantially vertical shaft, transport means for supporting goods to be heat treated in the shaft and for moving the goods from the top to the bottom of the shaft, means for introducing air at or near the base of the shaft and heating means intermediate the top and base of the shaft.

Further according to the present invention there is provided a method of heating goods comprising placing goods at the top of the substantially vertical shaft, lowering the goods down the shaft, heating the shaft intermediate its ends and introducing air at or adjacent its base such that as the goods are lowered they are progressively heated until they reach a maximum temperature at said heating zone and are progressively cooled as they progress towards the base of the shaft.

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawings in which:-

Fig. 1 is a horizontal cross-section through a kiln; and

Fig. 2 is a partial vertical cross-section taken on the line II - II of Fig. 1.

A vertical kiln comprises a framework incorporating four corner frame members 10 which support therebetween kiln wall panels 12 each having a base plate 14, a refractory and/or ceramic fibre insulation intermediate portion 16, and an inner refractory layer 18. Supports 20, two for each panel, are cantilevered out from the base plate 14 and project beyond the front face of the refractory layer 18 into the shaft 22 of the kiln.

A mechanism, not shown, is provided to move the panels either transversely of the shaft axis or vertically. In Fig. 1 the panels are shown in their innermost position and it should be observed that in this position a gap 24 is provided between the right hand panel 12 and the right hand edge of a pallet or bat 26 supported on the supports 20. The gap provides a passage for gases from the underside of the bat to the upper side on which ware 27 is supported.

On operation of the panel moving mechanism the panels 12 and their supports 20 are lowered down the shaft until the bat 26 is supported on the next lower set of supports 20. The first set of supports then move transversely away from the shaft axis such that they can be raised to their initial level without fouling the edges of the bat. Once at this initial level the mechanism moves them transversely inwards ready to receive another bat 26 from the set of supports above.

The corner frame members 10 of the kiln have a stepped cross-section and the sides of the panels 12 have a corresponding stepped cross-section to provide a convection and radiation seal.

To complete the seal the base plate 14 is provided with a flange 28 at each end thereof the flange incorporating a channel 30 in which is mounted a sealing strip 32 of a hard smooth low friction material such as fused aluminia or carbon, the strip 32 being spring loaded in such a way that it is urged out of the channel into contact with a flange 34 supported by the frame member 10. It will be realised that the seal strip 32 provides a relatively gas-tight seal between the movable panels 12 and the fixed frame member 10.

Fig. 2 shows that the panels 12 are so arranged that the gas passage 24 defined by one panel is arranged on the opposite side of the kiln from the passage 24 defined by the corresponding panel of the set of panels above or below said panel. With such an arrangement gas flowing upwards through the shaft is caused to pass in a relatively horizontal direction over the ware 27 on the bats 26, then upwards to the upper surface of the next bat, along this bat and then upwards at the opposite end thereof.

At the base of the shaft 22 (not shown) means are provided for introducing cold or pre-heated air into the kiln and means are provided also for supplying bats 26 supporting ware 27 to the top of the kiln. Heating means which may be electric elements or gas or oil burners are provided intermediate the base and top of the kiln and the mechanism for causing movement of the panels is so arranged that it progresses the bats 26 supporting ware 27

downwards through the kiln.

Thus, in operation, cold air is induced to rise up from the base of the kiln in the opposite direction to the movement of goods down the kiln so that the temperature of the air is increased as it rises upwards cooling the goods. When the rising air reaches or is near to the peak temperature of the kiln it is heated by the heating means to a temperature above the desired maximum temperature of the goods and heated gases then pass up the kiln giving off heat to the incoming goods passing downwards so that when the gases reach the top of the kiln the major part of the combustion heat has been transferred to the downward moving goods. The temperature of the hot air leaving the kiln will typically be about 150° to 250°C and of the goods leaving the kiln about 150° to 200°C. If the peak temperature is 1200°C then some 80% of the heat in the goods is recouperated into the system. Similarly some 80% of the heat in the gases at peak temperature is recouperated. Of course it is possible to pre-heat goods and/or the air before they are reintroduced into the kiln.

Means, for example an orifice, at the top and/or base of the kiln may be provided to control the flow of air therethrough, the orifice may be adjustable and may be automatically controlled.

It will be realised that the mechanism for controlling the movement of the panels will cause intermittent movement of the panels but it can be so regulated that it causes continuous movement thereof downwards through the kiln.

In the embodiment described above only one point of cold air admission and one point of heat introduction is described but cold air or heat can be added in any zone of the kiln to vary the

shape of the firing cycle of the goods passing therethrough. Similarly hot gases may be removed at any point. The temperature of the peak zone or zones may be controlled using conventional controlling techniques to regulate the flow of fuel to the burners or electricity to the heating elements. Thermodynamic analysis shows that less than the stoichoimetric quantity of gases is required so that the atmosphere is normally oxidizing. A small quantity of cold air may be required to be admitted at the burners along with fuel to improve the quality of combustion or to prevent "cracking" of the fuel and subsequent carbon build up on the burners but this air is not required for thermodynamic reasons. If a reducing atmosphere is required inside the kiln it can be obtained economically by introducing some of the gases leaving the kiln back into the base of the kiln as cooling gas so that when it supports combustion in the firing zone a reducing atmosphere is produced.

A normal type of heating and cooling cycle is obtained when the thermal content of the rising air is similar to the thermal mass per unit time of the bats or pallets and loads. An excessive flow of air modifies the heating curve to give quicker earlier heating and slower heating as the peak temperature is approached; cooling is similarly modified to give fast early cooling and slower cooling towards the bottom of the kiln. An insufficient flow of air gives the opposite effect.

The kiln may be loaded at the top manually and unloaded manually at the bottom but this is expensive in labour as well as being heavy and awkward work and the mechanical handling

means for loading and unloading may be provided, the means including, for example, a vertical storage magazine (not shown).

The bats or pallets for supporting the ware may be of conventional refractory form being made in one piece and the thermal diffusivity of the bat is suitable for cycles in the order of 4 to 12 hours through the kiln with a temperature difference between the adjacent zones of approximately 150°C. Kilns with very slow cycles or kilns with large temperature differences between adjacent zones may benefit by the use of composite bats containing one or more layer of high temperature insulation such as ceramic fibre together with layers of refractory bat material to cut down interzone heat transfer by conduction through the bats and to reduce thermal stresses in the bats.

Various modifications can be made without departing from the scope of the invention. For example a kiln may contain two or more stacks of bats built in one shaft or it may include more than one shaft each including one or more stacks.

The means for transporting the pallets or bats down the kiln may be modified, for example in a low total height kiln or a kiln with a light load or working at low temperatures where the bats retain most of their strength at peak temperature the bats may be supported directly on each other by conventional props or posts so that all the weight is transmitted downwards to the bottom bat. To transport the stack of bats through the kiln a simple lowering mechanism engageable with the bat next to the bottom bat is provided. On operation this engages the bat next from bottom and lifts the stack of bats away from the

bottom bat such that it can be removed, the mechanism then lowering the remainder of the stack and retreating such that it may be moved for subsequent operation on the new next from bottom bat. A fresh bat may then be placed on the top of the stack.

In a further modification operating on a principle similar to the principle described above with reference to Figs. 1 and 2 the supports 20 may be retractable members projecting through apertures in the insulating panels. In this modification supports are provided in one pair of opposed walls only and are arranged in each wall in groups of four. The panel sections supporting the inner two supports of the four are vertically moveable.

In operation the inner supports and the panel section on which they are mounted are raised slightly to lift the bat thereon clear of the outer supports and the outer supports are then retracted such that the bat resting on the inner supports can be lowered on downwards movement of the inner supports and the panel section on which they are mounted. After the bat has been lowered below the level of the outer supports the outer supports are advanced such that continued lowering results in the bat being placed on the advanced outer supports at the next lower level. After a small further downwards movement of the inner supports they are retracted and thereafter raised to their starting level.

CLAIMS:-

1. A kiln characterised in that it comprises a substantially vertical shaft (22), transport means (20,26) for supporting goods (27) to be heat treated in the shaft and for moving the goods from the top to the bottom of the shaft, means for introducing air at or near the base of the shaft and heating means intermediate the top and base of the shaft.

2. A kiln as claimed in claim 1, characterised in that the transport means include supports (20) and pallets or bats or containers (26) adapted to be removably mounted on said supports, the supports and pallets being so arranged that gases rising through the kiln are directed to pass substantially horizontally over the goods thereon.

3. A kiln as claimed in claim 2, characterised in that channels (24) are provided in the shaft walls at the opposite sides of alternate pallets (26).

4. A kiln as claimed in any one of the preceding claims, characterised in that it includes means for admitting air to the column, means for removing heated gases,and heating zones all at vertically spaced locations.

5. A kiln as claimed in any one of the preceding claims, characterised in that the transport means include a plurality of first and second sets of supports arranged on one pair of opposed walls of the shaft the supports of each set being arranged at the same level and all the supports being movable transversely of the shaft the second set being movable longitudinally of the shaft also such that a first set supporting a pallet may be retracted whereby the pallet is supported on a second

set which then lowers the pallet onto a now advanced first set at a lower level and this after retracting prior to being raised again to their starting level at which time they are advanced beneath a further pallet.

6. A kiln as claimed in any one of the preceding claims, characterised in that means are provided for controlling the flow of gas through the kiln.

7. A method of heating goods characterised in that it comprises placing goods at the top of the substantially vertical shaft, lowering the goods down the shaft, heating the shaft intermediate its ends and introducing air at or adjacent its base such that as the goods are lowered they are progressively heated until they reach a maximum temperature at said heating zone and are progressively cooled as they progress towards the base of the shaft.

8. A method as claimed in claim 7, characterised in that the gas is caused to flow in a sinuous manner up the shaft such that it passes over the goods in a direction substantially transverse to the shaft axis.

9. A method as claimed in any one of claims 7 or 8 , in which the goods are supported on pallets, bats or containers which are lowered intermittently down the shaft.

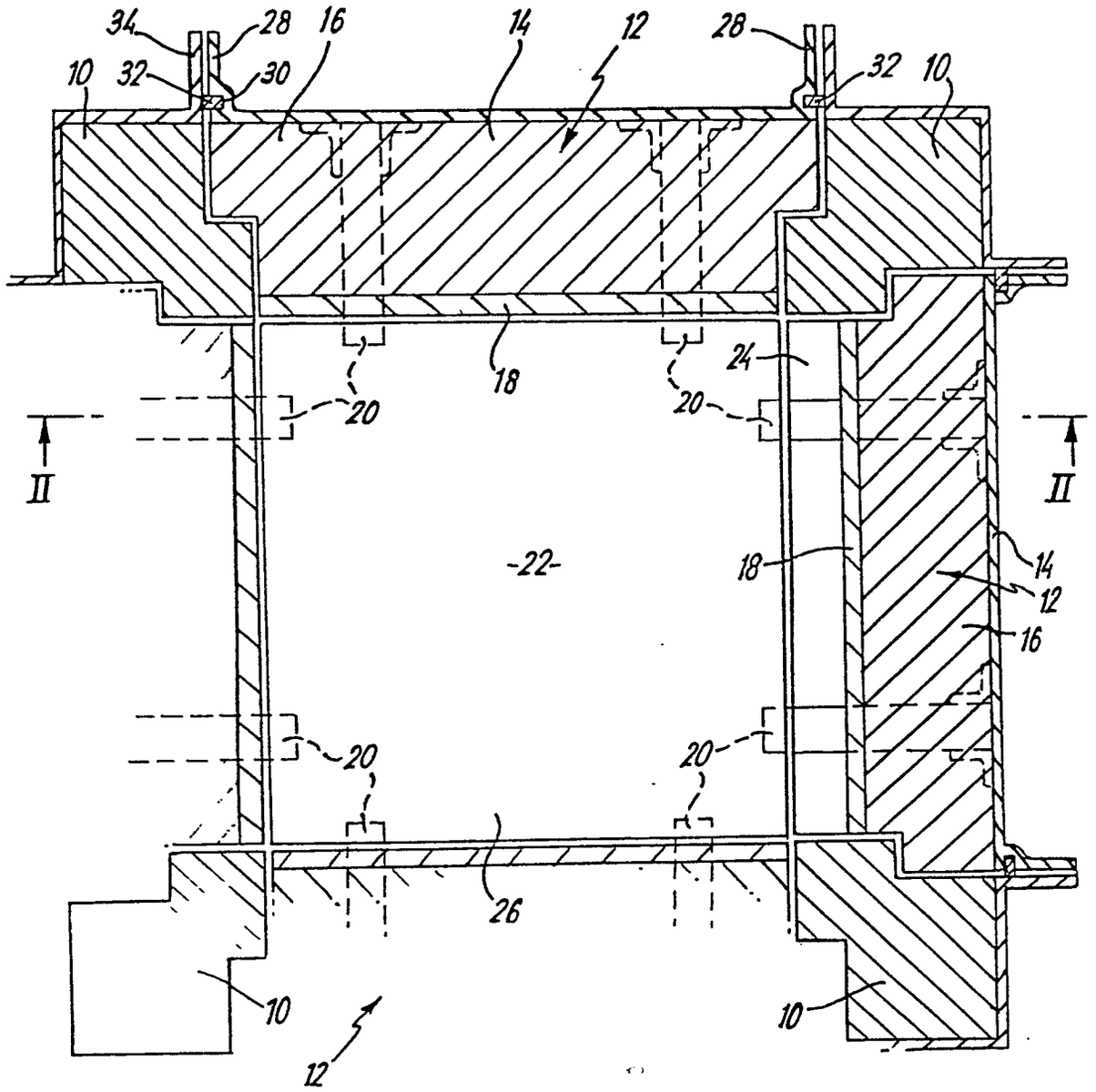
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FIG.1

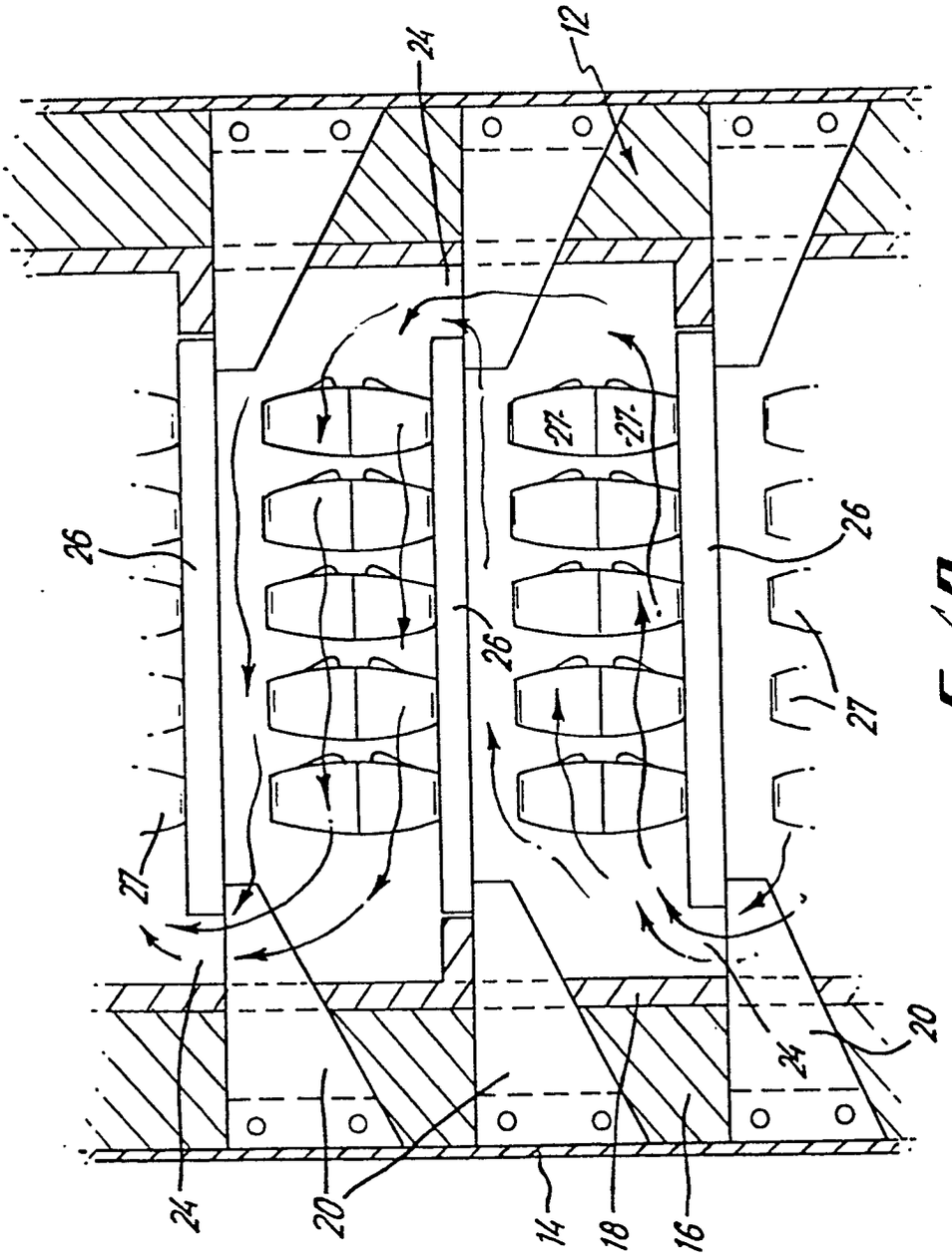

FIG.2