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(54) Tunnel kilns.

(57) A tunnel kiln comprising pre-heating, furnace and cooling zones (12′, 14′, 16′). Exhaust gases from the furnace zone are vented by vents (30a,30b) from regions at or adjacent the upstream and downstream ends of the furnace zone (14′). The heat from the vented exhaust gases is recuperated and applied to the kiln burner system (34,39) as preheated combustion air. Unlike conventional kiln practice, there is no depressurisation of the upstream end of the preheating zone (12′) to promote a flow of exhaust gases counter to the direction of passage of a payload through the kiln.

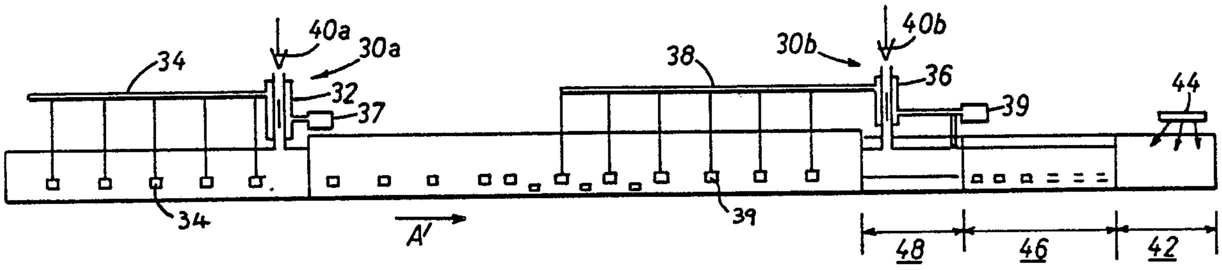

Fig 3

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IMPROVEMENTS IN TUNNEL KILNS

The present invention is concerned with tunnel kilns of the type used, for example, in the ceramic and brick industries to fire or bake products in their various stages of manufacture.

Tunnel kilns are usually static structures, the payload being transported through the kiln by a suitable conveying means whereby to encounter successively one or more pre-heat zones, one or more furnace zones and finally one or more cooling zones. In conventional kilns, cooling air is normally introduced into the downstream end of the kiln, considered in the direction of the payload through the kiln, and combustion air is introduced in the furnace zone or zones, the air and combustion gas products generally passing through the kiln counter to the direction of movement of the payload and exiting at the exhaust zone. Thus, in the conventional tunnel kiln, heat is generated principally at the intermediate furnace section of the kiln, for example by means of a plurality of gas or oil burners, the gaseous products of combustion being passed in a counterflow direction relative to the path of the payload or ware through the kiln so that heat is exchanged from these gas products to the payload as the latter progresses further into the kiln.

In the conventional kiln described above, the contraflow exhaust system for pre-heating the load is achieved by depressurising the tunnel kiln system at an appropriate location to achieve the required direction of travel of the exhaust gas towards the inlet end of the tunnel. This conventional system has, however, the disadvantage of causing the ingress of ambient air into the kiln system in the furnace (main heating) zone and in the pre-heat region. It can be shown that exhaust temperatures of about 200°C are commonly experienced with such systems whereas effective pre-heating would remove an amount of heat that would result in exhaust temperatures in the region of 500°C. Furthermore, the measured levels of oxygen in the exhaust gases of conventional systems also illustrate the degradation of the heat level and hence the temperature of the exhaust gases, typical oxygen levels in the exhaust gases being commonly of the order of 10% to 18%.

It is an object of the present invention, to provide a more efficient tunnel kiln system.

In accordance with the present invention, there is provided a tunnel kiln comprising pre-heating, furnace and cooling zones, and wherein exhaust gases from the furnace zone are vented from the top or sides of the kiln tunnel at regions at or adjacent the upstream and downstream ends of the furnace zone, and/or at or adjacent the downstream and upstream ends of the pre-heating and cooling zones, respectively, (considered in all cases in the direction of passage of payload through the kiln tunnel), at least some of the heat from exhaust gases vented in this manner being recuperated and applied to burner systems in the pre-heating and/or furnace zones as pre-heated combustion air.

In some cases, the highest temperature cooling zone can also be used to pre-heat combustion air, thus enabling sub-division of the furnace zone and pre-heat zone sections.

Preferably, the exhaust gases from the furnace zone are allowed to vent naturally (i.e. unforced) via flow regulation means, whereby the pressure within the furnace region can be controlled such as to prevent or minimise the ingress of extraneous air.

Cooling of the cooling zone is preferably effected by the use of one or more gas/gas recuperators disposed externally around the cooling zone.

Thus, in the present system, exhaust depression is eliminated altogether and there is no exhaust gas contraflow along the tunnel.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:-

Figs. 1 and 2 are highly diagrammatic longitudinal side and plan representations of a conventional tunnel kiln employing a contraflow exhaust system; and

Figs. 3 and 4 are similarly highly diagrammatic longitudinal side and plan representations of one embodiment of a tunnel kiln in accordance with the present invention.

Referring first to Figs. 1 and 2, the conventional tunnel kiln 10 comprises three basic zones, namely a pre-heating zone 12, a furnace zone 14 and a cooling zone 16. Objects (the payload) to be heat treated are inserted at the left-hand side of the kiln as viewed in Figs. 1 and 2 and travel from left to right along the kiln as indicated by the arrow A in Fig.1. The temperature of the objects is raised progressively as the objects pass through the preheat zone 12 and raised to a maximum in the furnace zone 14 where a substantially constant temperature is maintained until the objects reach the start of the cooling zone 16. The objects are progressively cooled in passing through the cooling zone before finally emerging from the right-hand side of the kiln.

In this conventional kiln, some form of heating devices, usually a plurality of gas or oil-fired burners, are disposed in the pre-heat and furnace zones 12,14. The hot gases from the burners and any combustion products are caused to flow in a direction B counter to the direction of movement A of the payload by lowering the pressure of the system in an exhaust zone region 18 at the inlet end of the pre-heat zone 12, for example by means of an external exhaust fan 20. The gases exhausted in this manner are indicated in Fig.1 by arrow C. Further exhaustion of these hot gases takes place via exhaust ports 22. Cooling air is introduced into the cooling zone 16 adjacent the outlet end of the kiln, by means of a fan 22, as indicated by the arrows E. The upstream part of the cooling zone 16 is also further cooled indirectly by air passed over it externally, as indicated by arrow F. This can include unforced and/or forced convective cooling. The heated air resulting from the forced cooling of the zone 16 can be used as pre-heated air which is applied to the furnace zone via a pump 24 and ductwork 26.

It will be appreciated that the exhaust depression at 18, provided to effect the contraflow of exhaust gases, also has the effect of causing the ingress of cold (ambient) air into the kiln systems, both directly into the kiln and into the exhaust system. As well as air introduced intentionally at the outlet end of the tunnel, which passes totally or in part through the main furnace zone 14 and therefore dilutes the applied heat, additional cold air may enter the system at any of a plurality of locations along the tunnel where the tunnel wall is not completely continuous for any reason, e.g. around burners, at joins between wall sections, e.t.c. Thus, even in the furnace and pre-heat zones, the applied heat is under depression from the exhaust fan so that the ingress of ambient air is again promoted.

The results of the use of a contraflow exhaust system therefore results in an additional heat requirement being necessary to achieve the necessary operational temperatures in order to counteract the cooling effect of the exhaust gases and the cool ambient air being drawn into the system.

The system of Figs. 3 and 4 in accordance with the present invention again comprises preheating, furnace and cooling zones $12'$, $14'$, and $16'$ and the payload is again transported through the system from left to right in the direction A', as viewed in Figs. 3 and 4. Unlike the system of Figs. 1 and 2, however, gases are not exhausted at the inlet end of the tunnel. Instead, provision is made for the heat applied in the main furnace zone $14'$ to be vented naturally (i.e. unforced) via outlet vents 30a, 30b disposed in the tunnel roof and/or sidewalls at or adjacent the upstream and downstream ends, respectively, of the furnace zone $14'$, or at the downstream and upstream ends of the preheat and cooling zones, respectively. The heat carried by the gases leaving via the vent 30a is then heat-exchanged in a radiation gas/gas recuperator 32 disposed around the vent 30a and applied by way of ductwork 34 to a plurality of gas burners 35 of the burner system in the pre-heating zone $12'$ (not simply to the pre-heating zone as such) as pre-heated combustion air by means of a pump 37. Likewise the heat carried by gases leaving via the vent 30b is heat-exchanged in another radiation gas/gas recuperator 36 disposed around the vent 30b and applied by way of ductwork 38 to burners 39 in the furnace zone $14'$, again as pre-heated combustion air, by means of a pump 39.

In most cases, it is advantageous for the vents 30a, 30b to include a means 40a, 40b for regulating the flow of exhaust gases therefrom, and hence the pressure within the furnace region of the kiln, in order to prevent the ingress of extraneous air thereto. By this means, close control of the atmospheric pressure in the furnace region can be obtained, for example to achieve a neutral or preferably slightly positive pressure condition. This contrasts to conventional kiln arrangements where there is usually a considerable pressure reduction brought about in the furnace region.

In the cooling zone $16'$, cooling air is directly inserted into a downstream end region 42 by means of a fan 44. Forced convective cooling takes place in an intermediate cooling region 46 and indirect forced cooling takes place in an upstream cooling region 48 in which, in this embodiment, the vent 36 is located.

The burner system can be of the tempered flame type to achieve the required time/temperature profile.

The use of pre-heated combustion air in this manner can be shown to bring about quantifiable efficiencies. By the use of the pressure regulation feature, extraneous air intake can be controlled or eliminated, thereby reducing the heat content required in the conventional system to heat extraneous air to kiln temperature. The heat requirement of the pre-heat zone $12'$ is directly applied using recuperated air and pre-heated air through the burner system. Any extraneous intake of ambient air is exhausted prior to entry into the high temperature zone. The fact that the extracted air from the furnace section is very hot in comparison with the low temperature products entering the pre-heat section means that one achieves a better heat exchange characteristic between the products and the pre-heating air compared to that achieved by conventional contraflowing.

Whereas two vents 30a,30b have been shown in the illustrated embodiment, more than two such vents may be included in other embodiments to suit the practical characteristics of any given kiln.

In a further modification, the hot air vented via the vent 30b can be extracted from the region 48 by way of a recuperator of the type described in my earlier U.K. Patent Specification No.2103773A to which reference is hereby directed. Such a recuperator could be disposed in the roof or side walls of the kiln region 48 so that the exhaust gases pass over both the inner and outer walls of the recuperator shell.

Claims

1. A tunnel kiln comprising pre-heating, furnace and cooling zones (12′,14′,16′), and in which hot gases are removed from the furnace zone (14′), characterised in that exhaust gases from the furnace zone (41′) are vented from the top or sides of the kiln tunnel at regions at or adjacent the upstream and downstream ends of the furnace zone (14′), and/or at or adjacent the downstream and upstream ends of the pre-heating and cooling zones (12′,16′), respectively, (considered in all cases in the direction of passage of payload through the kiln tunnel), at least some of the heat from exhaust gases vented in this manner being recuperated and applied to burner systems in the pre-heating and/or furnace zones as pre-heated combustion air.

2. A tunnel kiln as claimed in claim 1, wherein said vented exhaust gases are allowed to vent in an unforced manner via respective vents (30a,30b) containing flow regulation means (40a,40b), such that the pressure within the furnace zone (14′) can be controlled so as to prevent or minimise the ingress of extraneous air.

3. A tunnel kiln as claimed in claim 2, including one said vent (30a) at the downstream end of the pre-heating zone (12′), atmospheric air being forced over said vent by a fan (37) whereby to achieve gas/gas recuperation of the exhaust heat, the resulting heated air being applied by ductwork (34) to a plurality of burners in the pre-heating zone (12′).

4. A tunnel kiln as claimed in claim 3, including a second said vent (30b) at the upstream end of the cooling zone (16′), gas being forced over said second vent (30b) by a second fan (39) whereby to achieve gas/gas recuperation of the exhaust heat, the resulting heated air being applied by ductwork (38) to a plurality of burners (39) in the furnace zone (14′).

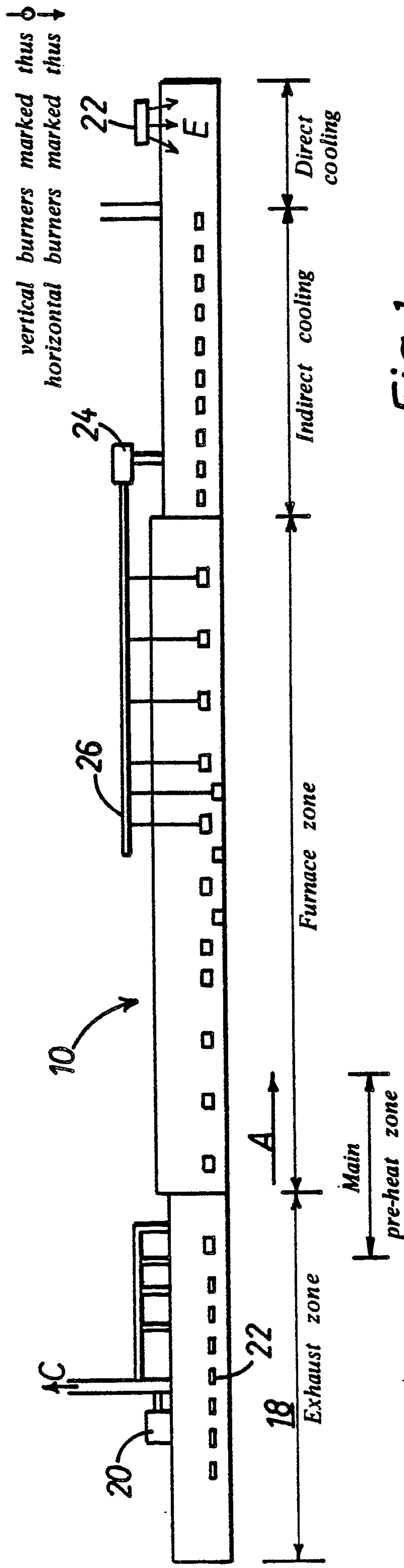
vertical burners marked thus
horizontal burners marked thus
22
E
24
26
10
A
C
20
22
18
Exhaust zone
Main pre-heat zone
Furnace zone
Indirect cooling
Direct cooling

Fig 1.

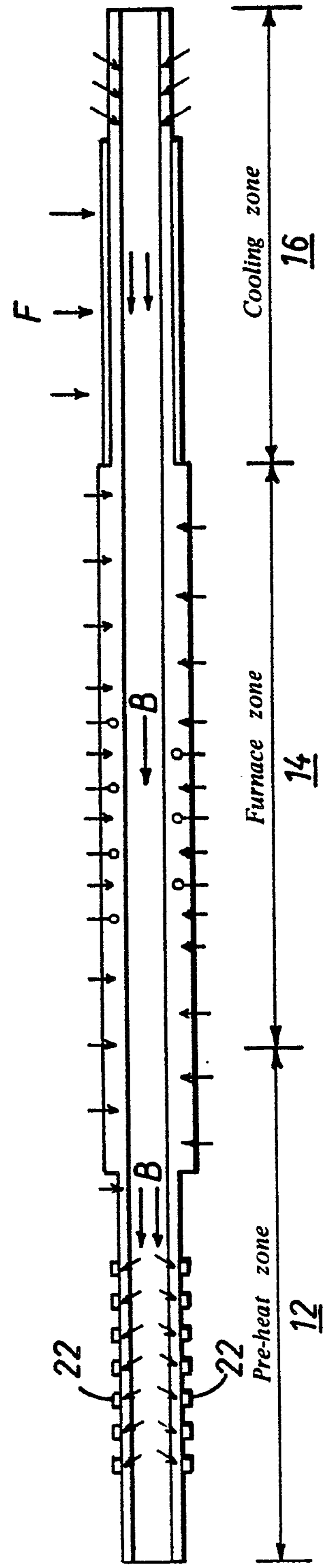
F
B
B
22
22
Pre-heat zone
12
Furnace zone
14
Cooling zone
16

Fig 2.

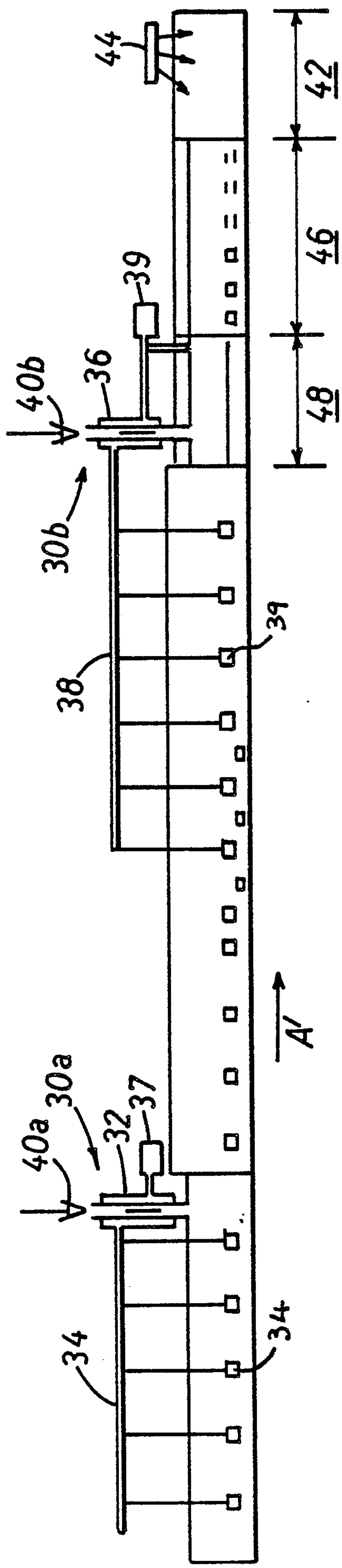
44
42
46
48
39
36
40b
30b
38
39
A'
40a
30a
32
37
34
34

Fig 3

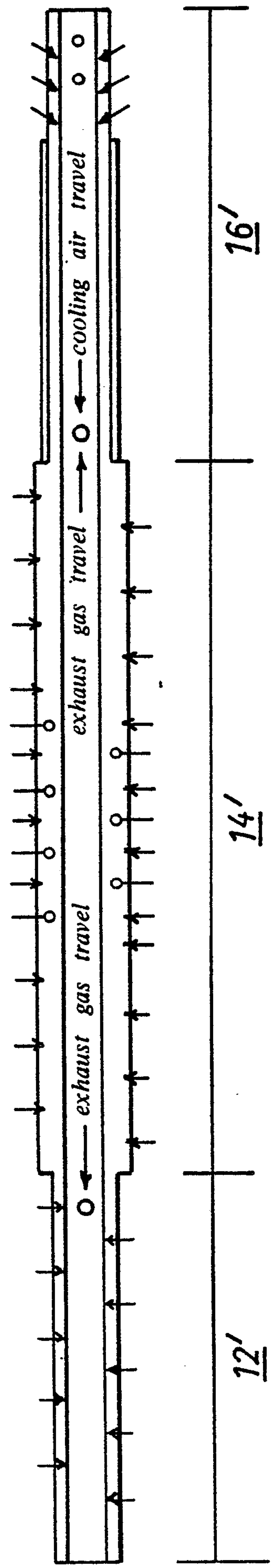
cooling air travel
exhaust gas travel
exhaust gas travel
16'
14'
12'

Fig 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 31 1482

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	FR-A-2 038 592 (KOHO'-ES GEPIPARI) * Page 5, paragraph 2; claims; figures *	1,4	F 27 B 9/30
X	WO-A-8 700 611 (HÄSSLER) * Abstract; figure 1; page 5, lines 24-32; page 6, lines 3-9 *	1,3	
X	EP-A-0 176 071 (ALUSUISSE) * Claims; figures *	1	
X	FR-A-2 405 448 (WELKO) * Claims; figures *	1	
A	US-A-4 573 909 (R.M. SCANLON)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F 27 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28-08-1989	COULOMB J.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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