

- [54] **COOLING APPARATUS FOR THE OUTLET OF A ROTARY KILN**
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- [58] Field of Search .....**263/33, 44; 165/105**

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[57] **ABSTRACT**

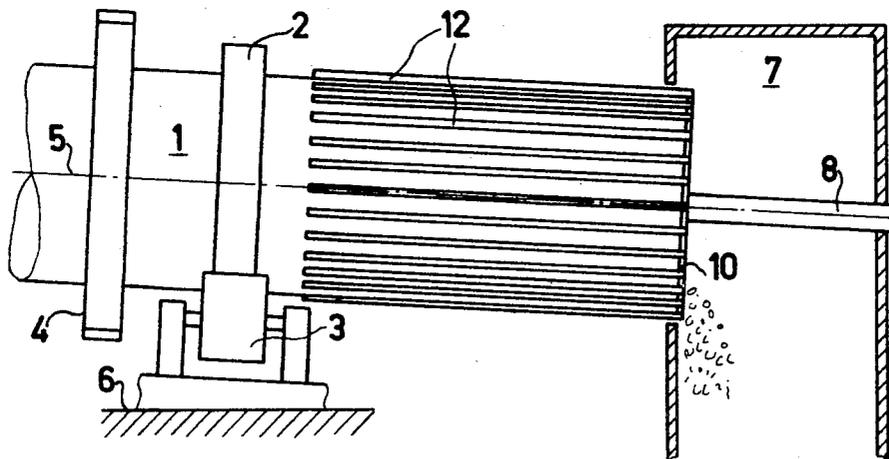
Cooling means for the outlet of a rotary kiln are disclosed. The cooling means comprises a plurality of closed boiler tubes containing a vaporizable liquid and its vapor. The tubes encircle the outlet end of this kiln and extend in the direction of the kiln's axis of rotation and are generally parallel with one another. The end portions of the tubes nearest the kiln outlet are connected in a thermally conductive manner with the cylindrical shell of the kiln. The remainder of the tubes are in the ambient atmosphere in which the kiln is operated. The means preferably includes an annular portion which extends radially inward from the ends of the tubes and adjacent to the end face of the kiln outlet to protect the face from heat radiating from the kiln. The annular member is preferably segmented and is made of a thermally conductive material.

**8 Claims, 7 Drawing Figures**

[56] **References Cited**

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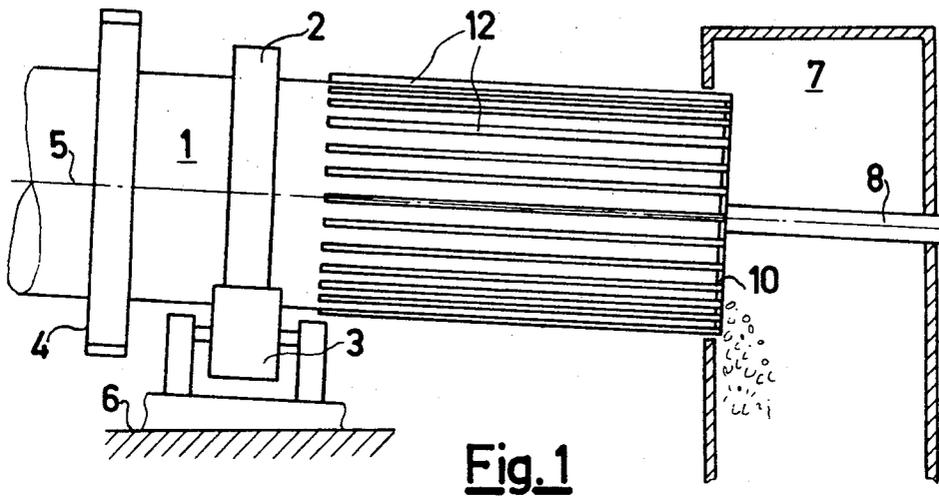


Fig. 1

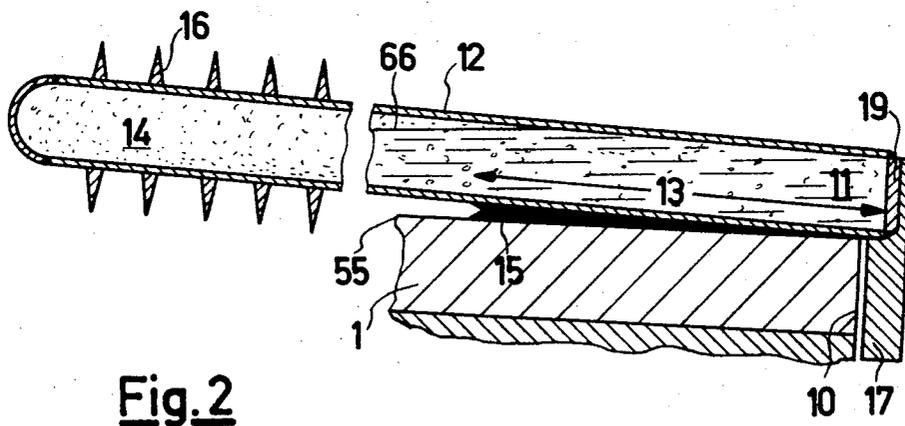


Fig. 2

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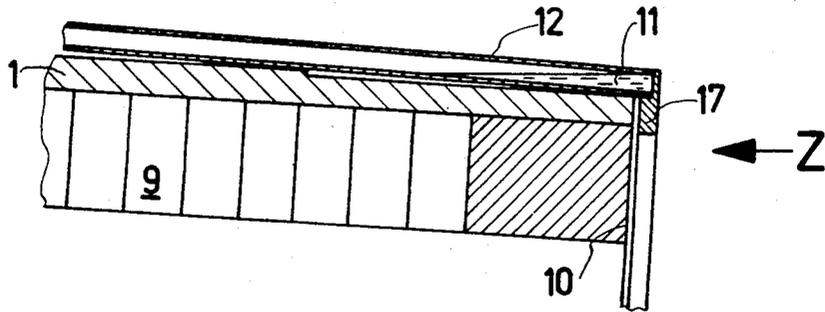


Fig. 3

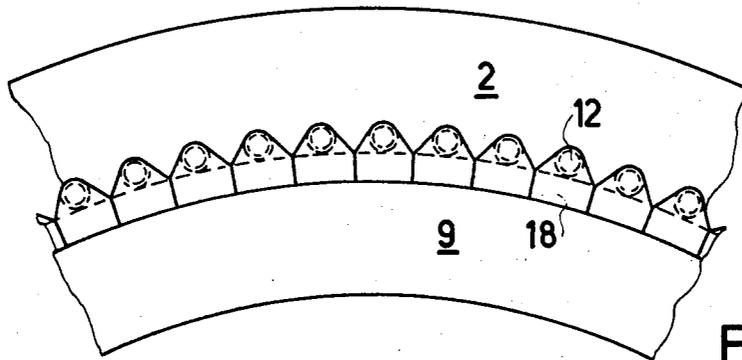


Fig. 4

Fig. 5

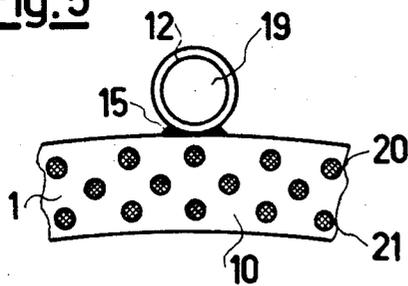
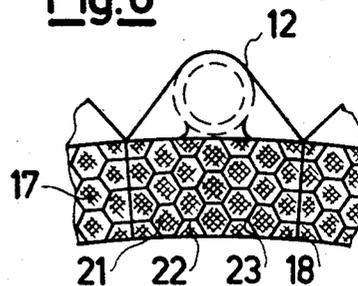


Fig. 6



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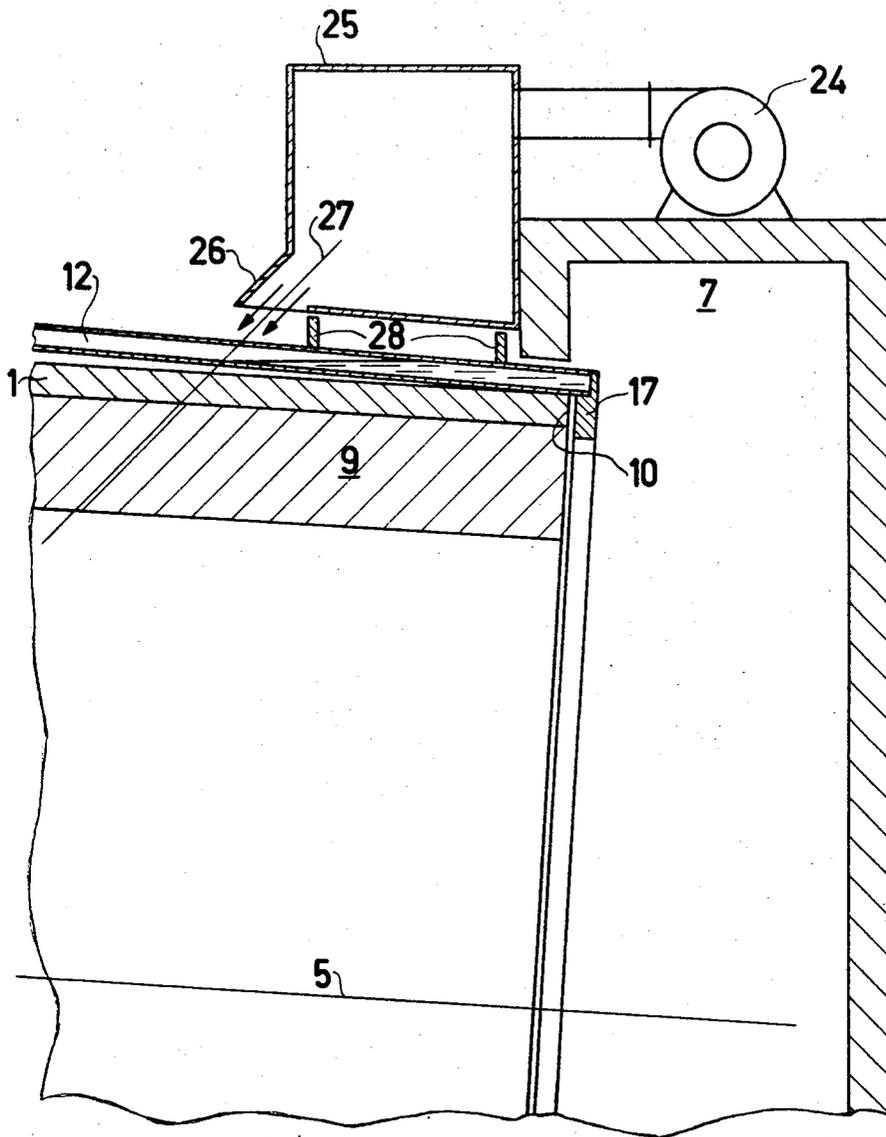


Fig. 7

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## COOLING APPARATUS FOR THE OUTLET OF A ROTARY KILN

### BACKGROUND OF THE INVENTION

In rotary kilns for the heat treatment of solid materials, more particularly kilns for the production of cement clinker, the kiln outlet is subjected to such high thermal stresses that a special cooling arrangement is required. For this purpose, in known installations the outlet end portion of a revolving drum or cylinder of a rotary kiln is provided with an encircling jacket which extends through the kiln end seal into the kiln end itself, and cooling air is blown in through the annular gap between the cylinder shell and the jacket. In order to prevent the cooling air entering the kiln, which would reduce the flame temperature and impair the thermal efficiency of the installation, it is known to arrange in the annular gap guide plates which define ducts for discharging the cooling air to the environment. But this is possible only to a limited extent, since the walls of the annular gap and the ducts constantly vary their relative positions owing to the thermal expansion which occurs. In kilns having a high thermal load, moreover, cracks quickly occur in the jacketing of the annular gap, so that cooling air can enter the kiln end from the annular gap. In addition, the last axial outlet end portion in modern kilns generally consists of heat-resistant steel segments which are provided relatively to one another and relatively to the outlet end face of the shell plating, for constructional reasons, with a clearance which also varies with the thermal expansion phenomena occurring, and this additionally results in cooling air passing from the annular gap into the kiln. Finally, the air cooling achieved has not kept up with the high thermal loads which can be expected nowadays at a kiln outlet end.

### THE INVENTION AND ITS OBJECTS

The invention has as its object to overcome these disadvantages and to achieve adequate cooling of the outlet end portion of a rotary kiln. For this purpose, an outlet end portion of a rotary kiln is so constructed according to the invention that externally on the cylinder shell there are arranged, distributed uniformly over the periphery, boiler tubes which contain a liquid for boiling, the said tubes being connected for conduction of heat to the cylinder shell over a relatively short axial outlet end portion and over the remaining axial portion adjoin the surrounding atmosphere, the arrangement being such that when the said liquid is acted upon by heat from the kiln it is evaporated in the hot region of the boiler tubes corresponding to the aforesaid axial outlet end portion and is condensed in the cold region giving up heat to the surrounding atmosphere.

According to a special form of embodiment there is arranged at the outlet side of the outlet end face of the cylinder shell an annular disc of a material which is a good conductor of heat, the said disc being coaxial with the cylinder axis and occupying at least the radial extent of the cylinder shell, the said disc being connected to the outlet-side ends of the boiler tubes in thermally conducting manner and being arranged to be thermally insulated relatively to the end face of the cylinder shell.

The aforesaid annular disc is preferably sub-divided into a number of ring segments corresponding to the number of boiler tubes, the said segments covering the boiler tubes radially.

A further feature consists in that the annular component with which the outlet-side ends of the boiler tubes are connected, i.e. the outlet-side end of the cylinder shell or the annular disc, comprises cavities which open towards the kiln end. The axes of the cavities extend substantially parallel to the cylinder axis and contain heat-insulating material.

In a preferred form of embodiment, the boiler tubes comprise, in their cold portion, means for increasing the surface area adjoining the environment.

A further feature consists in that an annular duct is provided which surrounds the cylinder and is connected to a source of cooling air and comprises an annular nozzle. The axes of the annular nozzle cross-section intersect the cylinder axis at a point and being situated on a cone coaxial with the cylinder, whose apex coincides with the aforesaid point of intersection and whose base is situated at the outlet side of the cone apex. The nozzle axes intersect the axes of the boiler tubes in the cold portion thereof.

In such a form of embodiment, the annular duct is advantageously connected to the cylinder-side portion of the kiln end, and at the outlet region of the annular nozzle there is arranged in the annular space radially bounded by the cylinder shell and the annular duct at least one sealing rib which bounds an annular gap with that wall of the annular duct which is nearest the cylinder shell, or with the cylinder shell.

Examples of embodiments of the invention are shown in a simplified manner in the drawings wherein:

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a view of the outlet end portion of a rotary kiln of cylindrical type with the kiln end shown in section, for the production of cement clinker,

FIG. 2 shows a detail from FIG. 1 on a larger scale,

FIG. 3 shows in fragmentary form an axial section through a modified form of the rotary kiln outlet on a larger scale,

FIG. 4 shows a view in the direction of the arrow Z in FIG. 3,

FIGS. 5 and 6 each show fragmentary views in the axial direction of an end portion of a rotary kiln cylinder of a different constructional form on a larger scale, and

FIG. 7 shows an axial section through a fragmentary portion of another rotary kiln.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows the outlet-side end of a rotary kiln cylinder having the cylinder shell 1, the outermost race ring 2, a visible bearing roller 3 and a toothed annulus 4 for driving the cylinder. The axis 5 of the cylinder is inclined by for example 3 percent relatively to the horizontal foundation 6. 7 designates the kiln end and 8 the fuel nozzle. FIGS. 3, 4, and 7 show the refractory brickwork 9 within the cylinder shell 1.

Provided externally on the cylinder shell 1, distributed uniformly over the periphery and approximately parallel to the cylinder axis 5, are closed boiler tubes 12 containing a liquid for boiling 11, these tubes slightly projecting beyond the outlet end face 10 of the cylinder shell. These tubes are connected in thermally conductive manner to the cylinder shell 1 over a relatively short axial outlet end portion 13. Over the

remaining axial portion the boiler tubes 12 are in contact with the atmosphere. When subjected to heat from the kiln, the liquid in the hot region of the boiler tubes 12 corresponding to the axial outlet end portion 13 evaporates and is condensed in the cold region 14 giving up heat to the atmosphere.

In the example shown in FIG. 2, the boiler tubes 12 are inclined by 1.5 percent relatively to the generatrices 55 of the cylinder shell 1, converging towards the outlet of the cylinder. The gap formed by this inclination is filled with weld metal 15 in the short axial portion 13, and the thermally conductive connection is achieved by welding. Alternatively, it is possible to use a soldered connection, or a releasable connection by tube clips or the like, although in this case care must be taken to ensure the largest possible area of contact with the cylinder shell. FIG. 3 shows that the cylinder shell 1 is of reduced thickness over the outermost axial portion. This known measure, forming a step, is advantageously used for giving the boiler tubes the desired inclination relatively to the cylinder axis. With a thickness of for example 5 cm for the cylinder shell 1, the axial portion 13 amounts for example to about 10 cm and the entire length of a boiler tube 12 for example 3 m to 4 m. The dimensions and number of the boiler tubes and also the properties of the liquid used for boiling are adapted to the amount of heat which has to be discharged, the temperature of the environment and the surface area of the boiler tubes. The cold region 14 of the boiler tubes 12 comprises ribs 16 for increasing the surface area bordering on the environment; it is also possible to use corrugated strips, spikes or the like.

Since the axis 5 and the generatrices 55 of the cylinder shell 1 are inclined to the extent of 3 percent relatively to the horizontal, on the foundation 6, the boiler tube 12 situated at the top of the cylinder shell, as FIG. 2 shows, is inclined by 4.5 percent relatively to the horizontal or the surface level 66 of the liquid 11; and the lowermost boiler tube situated at the underside of the cylinder shell is inclined by 1.5 percent relatively to the horizontal, or the surface level of the liquid. This means that even in the boiler tube 12 situated at the lowest point of the cylinder shell 1, its outlet end is the lower end, and the hot region is always filled with liquid. However, it is also possible to fix the inclination of the axis of the cylinder shell and the boiler tubes relatively to the latter in such a manner that the outlet end of the lowermost boiler tube situated on the underside of the cylinder shell is higher than the end remote from the outlet, so that the hot region of the boiler tube is not always filled with liquid. However, in such a case there is no fear of inadequate heat transfer; on the contrary, the temporary absence of liquid in the hot region of a boiler tube is balanced by the fact that the liquid is circulated in the boiler tubes.

In contrast to the illustrated embodiments, the boiler tubes may be arranged parallel to the cylinder axis. However, whether the boiler tubes are inclined relatively to the cylinder axis and at what inclination they should be inclined depends on the inclination of the cylinder axis relatively to the horizontal, the construction of the outer surface of the cylinder shell, and the space available, and had nothing to do with the essential matter of the invention.

The features described ensure adequate cooling of the outlet of a rotary kiln, and the disadvantages which are unavoidable with the known air cooling arrangements no longer occur.

At the outlet side of the outlet end face 10 of the cylinder shell 1 there is arranged an annular disc 17 of a material constituting a good conductor of heat, which disc is coaxial with the drum axis 5 and extends radially inwards over the end surface of the cylinder shell and radially outward to the radially outer points of the boiler tubes 12. This annular disc 17 is connected in thermally conductive manner to the outlet end portions of the boiler tubes. Relatively to the end wall 10 of the cylinder shell 1, the annular disc 17 is arranged in thermally insulated manner, these parts being spaced at a small axial distance from one another. This spacing is shown exaggeratedly large in the drawings for the sake of easier reading. At all events, the clearance of about 2 mm which always occurs for manufacturing reasons between the two parts would be sufficient for thermal insulation, and individual local points of contact would not produce any considerable flow of heat.

The features described protect the outlet end of the cylinder shell from direct heat radiation, the heat radiating towards the annular disc in the axial direction being transferred to the boiler tubes.

It has been found advantageous to sub-divide the annular disc 17 into as many ring segments 18 as there are boiler tubes 12. In this way thermal stresses in the annular disc are obviated.

FIG. 5 shows the outlet end face 10 of a cylinder shell 1 and also the outlet-end cover 19 of a boiler tube 12, and also its connecting weld 15 with the cylinder shell. The portion of the cylinder shell connected to the outlet ends of the boiler tubes comprises cavities 20 which are open towards the kiln end and have axes parallel to the cylinder axis, these cavities accommodating heat-insulating ceramic material 21. The cavities 20 are preferably drilled. In FIG. 6 an annular disc 17 is shown which has ring segments 18 which are connected to the outlet ends of the boiler tubes 12. The ring segments 18 extend radially outwardly to cover the boiler tubes 12. In the radial region of the cylinder shell they comprise honeycomb cells 22 which define cavities 23 which are open towards the kiln head 7 and have axes parallel to the cylinder axis and which accommodate heat-insulating ceramic material 21. The walls of the cells are preferably cast in one piece with the ring segments. Alternatively, it is also possible to solder a sheet metal structure to the ring segments. The measure of providing that annular component to which the outlet ends of the boiler tubes are connected, namely the outlet end of the cylinder shell or the annular disc, with ceramic material contributes additionally to protecting the outlet end face from being acted upon directly by radiated heat.

The rotary kiln shown in FIG. 7 comprises an annular duct 25 which surrounds the cylinder, is connected to a cooling air fan 24, and has an annular nozzle 26, the axes 27 of the annular nozzle cross-sections intersecting the cylinder axis 5 at one point and being situated on a cone coaxial with the cylinder whose apex coincides with the aforesaid point of intersection and whose base is situated at the outlet side of the cone apex, and that the nozzle axes intersect the axes of the boiler

tubes 12 in the cold region 14 thereof. The annular duct 25 is connected to the outlet-side portion of the kiln end 7, and at the outlet side of the annular nozzle 26 there are arranged in the annular space bounded radially by the cylinder shell 1 and the annular duct 25 two sealing ribs 28 which in each case bound an annular gap with that wall of the annular duct 25 which is nearest the cylinder shell. In this way a pressure cushion of cooling air is built up at the sides of the sealing ribs 28 remote from the outlet. This pressure cushion and also the impulse of the cooling air issuing from the annular nozzle insure that no cooling air will enter the kiln end 7.

These features as described effect a particularly intensive discharge of heat and they make it possible where this is necessary for any reason, for example since at the outlet side space is required for a race ring, to limit the length of the boiler tubes. It was initially mentioned that the liquid 11 in the boiler tubes 12 evaporates when the tubes are subjected to heat. After the description of the illustrated examples of embodiment it will be readily apparent how heat is supplied to them. In all cases the heat radiating from the interior of the cylinder shell 1 radially on to the inner cylinder shell surface and also, in the case of installations without an annular disc 17, from the interior of the kiln end 7 axially on to the outlet-side end of the cylinder shell, flows through the cylinder shell to the boiler tubes. Where an annular disc 17 is provided, the heat radiating on the latter flows through it to the boiler tubes, and finally heat radiates from the interior of the kiln end 7 directly on to the boiler tubes also, as will be readily apparent from FIG. 7.

I claim:

1. Cooling apparatus for the outlet of a rotary kiln, of the type including a cylindrical shell (1) having an inner refractory lining (9) characterized in that a plurality of closed boiler tubes are mounted externally on the cylindrical shell, the tubes being uniformly distributed over the periphery of the shell and at least approximately parallel with the cylinder axis (5), said tubes containing a liquid (11) for boiling and having their ends substantially in alignment with the outlet-side end face (10) of the cylindrical shell, which ends are connected in thermally conductive manner to the cylindrical shell over a relatively short axial end portion (13), the remaining axial portion of the tubes being in contact with the environment whereby liquid in said ends absorbs heat from the kiln and is vaporized and said vapor condenses in said remaining axial portion giving up heat to the environment, the condensate in

each tube being returned to its said end.

2. Cooling apparatus according to the claim 1, further characterized in that at the outlet side of the outlet end face (10) of the cylinder shell (1) there is arranged an annular disc (17) of a thermally conductive material which is coaxial with the cylinder axis (5), occupies at least the radial extent of the cylindrical shell, the disc being connected in thermally conductive manner to said ends of the boiler tubes (12) and arranged so as to be thermally insulated relatively to the end face (10) of the cylinder shell (1).

3. Cooling apparatus according to claim 2, characterized in that the annular disc (17) is sub-divided into a number of ring segments (18) corresponding to the number of boiler tubes (12), the said segments extending radially across said ends of the boiler tubes.

4. Cooling apparatus according to the claim 1, characterized in that the end face (10) to which said ends of the boiler tubes (12) are connected, comprises cavities (20) which are open toward the kiln end (7) and have axes substantially parallel with the cylinder axis; and heat-insulating material (21) received in said cavities.

5. Cooling apparatus according to claim 2, further characterized in that said disc (17) comprises cavities 23 which are open toward the kiln end (7) and having axes substantially parallel with the cylinder axis; and heat insulating material received in said cavities.

6. Cooling apparatus according to claim 1, further characterized in that the boiler tubes (12) include over at least a part of said remaining portions, means (16) for increasing the surface area exposed of the environment.

7. Cooling apparatus according to claim 1, further characterized in that an annular duct (25) surrounds the cylinder, and is connected to a cooling air source (24) and which includes an annular nozzle (26), the axes (27) of the annular nozzle cross-sections intersecting the cylinder axis (5) at a point and being situated on a cone which is coaxial with the cylinder, whose apex coincides with said point of intersection and whose base is situated at the outlet side of the cone apex, and in that said nozzle axes (27) intersect the axes of the boiler tubes (12) in a cold region (14) thereof.

8. Cooling apparatus according to claim(7), further characterized in that said annular duct encircles the shell near the outlet end of the kiln and defines together with said shell an annular gap; at least one radial sealing rib extending from one boundary wall of said gap toward another boundary wall of said gap.

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