B. E. ELDRED.

ROTARY FURNACE STRUCTURE.

APPLICATION FILED JUNE 18, 1913.

1,238,394.

Patented Aug. 28, 1917.

2 SHEETS—SHEET 1.

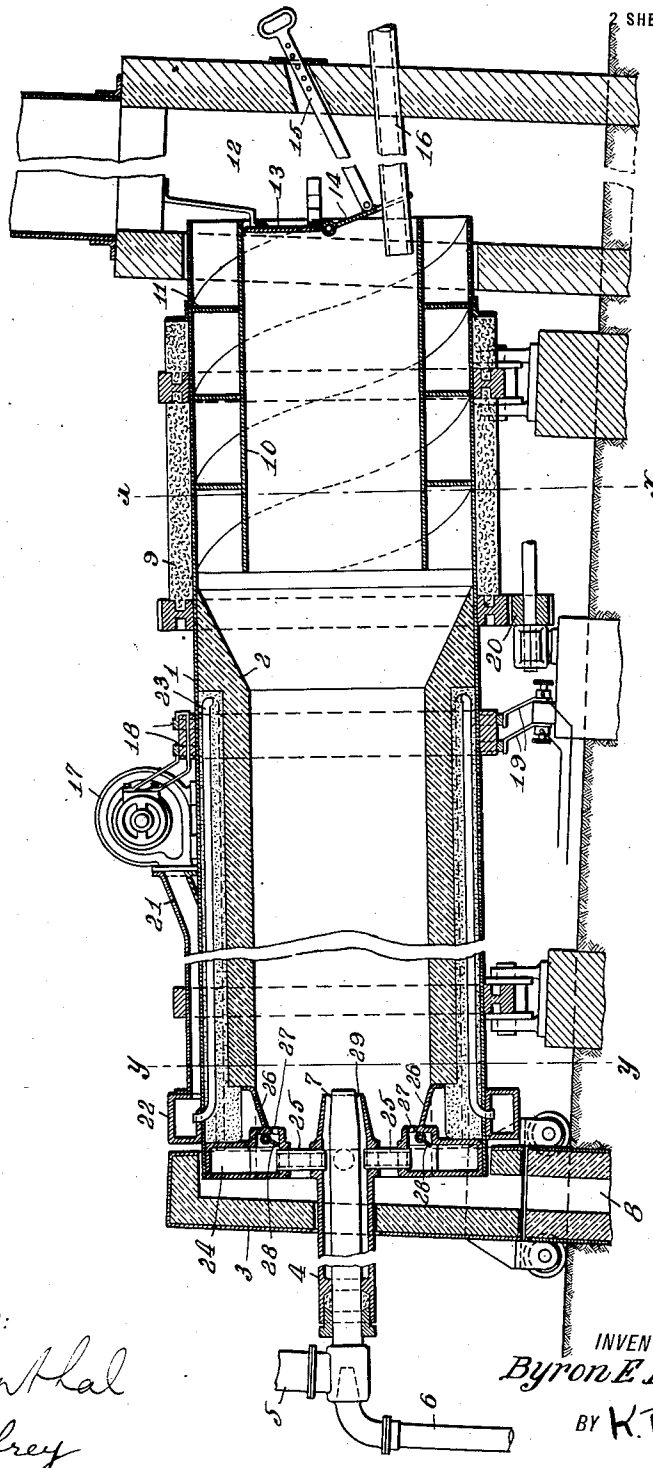


FIG. 1

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2 SHEETS—SHEET 2.

Fig 3

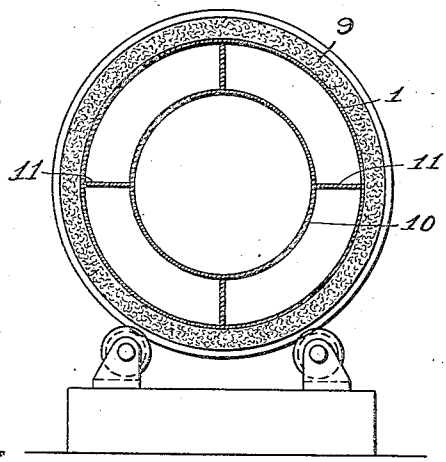


Fig 2

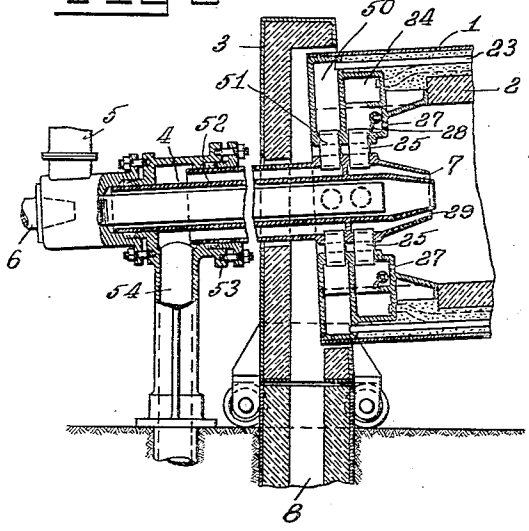


Fig 4

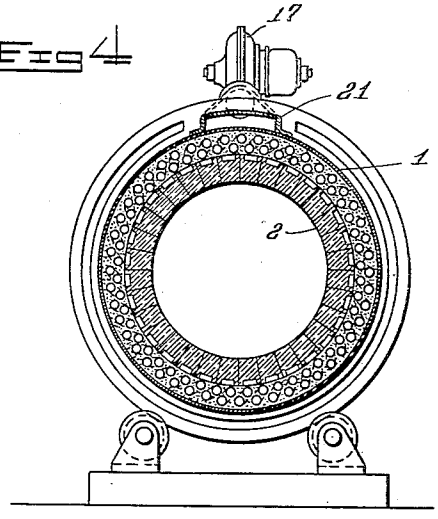
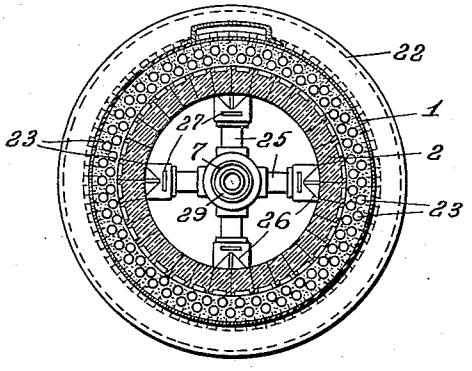


Fig 5



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UNITED STATES PATENT OFFICE.

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ROTARY FURNACE STRUCTURE.

1,238,394. Specification of Letters Patent. Patented Aug. 28, 1917.

Application filed June 18, 1913. Serial No. 774,315.

To all whom it may concern:

Be it known that I, BYRON E. ELDRED, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Rotary Furnace Structures, of which the following is a specification.

This invention relates to rotary furnace structures, and in particular to rotary cement kilns; and it comprises, in a specific embodiment of the invention, a rotary cement kiln having channels or passages arranged in its walls through which a forced current of air may be passed longitudinally of the kiln for the purpose of regulably reducing the temperature of the outer surface of the kiln and consequently the radiation loss therefrom, and return channels connected thereto and arranged between the first mentioned channels and the refractory lining, through which the warmer air passes maintaining the lining and the interior of the kiln at the necessary high temperature, the air supplied to and circulated through said passages being fed thence to the inside of the kiln at its mouth by means preventing leakage of the circulation air and insuring complete control thereof; all as more fully hereinafter set forth and as claimed.

In various operations it is common to heat comminuted or powdered material in a rotary inclined cylinder provided with internal firing means. One of the most familiar types of such operations is illustrated by the manufacture of cement in rotary kilns, and it is with the manufacture of cement that the present invention deals most particularly.

In the manufacture of Portland cement in the manner usual in this country, a supply of a powdered mixture of limestone and clay or of powdered and corrected cement rock is fed in at the upper end of an inclined rotary kiln and is caused to travel as a comparatively thin layer along the bottom of the revolving kiln against a more or less axial, oppositely traveling current of flame and hot gases derived from a burning jet of powdered coal or other fuel at the lower or discharge end of the kiln. The temperature inside the kiln is rather high throughout its length, varying from about 650° F. at the upper end to 2750° F. or more near the lower or discharge end. In the upper portion of the kiln drying and then calcination occur; the material being dried, dehydrated and then the limestone decomposed and causticized with evolution of carbon dioxid. In the lower portion an incipient fusion or clinkering takes place as chemical union between the caustic lime and the constituents of the clay occurs. The relative lengths of these portions or zones varies with the total length of the kiln, with the operation, with the materials, etc.; but ordinarily it may be said that with a short kiln, at the upper end about a quarter of the length is utilized in drying and heating, in the next zone about half the length is performing calcination and less than a fifth of the length is concerned in the clinkering. The very hot zone extends something like 12 to 15 feet from the mouth or lower end.

The heat losses in this cement-burning operation are great and are due to various sources. After deducting the heat units required for calcining and drying and the heat units carried away in the clinker and stack gases from the total heat units sent into the kiln by the combustion of the fuel used (some allowance being made for a small evolution of heat in the exothermic reaction of clinkering), about 35 per cent. of the total heat of the fuel still remains unaccounted for. This represents heat lost by conduction and radiation through the kiln lining and the steel shell.

In the usual rotary kiln structure, there is a lining of refractory material and a steel shell. The axial flame is so produced, regulated and adjusted that it will deliver enough heat to calcine and clinker the material but not melt down the refractory lining on which the material lies. Conduction and radiation are relied upon to keep the temperature of this refractory lining and of the steel shell down to a safe point and dissipate the excess heat units. The steel shell must not become hot enough to impair its rigidity or structural strength. Obviously, with a heavy rotary brick lined kiln 60 to 200 feet long and 7 to 8 feet in diameter, great strength and rigidity are necessary in the steel shell and the shell cannot be allowed to become too hot. The radiation of heat is therefore necessary with the usual structure; if there were not a high heat loss by conduction and radiation the kiln lining and shell would suffer and the kiln might collapse of its own weight. Some heat loss by radiation is

therefore necessary with the usual structure. But apart from this sheer loss of heat units by radiation, there is another source of loss in that more fuel must be burnt to furnish these heat units and this in turn makes a greater mass of gases going through the kiln with an increase in the loss of heat units in the waste gases. Heat insulation of the kiln in the hot zone in the manner usual with other structures, by an outer jacket of magnesia or the like is of course not practical since this would involve overheating of the lining and of the steel shell.

The object of the present invention is, without interference with the heat conduction necessary to safeguard the lining, to materially reduce this radiation loss. This is done by an interception and recovery of the heat units at a point between the shell and the inner surface of the lining. A saving in fuel is effected, due in part directly to the reduction of radiation losses, and in part to the fact that the volume of gases required to maintain the proper temperature within the kiln is thereby rendered smaller with a consequent reduction in the amount of heat carried off to the stack by the waste gases.

The rate of radiation from a hot body is variously expressed as a complex function of the temperature of the radiating surface, and depends upon the character and extent of the surface as well as the temperature of the environment. In ordinary rotary kiln practice the temperature of the outer kiln surface or steel shell is commonly from 400° to 450° F., under usual conditions of present practice at the hot or clinker discharge end and the heat losses by radiation from the whole kiln may be assumed to be about 35 per cent. of the heat units represented in the fuel used. This represents a loss which has been hitherto unavoidable in practice, since, as before explained, to insulate the kiln with an outer layer of non-conductive material so as to get an exterior surface of lower temperature and hence of lower radiation rate would unduly raise the temperature of the steel shell and thereby destroy the kiln.

According to the present invention I construct a rotary cement kiln with a steel outer shell and a refractory lining, but I provide passages or channels underneath the steel shell and between it and the lining or embedded in the lining through which a forced draft of air or other cooling gas may be circulated to reduce the temperature of the kiln radially beyond the passages in the shell. The usual amount of conduction of heat through the lining may occur but this heat is intercepted before reaching the shell. The heat carried away by the circulating cooling gas may be, and most advantageously is, returned to the kiln at the mouth or lower end by feeding it in as a constituent of the firing mixture or for aiding the combustion of the flame. Except in this indirect way, there is no communication between the channels in the kiln lining and the kiln interior. Air is not allowed to pass directly from the channels radially inward through the lining into the inside of the kiln, since any such feed of air inward would change the conditions within the kiln from those obtaining in the usual practice. In the present invention, the inner surface of the kiln lining is, so far as may be, kept at the usual temperature. There is no attempt in the present structure to reduce the rate of heat transfer or conduction between the kiln interior and a given point somewhat short of the steel shell, that is, the point of location of the cooling passages. The transfer of heat thence outward to and through the steel shell is, however, prevented as far as possible. This object may be furthered by placing a layer of heat insulating material between the steel shell and the air passages. With the aid of these cooling ducts, I am able to keep the outer surface, and the steel shell, down to a relatively low temperature without in any way interfering with the normal interior operation of a standard rotary kiln. As is well known, seemingly unimportant alterations in cement kiln operation may make profound differences in operation and hence in the quality of cement produced and any interior change is therefore to be avoided. The described method of construction I believe to be broadly new in a rotary cement kiln.

In order to insure adequate and efficient cooling of the steel shell by the novel means above described it is necessary to provide means for rapid and positive circulation of the cooling gas or air through the channels. For this purpose I have devised a circulating system which is broadly new in rotary heating furnaces. In this system, the means for propelling the cooling gas through the cooling channels, such as a fan, may be mounted to revolve with the kiln, thus avoiding the use of a stationary box or plenum chamber for supplying air to the cooling channels. With such a stationary box or head fitted to a revolving kiln there would always be more or less leakage and other trouble by reason of the necessary loose joints. In the present system, the air-forcing means and the cooling channels are in effect a unitary structure. Furthermore the air, after passing through the cooling channels, may be sent into the kiln through suitable twyer means located in coöperative relation to the firing means and also mounted to revolve with the kiln.

In a simple embodiment of the invention, the cooling channels between the shell and the refractory brick lining may run substantially parallel to the kiln axis and com-

prise superimposed channels, the return channels wherein the air is at the higher temperature being next to the lining to maintain the proper degree of heat within the kiln, the outer channels containing the colder air whereby the temperature of the shell is kept relatively low. They may however run peripherally of the kiln as well as lengthwise, as for example being helically disposed. A fan with an electric motor drive direct connected thereto is mounted on the kiln, the motor leads being connected to annular contact strips encircling the kiln to which brushes, wiping contacts, or the like, supply current for driving the motor from any convenient source. The fan may take air from any suitable source outside of the kiln and force it through the cooling channels and thence into the kiln at the firing end.

Assuming the skin temperature of the kiln at the hot end to be maintained by the means above described at about 280° F. to 300° F., other conditions remaining constant, with the heat intercepted and returned it is found that the heat loss is correspondingly reduced from about 35 per cent. to around 19 or 20 per cent. of the total heat in the fuel. A reduction from 400° F. to 100° F. outside temperature gives a saving of something like 70 per cent. of the radiation losses, or about 25 per cent. of the total fuel.

In referring to cooling channels in the kiln walls, it is to be understood that these are not necessarily a plurality of discrete passages. In fact they may be merged into one substantially uninterrupted annular space between the outside shell and the inner brick work. But the terms channels or passages are convenient and are therefore used here, though not in a restricted sense. There may moreover be several sets of these channels at different radial distances from the axis of the kiln, the air flowing longitudinally of the kiln through one set and then in the opposite direction through the next set, and so on until discharged into the end of the kiln.

The cooling air which is heated in these channels in intercepting the heat which would otherwise go to the steel shell is discharged into the clinker end of the kiln, either through the firing means to take part in the formation of the flame or immediately over the hot clinker, whereby its temperature is still further raised, to aid in the combustion of such flame. In either event, it serves to replace a part of the air which would be otherwise introduced into the kiln for purposes of combustion and its heat is added to that developed in the kiln.

In a further development of my invention, I may even heat-insulate the shell at the lower or hot end of the kiln. With a sufficiently active circulation of air between the shell and the lining, the shell may be kept cool enough to permit using heat insulation. And in any event, I may advantageously heat-insulate the upper or cooler end of the kiln; and I may also advantageously use means for forcing a heat transfer between the outgoing gases and the incoming raw material in a manner more perfect than is usual in the ordinary type of kiln. In the ordinary kiln, the hot gases at the upper end tend to flow along the arch a number of feet away from the raw material which is passing along the bottom of the kiln and since the volume of these hot gases is less in the present invention, the use of such means for improving the heat recovery at the upper end of the kiln is particularly advantageous.

In the accompanying drawings I have shown, more or less diagrammatically, an assemblage of apparatus elements within the scope of the present invention. In this showing—

Figure 1 is a central vertical section, broken away, of a complete kiln;

Fig. 2 is a fragmental vertical section of a modification, showing another means of introducing the air;

Fig. 3 is a transverse vertical section on Fig. 1 along line *x—x*;

Fig. 4 is a similar section of Fig. 1 along line *y—y*, showing the structure of the preheating portion of the kiln; and

Fig. 5 is another transverse vertical section of Fig. 1 along the same line but looking toward the mouth of the kiln.

In the inclined rotary kiln of Fig. 1, element 1 represents the steel shell; 2 the usual refractory lining; 3 is a front housing through which passes firing means 4, comprising a coal inlet 5 and air inlet 6 feeding fuel to burner 7. At its base the housing discharges clinker into the usual clinker duct 8. As shown, the refractory lining stops at a point short of the upper end of the kiln leaving bare metal exposed. Around this metal is a layer of heat insulation 9. Supported within this bare portion of the shell and spaced a suitable distance therefrom is a steel or iron cylinder 10. The space between the cylinder (10) and the shell proper forms a channel for hot waste gases going to the stack. Such gases are forced to travel aroung this space in a helical direction by partition 11. At its rear end, this waste gas channel opens into the usual dust chamber 12. The end of the cylinder (10) is substantially stopped by a diaphragm 13 having a movable portion or damper 14, which may be adjusted by rod 15. Duct 16 for the introduction of raw material enters below this damper. Mounted on the shell of the kiln is fan 17 receiving current from annular leads 18. Against these leads may bear spring contacts 19. The kiln

is driven in the usual way by gear 20. As shown, this fan which is mounted well toward the rear end of the kiln delivers air into the duct 21 which communicates with annular box 22 which rotates with the kiln. As shown, pipes 23, located between the wall of refractory material and the steel shell, take the air to a point back of the fan and then return it through a U-bend to the mouth of the kiln where it enters rotating channels 24. On the cylinder are shown four hollow arms (see Fig. 5) 25 which communcate with 24 and also with the burning means. On these arms are plow-shaped devices 26 in the path of the emerging clinker. In an upper position of the kiln orifices 27 set to discharge air over the clinker are closed by a little flap valve 28. As so shown, a portion of the heated air may be discharged immediately above the hot clinker from the arms when in a low position of the kiln. The residue of the air goes to the burning means and emerges as a concentric jet around the flame channel 29.

In the operation of the structure shown, raw cement material is fed in through duct 16 opening into shell 10. The hot gases from the lower part of the kiln, instead of being fed directly over the material which is to be heated up, are forced by spiral 11 to flow around 10 heating it up. Some feed of gases, however, goes over the material, the amount being adjustable by opening or closing damper 14.

The provision of this structure at the upper end of the kiln not only allows me to effect a further economy of heat but permits the use of a shorter upper kiln portion when using the described expedients in the hot or clinkering zone. The net effect of cutting down radiant heat in the described manner is to lower the consumption of fuel and thereby reduce the volume of hot gases. With this less volume to attain the ordinary results in the upper end of the kiln, the kiln must be lengthened or special expedients, such as this, adopted. In the ordinary kiln, the waste gases must be discharged at a relatively high heat for the reason that with the usual 60-foot kiln these gases form a stratum hugging the upper arch of the kiln and giving heat to the lower part of the kiln mainly by imparted heat to the inner wall of the kiln which in its revolution passes under the material. By the structure shown, hot gases are forced to pass in actual contact with the heat-receiving wall and give up their heat to it and therefore to the material. The gases are forced to give up their heat to the material. In the usual operation, where the gases go only in the upper arch, they may escape at a temperature as high as 800° F., even where wet material, such as slurry, is fed into the kiln; material which for 25 feet or more cannot be heated above 212° F. This expedient conduces to a great economy of heat, since it allows the discharge of the waste gases at a temperature as low as may be desired to secure proper draft conditions. Since the temperatures in this part of the kiln are comparatively low and the steel shell need not be cooled, the heat insulation 9 is useful.

The material introduced through 16 passes through 10 as a traveling stream in the usual manner, being thoroughly heated. If the raw material is a slurry, element 10 acts as an efficient drier and discharges the material hot and dry into the kiln. The material passes down over the lined portion of the kiln 2 in the usual manner and is successively calcined and clinkered by flame from burner 29. The temperature on the interior of 2 may be that usually prevailing in the similar parts of an ordinary kiln. The present invention makes no difference in these respects. It is a useful expedient to build the lining of arch bricks. Air is forced by fan 17 through 21 and 22. Reaching 23 it flows backward and then forward picking up heat units as it goes and is finally delivered into 24 whence a portion passes over the white hot clinker acting to cool it and itself becoming further heated and then serving in the combustion of flame from 7. Another portion of the heated air passes through 29 and emerges as an encircling layer of heated air around the flame. All of the air may be introduced over the clinker or all may be sent through the twyers.

In the structure of Fig. 2 an alternative method of feeding air is employed. This structure is similar to that of Fig. 1 but it does not carry the fan rotating with the kiln. In lieu thereof is an air box 50 rotating with the kiln and communicating through 51 with an annular channel 52. This annular channel, which is cool, rotates in stationary casing or bearing 53 forming an extension of stationary air duct 54. Air passing upward through 54 goes through 52 and 51 into rotating chamber 50, whence it goes backward in the manner described with regard to Fig. 1, through channels 23.

What I claim is:—

1. A rotary kiln comprising a revolubly mounted furnace body lined with refractory material and having a steel shell, air ducts between said lining and shell, said air ducts comprising feeding channels and return channels, internal firing means at one end of said body, air propelling means mounted to revolve with said body for supplying air through said ducts, whereby such air is heated, and means for conducting such heated air to the firing means.

2. A rotary kiln comprising a revolubly mounted furnace body lined with refractory material and having a steel shell, air ducts between said lining and shell, said air ducts

comprising feeding channels and return channels, firing means at one end of said body, a fan mounted on said body and arranged to discharge air through said ducts, means for driving said fan, and means for conducting heated air from said walls to said firing means.

3. In combination, a rotary kiln provided with a metal shell, with a refractory lining and with internal firing means and having air propelling means mounted on said kiln, air channels between the lining and shell connected to said air propelling means, and return channels interposed between said air channels and lining and communicating with the air channels, and means for conducting said air to the firing means.

4. A rotary cement kiln comprising a revolubly mounted kiln body having internal walls of refractory material and provided with longitudinally extending channels in said walls, an outer shell surrounding said refractory material, said channels communicating with the interior of the kiln only at a terminal portion thereof, return channels communicating with the first mentioned channels, internal firing means, and positively operating means for passing a current of air through said channels to said firing means.

5. A rotary kiln comprising, in combination, a revolubly mounted kiln body, internal firing means, said kiln body having a metal shell and an interior wall of refractory material, and positively operating means structurally unitary with said body for forcing air between said wall and said shell longitudinally of the kiln, and returning said air between the wall and shell.

6. A rotary kiln comprising, in combination, an internally fired and revolubly mounted kiln body, said kiln body having an inner wall of refractory material and an outer shell of metal and a positively operating air circulating device for forcing air between said wall, said device being adapted to revolve with said kiln body longitudinally of the kiln, and returning said air between the wall and shell.

7. A rotary kiln comprising an iron or steel shell, a refractory lining therefor, both revolubly mounted, air channels arranged between the shell and the lining and extending in a direction generally longitudinal to the kiln a distance from one end, return channels communicating therewith, means for internally firing the kiln, means revoluble with the kiln for positively supplying air to said channels, whereby such air may become heated, and means communicating with said return channels for conducting such heated air to said firing means.

8. A rotary cement kiln comprising a revolubly mounted kiln body provided with an inner refractory wall and internal firing means, longitudinally extending channels in the kiln wall, return channels communicating therewith, means having uninterrupted connection with said channels for positively supplying cool air thereto whereby such air may become heated, and means adjacent the firing means and in communication with said return channels for delivering the heated air from said channels into the kiln.

9. A rotary cement kiln comprising a steel shell lined with refractory brick and revolubly mounted, spaces in the kiln walls located under the steel shell and extending longitudinally of the kiln, means for positively passing air through said spaces lengthwise of the kiln, whereby such air may become heated, and means communicating with said spaces adapted to receive the heated air and deliver it into one end of the kiln.

10. A rotary cement kiln comprising a steel shell lined with refractory brick and revolubly mounted, a space in the kiln walls located under the steel shell and extending longitudinally of the kiln, an electrically driven fan mounted on the revoluble kiln body and arranged to supply air to said channels, and ducts arranged at one end of the kiln, communicating with said space and adapted to deliver the air inside the kiln after passage through the cooling space.

11. In a rotary cement kiln comprising a rotary steel-jacketed refractory lined inclined cylinder and provided with firing means, means for positively intercepting heat at a point between the lining and jacket and for delivering the intercepted heat to the firing means.

12. A kiln comprising a revolubly mounted steel cylinder provided with a refractory lining at its lower part, firing means for such kiln, means between lining and cylinder for intercepting heat and returning the heat to the firing means and an exterior heat insulation on the unlined remainder of the kiln.

13. A rotary steel-jacketed refractory lined inclined cement kiln provided with heat-insulating means external to the jacket toward the upper end of the kiln, and internal heat intercepting means between said jacket and the refractory lining toward the lower end of the kiln, and means for conducting the intercepted heat to the interior of the kiln.

In testimony whereof, I affix my signature in the presence of two subscribing witnesses.

BYRON E. ELDRED.

Witnesses:

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R. W. EARLE.