March 31, 1959 K. J. SYLVEST 2,879,983

METHOD AND APPARATUS FOR COOLING MATERIAL IN BULK

Filed June 5, 1957 3 Sheets-Sheet 1

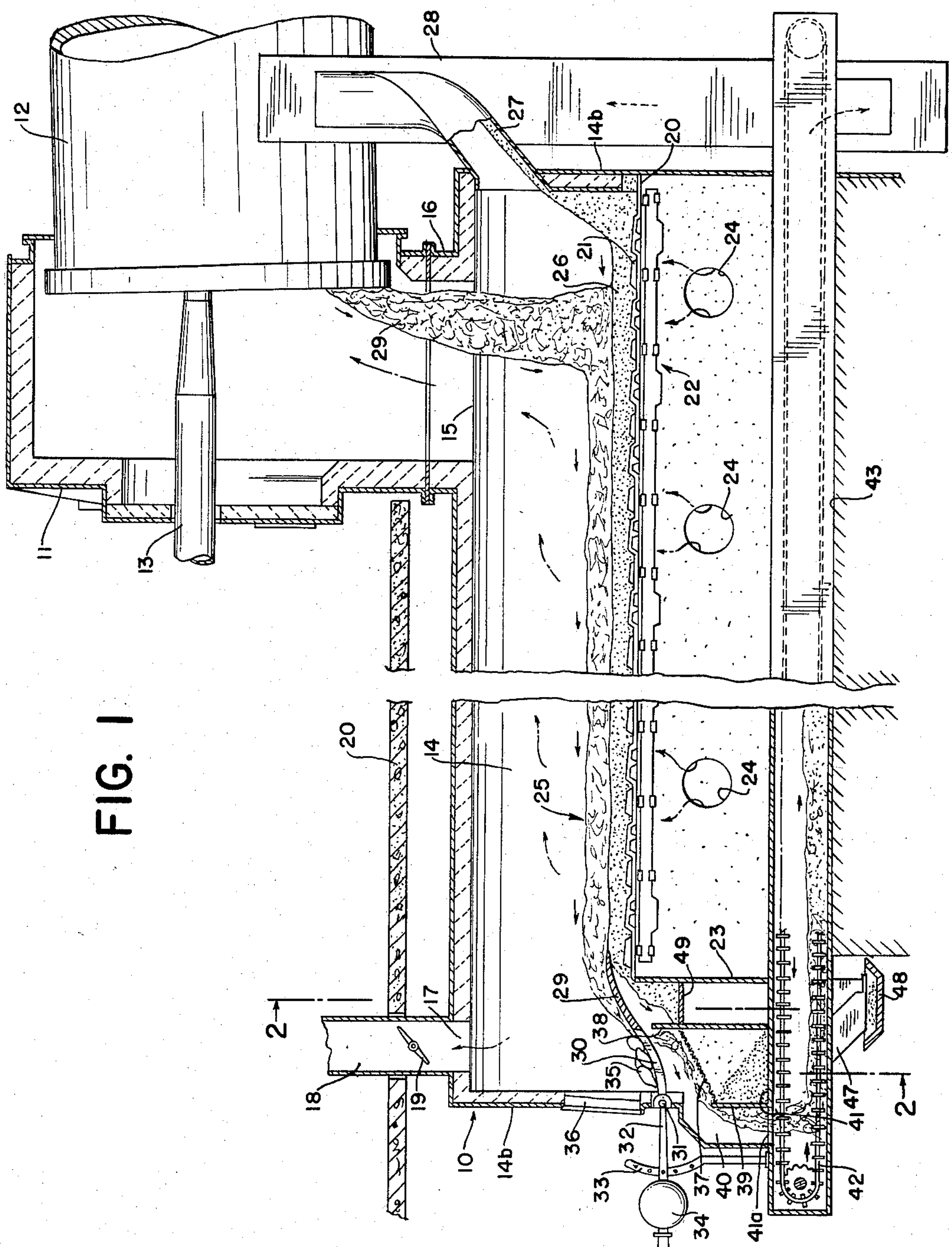

FIG. 1

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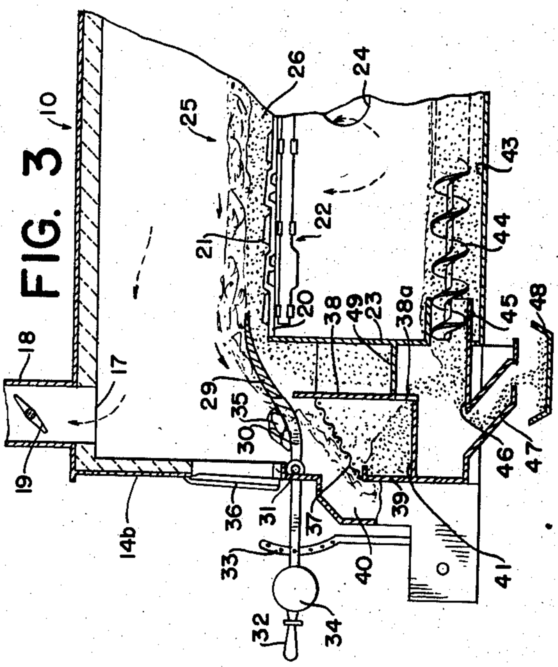

FIG. 3

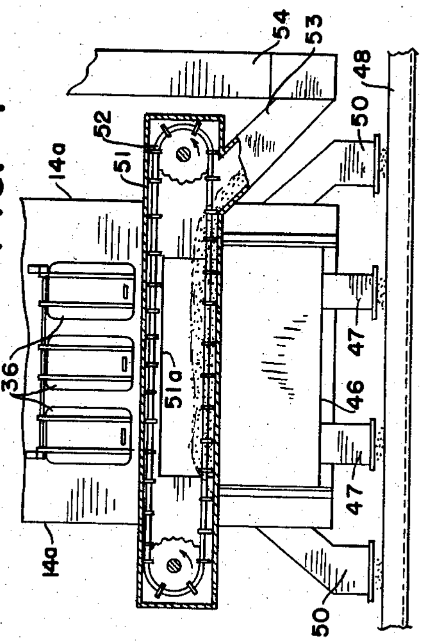

FIG. 4

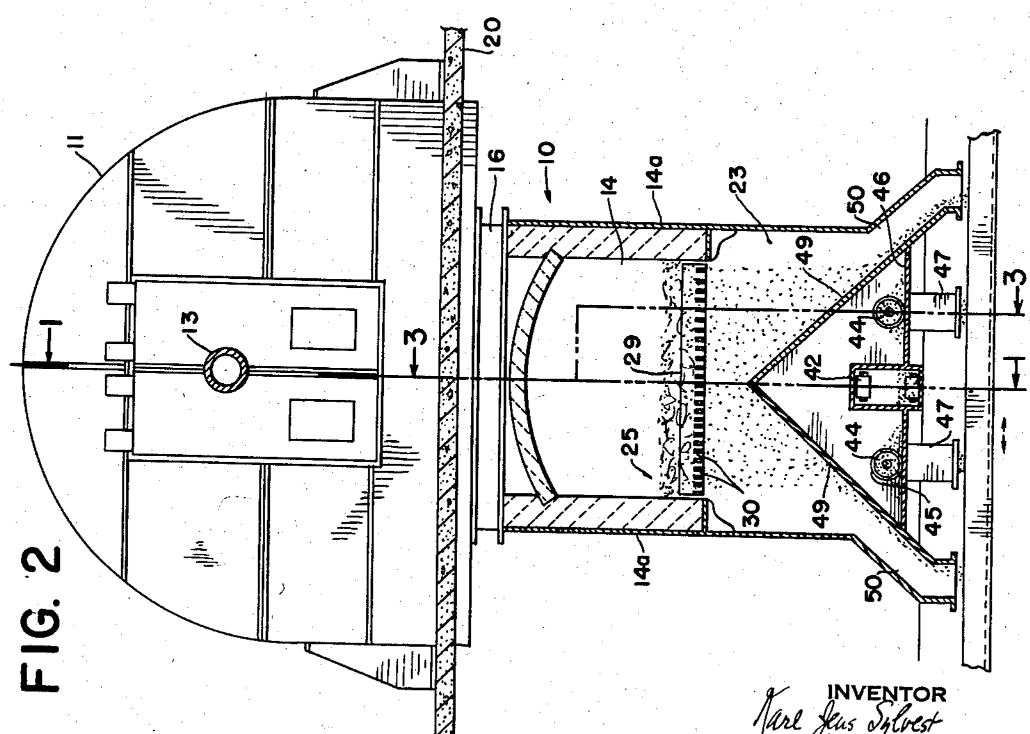

FIG. 2

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3 Sheets-Sheet 3

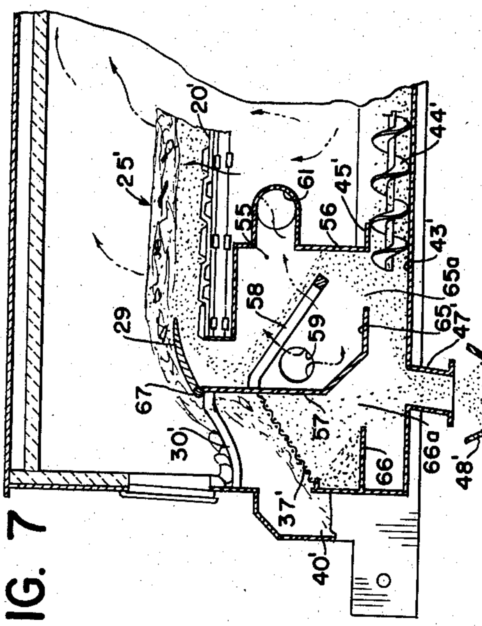

FIG. 7

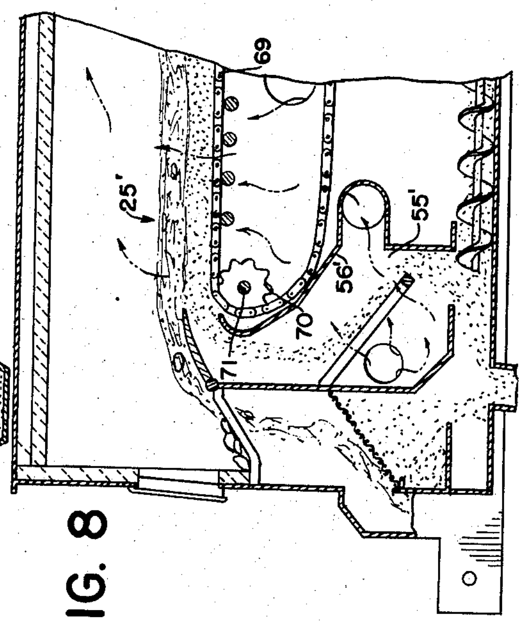

FIG. 8

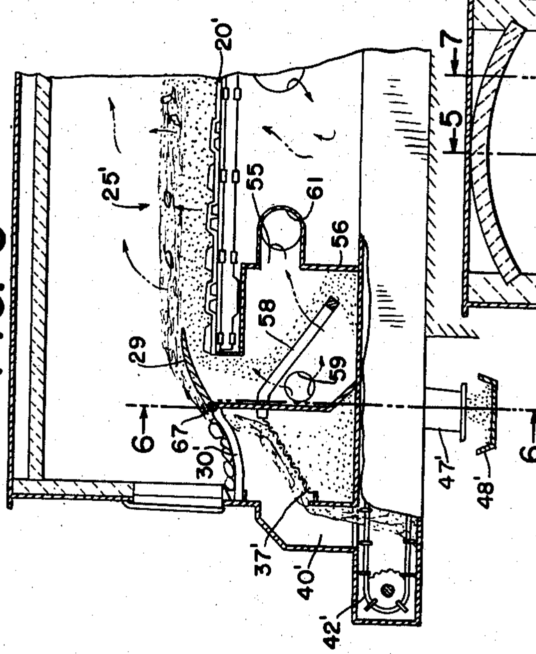

FIG. 5

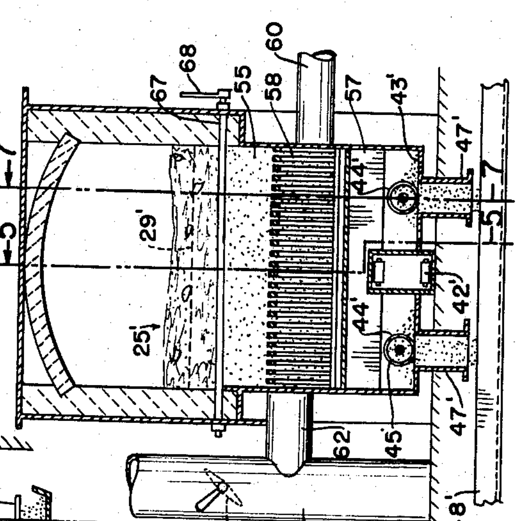

FIG. 6

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METHOD AND APPARATUS FOR COOLING MATERIAL IN BULK

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Application June 5, 1957, Serial No. 663,734

14 Claims. (Cl. 263—32)

This invention relates to the cooling of granular or lumpy material issuing from a kiln and typified by cement clinker, burnt lime, or roasted or sintered ore and, more particularly, the invention is concerned with a novel method for cooling materials of the stated type by passing cooling air through a bed of the material being advanced on an air-permeable support. In the practice of the method, the support is protected against exposure to high temperatures and the heated air produced in the cooling operation is utilized as secondary air in the kiln, in which the material was burned, and also, in some cases, as primary air forming part of the combustible fuel-air mixture consumed in the kiln. In addition to the method, the invention includes a cooling apparatus, by which the new method may be advantageously practiced.

In the cooling of very hot material, such as cement clinker, one method used heretofore involves depositing the material in a layer on a permeable support and then passing cooling air through the support and layer in a single pass. The support used in such an operation is subjected to very high temperatures where the material is deposited thereon and, as a result, it is necessary to make the support of expensive heat-resistent steel and, even then, the support has a relatively short life. In addition, cooling the material by passage of air once therethrough is not highly efficient because of the large amount of air required. Accordingly, the cooling air is frequently passed through the layer on the half of the support remote from the kiln and the partially-heated air is then passed through the remainder of the layer. This double pass method is more economical with respect to the amount of air required than the single pass method, but requires about 25% more support area for an equivalent cooling operation.

The present invention is directed to the provision of a method of cooling hot material issuing from a kiln by the use of cooling air, which requires substantially less air and support area than are required in the single pass method above described and can be practiced by the use of a support not made of expensive heat-resistant steel.

The new method involves a double pass of the material, in that a layer of partially cooled material is formed upon a support and the hot material issuing from the kiln is deposited on that layer. The bed formed of the two layers is advanced on the support and cooled by a single pass of air therethrough and, at the end of its travel, the bed is divided into at least two fractions differing in temperature. The cool fraction is then discharged, while the warm or partially cooled fraction is returned to the part of the support near the kiln to form the layer, which becomes the lower part of the bed.

The apparatus for the practice of the method comprises a chamber having an inlet and an outlet and subdivided into upper and lower sub-chambers by the air-permeable support, which may be a traveling grate, but

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is preferably a fixed grate with conveying elements reciprocating thereon. At the end of the support adjacent the outlet, means are provided for dividing the bed of material and such means preferably take the form of a blade lying parallel to the the surface of the support and acting to separate the bed into a lower cooled fraction and an upper partially cooled fraction. The partially cooled fraction is returned to the support near the chamber inlet to form the layer on the support and is preferably screened to remove both over size lumps and fine particles before being returned. Also, before return of the partially cooled fraction to the support, the fraction may be subjected to a crushing operation, if it contains oversize lumps in too great a proportion to permit their removal by screening. The lower cooled fraction is carried out of the chamber and, if desired, may be subjected to a supplemental cooling operation before discharge. Fine particles, which have passed through the support, may be collected and combined with the finished cooled product. The hot cooling air, which has passed through the support, travels through a connection to the kiln, where it serves as secondary combustion air, while a controlled proportion of the heated air may be removed from the chamber and employed as primary air of combustion or discharged into the atmosphere. The hot material issuing from the kiln travels through the connection counter-current to the heated air, and is deposited on the layer of material on the support to complete the bed to be cooled.

For a better understanding of the invention, reference may be made to the accompanying drawings, in which—

Fig. 1 is a vertical longitudinal section on the line 1—1 of Fig. 2 of a cooling apparatus embodying the invention;

Fig. 2 is a sectional view on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view on the line 3—3 of Fig. 2;

Fig. 4 is a front elevational view with parts shown in section of a modified form of the apparatus;

Fig. 5 is a vertical longitudinal sectional view on the line 5—5 of Fig. 6 of a modified form of the new cooler;

Fig. 6 is a sectional view on the line 6—6 of Fig. 5;

Fig. 7 is a sectional view on the line 7—7 of Fig. 6; and

Fig. 8 is a vertical sectional view through the discharge end of another modified form of the new cooler.

In Fig. 1, the cooler **10** is illustrated as mounted below a hood **11**, into which the lower end of a rotary kiln **12** projects with the burner tube **13** passing through the hood and entering the end of the kiln. The cooler includes a chamber **14**, which has side walls **14*a*** and end walls **14*b*** lined where necessary with refractory material, and the top of the chamber is provided near one end with an inlet opening **15** and a connection **16** leading from the opening to the bottom of hood **11**. The hot material issuing from the kiln and discharged into the hood passes through the connection **16** into the chamber and air, which has been heated by cooling the material, passes through the connection counter-current to the material and enters the kiln. At the other end of the chamber, its top is provided with an outlet opening **17**, from which a stack **18** containing an adjustable damper **19** leads upward through the burner's platform **20**.

The interior of the chamber **14** is divided into upper and lower sub-chambers by an air-permeable support, along which a bed of the material travels through the chamber. The support may be a traveling grate, but is preferably part of a conveying apparatus of the types shown in Nielsen United States Patents 2,498,218 and 2,743,007. The patented conveying apparatus includes an air-permeable stationary support **20**, which is horizontal or slightly downwardly inclined in the direction of travel of the material away from the inlet opening 15, and the material is advanced along the support by conveying elements 21 resting on top of the support and connected through the support to a structure 22, which is mounted beneath the support and is reciprocated by suitable means. The support 20 extends from the chamber end wall 14*b* adjacent the inlet 15 to a vertical transverse partition wall 23 extending between the chamber side walls 14*a* and cooling air is admitted into the sub-chamber beneath the support through a plurality of openings 24, to which lead pipes connected to a fan.

The material traveling along the support is in the form of a bed 25 made up of a layer 26 of partially cooled material, which is distributed upon the support 20 near the end wall 14*b* adjacent inlet 15 by a chute 27 leading downwardly from the upper end of an elevator 28. The hot material 29 issuing from the kiln and entering the cooler through the connection 16 is deposited on the top of layer 26 and forms the upper part of a bed advanced along the support.

Just before the bed 25 reaches the end of support 20, it is subdivided into upper and lower fractions by a blade 29, which is mounted on the inner ends of a plurality of bars 30 forming a screening device. The outer ends of the bars are pivoted on a shaft 31, to which is attached a handle 32 adjustable to different positions along a curved guide 33 and carrying a counterweight 34. The upper fraction of the bed travels over the blade 29 and falls between the bars 30 with oversize lumps 35 retained on the bars and later removed from time to time through clean-out doors 36 in the end wall of chamber 14. After passing the bars 30, the fraction lands upon an inclined screen 37, which lies between and is supported by partition walls 38, 39, which extend across the chamber 14 from one side wall 14*a* to the other. The material, which slides off the screen, falls through a passage 40 lying between wall 39 and the adjacent end wall 14*b* of the cooler and the material lands on a floor 41, which closes the bottom of the space between walls 38 and 39 and the lower end of passage 40. Floor 41 has an opening 41*a*, through which the material enters the casing of a drag chain conveyor 42, which extends lengthwise of the cooler and delivers the material to the lower end of elevator 28.

The fine material, which falls through the support 20, collects on the floor 43 of the sub-chamber beneath the support and the material is continually removed from the sub-chamber by a pair of screw conveyors 44, the forward ends of which lie within cylindrical casings 45 surrounding openings in wall 23. The material leaving the conveyors collects on a floor 46 having openings from which lead inclined chutes 47. The fine material, which has passed through screen 37 and collects on floor 41, flows through openings 38*a* in wall 38 and lands upon floor 46 to mingle with the material being advanced by the conveyor screws 44. The combined fine material flows through chutes 47 and is deposited upon a conveyor 48.

A pair of plates 49 are mounted between the walls 23 and 38 and the plates 49 meet in the median longitudinal plane through the cooler and diverge downwardly past the edges of floor 46. Near the lower ends of the plates, they form parts of chutes 50, which terminate above the conveyor 48. The material, which forms the lower layer 26 of the bed and has passed twice through the cooler, falls from the end of support 20 and lands upon plates 49. The material then slides down the plates and through the chute 50 to the conveyor 48, where it is mixed with the fines discharged through chutes 47.

In the operation of the apparatus, the hot material issuing from the kiln falls upon a layer of partially cooled material covering the support 20, so that the support is protected against damage from the high temperature of the hot material. During the advance of the bed of material along the support, the material is cooled by the flow of air forced therethrough and the major proportion of the air, which is heated by contact with the material, enters the kiln to serve as secondary air of combustion, while a controlled minor proportion is drawn off through stack 18 for use as primary air of combustion or for discharge to the atmosphere. At the end of the support, the bed of the material is divided by the blade 29 and the material, which has made its second passage through the cooler, falls upon plates 49 and is discharged upon conveyor 48 through chutes 50. The partially cooled material traveling over the top of the blade 29 is first screened by bars 30 to remove oversize lumps and then by screen 37 to remove fines and the screened material is delivered to the conveyor 42 and returned to the cooler by elevator 28 and chute 27 to form the underlying layer on the support. The fines, which have passed through the support, and the fines from the fraction being returned, which have passed through the screen 37, are removed from the cooler and discharged upon conveyor 48. The cooled material plus the fines is delivered by conveyor 48 to a place of discharge.

In the modified cooler shown in Fig. 4, the drag chain conveyor 42 and its casing and the elevator 28 are dispensed with. Also, the passage 40 receiving material, which slides off screen 37, is replaced by a horizontal casing 51 having an opening 51*a*, through which the material sliding off the screen enters the casing. Casing 51 extends across the front of the cooler and encloses a drag chain conveyor 52, which advances the material through the casing to a chute 53 leading to the bottom of an elevator 54. The elevator extends upwardly at an angle along the side of the cooler to a point adjacent the top of chute 27 and the chute is connected to receive material discharged by the elevator and lead the material into the cooler to form the underlying layer on support 20. Thus, in the modified construction, the horizontal conveyor 51 and the inclined conveyor 54 take the place of the horizontal conveyor 42 and the elevator 28.

In the modified construction shown in Figs. 5–7, incl., the bed 25′ being advanced along the permeable support 20′ is divided into two fractions by the blade 29′ and the lower fraction, which has been cooled by two passages through the cooler, enters a chamber 55 defined by partition walls 56 and 57, which extend across the cooler between its side walls. The material entering chamber 55 falls upon an inclined air-permeable support 58 and air under pressure is admitted to the chamber beneath the support through an opening 59 connected by a pipe 60 to a fan. The air travels through the support and the layer of material thereon and is discharged to the atmosphere through an opening 61, from which a pipe 62 leads to a stack 63 containing damper 64. The material sliding from support 58 lands upon a floor 65 having an opening 65*a*, through which the material travels to fall upon floor 43′. The wall 56 of chamber 55 has a pair of openings surrounded by cylindrical casings 45′, into which extend the ends of conveyor screws 44′ operating in the sub-chamber beneath the support 20′ to discharge the fine material which has passed into the sub-chamber through the support. The fine material combines with that issuing from chamber 55 through the opening 65*a* and the combined material leaves the cooler through a pair of chutes 47′ discharging into a conveyor 48′. The material, which passes over the blade 29′, is screened for removal of oversize lumps by bars 30′ and then falls upon a screen 37′. The fines passing through screen 37′ fall upon a floor plate 66 having an opening 66*a*, which permits the material to fall upon floor 43′ to escape through chutes 47′. The material, which passes off the screen 37′ travels down through the passage 40′ to enter the casing of a drag chain conveyor 42′, by which the material is returned to form the underlying layer on the support 20′.

In the modification of Figs. 5–7, incl., the blade 29′ is mounted on a shaft **67** supported in the side walls of the cooler and having an operating handle **68** at one end for adjustment of the blade in relation to the support **20'**. The bars **30'** forming the grate for removal of oversize material are not attached to blade **29'** or to shaft **67** but are fixed in position and not adjustable with the blade.

With the construction shown in Figs. 5–7, incl., the quantity of air employed for cooling the bed **25'** is controlled, so that it provides the amount of air, which can be utilized in the kiln as secondary air of combustion. The cooled fraction of material leaving the bed is then given its final cooling in chamber **55** by air supplied through pipe **60**. The air used in the supplemental cooling of the fraction is controlled in amount by the damper **64** and is discharged into the atmosphere. With the arrangement described, no excess air is introduced into the kiln and the amount of air employed in the supplemental cooling of the material is controlled to give the desired cooling effect without waste.

The modified construction shown in Fig. 8 is the same as that shown in Figs. 5–7, incl., except that the means for conveying the bed **25'** of material through the cooler takes the form of an endless chain grate **69** of conventional form and mounted on sprocket wheels **70** on transverse shafts **71**, one of which is driven. Because of the differences between such a traveling chain grate and the conveying means used in the other constructions shown and including the stationary support **20'**, the wall **56'** of the supplemental cooling chamber **55'** in the Fig. 8 construction has been changed from that shown in Figs. 5–7, incl., to provide room for the returning stretch of grate **69**. The operation of the Fig. 8 cooler is the same as that of the cooler shown in Figs. 5–7, incl.

I claim:

1. A method of cooling hot granular or lumpy material issuing from a kiln, which comprises continuously forming a substantially uninterrupted layer of partially cooled material and advancing the layer in its plane, distributing hot material issuing from the kiln upon the layer adjacent the place of formation thereof to form therewith a traveling bed, passing cooling air upwardly through the bed to cool the material therein, dividing the bed at the end of a selected travel thereof into at least two fractions differing in temperature, discharging the coolest fraction, and returning another fraction of the bed to the place of formation of the layer and utilizing the returned material for the formation of the layer.

2. The method of claim 1, in which a controlled proportion of the air, which has passed through the bed, is directed to the kiln for use in the combustion of fuel therein.

3. The method of claim 1, in which the bed is divided into cooled and partially cooled fractions and air is passed through the cooled fraction after separation of the fraction from the bed.

4. The method of claim 3, in which the amount of air passed through the bed is controlled so as to be not substantially in excess of that required as secondary air of combustion in the kiln, and air is passed through the cooled fraction after separation of the fraction from the bed to cool the fraction to the desired final temperature,

the air passed through the fraction being discharged into the atmosphere.

5. The method of claim 1, in which fine particles fall from the layer and are combined and discharged with the coolest fraction of the bed.

6. The method of claim 1, in which the bed is divided into upper and lower fractions, of which the lower fraction is formed of the layer and the upper fraction is formed of the material which was deposited upon the layer, the lower fraction is discharged, and the upper fraction is utilized in the formation of the layer.

7. The method of claim 6, in which the upper fraction removed from the bed is screened to remove oversize lumps before being utilized for the formation of the layer.

8. An apparatus for cooling hot granular or lumpy material issuing from a kiln, which comprises a chamber having an inlet at one end and an outlet spaced from the inlet, means for supporting a bed of material within the chamber and advancing the bed from the inlet to the outlet, including an air-permeable support extending from beneath the inlet toward the outlet and dividing the interior of the chamber into upper and lower subchambers, means for supplying air to the lower subchamber for passage through the support and bed into the upper sub-chamber, means adjacent the inlet for distributing partially cooled material upon the support to form a layer, means adjacent the outlet for dividing the bed into at least two fractions differing in temperature, means for conducting a cool fraction of the bed to the outlet, means for transferring a warm fraction of the bed to the distributing means, and means for conducting heated air from the upper sub-chamber through the inlet to the kiln and hot material from the kiln through the inlet to be deposited upon the layer on the support.

9. The apparatus of claim 8, in which the bed is divided by a blade extending across and parallel to the surface of the support and entering the bed of material.

10. The apparatus of claim 9, in which the blade is movably mounted for adjustment to vary the spacing of the edge of the blade from the support.

11. The apparatus of claim 9, in which the fraction passing over the top of the blade falls upon a screening device for retaining oversize lumps, while allowing the remainder of the fraction to pass.

12. The apparatus of claim 11, in which the fraction freed of oversize lumps travels over a screen, through which fine particles pass for combination with the cool fraction to be discharged.

13. The apparatus of claim 9, in which the fraction passing beneath the blade enters a compartment and falls upon an air-permeable support, and means are provided for passing air through the material on the support in the compartment and then discharging the air into the atmosphere.

14. The apparatus of claim 8, in which means are provided for removing from the lower sub-chamber material, which has entered the sub-chamber through the support.

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