Feb. 26, 1952 L. S. PETERSEN 2,587,378

METHOD OF COOLING BULK MATERIAL

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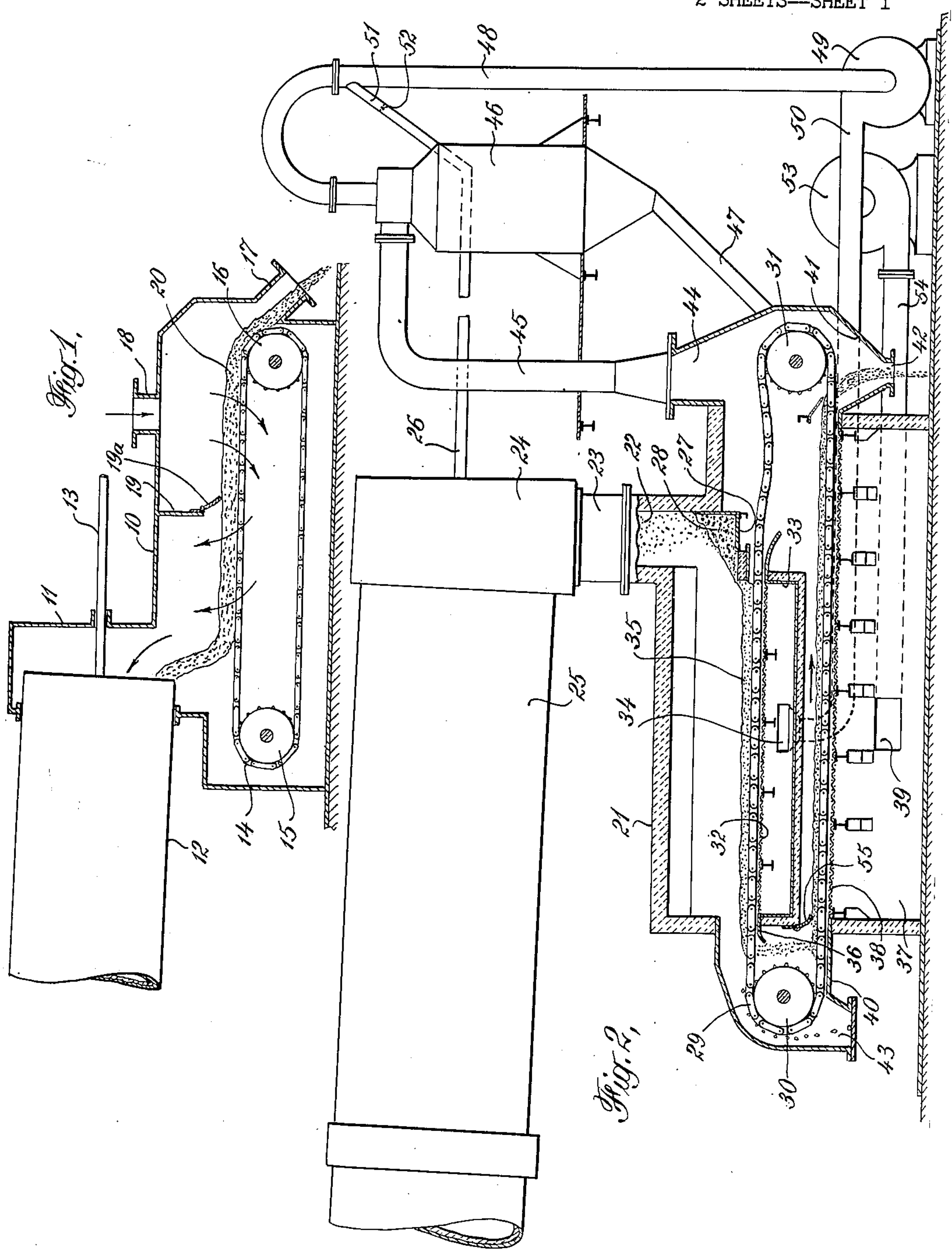

Fig. 1.

Fig. 2.

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2 SHEETS—SHEET 2

Fig. 3,

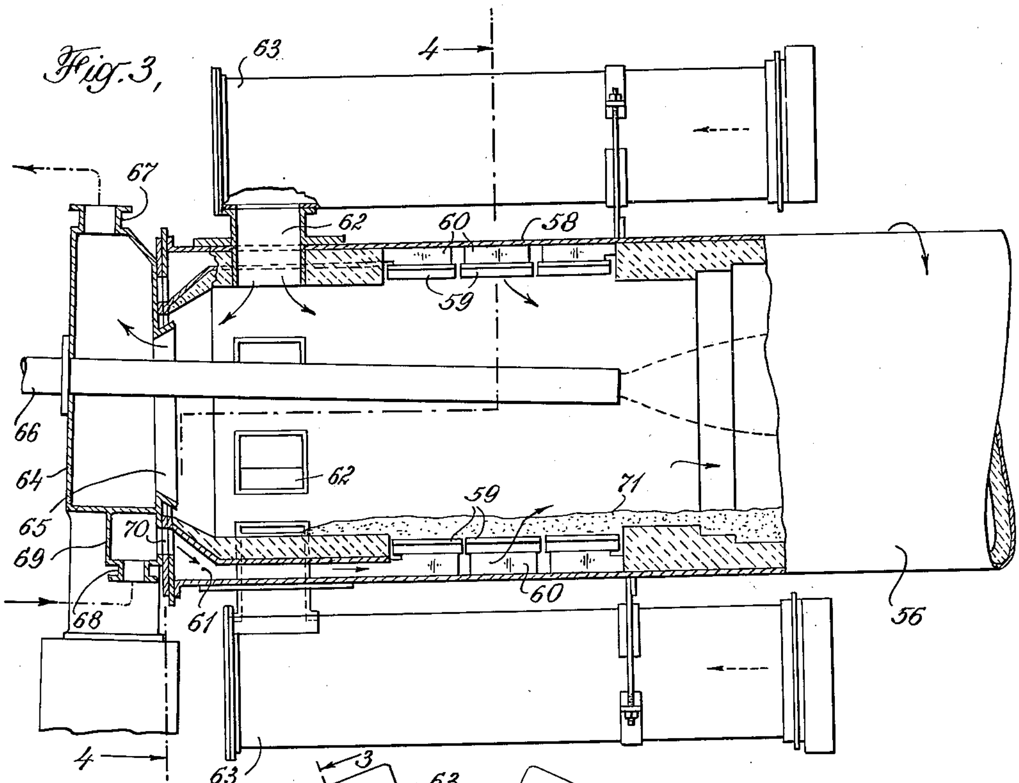
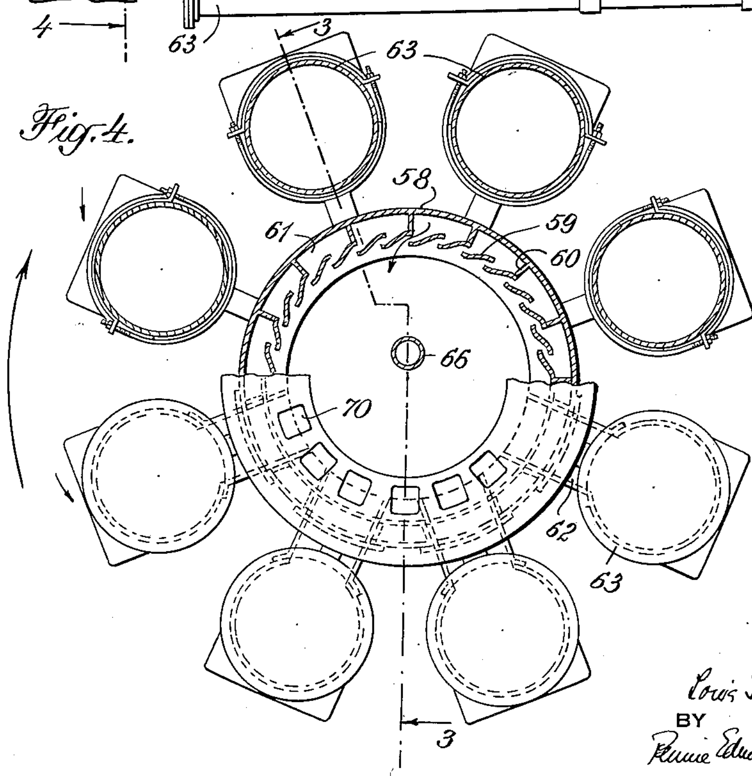


Fig. 4.



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METHOD OF COOLING BULK MATERIAL

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5 Claims. (Cl. 263—52)

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This invention relates to the cooling of bulk material discharged from a kiln after having been burned therein by combustion of a fuel-air mixture, examples of such materials being cement clinker, burnt lime, roasted iron ore, aluminum oxide, etc. More particularly, the invention is concerned with a novel method of cooling bulk materials by means of air in an efficient manner and utilizing the heated cooling air in the combustion of the fuel in the kiln.

Air coolers for cooling bulk material discharged from a kiln after having been burned therein are well known and, in such coolers, the temperature of the material is reduced to the desired degree, before the material is passed to storage or subjected to further treatment, and heat is recovered by the heating of the cooling air. The heated cooling air may then be used as preliminary or secondary air for the combustion of the fuel in the kiln, although usually the amount of air employed for cooling the material is greater than that required for combustion purposes. Accordingly, some of the air used for cooling has heretofore been allowed to escape to the atmosphere, with the result that heat is lost and dust entrained in the air is discharged into the atmosphere.

The present invention is directed to the provision of a method of cooling which overcomes the disadvantages of the prior methods and, in the practice of the new method, the cooling is effected in two stages and in such manner that at least part of the air is employed in both stages and then utilized as secondary air in the kiln. The remainder of the cooling air, if any, which was utilized in the low temperature stage of the cooling, may then by-pass the high temperature stage and be introduced into the kiln either as primary or secondary air.

Air coolers, in which two stage cooling is employed, have been used heretofore but, in such coolers, the air currents pass through the two stages of the cooler in parallel, so that cold air is used in each stage. The air, which cools the material in the high temperature stage adjacent the kiln, is then introduced into the kiln ordinarily as secondary air, while the air employed in the low temperature stage is usually discharged into the atmosphere. In the practice of the method of the invention, the air employed in the

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high temperature cooling has been used in the low temperature stage and all of the air employed in the low temperature stage may be used in the high temperature cooling or part of this air may be withdrawn and employed as either preliminary or secondary air of combustion. While the cooling action in the high temperature stage is somewhat less than that occurring in the prior coolers, in which cold air is employed in both stages, it has been found in practice that a highly efficient cooling action is obtained in the practice of the new method.

In cooling bulk material in accordance with the method, the material is advanced in a thin layer from the exit end of the kiln to a delivery point and air is passed in contact with the material in a part of the layer remote from the kiln to effect final cooling of the material and preliminary heating of the air. At least part of the heated air is then passed in contact with the material in the part of the layer adjacent the kiln to effect preliminary cooling of the material and final heating of the air. The finally heated air is then introduced into the kiln to serve as secondary air for combustion. If, in the practice of the method, all of the air employed in the low temperature cooling stage is also used in the high temperature stage, all of the heated cooling air is employed as secondary air in the kiln. If desired, however, part of the air used in the low temperature may be employed in the kiln, either as primary or secondary air and the remainder may be used in the high temperature stage.

In carrying out the method, the material may be advanced from the exit end of the kiln to the delivery point by means of an endless conveyor within a chamber connected to the kiln hood and having an inlet for air and an outlet for material. The space within the chamber above the conveyor is subdivided by a partition and air entering the inlet flows down through the material and conveyor at one side of the partition and, at the other side, flows up through the conveyor and material. The heated air then passes through the hood into the kiln to serve as secondary air of combustion.

Another form of apparatus for the practice of the method includes an endless conveyor having stretches moving in opposite directions. The material discharged from the kiln is deposited upon one stretch of the conveyor and passes therefrom to the second stretch, which delivers the material to the point of discharge. The low temperature stage of cooling is effected by passing air through the second stretch of the conveyor and the material thereon and the high temperature cooling is effected by passing all or part of the air utilized in the low temperature stage through the first stretch of the conveyor and the material thereon.

Instead of using a conveyor in the practice of the method, the kiln may be equipped with an extension receiving the burned material from the hot zone and provided with grates, through which cooling air may flow to pass through the material traveling down the kiln extension. The material passes from the extension into cooling tubes mounted on the extension and lying lengthwise of the kiln. The material forms a thin layer in both the extension and the tubes and the low temperature cooling is effected by air drawn through the tubes counter-current to the material and entering the kiln extension. Part of the air entering the extension from the tubes passes upward through the extension into the kiln to serve as secondary air of combustion, while the remainder of the air is withdrawn from the extension and then returned beneath the grates in the extension, so as to flow upward through the layer of material on the grates and effect the high temperature cooling. The air used in the high temperature stage passes from the extension into the kiln to serve as secondary air.

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

Fig. 1 is a longitudinal vertical section through one form of apparatus for practicing the new method;

Fig. 2 is a view, partly in elevation and partly in longitudinal vertical section, of another form of such apparatus;

Fig. 3 is a view, partly in elevation and partly in longitudinal vertical section, of a third form of such apparatus on the line 3—3 of Fig. 4; and

Fig. 4 is a sectional view on the line 4—4 of Fig. 3.

The apparatus shown in Fig. 1 includes a chamber **10** connected to the lower end of the hood **11**, into which projects the discharge end of a rotary kiln **12**. A fuel-air mixture is introduced into the kiln through a burner pipe **13** projecting through the hood and into the kiln and the hot product of the kiln falls upon the upper stretch of a gas-permeable conveyor **14**, such as a chain grate, within the chamber. The conveyor is trained about drums **15**, **16** and drum **16** lies close to an outlet **17**, through which the material discharged from the conveyor may leave the chamber. The chamber is provided with an air inlet **18** at its top above the discharge end of the conveyor and the space within the chamber above the conveyor is subdivided by a transverse partition **19**, which depends from the top of the chamber and has a flexible lower end section **19***a* lying in contact with the layer **20** of material on the conveyor.

In the operation of the apparatus shown in Fig. 1, cooling air introduced through inlet **18** passes down through the layer of material and the conveyor at the right of partition **19** to effect low temperature cooling of the material and preliminary heating of the air. The air then flows beneath the upper stretch of the conveyor past partition **19** and flows upwardly through the conveyor and material and through the hood **11** into the kiln to serve as secondary air. All of the air heated in the final cooling of the material is used for cooling the material in the high temperature cooling stage and all of the air thus heated in the two stages is used for secondary air of combustion in the kiln.

The installation illustrated in Fig. 2 comprises a chamber **21** having an inlet **22** for material, which is connected by a clinker chute **23** to the bottom of the hood **24** of a rotary kiln **25**. A fuel-gas mixture is supplied to the kiln through a burner pipe **26** extending through the hood and into the kiln. A platform **27** is mounted on the wall of the chamber below inlet **22**, so that clinker discharged from the kiln and landing on the platform forms a pile **28** having a sloping surface, down which additional material moves.

An endless conveyor **29** is trained about rotary drums **30**, **31** within the chamber and the upper stretch of the conveyor passes along the upper surface of gas-permeable support **32** forming the top of a wind box **33** mounted in the chamber between the two stretches of the conveyor and having an inlet **34**. The conveyor is of the chain type and the links are sufficiently spaced to permit large pieces of the material to pass between them. As the material flows from pile **28** on platform **27**, it forms a layer **35** advanced over the top of support **32** by the conveyor. A plate **36** is mounted beneath the upper stretch of the conveyor at the end of support **32**, toward which the material is advanced, and, when the material is moved over the plate, it drops between the links of the conveyor.

The lower part of the housing below the lower stretch of the conveyor forms a second wind box **37** having a gas-permeable support **38** at its top and an air inlet **39**. The material passing through the links of the upper stretch of the conveyor and dropping from plate **36** falls upon a plate **40**, which is an extension of the perforated support **38**, and the material is then advanced by the lower stretch of the conveyor along plate **40** and support **38**. When the material reaches the end of wind box **37**, it drops between the links of the conveyor and enters hopper **41** having an outlet **42**.

The chamber is provided beneath drum **30** with a hopper **43** to collect large pieces of the material, which have not fallen through the upper stretch of the conveyor. Hopper **43** is normally closed and is opened from time to time for discharge of the material collected therein.

The chamber **21** is provided at its top above hopper **41** with an air outlet **44** connected by a duct **45** to a dust separator **46**. Solid particles collected in the separator return through duct **47** to chamber **21** and drop into hopper **41** to flow out through discharge **42**. The air leaving the separator **46** is conducted by duct **48** to the intake of a fan **49** and the outlet of the fan is connected by a duct **50** to the inlet **34** of wind box **33**. A branch duct **51** containing a damper **52** leads from duct **48** to burner pipe **26**, so that part of the air issuing through outlet **44** from the chamber may be supplied to the burner pipe to form part of the primary air of combustion.

A fan **53** supplies air through a duct **54** to the inlet **39** of wind box **37**. The air escaping upwardly through support **38**, the lower stretch of the conveyor, and the layer of material thereon, is prevented from flowing into the space above the upper stretch of the conveyor by a flexible partition means **55** mounted on wind box **33** and bearing on the layer of material on the lower stretch of the conveyor.

In the operation of the installation described, the hot product of the kiln falling through chute **23** and entering chamber **21** through inlet **22** is deposited to form layer **35** on the support **32**. The material is advanced along the support by the upper stretch of the conveyor and, during its advance, the material is cooled by air issuing from wind box **33** through material inlet **22** and passes up the clinker chute **23** and through hood **24** to enter the kiln, where it serves as secondary air of combustion. The material falling off plate **36** to the lower stretch of the conveyor is advanced over plate **40** and permeable support **38** to be discharged into hopper **41**. In its advance over support **38** by the lower stretch of the conveyor, the material is cooled by air escaping from wind box **37**. The air, which has been passed through the material being advanced by the lower stretch of the conveyor, is freed of dust in separator **46** and a part of the air determined by the setting of damper **52** passes to the burner pipe and serves as primary air of combustion. The remainder of the air from the separator is delivered by fan **49** into wind box **33** for use in the high temperature stage of cooling of the material on the upper stretch of the conveyor, and then flows up into the kiln, as described.

In the installation described, it will be noted that all of the air, which has been preliminarily heated in the low temperature stage of cooling of the material on the lower stretch of the conveyor, may be employed in the high temperature stage and then used as secondary air of combustion. Instead, part of the air heated in the low temperature cooling stage may be used as primary air and the remainder in the high temperature stage. All of the air employed in the high temperature stage is air, which has been heated in the low temperature stage, and all of the air used for high temperature cooling is supplied to the kiln as secondary air.

The apparatus illustrated in Figs. 3 and 4 comprises a rotary kiln **56** having an extension **58** provided with grates **59** mounted on supports **60** attached to the inner surface of the extension. Longitudinal passages **61** lead from the lower end of the extension to the space beneath the grates and, beyond the grates, the extension is provided with outlets **62** leading to conventional cooling tubes **63** mounted lengthwise of the extension on the outside thereof, the tubes being open at their upper ends and containing means for advancing material through them, as the kiln rotates.

A stationary casing **64** is mounted at the lower end of the extension **58** and the casing has an air inlet opening **65** in its wall at the end of the extension. A burner pipe **66**, for supplying a fuel-air mixture to the kiln, projects through casing **64** and into the extension. The casing **64** has an air outlet **67** connected to the inlet of a fan (not shown) and the outlet of the fan is connected to the inlet **68** of a stationary casing **69** mounted beneath casing **64** and having outlets **70** aligned with the ends of passages **61** at the lower part of extension **58**.

In the operation of the apparatus shown in Figs. 3 and 4, the hot product of the kiln travels down through the extension to form a thin layer **71** overlying the grates **59** at the lower side of the extension. The material issues through outlets **62** and enters the cooling tubes **63**, up which the material is conveyed in thin layers by the usual means to escape at the upper ends of the tubes. At its upper end, the kiln is connected with a chimney and, if necessary, also with a fan, so that there is reduced pressure in the extension. Air is, accordingly, drawn through the cooling tubes into the extension and, as the air flows countercurrent to the thin layers of material in the tubes, the air effects the low temperature stage of cooling and is preliminarily heated. Some of the air thus heated is drawn upward through the extension into the kiln to serve as secondary air of combustion. The remainder of the air heated in the low temperature cooling stage is drawn into casing **64** by the fan connected to the casing outlet and all or part of the air drawn from casing **64** is returned to casing **69** and flows through passages **61** into the spaces beneath grates **59** at the lower part of the extension. The air escaping upwardly between the grates and through the layer **71** of material effects the high temperature stage of cooling of the material. The air heated in the high temperature cooling stage then flows through the extension into the kiln to serve as secondary air for combustion.

With the arrangement described, all of the air used in the high temperature cooling stage is air, which has been employed in the low temperature stage. Some of the air heated in the low temperature stage passes directly to the kiln to serve as secondary air and the remainder, or a part thereof, is then used in the high temperature stage. If desired, the air drawn from casing **64** may pass through a cyclone separator similar to separator **46** before passing to the fan and being returned to casing **69**.

Reference is made to applicant's co-pending application Serial No. 197,564, filed November 25, 1950, Apparatus for Treating Bulk Material, which relates to an apparatus, which may be used in the practice of the method of the present application.

I claim:

1. The method of burning and cooling bulk material which comprises burning the material in a kiln by combustion of a fuel-air mixture until the material has been burned to the desired extent, then discharging the material from the kiln, forming the discharged material into an elongated bed, advancing the bed of material as a thin layer from the exit end of the kiln to a delivery point, passing air transversely and completely through a part of the bed remote from the kiln to effect final cooling of the material and preliminary heating of the air, preliminarily reducing the temperature of the material by passing at least part of the heated air transversely and completely through a part of the bed adjacent the kiln, said preliminary reduction of the temperature of the material resulting in a final heating of the air, and introducing the finally heated air into the kiln to serve as secondary air of combustion during the burning of the material.

2. The method of claim 1 in which a part of the air which was passed through the material to effect final cooling of the material is supplied to the kiln and used therein as primary air for the burning of the material in the kiln.

3. The method of claim 2 in which the air which was passed through the material to effect final cooling thereof is subjected to a separation operation to remove entrained solids therefrom.

4. The method of claim 1 in which a part of the air which was passed through the material to effect final cooling of the material is separated

from the remainder thereof before any part of the remainder thereof is passed through the bed of material adjacent the kiln to effect preliminary reduction of the temperature of the material and is supplied to the kiln and used therein as primary air for the burning of material in the kiln.

5. The method of claim 1 in which the bed of material is advanced as a thin layer in successive stages, the air is passed through the layer in the second stage remote from the kiln to effect the final cooling of the material, and at least a part of the resulting heated air is thereafter passed through the first stage adjacent the kiln to effect the preliminary reduction of the temperature of the material.

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