United States Patent

Devel

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[54] **MATERIAL COOLER WITH RECYCLING OF COOLING GAS**

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[51] **Int. Cl.**...**F26b 9/00**

[58] **Field of Search** 34/164; 263/32, 33, 44, 53

[56] **References Cited**

UNITED STATES PATENTS

2,587,378	2/1952	Petersen	263/44
2,846,778	8/1958	Markle	34/164
3,276,755	10/1966	Bast	263/53 R
3,522,012	7/1970	Blann	263/53 R

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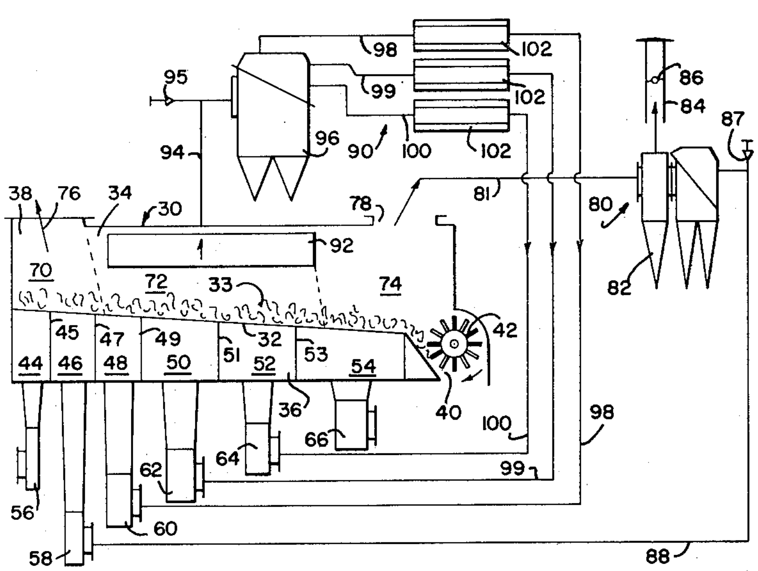
[57] **ABSTRACT**

A cooler for hot material such as cement clinker with an arrangement for recycling cooling air. The cooler includes a housing divided into an upper material chamber and a lower plenum chamber by a gas permeable grate which supports and advances the material through the material chamber. Ambient cooling air is blown through the hottest and the coolest material. Two air recirculation circuits are employed. The ambient air blown through the coolest material is divided so that a portion goes to each recirculation circuit. One recirculation circuit returns air to the plenum chamber at a point where it will pass through the material to be cooled and then be conducted to the furnace. The other recirculation circuit returns air to the plenum chamber at points where it will pass through the material and some of it will be conducted to a furnace, while the remaining air will be returned to the recirculation circuit. An indirect heat exchanger is mounted in one of the recirculation circuits.

10 Claims, 3 Drawing Figures



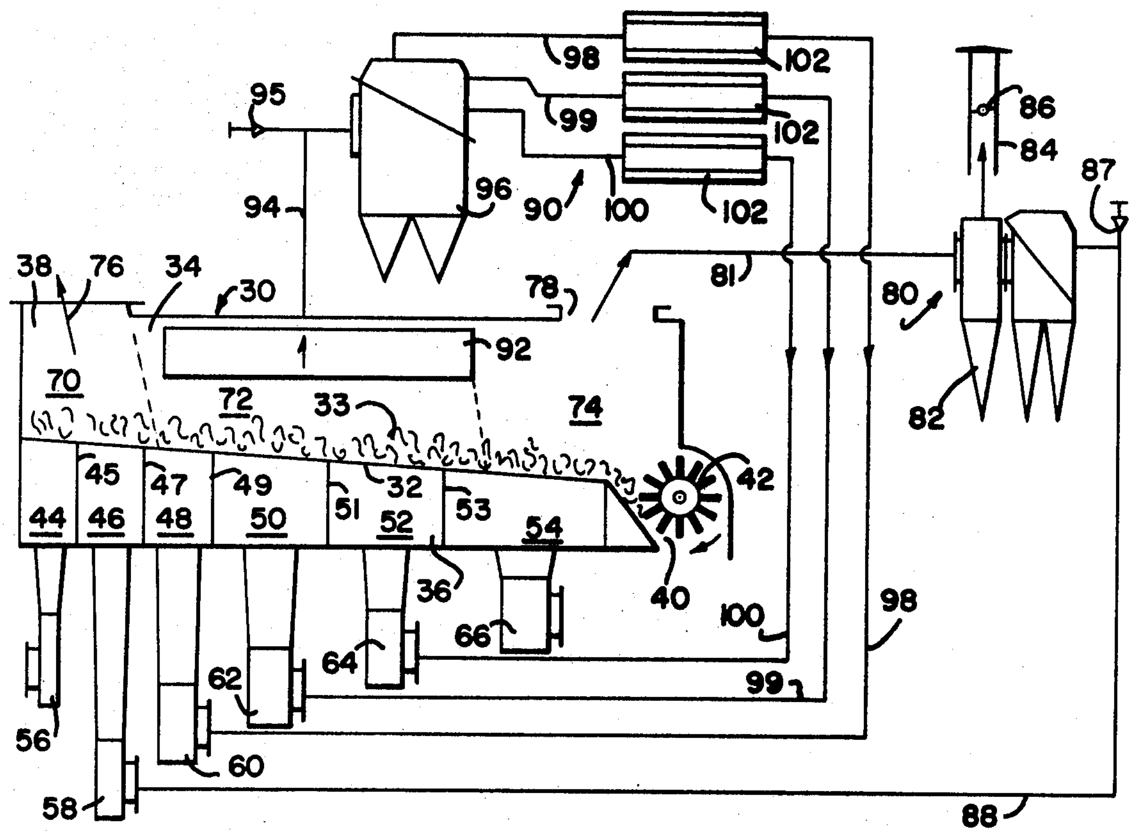
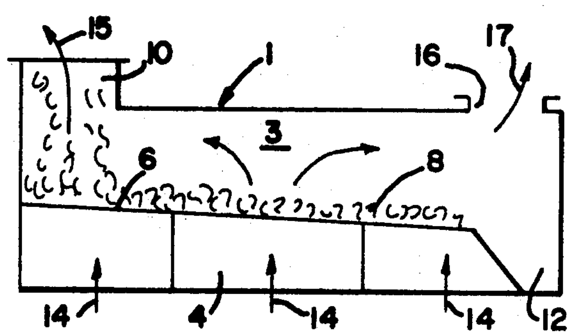


FIG. 3

FIG. 1



PRIOR ART

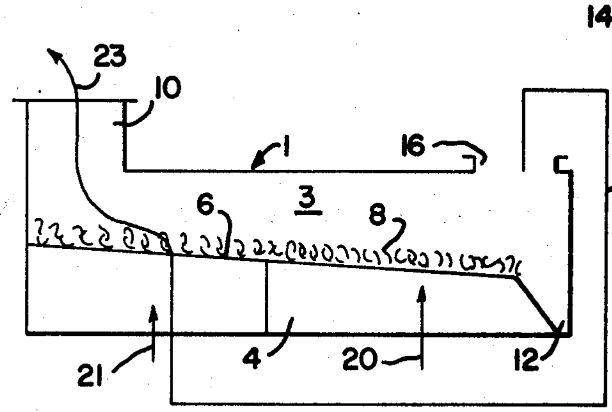


FIG. 2

PRIOR ART

MATERIAL COOLER WITH RECYCLING OF COOLING GAS

BACKGROUND OF THE INVENTION

This invention relates to coolers for hot particulate materials such as hot cement clinker. More particularly, this invention relates to a cooler for particulate material which employs a recycling of the cooling gas.

Prior to the present invention, it was known to cool hot material such as cement clinker which is discharged from a furnace such as a rotary kiln by supporting a bed of the material on a gas permeable grate and blowing air through the grate and bed of material. The grate arrangement is used to advance the material through the cooling apparatus. One such cooler is shown in U. S. Pat. No. 2,846,778 which employs a plurality of alternately movable and stationary grates for advancing the material through the cooler.

The prior art cooler described in U. S. Pat. No. 2,846,778 has the advantage of air quenching cement clinker as it is discharged from a rotary kiln, and the further advantage that a portion of the cooling air which is heated as it cools the hot cement clinker from a temperature of about 2500° F to about 150° F can be returned to the furnace as combustion air. Since this air is already heated, the system can result in substantial fuel savings in the cement making process.

A particular disadvantage of the arrangement shown in the above mentioned prior patent is that only a portion of the air needed for cooling the hot material can be returned to the furnace. The remaining air must be exhausted to atmosphere. However, as the cooling air passes through the hot material, it entrains dust and solid materials which must be removed from the exhausted air in order to avoid polluting the atmosphere. In order to remove these pollutants, high efficiency dust collectors such as bag houses or electrostatic precipitators must be used. These high efficiency collectors add great expense to a cooler installation.

In the past, it has also been suggested to recirculate that portion of the cooling air which is not sent to the furnace as combustion air. However, recirculation systems that have been proposed prior to the present invention have substantially reduced the ability of the cooler to cool the hot material. Although it has been proposed to add a heat exchanger to the recycle circuit, the ability of the cooler to cool hot material is still less than desirable.

SUMMARY

It is the principal object of this invention to provide an apparatus for cooling hot particulate material such as cement clinker which retains the advantages of prior cooling apparatus yet eliminates their disadvantages.

It is another object of this invention to provide a cooling apparatus for hot material which substantially reduces or eliminates the necessity of employing high efficiency dust collectors while maintaining the ability of prior art apparatus to cool hot material.

In general, the foregoing and other objects will be carried out by providing apparatus for cooling hot particulate material such as cement clinker discharged from a furnace such as a kiln comprising a housing having an inlet for material to be cooled and an outlet for cooled material; porous grate means mounted in and dividing said housing into an upper material chamber and a lower plenum chamber; said porous grate means being adapted to support a bed of material in the material chamber; means dividing the plenum chamber into a plurality of compartments; first blower means for supplying ambient cooling gas to at least one of said compartments for passage through said porous grate means and the bed of material for cooling the material; first recirculation means for exhausting at least some of the ambient cooling gas from said material chamber after it passes through the material and recirculating it to at least one of said compartments for passage through the porous grate and material for cooling the material; and second recirculation means for exhausting at least some of the ambient cooling gas from said material chamber after it passes through the material and recirculating it to at least one of said compartments for passage through the porous grate and material for cooling the material; said second recirculation means being adapted to exhaust from said material chamber at least some of the cooling gas which has been recirculated through said second recirculation means whereby a mixing of ambient cooling gas and recirculated cooling gas is achieved.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be described in connection with the annexed drawing wherein:

FIG. **1** is a diagrammatic view of one form of the prior art;

FIG. **2** is a diagrammatic view of another form of the prior art; and

FIG. **3** is a generally diagrammatic view of the cooling apparatus of the present invention.

DESCRIPTION OF THE PRIOR ART

Referring to FIG. **1**, there is shown a cooler for hot material such as cement clinker which has been in use for some time and may be of the type shown in U. S. Pat. No. 2,846,778. It includes a housing **1** which is divided into an upper material chamber **3** and a lower plenum chamber **4** by means of a porous grate means **6**. The grate means **6** may be of the type shown in the above mentioned patent and includes a plurality of alternately stationary and reciprocating grates for supporting a bed **8** of particulate material to be cooled and advancing the material through the cooler. The cooler is provided with a material inlet **10** for receiving hot material from a furnace such as a rotary kiln (not shown). The cooler also includes an outlet **12** for cooled material.

The plenum chamber is divided into a plurality of compartments and ambient cooling air is supplied to these compartments from suitable blowers (not shown) as indicated by the arrows **14**. The cooling air passes through the porous grates and material bed to cool the material.

As the air passes through the bed of material, it is heated by the hot material. A portion of this air is directed toward the kiln as combustion air as designated by the arrow **15**. The remainder of the air is exhausted to atmosphere from the cooler through an exhaust conduit **16** as shown by arrow **17**.

It has been found that the amount of air which is required to cool cement clinker is about three times the amount of combustion air which can be used by the rotary kiln used in the clinkering process. Thus, if the amount of air needed to cool the clinker is taken as 3N and the amount of air which can be used by the kiln is 1N, then the amount of air exhausted to atmosphere is 2N.

As the cooling air passes through the bed of material, it entrains dust and solids which must be removed before the air is exhausted to atmosphere. In order to comply with pollution control laws, it is necessary to use high efficiency dust collectors. The large quantity of air as represented by 2N which must pass through the high efficiency collectors necessitates a very large dust collection system which can cost as much as the cooler.

In FIG. 2, there is shown a prior art arrangement which attempts to eliminate the dust collection system by recirculating the air which would be vented to atmosphere in the system of FIG. 1. The cooler itself is similar to that of FIG. 1 and like parts have been designated with like numerals.

In the arrangement of FIG. 2, ambient cooling air is blown through the coolest material in the cooler as indicated by arrow **20** by blowers (not shown). This air is exhausted through exhaust conduit **16** and conducted by a suitable conduit **22** to be blown through the hottest zone of the cooler **1** as indicated by arrow **21**. This air is then returned to the kiln as combustion air as indicated by arrow **23**.

With the system shown in FIG. 2, half the air used is returned to the kiln, which is fixed at 1N because that is the maximum air which can be used by the kiln. Thus, the total air which flows through the material to cool the material is 2N if a closed system is to be maintained. However, in order to properly cool some materials such as cement clinker, it is advantageous to maintain the ratio of total air through the bed to the air returned to the kiln higher than two, and preferably three.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In order to provide a closed system wherein the ratio of total air through the bed to fresh air or air returned to the kiln is three, I have provided the arrangement shown in FIG. 3.

Referring to FIG. 3, the material cooling apparatus of the present invention is generally indicated at **30**. The cooler includes a gas permeable grate means **32** dividing the housing into an upper material chamber **34** and a lower plenum chamber **36**. The porous grate means may be similar to that shown in U.S. Pat. No. 2,846,778 and serves to support a bed **33** of material to be cooled and advance the material through the cooler.

The housing is provided with a material inlet **38** for receiving material to be cooled such as cement clinker from a furnace such as a rotary kiln (not shown). The housing also includes a material outlet **40** for discharging cooled material from the apparatus. A breaker **42** of any well-known type is positioned in the outlet **40**.

The plenum **36** is divided into a plurality of compartments **44, 46, 48, 50, 52** and **54** by divider means **45, 47, 49, 51** and **53**. Blowers **56, 58, 60, 62, 64** and **66** are flow connected to the compartments **44, 46, 48, 50, 52** and **54** respectively for supplying cooling gas to the plenum **36** for passage through the porous grate **32** and bed of material **33** to cool the material.

The material chamber **34** may be considered to be divided into three zones **70, 72** and **74** and indicated by the broken lines. There is no actual physical division of the chamber **34**. The zone **70** represents the zone of hottest material, the zone **74** represents the zone of coolest material, and the zone **72** has material of intermediate temperature.

Ambient cooling air is supplied by blower means **56** and compartment **44** to the hottest zone **70** to provide an initial air quench of the hot material admitted to the cooler. This air is heated by the hot material and returned to the furnace as combustion air through a suitable conduit such as material inlet **38** as shown by arrow **76**.

Ambient cooling air is also supplied by blower means **66** and compartment **54** to the coolest zone **74** and to the intermediate zone **72**. This ambient air serves to achieve the final cooling of the material.

Some of the air which passes from compartment **54** through the porous grate **32** and bed of material is exhausted from the zone **74** of chamber **34** through an outlet **78** and a first recirculation system **80** which includes a duct **81** connected to a dust collector **82**. A stack **84** with a control damper **86** may be provided to permit adjustment during start-up periods and to ensure operational safety in case of irregular material feed or unstable conditions. From the dust collector **82**, the recirculated air is supplied to blower means **58** by duct **88**. A bleed input valve **87** may be provided to add cool ambient air to the recirculated air during start-up and periods of unstable operation. From blower means **58**, the recirculated air is directed into zone **70** and after passing through the hot material, is conducted to the furnace as hot combustion air along with the air supplied by blower means **56**.

That portion of the ambient cooling air supplied by blower **66** which passes into intermediate zone **72** is exhausted from the material chamber **34** to a second recirculation means generally indicated at **90**. The second recirculation means **90** includes a hood **92** mounted in the zone **72** for collecting cooling air which passes through the material in that zone. A duct **94** is flow connected to the hood **92** and conducts the exhausted air to dust collector **96**. A bleed valve **95** may be provided for admitting cold air during start-up and periods of unstable operation.

Air discharged from the collector **96** is divided into three parts in the embodiment shown as illustrated by conduits **98, 99** and **100**. An indirect heat exchanger **102** is mounted in each of the ducts **98, 99** and **100** for cooling the air exhausted from the intermediate zone **72**. The ducts **98, 99** and **100** supply the thus cooled air to blowers **60, 62** and **64**, respectively.

Air supplied by blowers **62** and **64** to compartments **50** and **52**, respectively, passes through the grate **32** and material **33** in the intermediate zone **72** and is exhausted from the chamber **34** by hood **92** of the second recirculation means **90** and is mixed therein with ambient cooling air from blower **66** and compartment **54**. Air supplied by blower **60** to compartment **48** passes through the grate means and material bed and is exhausted from chamber **34** partially through the second recirculation system **90** and partially through the material inlet **38** to the furnace.

From the foregoing, it can be seen that the compartments **44** to **54** and partitions **45** to **53** are positioned so that there is a mixing of ambient cooling air and recirculated cooling air. This mixing of the cooling air insures a renewal of the cooling air and a continuous operation of the system.

An example of the cooler system will now be given which is designed to cool **1500** tons of material per day.

The temperature T of air in zone **70** is about 870° C; the temperature θ of air in zone **72** is about 300° C; and the temperature t of air supplied to compartment **46** is about 120° C.

The fans or blowers **56** to **62** have the following capacities:

Blower Number	Capacity in m^3/min.	Vol. in Nm^3/kg of Clinker	Temperature of Air in °C
56	340	0.31	20
58	700	0.45	140
60	670	0.45	120
62	930	0.62	120
64	750	0.50	120
66	660	0.59	20

In the example given, it is believed that compartment **48** received 0.45 Nm^3/kg air and delivers about 0.14 Nm^3/kg air to zone **70** and about 0.31 Nm^3/kg air to zone **72**. Compartment **54** receives a volume of ambient air of 0.59 Nm^3/kg and is believed to deliver 0.14 Nm^3/kg to zone **72** and 0.45 Nm^3/kg to zone **74**.

The mixing of ambient and recirculated cooling air may be illustrated by the following table:

Zone No.	Total volume blown, Nm.³/kg.	Compt. item No. which feeds corres. zone	Partial volume blown, Nm.³/kg.	Temp. air, ° C. at fan	Flow of fresh air in at 20° C.	Flow of air out of compt., m.³/min.	Total volume blown in, m.³ min.
70	0.9	44	0.31	20	340	340	340
		46	0.45	140		700	700
		48	0.14	120		220	210
72	1.57	48	0.31	120			460
		50	0.62	120			930
		52	0.50	120			750
		54	0.14	20	160		160
74	0.45	54	0.45	20	560		500

The total quantity air in Nm^3/kg of material which is returned to the kiln as combustion air is 0.31 + 0.45 + 0.14 or 0.90 Nm^3/kg. The total air used for cooling the material is the sum of the volume of air supplied to the compartments **44** to **54** which is 2.92 Nm^3/kg or about three times the volume returned to the kiln. The volume of ambient air supplied to the system by blowers **56** and **66** equals the volume returned to the kiln.

It should be apparent from the foregoing that with the recirculation system of the present invention, the volume of air used to cool the material can be maintained at an effective level of about three times the amount of air which may be returned to the furnace without requiring venting to atmosphere. The need for expensive, high efficiency dust collectors has been eliminated. The collectors **82** and **96** need only be relatively inexpensive mechanical collectors.

It is intended that the foregoing be merely a description of a preferred embodiment and that the invention be limited solely by that which is within the scope of the appended claims.

I claim:

1. Apparatus for cooling hot particulate material such as cement clinker discharged from a furnace such as a kiln comprising:

a housing having an inlet for material to be cooled and an outlet for cooled material;

porous grate means mounted in and dividing said housing into an upper material chamber and a lower plenum chamber;

said porous grate means being adapted to support a bed of material in the material chamber;

means dividing the plenum chamber into a plurality of compartments;

first blower means for supplying ambient cooling gas to at least one of said compartments for passage through said porous grate means and the bed of material for cooling the material;

first recirculation means for exhausting at least some of the ambient cooling gas from said material chamber after it passes through the material and recirculating it to at least one of said compartments for passage through the porous grate and material for cooling the material; and

second recirculation means for exhausting at least some of the ambient cooling gas from said material chamber after it passes through the material and recirculating it to at least one of said compartments for passage through the porous grate and material for cooling the material;

said second recirculation means being adapted to exhaust from said material chamber at least some of the cooling gas which has been recirculated through said second recirculation means whereby a mixing of ambient cooling gas and recirculated cooling gas is achieved.

2. The apparatus of claim **1** further comprising conduit means for conducting at least some of the cooling gas from said material chamber to a furnace after it passes through said material.

3. The apparatus of claim **2** further comprising heat exchanger means mounted in said second recirculation means for cooling the gas which is exhausted from said material chamber.

4. The apparatus of claim **3** wherein said means dividing said plenum chamber into compartments is positioned so that at least some of the cooling gas recirculated through said second recirculation means is conducted to a furnace by said conduit means.

5. The apparatus of claim **4** wherein said cooling gas recirculated through said first recirculation means is supplied to a compartment positioned so that the gas is conducted to a furnace by said conduit means.

6. The apparatus of claim **5** further comprising second blower means for supplying ambient cooling gas to at least one of said compartments for passage through said porous grate means and bed of material.

7. The apparatus of claim 6 wherein said first blower means is adapted to supply ambient cooling air to a compartment adjacent said outlet and said second blower means is adapted to supply cooling air to a compartment adjacent said inlet.

8. The apparatus of claim 7 wherein each of said first and second recirculation means includes means for supplying ambient air to the cooling gas after it is exhausted from the material chamber and before it is recirculated to said compartment.

9. The apparatus of claim 8 further comprising dust collector means mounted in each of said first and second recirculation means.

10. The apparatus of claim 9 wherein said second recirculation means includes hood means mounted in said material chamber.

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