Jan. 9, 1968 O. L. STEWART 3,362,857

CONTINUOUS HEAT TREATING SYSTEM

Filed April 15, 1965 5 Sheets-Sheet 1

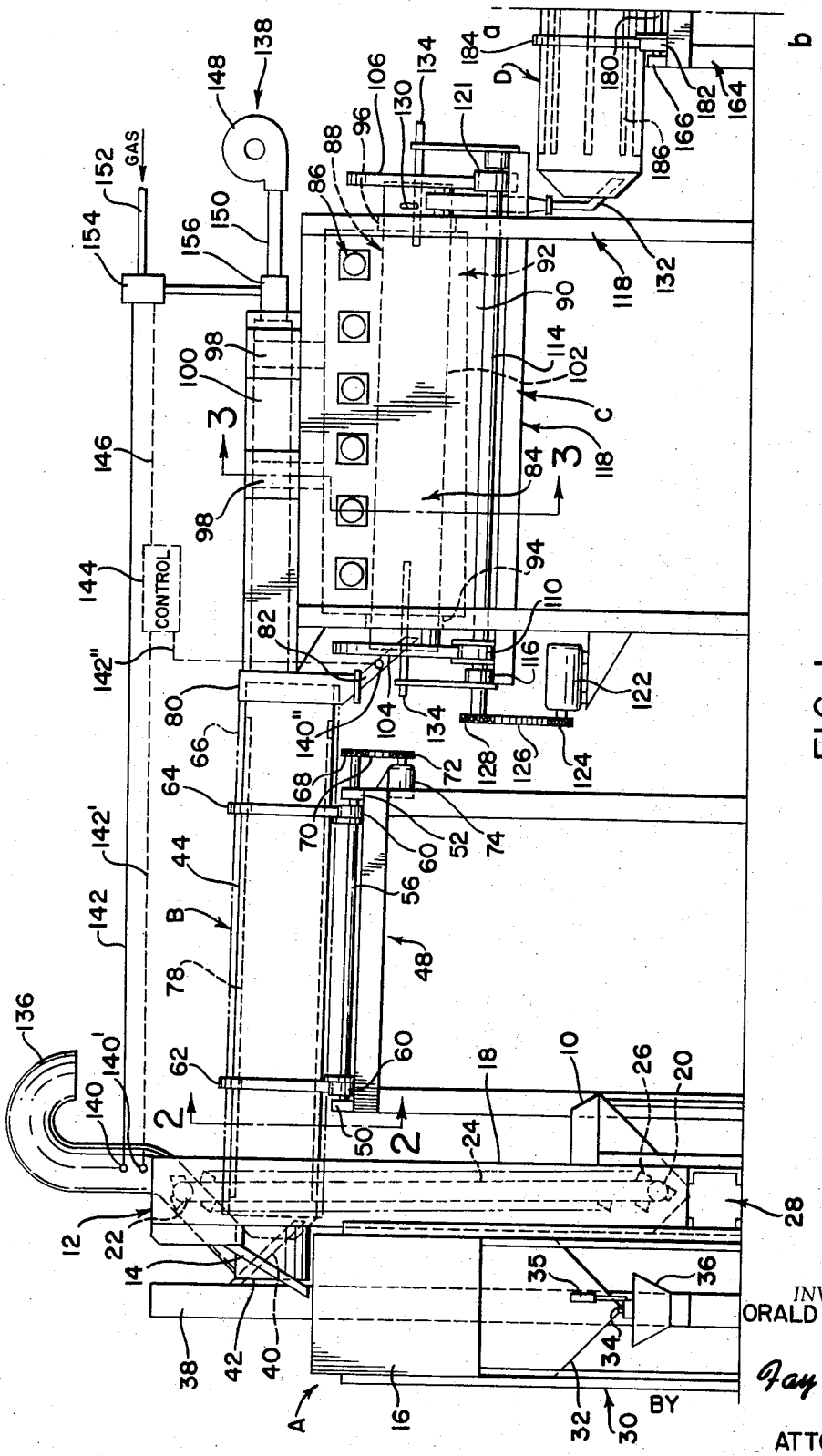


FIG. 1

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CONTINUOUS HEAT TREATING SYSTEM

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FIG. 1A

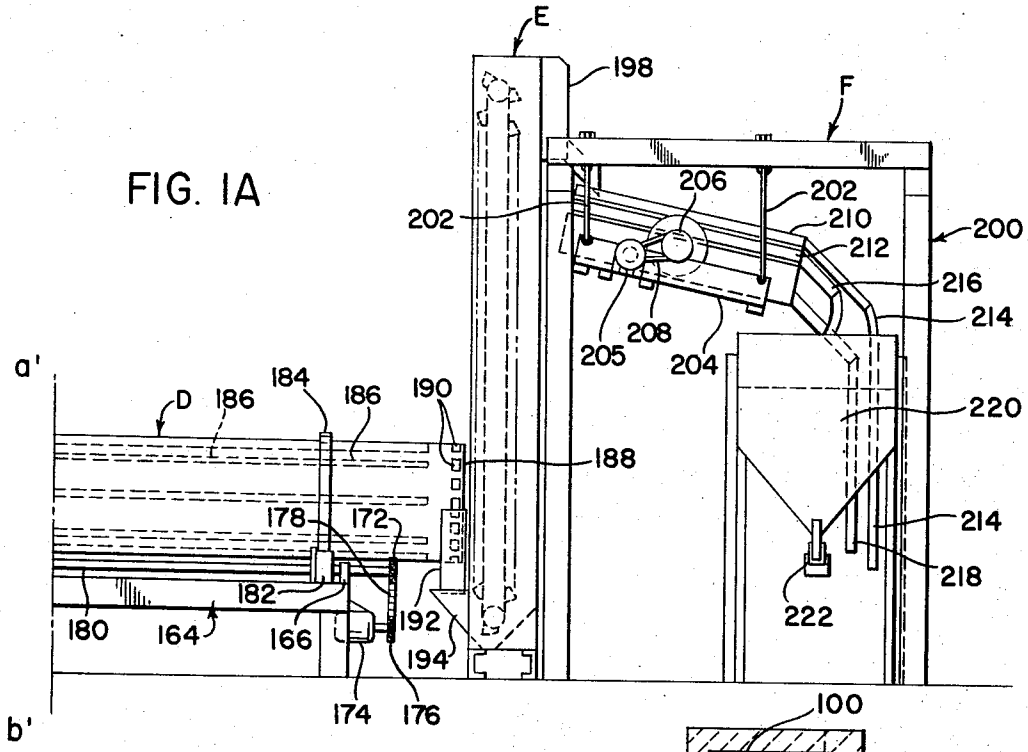
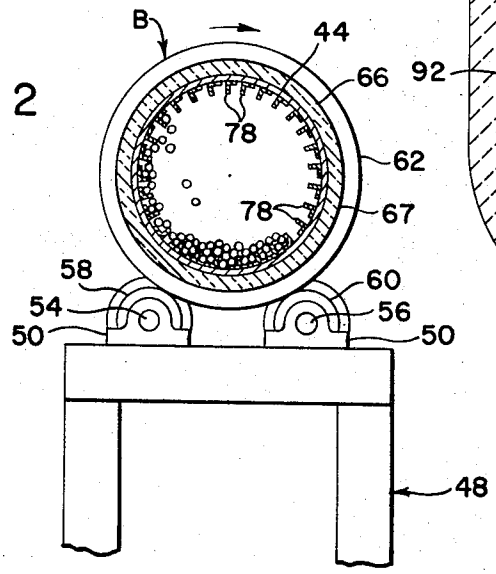


FIG. 2



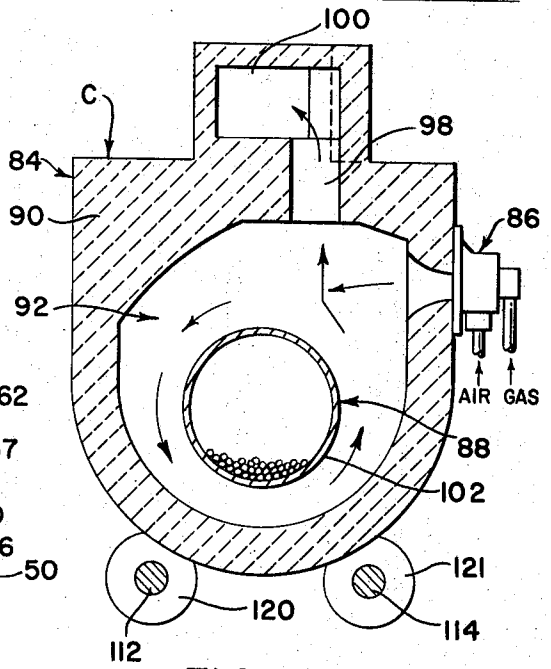


FIG. 3

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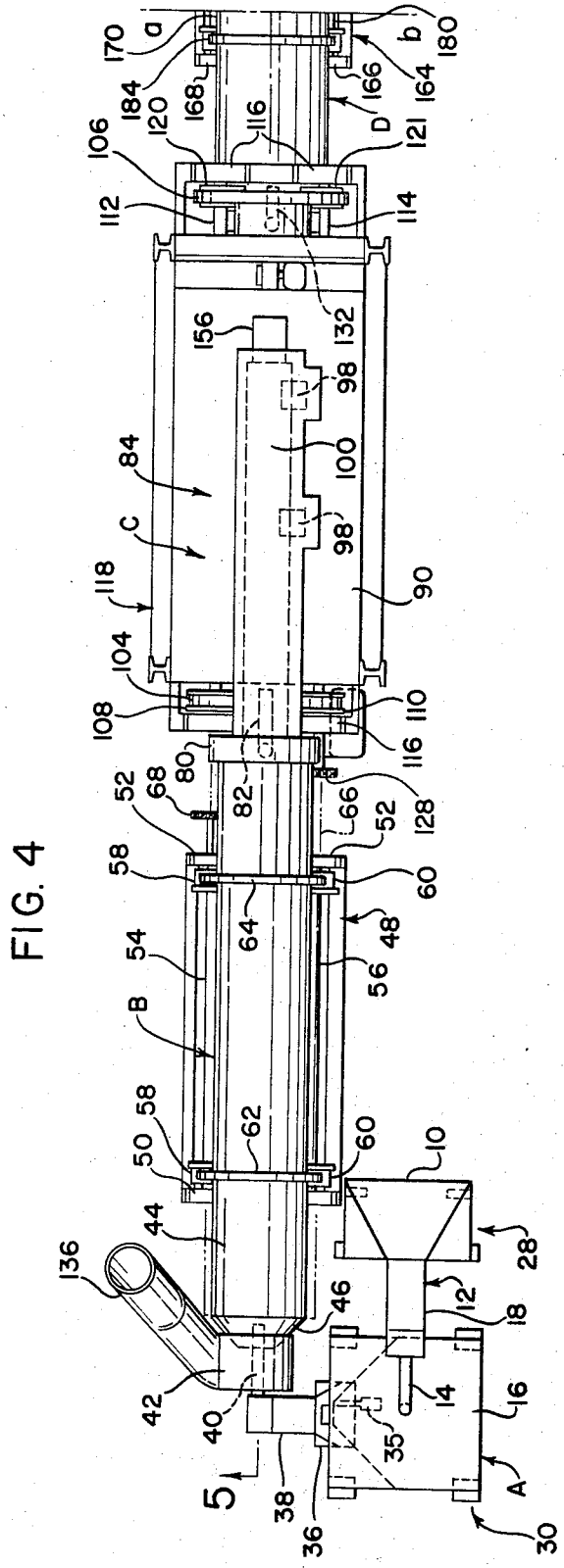


FIG. 4

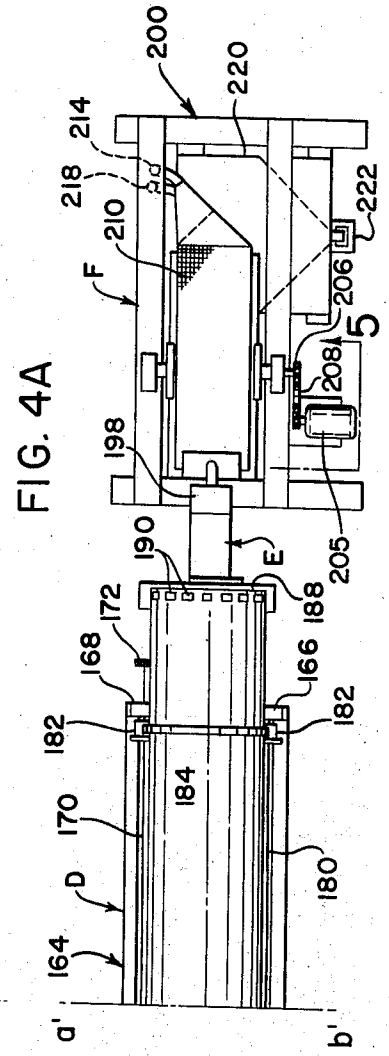


FIG. 4A

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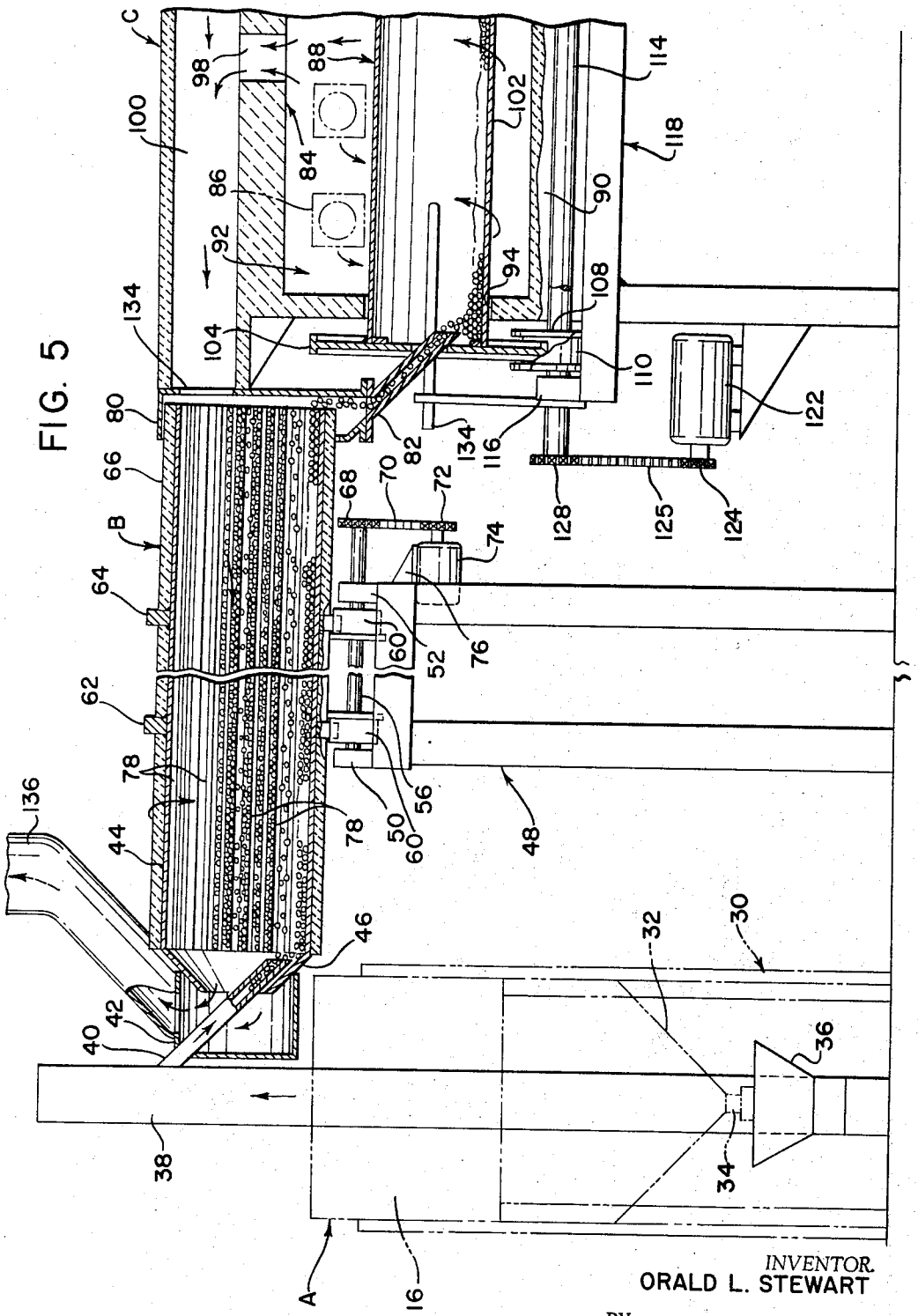
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FIG. 5



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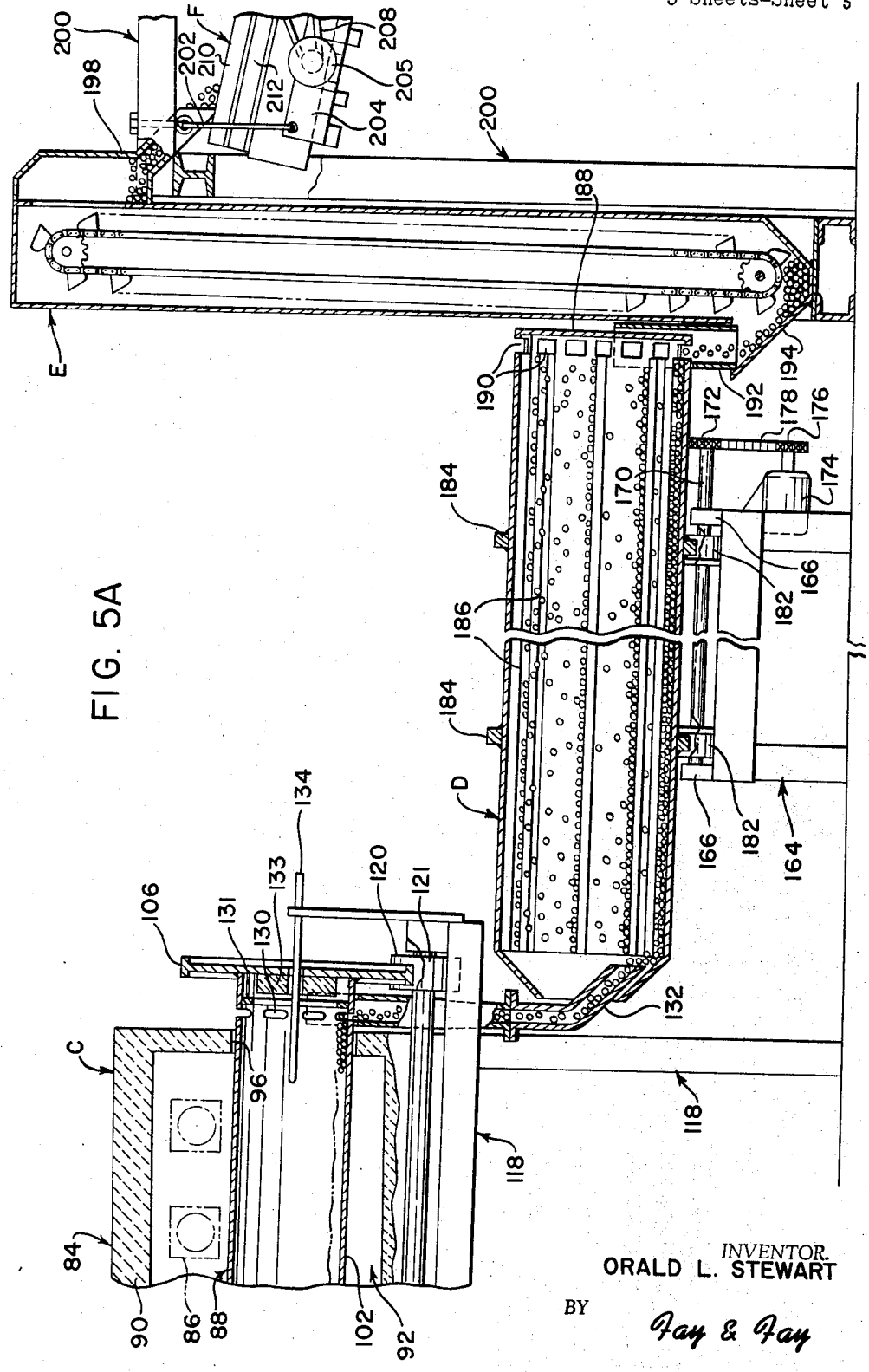


FIG. 5A

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United States Patent Office 3,362,857
Patented Jan. 9, 1968

3,362,857

CONTINUOUS HEAT TREATING SYSTEM

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Filed Apr. 15, 1965, Ser. No. 448,523
10 Claims. (Cl. 148—126)

ABSTRACT OF THE DISCLOSURE

The disclosure relates to a method and apparatus for heat treating metal abrasive material continuously through a rotary retort preheater, a primary smooth bore externally heated rotary retort furnace, a rotary cooling device and a size segregating screen. The hot gases which heat the exterior of the smooth bore retort are collected and conveyed into the preheating retort to minimize fuel cost. No significant combustion occurs inside the primary retort to insure a predictable desired chemical composition of the abrasive material.

Temperatures within the various zones of the apparatus are sensed and auxiliary means to automatically maintain the proper temperature at all times during the travel of the material through the apparatus are provided.

This invention generally relates to a continuous heat treating system. More particularly, the invention relates to a heat treating system, especially adapted to continuously, efficiently and economically heat treat metal abrasive shot. Still more particularly, the invention relates to a highly economical and very efficient heat treating method and apparatus, wherein the combustion or stack gases of the heat treating furnace are utilized, either with or without auxiliary heat, for the purpose of heating a preheat furnace used to raise the initial temperature of the metal shot before it enters the primary heat treating furnace. The terms "metal abrasive shot," "shot" and "metal abrasive particles" will be used throughout in referring to abrasive metal shot as well as abrasive metal grit.

In the manufacture of metal abrasive, molten iron or steel is broken into small bodies of a generally spherical shape by pouring the molten metal through a water spray, or by some other suitable method, and allowing it to fall in a water bath. The metal abrasive in this "as cast" state is relatively brittle and possesses poor mechanical properties. It follows, therefore, that in order to render the shot more serviceable and more valuable, it must be subjected to a heat treatment which will refine the grain, relieve the internal stresses, and change the elements into a more homogeneous mass and develop the desired physical and mechanical properties.

To accomplish this, the shot is heated slowly to a temperature above the critical temperature of approximately 1333° F., preferably to a temperature of from 1550 to 1800° F., and held at this temperature for a sufficient length of time to allow the solution of free cementite in austenite and the deposition of some temper carbon modules. As the metal shot is held above the critical temperature, the cementite is dissolved in the austenite with precipitation of carbon by the austenite proceeding simultaneously at the holding temperature until all of the free cementite has by degrees been dissolved and most of the carbon has been precipitated. At this point, the metal abrasive is air cooled to the critical temperature. As the cooling proceeds, more carbon is precipitated from the austenite until the eutectoid composition is reached. In the critical temperature range, the austenite is then isothermally transformed to pearlite.

In general, the preferred embodiment of the invention involves a method and apparatus for continuously feeding iron or steel metal shot particles into a rotating, preheating chamber which raises the temperature of the particles to a temperature of from 500 to 1000° F.; continually transferring the preheated shot particles to a rotating retort in heat-treaing furnace which raises the temperature thereof to 1550 to 1900° F. and holds such a temperature for a period sufficient to form the desired grain structure in particles; continually discharging the heated metal particles to a rotating chamber where they are allowed to cool to about 200° F. before being discharged therefrom and elevated to a classifier, and finally to a finished product storage.

More particularly, the invention involves a method and apparatus of the foregoing nature wherein the exit products of combustion of the primary heat treating furnace are used to heat the preheating chamber with or without the use of auxiliary heat. The addition of auxiliary heat is made in accordance with the dictates of a temperature sensitive device in communication with such exit gases.

In view of the foregoing, it is accordingly an object of this invention to provide a method and apparatus for heat treating metal abrasive particles as economically as possible.

Another object of this invention is to continuously and automatically heat treat metal abrasive particles as economically as possible.

Another object of this invention is to provide a method and apparatus for continuously and economically heat treating metal abrasive particles which includes the use of a preheat retort.

Another object of this invention is to provide a method and apparatus for continuously heat treating metal shot particles wherein the exit or combustion products of the primary heat treating furnace are channeled to a rotary preheat chamber to thereby utilize the caloric value of said exit gases to preheat the shot prior to its entrance into the primary furnace.

A still further object of this invention is to provide an economical method of heat treating metal abrasive particles wherein a rotary preheat chamber continuously discharges preheated shot to the primary furnace and the exit gases of the primary furnace are used to preheat the shot in the rotary preheat chamber.

A still further object of this invention is to provide a method and apparatus for continuously and economically heat treating metal abrasive particles wherein the exit gases of the primary furnace are used in combination with an auxiliary source of heat to preheat shot to an even greater degree prior to its entrance into the primary furnace.

Another object of this invention is to provide a method and apparatus for continuously heat treating metal shot wherein exit gases of a primary heat treating furnace are used to heat the preheating chamber in combination with auxiliary heating means which are actuated by a temperature-responsive device in communication with the gases passing through the preheater.

A still further object of this invention is to provide a continuous method and apparatus for heat treating metal shot wherein the exit gases of a primary heat treating furnace are used to raise the temperature of the metal particles in a preheater, used in combination therewith, to thereby obtain a longer time above critical temperature in the primary heat treating furnace.

Another object of this invention is to provide an apparatus wherein the exit gases of the primary heat treating furnace are used to raise the temperature of the abrasive metal particles in a preheating chamber, used in combination therewith, to thereby increase the capacity and rate of production of the apparatus.

A still further object of this invention is to provide a method and apparatus for continuously heat treating

metal abrasive particles wherein the exit gases in the primary heat treating furnace are used to raise the temperature of the metal in a preheater, used in combination therewith, to increase the over-all fuel efficiency.

These and other objects of the invention will become apparent by further consideration of the specification and drawings.

Referring now to the drawings, wherein like reference numerals refer to like elements:

FIG. 1 is a fragmentary front elevational view of the apparatus showing the feed means, the preheater, and the primary heat treating furnace;

FIG. 1A is a fragmentary view taken along line *a*—*b* of FIG. 1, in elevation showing the remainder of the apparatus not shown in FIG. 1, comprising the cooling retort and the size separation apparatus;

FIG. 2 is a cross sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a cross sectional view of the primary heat treating furnace taken along the line 3—3 of FIG. 1;

FIG. 4 is a fragmentary top view of the apparatus showing the feed mechanism, the preheat retort, the primary heat treating furnace, and a portion of the cooling retort;

FIG. 4A is a fragmentary top view taken along line *a'*—*b'* of FIG. 1 showing the remainder of the apparatus including the rest of the cooling retort and the size separation apparatus;

FIG. 5 is a fragmentary elevational view, partially in section, showing the structural relationship between the primary heat treating furnace and the preheating retort;

FIG. 5A is a fragmentary elevational view, partly in section, showing the remainder of the apparatus which includes the cooling retort, elevating means, and size separation apparatus.

Referring more particularly to the drawings, it will be noted that applicant's heat treating system comprises six basic components interconnected in a particular manner and including a materials handling and feeding apparatus A, which feeds the "as case" metal particles into a preheating chamber B, wherein the raw or "as case" metal particles are preheated to a temperature of from 500 to 1000° F. before it passes into the primary heat treating furnace C. In the primary furnace C, the preheated shot is raised to above the critical temperature and preferably to from 1550 to 1900° F. and maintained at this temperature for a sufficient length of time to adequately refine the grain structure, relieve the internal stresses and develop the desired homogeneity. The metal abrasive is then discharging into the shot cooling chamber D, wherein the temperature of the shot is allowed to drop to about 200° F. without the use of cooling means of any type, before being discharged into the materials handling apparatus E.

While a cooling chamber without the use of external cooling means is preferred in the case of normalizing cast iron shot it will be understood that appropriate cooling apparatus may be provided to accomplish the necessary rate of cooling, depending upon the composition of the metal shot itself and the final grain structure and properties desired. Force air, a water spray or a water bath may be used in connection with this system if the specific heat treatment requires it. The materials handling apparatus E elevates the heat treated shot and deposits same into the shot classifying apparatus F, which separates the various sizes of the final product and deposits the different sizes into different receptacles.

The materials handling and feeding apparatus at the input end of the system comprises a hopper **10** into which the raw or "as case" shot is dumped. The metal abrasive may be brought to the hopper by belt conveyors in communication with storage bins or by other conventional materials handling equipment. An elevator **12** carries the shot from the hopper **10** and deposits the same through a chute **14** into a supply bin or hopper **16**. Elevator **12** is of a conventional type which includes an outer housing **18**, a drive sprocket **20**, an idler sprocket **22**, and a belt **24** mounting buckets **26** disposed between the drive and idler sprockets. Power transmission means for the elevator **12** are not shown but may be of any suitable type, such as electric motors. The elevator is supported by any suitable structural members, such as generally indicated at **28**. The supply bin or hopper **16** is supported by suitable structural members of a conventional type, generally indicated at **30**.

The supply hopper **16** has a V-bottom opening **32** into a feed control means **34**. The feed control means may be of any suitable type, such as a gate type of opening operated by a solenoid actuated air cylinder **35**. In this regard, it should be noted that the flowability characteristics of metal abrasive shot and grit is quite analogous to a fluid. It is preferred that the feed control means **34** comprise a constant rate metering device with an automatic cut-off and warning signal in the event of a malfunction at any point in the system. The metal shot flows through the feed control means **34** and into an elevator feed hopper **36** in communication with the interior of the feed elevator **38**. The elevator **38** is also of conventional design and may be of the structure discussed above with regard to elevator **12**.

Shot is carried upwardly by elevator **38** and deposited into the preheat chamber B through a feed chute **40**. The feed chute **40** extends through the interior of a hood **42** disposed over the end of the preheat chamber, as will be discussed in more detail hereinafter.

The preheat apparatus comprises an essentially cylindrical body **44** having a generally frustoconical cowling **46** secured thereto at the input end. The body may be made of any suitable material which will stand temperatures up to 1000° F. In practice, the body **44** will be typically 3 feet in diameter and 15 feet long. The body **44** may be positioned substantially horizontally or disposed at a slight angle, being lower at the outlet end than the input end. In practice, it has been found that a preheat chamber of the aforementioned size, being disposed at an inclination of a fall of two inches in 15 feet and rotating at from 7 to 10 r.p.m. will handle about four tons of metal abrasive shot per hour. Under certain operating conditions, however, it has been found that the retort will possess superior operating characteristics and have a greater capacity if disposed substantially horizontally.

Suitable structural members, generally indicated at **48**, are provided to support the preheater at an elevation with respect to the primary furnace C. Secured upon the upper surface of the frame or structural member **48** are two pairs of opposed, spaced pillow blocks **50** and **52**. Opposed shafts **54** and **56** are journaled within the spaced pillow blocks **50** and **52**. Two opposed flanged rollers **58** are secured to the shaft **54**, and two spaced, opposed flanged rollers **60** are secured to the shaft **56**. The generally cylindrical body **44** is provided with two spaced tires or driving rings **62** and **64**, which cooperate with the rollers **58** and **60**. It is apparent from FIGS. 2 and 5, that the tires or driving rings **62** and **64** are securely fastened to the exterior surface of body **44** and extend outwardly through an insulating material **66** carried by body **44**. The insulating material is covered by sheet metal or the equivalents. The use of the flanged rollers as illustrated accommodates thermal expansion of the apparatus.

Securely fastened to the end of shaft **64**, as by means of a keyway and key, or pin, is a sprocket **68** which is driven by a chain **70** received upon and driven by a drive sprocket **72** upon the end of the shaft of motor **74**. The motor **74** is secured to the framework **48** by any suitable means such as a bracket **76**. The speed of the motor and the respective sizes of the drive sprocket **72** and the driven sprocket **68** are selected so that the preheater body **44** rotates at the appropriate speed, which is preferably from 7 to 10 r.p.m. in the case where the body is 3 feet in diameter and 15 feet long, and is in-

clined with a fall of 2 inches in 15 feet. By driving the body at spaced points by means of the driven shaft **54** there is no torque applied to the body **44** thereby alleviating many structural and maintenance problems.

As the shot enters the inlet end of the preheater body **44**, as clearly indicated in FIG. 5, it is carried up along the side of the generally cylindrical body by means of the longitudinally extending angles or rods **78**. It is preferred to use angle bars as illustrated and in practice it has been found that 2" by 2" angles on three inch centers, point to point measurement, around the interior of the body are preferred. These rods or bars carry the raw shot from a position in the lowermost portion of the body member to a position along the side thereof, at which point particles roll off and fall to the bottom. This technique of agitation allows the particles to be more thoroughly and uniformly exposed to the hot gases which are passing longitudinally through the preheat furnace. This will be discussed in more detail hereinafter.

A generally cylindrical hood **80** encloses the exit end of the preheater and is spaced therefrom a suitable distance to provide a clearance for rotation of the body **44**. A funnel or chute **82** is secured to the lower part of the hood **80** to provide a means for transferring the preheated shot from the preheater B to the primary furnace C. In referring to FIG. 5, it will be noted that the hood **80** is spaced from the end of the preheat chamber sufficiently to allow preheated shot to pass from the end of the body **44** and into the funnel or chute **82**, which transfers the shot to the primary furnace.

Baffles may be provided in the interior of body **44** for the purpose of creating turbulence in the hot gases, thereby improving the efficiency of heat transfer to the shot. The baffles may occupy a major portion of the central cross sectional area of the body **44** and be secured therein by means of a spinder shaped frame attached to the inner walls thereof.

The specific structural details of the primary heat treating furnace are discussed in more detail in applicant's copending application Ser. No. 167,021, filed Jan. 18, 1962, now U.S. Letters Patent No. 3,201,289, and accordingly the description to follow is directed to its general mode of operation and particularly to the manner in which the coaction is achieved between the primary furnace and the preheat chamber.

As illustrated in FIG. 3, the primary heat treating furnace comprises a housing means **84** which includes an elongated, trough-shaped refractory structure **90** having a central region or cavity **92** which is of a generally semicircular configuration in its lower portion and of a large irregular shape in its upper portion, adjacent the plurality of heating means generally indicated at **86**. A retort means **88** extends through openings **94** and **96** in the ends of the housing means **84**, and is supported externally for rotation therein about the axis of the generally semi-circular lower portion of the cavity to provide for the efficient distribution of heat in the furnace.

Stacks **98** provide fluid communication between the upper portion of the combustion chamber or cavity **92** and a manifold **100**. The heating means **86** include conventional air-gas burners, such as the type produced and sold by North American Manufacturing Co. of 4464 E. 71st, Cleveland, Ohio, 44105, under the designated Series 4423–3B. These burners are mounted in openings in the housing and are capable of close regulation by automatically varying the air-gas supply and ratio in the manner discussed in detail in the aforementioned copending patent application.

As will be observed from FIGS. 3, 5, and 5A, the retort means **88** of the primary furnace comprises an elongated, generally cylindrical smooth bore metal casing **102** having a length greater than the housing means **84** and extending therethrough via openings **94** and **96**. Secured to opposite ends of the generally cylindrical casing are generally cylindrical tires **104** and **106**. The particular structure which is preferred to secure the tires **104** and **106** to the casing member is set out in detail in the above-mentioned copending application.

The tire **104** serves as a driving means to rotate the retort **88** which is supported at the input end upon two flanged wheels **108** and **110**. The flanged wheels **108** and **110** are secured to shaft idler **112** and the driven shaft **114** respectively in any suitable manner. The shafts **112** and **114** are rotatably mounted in pillow blocks **116** which are rigidly secured to the structural supporting member generally indicated at **118**. Secured to the ends of the shafts **112** and **114** at the opposite ends to the flanged wheels **108** and **110** are two similar but smooth wheels **120** and **121** respectively which rotatably support the generally cylindrical tire **106** which is secured to the end of the casing **102**.

By driving the retort from two spaced positions by means of driven shaft **114** and wheels **110** and **121** no torque is transmitted through the retort thereby eliminating many structural and maintenance problems in this apparatus which are particularly acute at the temperatures involved.

Motor means **122** drives a power train which includes a drive sprocket **124**, a drive chain **125**, and the driven sprocket **128**, which is rigidly secured to the end of shaft **114**. The flanged wheel **110** and the smooth wheel **120** in cooperation with tires **104** and **106** respectively serve to drive the smooth bore metal casing. The rotatable metal casing **102** may be positioned either horizontally or slightly inclined being lower at the outlet end than at the inlet end. Accordingly, it is necessary that wheels **108** and **110** be flanged so that they will overlap the tire **104** slightly to prevent any shifting of the smooth bore casing if it is to be operated in an inclined position.

As will be observed from FIGS. 3, 5 and 5A, the retort means **88** of the primary furnace comprises an elongated, generally cylindrical smooth bore metal casing **102** having a length greater than the housing means **84** and extending therethrough via openings **94** and **96**. Secured to opposite ends of the generally cylindrical casing are generally cylindrical tires **104** and **106**. The particular structure which is preferred to secure the tires **104** and **106** to the casing member is set out in detail in the above-mentioned copending application.

The tire **104** serves as a driving means to rotate the retort **88** and it is supported upon two flanged wheels **108** and **110**. The flanged wheels **108** and **110** are secured to shafts **112** and **114** in any suitable manner. The shafts **112** and **114** are rotatably mounted in pillow blocks **116** which are rigidly secured to the structural supporting member generally indicated at **118**. Secured to the ends of the shafts **112** and **114** at the opposite ends to the flanged wheels **108** and **110** are two similar but smooth wheels **120** and **121** which rotatably support the generally cylindrical tire **106** which is secured to the end of the casing **102**.

It will be observed that the casing **102** is provided at the exit or outlet thereof with a plurality of circumferentially spaced openings **130**. These discharge ports **130** are spaced generally symmetrically around the periphery of the discharge end of the metal casing. It will be noted that the discharge openings are outside of the housing means **84** and serve to continuously discharge the heat treated shot without significant loss of heat from the furnace. As the heat treated shot passes thrrough the openings **130**, it drops through a chute **132** which leads to the input end of the shot cooling apparatus generally designated D.

Adjacent the openings **130** a radially inwardly extending ring **131** is secured to the inner surface of the casing **102** to arrest the travel of the shot and insure that it passes through the openings and does not become logged against the end of the casing. A suitable disc shaped insulating means **133** is secured to the inner surface of the tire **106** to reduce the heat transfer to the tire.

The primary furnace also includes thermocouples **134** disposed at opposite ends of the retort and interconnected with suitable control means to insure that the proper operating temperature is maintained at the various zones throughout the furnace. Control means are provided to control the rate of fuel and air input to the various burners **86** and also control the fuel-air ratio to thereby assure that the proper temperature is maintained at the various zones throughout the furnace, as also explained in more detail in applicant's copending application Ser. No. 167,021.

This heat treating system is being illustrated in connection with the use of a gaseous fuel, which is preferred if economically available. However, electric power may also be used by making minor modifications in the apparatus. If the system is operated with electric power, the hot gases from the primary furnace would be used in the same manner as the hot combustion gases which are produced by the apparatus illustrated.

As described earlier the hot combustion gases from the burners pass upwardly through the stacks **98** and into the manifold **100**, which leads through an opening **134** in the hood **80** and discharges into the preheat chamber. The hot combustion gases pass through the rotating preheat chamber B, transferring the heat to the raw shot and finally exit through the hood **42** and to the atmosphere through a stack **136**.

In the embodiment illustrated the preheating retort B is positioned adjacent to the primary furnace. Alternatively the preheat retort may be disposed vertically of the primary furnace if plant design problems so dictate. If the preheat furnace is positioned vertically above the primary furnace, the hot gases will leave the manifold as described and pass upwardly into the preheat retort. The preheated shot will accordingly fall by gravity and be transferred into the primary furnace.

The primary heating furnace is provided with an auxiliary heating means generally indicated at **138**, mounted in the end of the manifold **100** opposite the exit end thereof. Positioned in the discharge stack **36** on the preheat retort is a temperature sensing device **140** which is interconnected with control apparatus to actuate the auxiliary heating means when it is needed. In the preferred embodiment the temperature sensing device **140** includes a sealed mercury filled tube.

The preferred embodiment of auxiliary heating means **138** generally comprises signal transmitting means **140** and **142**, a blower **148**, duct **150** leading from the blower to the burner, a gas supply line **152**, a gas regulating means **154**, and an auxiliary burner **156**. The auxiliary burner operates intermittently between a pilot range and full heat range as dictated by the burner control apparatus. The blower **148** operates continuously and when additional heat is needed, the auxiliary burner is changed from pilot level operation to full heat operation.

When the temperature of the preheating gases from the heaters **86**, as measured by the temperature sensing device **140**, drops below a predetermined point, the mercury in the sealed tube **142** contracts, thereby transmitting a signal through the conductor **142** to the gas regulating means **154**. Upon receipt of the appropriate signal, the gas regulating means **154** adjusts the rate of feed of gas to the burner to provide the proper amount of gas to operate the burner at full heat with a proper air-gas ratio.

If preferred, other control means, such as dampers, lower speed controls and gas flow regulator valves could be provided in the auxiliary heat means.

As an alternative, the auxiliary heating means may be controlled by means of a temperature sensitive device **140**, preferably a thermocouple and signal transmitting means **142'**, **144** and **146**. In operation, a signal will be sent to control means **144** through conductor **142'** in response to a temperature drop in the exit gases as measured by the thermocouple **140'**. Control means **144** will then operate to transmit the appropriate signal through **146** to the gas regulating means **154**.

As noted, the auxiliary heating means is in operation only as needed and when the temperature of the flue gases, as enhanced by the heat supplied by the auxiliary burner, reaches the desired level, the control mechanism, consisting of signal transmitting means **140**, and regulator **154**, are deactuated to put the auxiliary burner out of full heat operation. The pilot is, of course, left in operation continuously, as well as the blower.

While the temperature sensing devices **140** and **140'** are illustrated as being positioned in the stack through which the gases leave the preheat retort, it may alternatively be positioned at the discharge end of the preheater in contact, directly or indirectly, with the shot as illustrated at **140''**. A signal from **140''** would be transmitted through conductor **142''** to control means **144**.

As a further alternative for controlling the auxiliary heating means, the blower could also be operated intermittently in accordance with an appropriate signal from the control means in response to a signal from the temperature sensitive devices **140**, **140'** and **140''**.

It is advantageous in certain instances to recycle a major portion of the gases passing through the preheater back to the gas input end of the chamber **44**. This can be accomplished by appropriate ducting and serves, to increase the gas velocity therethrough and thereby enhance heat transfer efficiency to the incoming shot.

A blower or other suitable means should be provided and the recycle system must include an escape duct in order to maintain the proper pressure differential between the primary furnace and the pre-heat chamber. An auxiliary heating means may also be provided in the recycle system itself. In the embodiment illustrated the exit gases leaving the preheater through stack **136** would be recycled, preferably by means of a blower, into the discharge end of the manifold on the primary furnace. The arrangement of the preheater vertically with espect to the primary furnace, mentioned supra, is particularly adapted to the recycling system.

This concept of using the stack gases of the primary furnace to heat the raw shot in the preheater amounts to a no-cost method of raising the temperature of the incoming material, thereby giving a longer soak time above the critical temperature in the primary normalizing furnace, as well as increasing the rate of production of a given capacity apparatus. The over-all efficiency is also markedly improved because the heat in the stack or waste gases would otherwise be lost.

The use of the auxiliary heating means is in effect a method of controlling the over-all heat balance in the system, with the auxiliary means intermittently operating between pilot range and full heat range to retain a relatively constant gas temperature in the stack from the preheater. A substantially constant temperature of the input gases should be maintained in the preheat chamber. This assures that a relatively constant volume of shot passing through the preheater will be discharged therefrom at a relatively constant temperature.

The heat treating system of this invention involves a substantially constant rate of material flow throughout the apparatus with the utilization of auxiliary heat to maintain a relatively uniform temperature of the product at various points in the system.

The heat treated shot leaves the primary furnace C by passing through openings **130** of the retort thereof and through the chute **132** into the cooling chamber.

As mentioned, various cooling techniques may be employed, depending upon the character of the incoming metal particles and the properties desired in the final product. In the case of normalizing, still air cooling is employed without the use of external cooling means and the system is illustrated in this connection.

The cooling chamber D includes a superstructure or frame member **164** which mounts two pairs of proposed

pillow blocks **166** and **168** and a pair of rotatable shafts **170** and **180** extending therebetween and rotatably journaled therein. A driven shaft **170** extends between near pillow blocks **168** and carries a driving sprocket **172** on one end thereof. The sprocket **172** is driven by a power train which includes a motor **174**, a drive sprocket **176**, and a chain **178**, extending between the sprocket **176** and sprocket **172**. A second idler shaft **180**, which is substantially coplanar with the shaft **170**, extends between the opposed panel blocks **166**. Both the driving shaft **170** and the idler shaft **180** mount a pair of opposed flanged rollers **182** which cooperate with spaced opposed tires **184** carried by the outer periphery of the chamber to thereby rotate same. It will be noted that the relationship between the opposed flanged rollers **182** and the tires **184** on the chamber is such that the drum will be maintained in its normal position during rotation on an incline.

The heat treated shot entering the cooling chamber through the chute **132** is carried up along the side of the generally cylindrical drum by means of the longitudinally extending bars or strips **186**. The bars function to carry the hot shot from the lower portion of the drum to a point above the axis thereof to agitate or mix the heat treated shot and facilitate a more uniform dissipation of heat. The rods or bars also facilitate uniform movement of the shot from the input end to the discharge end.

The exit or lower end of the cooling chamber is closed by a plate **188**. A plurality of holes **190** are substantially uniformly placed around the circumference of the cooling chamber in proximity to the plate to permit discharge of the shot in a manner similar to that described in connection with the primary furnace. In practice the shot is at a temperature of about 180–250° F. as it leaves the cooling chamber. The final temperature of the shot is not a significant feature and is controlled primarily by the temperature limitations of the materials handling equipment that is used subsequently.

It will be recognized that for certain heat treatment operations, the use of a cooling means would not be necessary and that for other heat treatment operations, it might be preferable to supplement the retort with a cooling means such as forced air or a water spray. Under certain conditions the heat treated shot is discharged from the primary furnace into a water bath. In some systems a combination of various cooling means will be employed to accurately control the rate of cooling.

As the shot leaves the cooling chamber through the openings or ports **190**, it passes through the chute **192** and into a hopper **194** which feeds an elevator generally designated E. The elevator amounts to a conventional bucket elevator and accordingly will not be discussed in detail.

The shot is elevated from the hopper **194** and deposited at the upper end of the elevator into a chute **198** which leads to the size separation apparatus designated by the letter F.

The classification or size separation apparatus comprises a frame member generally designated **200** which suspends the screening apparatus by means of resiliently mounted supports **202**. The supports **202** are resiliently attached to the frame **204** of the screening apparatus. A motor **205** is mounted on the frame **204**, and rotates a drive pulley **206** by means of a chain or equivalent drive means **208**. Various types of screening apparatus are suitable depending upon the size range of the shot being processed, and the degree of classification desired in the end product.

For purposes of illustration a screening mechanism characterized as a two deck screen is used. It will be seen that this type of screening apparatus will separate the material into three distinct size ranges.

The screening apparatus comprises a first or top screen **210** and a second or lower screen **212**. As the metal shot is placed upon the first screen **210**, the largest particles will not pass through the screen **210** but will travel therealong and off the end thereof into a chute **214** which leads to a particular receptacle to contain a shot larger than a given size. That fraction of the shot which is smaller than the screen size of the screen indicated at **210**, but too large to pass through the screen **212**, passes from the end of screen **212** and into a chute **216** which leads to a separate receptacle for shot of a given size range. That fraction of the shot which passes through both screens **210** and **212** is discharged in a chute **218** and to an appropriate receptacle.

It will be noted that chute **216** is discharged into a hopper **220**. The hopper **220** is of a conventional design which amounts to a V-bottom bin having a discharge mechanism **222** at the bottom thereof.

In reviewing the operational characteristics of the continuous heat treating system, it will be noted that the raw shot passes from the feed hopper **10** through the elevator **12** and into the supply hopper **16**, from which it is elevated by means of the feed elevator **38** and discharged into the preheat chamber B through a chute **40**. The shot is preheated in this chamber to a temperature of from about 500–1000° F. by means of the combustion gases from the primary furnace, either alone or as enhanced by auxiliary heat, passing therethrough countercurrently to the direction of flow of the shot. The shot is discharged from the preheater B through the chute **82** into the primary heat treating furnace C which raises the temperature thereof to a point above the critical temperature, up to 1900° F., for a period sufficient to accomplish the heat treatment desired and discharges same through openings **130** and into the chute **132** leading to the cooling chamber. As the heat treated shot passes through the cooling chamber, it is allowed to cool sufficiently to be handled without difficulty and is elevated, by means of elevator F and deposited in the classification or size separation apparatus. The size separation apparatus classifies the material according to predetermined size ranges and deposits the various sizes in separate containers.

It was found that by constructing the rotary drum of the preheat and primary heat treating furnace, as well as the rotary cooling drum, having dimensions of 3 feet in diameter and 15 feet long, that approximately one ton of shot per hour could be processed by rotating these rotary drums at from 7 to 10 revolutions per minute. With the gases entering the preheat furnace, either combustion gases alone or as a combination of combustion gases plus auxiliary heat at 900° F., it was found that the incoming shot leaves the preheat furnace at about 600° F.

The integrated continuous heat treating system of this invention has been found to be highly efficient. The efficiency and economical nature of this apparatus is attributed in part to the fact that the combustion gases in the primary furnace are not wasted but are used to preheat the as-cast shot. This feature offers a two-fold advantage; namely, (1) the total amount of heat input to the primary surface can be reduced, and (2) the rate of processing can be improved and the capacity of the apparatus increased because a given soak time at the critical temperature or above can be achieved since it is only necessary to heat the shot from a temperature of 600° F. instead of from ambient temperature. The over-all result is to improve the efficiency and capacity of the entire system.

Although a particular embodiment of this invention has been shown and described, it will be understood that various modifications and improvements may be used and various changes of design may be incorporated without departing from the spirit and scope of the invention as defined by the appended claims.

The invention claimed is:

1. A method of continuously heat treating metal abrasive particles comprising the steps of

continuously passing the metal abrasive through a rotating preheating means;

preheating the metal abrasive to a temperature of from 500 to 1200° F. as it passes through the preheating means;

continuously discharging the preheated metal abrasive from the preheating means into a primary heat treating furnace having an externally heated rotary retort;

heating the metal abrasive in the primary heat treating furnace primarily by conducting heat through said retort to said metal abrasive and without substantial combustion in said retort from a temperature of from 500 to 1200° F. to a temperature of from 1550 to 1900° F.;

conveying heated gases from the primary furnace to the preheating means;

discharging the metal abrasive from the primary heat treating furnace into a rotating cooling chamber and allowing it to cool.

2. The method of claim **1** further characterized in that the metal abrasive from the cooling chamber is continuously transferred to a size separation apparatus wherein the metal abrasive is classified according to different size ranges.

3. The method of claim **2** further characterized in that auxiliary heat is added to the heated gases from the primary heat treating furnace to maintain a relatively constant temperature of the gases entering the preheating means.

4. An apparatus for continuously heat treating metal abrasive particles comprising

a rotating preheating chamber to preheat raw metal abrasive;

a primary furnace for continuously heat treating the preheated metal abrasive including a rotating retort;

means interposed between the preheating chamber and the primary furnace for transferring the preheated metal abrasive from the preheating chamber to the primary furnace;

a plurality of heaters externally of said retort for supplying heat to said primary furnace by conducting heat through the retort wall;

means on said primary furnace, in fluid communication with said preheating chamber for collecting the gases exteriorly of said retort heated by said heaters and transferring same to the preheating chamber;

auxiliary heating means in communication with said last-mentioned means and operable to maintain the temperature of the gases entering the preheating chamber relatively constant;

and a rotating cooling chamber positioned to continuously receive metal abrasive from the primary furnace.

5. The apparatus of claim **4** in which the auxiliary heating means is operable in response to a temperature sensing means in communication with the preheated shot entering the primary furnace.

6. A system for continuously heat treating metal abrasive particles comprising

a continuously rotating preheating chamber to receive and heat the raw shot;

a primary heat treating furnace including a continuously rotating smooth bore retort;

means to transfer the metal abrasive from the preheating chamber to the primary furnace;

said primary furnace including a plurality of heaters exteriorly of said retort to supply heat by conduction through said retort wall and without substantial combustion in said retort for raising the temperature of the metal abrasive;

a manifold on the primary furnace in fluid communication with said preheating chamber to receive the hot gases from said heaters and discharge same into said preheating chamber;

an exhaust stack on said preheating chamber;

temperature sensing means in said exhaust stack to measure the temperature of the gases being discharged therefrom;

auxiliary heating means on said manifold and responsive to said temperature sensitive means to maintain the gases being discharged from the preheating chamber at a relatively constant temperature;

and a rotating cooling chamber to receive the hot metal shot from the primary furnace.

7. The system of claim **6** further characterized in that the metal abrasive from the cooling chamber is transferred to a size separation apparatus which classifies the metal into various sizes.

8. The system of claim **7** wherein the preheating chamber is provided with a plurality of baffles to create turbulence in the gases passing therethrough to thereby increase the rate of heat transfer to the metal abrasive particles.

9. A system for continuously heat treating metal abrasive particles comprising

a continuously rotating preheating chamber to preheat raw metal abrasive;

a primary heat treating furnace including a continuously rotating retort;

means to transfer the metal abrasive from the preheating chamber to the retort of the primary heat treating furnace;

a plurality of burners in said primary furnace which supply heat to the interior of the retort by conduction through the retort without substantial combustion in said retort;

a manifold on the primary furnace in fluid communication with the preheat chamber to receive the hot combustion gases from said burners and discharge same into said preheat chamber;

auxiliary heating means on said manifold;

control means operable to effect intermittent adjustment of fuel supply to said auxiliary heating means to maintain the desired temperature of the shot leaving the preheat chamber.

10. The system of claim **9** further characterized in that the control means includes

a temperature sensitive device positioned to measure the temperature of the gases being discharged from the preheating chamber;

a blower to supply air to the auxiliary burner;

control means interconnected between a source of gas and the auxiliary burner and operable in response to a signal from said temperature sensitive device to meter the proper amount of gas to said burner to operate it at the desired heat range.

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