Nov. 24, 1942. G. E. CONNOLLY 2,302,841

METHOD AND APPARATUS FOR ROASTING MERCURY ORES AND THE LIKE

Filed May 2, 1942

Fig. 1.

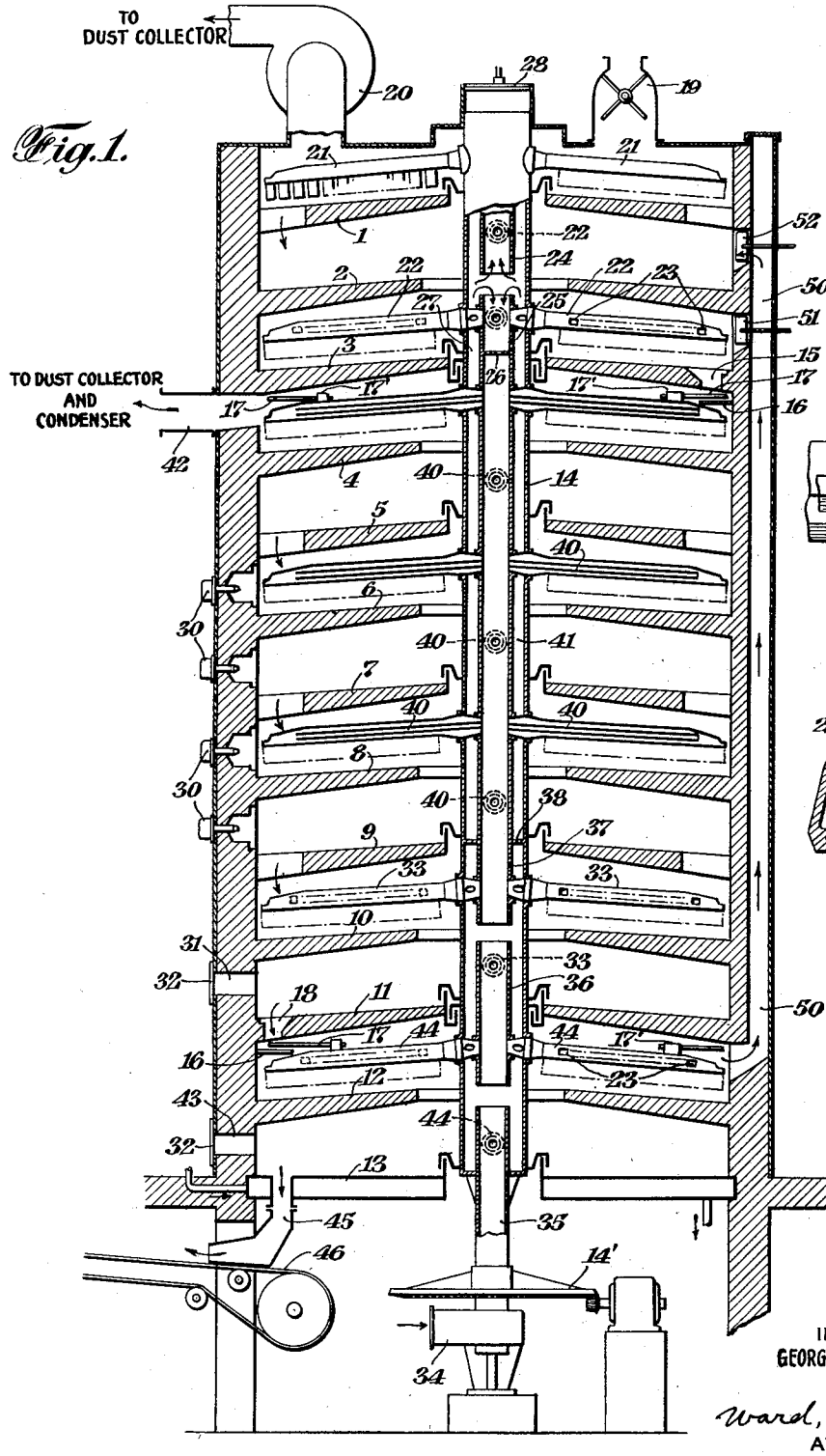


Fig. 2.

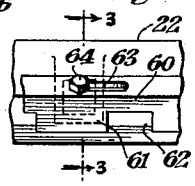
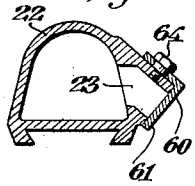


Fig. 3.



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METHOD AND APPARATUS FOR ROASTING MERCURY ORES AND THE LIKE

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4 Claims. (Cl. 75—81)

This invention relates to methods and apparatus for treating mercury ores and the like, by roasting, to recover mercury.

Heretofore in the treatment of cinnabar ores and the like for the recovery of mercury, it has been the usual practice to subject the ore to roasting treatment in furnaces such as rotary kilns having a single compartment or zone in which a considerable amount of heat has to be applied, first to expel moisture and then to bring the ore up to the necessary temperature to expel mercury vapor. The mercury vapor, together with gases of combustion and water vapor, are then conducted through a condenser for recovery of the mercury. After the mercury vapor has been expelled from the ore, the calcines are discharged while still at a relatively high temperature and thus too hot to be carried away on standard types of belt conveyors. Hence it is customary to manually tram the hot calcines to the dump. Such a process is inefficient in that considerable heat is lost through discharge of the calcines while hot, and where the process is carried out in rotary kilns considerable recoverable mercury will be lost in calcines due to lack of thorough uniform roasting of all of the ore. A particularly serious drawback of this method also resides in the fact that the volumes of gases and water vapor, with respect to the amount of mercury vapor therein, as discharged from the furnace, are too large to permit efficient operation and use of the condensing system. With the present invention, all of these difficulties are overcome and the plant efficiency is substantially improved. Manual labor is avoided and the entire operation of the furnace and power plant may be cared for by a single attendant.

Various further and more specific objects, features and advantages of the invention will clearly appear from the detailed description given below taken in connection with the accompanying drawing forming a part of this specification and illustrating by way of example one form of apparatus which may be used in carrying out the invention. The invention consists in such novel features, combinations of parts, methods and method steps as may be shown and described herein.

In the drawing, Fig. 1 is a vertical sectional view illustrating one form of furnace apparatus embodying the invention and in which the process of the invention may be carried out;

Fig. 2 is an enlarged detailed view of a portion of one of the rabble arms of the furnace of Fig. 1, showing an improved air discharge outlet construction; and

Fig. 3 is a sectional view taken along line 3—3 of Fig. 2.

In general, the invention may be carried out by passing the ore successively over a plurality of enclosed superposed hearths, including one or more upper hearths forming a drying and preheating zone, an intermediate plurality of hearths forming a burning and soaking zone (herein generally called the burning zone), and one or more lower hearths forming a cooling zone. Preferably means are provided between these zones for maintaining them separate against the passage of gases between adjacent zones, yet permitting the ore to gradually pass from zone to zone as required. Thus the mercury vapor and combustion gases evolved from the burning and soaking zone may be discharged independently of gases, water vapor or air from other zones. Hence this mercury vapor does not have to include much water vapor nor any of the air which has been used to preheat and dry the ore, nor any air which has been used to cool the ore. For reasons hereinafter explained, these facts make possible the condensation of the mercury vapor with greatly improved efficiency. The air which may be introduced into the cooling zone for cooling the ore before it is discharged, is preferably, after being substantially heated by passage through the cooling zone, conducted into and through the preliminary drying and preheating zone, so that thereby heat is taken from the ore before it has discharged, and utilized to preheat and dry the incoming ore. Further features contributing to the improved and economical operation of the method will be apparent in connection with the following description of the furnace apparatus.

As shown in Fig. 1, the furnace may have upper hearths Nos. 1, 2 and 3, providing a drying and preheating zone, intermediate hearths 4 to 11 inclusive, forming a burning zone, and lower hearths 12 and 13 providing a cooling zone. The number of hearths in each zone may be varied depending on the furnace capacity and other factors. The furnace may be provided with a rabbling structure comprising a central shaft as at 14, rotated by motor driven gearing 14' of suitable known construction as shown beneath the furnace. This shaft may carry a plurality of rabble arms, of constructions hereinafter described, and having rabble teeth cooperating with each hearth, for periodically rabbling the material inwardly and outwardly of alternate

hearths, thereby gradually advancing the ore over each hearth, and through peripheral or central discharge ports in the various hearths down through the furnace. In this respect the construction may be similar to that of the multiple superimposed hearth furnaces shown for example, in the patents to Herreshoff No. 976,175 and Baird 1,669,925, although for the purposes of this invention numerous important and novel modifications will be necessary, including the three zone arrangement and other improvements hereinafter described.

The discharge ports as at 15 through hearth No. 3, which separates the drying and burning zones, are accompanied by ore luting means or other suitable known means, for preventing the passage of gases through these ports between these zones. Such luting means may for example comprise a shelf as at 16, for supporting a pile of ore beneath the discharge port, and scrapers as at 17, adjustably mounted by clamps 17' on rabble arms, for periodically dislodging predetermined amounts of ore from such shelves onto hearth No. 4. The gas ports, as at 18, in hearth No. 11 which separates the burning and cooling zones, may similarly be provided with ore luting means as shown.

The ore may be introduced onto the top drying hearth 1, through an inlet as at 19, of a suitable known type, which will prevent the discharge of any substantial amount of gas at this point. Air which has passed through the upper zone may be discharged from the furnace, through a dust collector, as by a suction blower 20 connected through the top of the furnace as shown. The collected dust may be added to the intake ore.

The rabble arms as at 21, carried by the central shaft and cooperating with the upper hearth 1, may be of any suitable known type and need not be provided with internal cooling means. The rabble arms as at 22 cooperating with hearths Nos. 2 and 3, are preferably of a hollow type provided with apertures as at 23 for discharging heated air along the trailing faces of the arms onto the ore. Two of such arms may be provided at hearth No. 2 while preferably a larger number, for example four arms, are provided at hearth No. 3 for more rapidly advancing the ore over this warmer hearth to insure that the ore will be discharged therefrom before mercury vapor is evolved and to insure that the discharge ports of hearth No. 3 are kept filled. The inner ends of the rabble arms may as shown be secured in a suitable well-known way to internal shaft sections as at 24, 25. The internal shaft section 25 is provided with a barrier 26, so that air which is to be discharged from openings 23 will be that which passes up through annular space 27 between the inner and outer shaft sections. This air will have been preheated by passing through the cooling conduits of the rabbling structure of the burning zone. Thus, the heat value of this air is economically used to aid in raising the temperature in the drying zone. It is noted that between the internal shaft sections 24 and 25, a gap is provided enabling this preheated air to readily enter the inner ends of all of the rabble arms 22. If any excess air is available in the rabbling structure beyond what is desired to be discharged in the furnace, such excess may be discharged as through a butterfly valve 28 at the top of shaft 14.

For securing the desired roasting temperatures within the burning zone, a number of oil, gas or other fuel burners as at 30, of suitable known form may be provided, for example at hearths Nos. 6 to 9 inclusive. Considerable air for combustion purposes may be introduced at the burners. Further air may be introduced for example through one or more air intake ports as at 31 extending through the furnace wall at the lower part of the burning zone. These air intake ports may be provided with adjustable sliding covers as at 32. Additional air may also be introduced to the burning zone through apertures in rabble arms 33 at the lower two hearths Nos. 10 and 11 of the burning zone. That is, the rabble arms 33 may be of the same construction as the arms 22 above described. The air introduced through intake ports 31 and rabble arm apertures, at hearths Nos. 9 and 10 may ordinarily constitute about 75% of the air required for combustion purposes in the burning zone.

The cooling air for the rabbling structure may be introduced to the central shaft of the furnace in a well-known way as through an inlet 34 at the base of central shaft section 35 beneath the furnace. From the shaft section 35 this air may be conducted up into other inner shaft sections 36, 37, gaps being provided above and below the section 36 permitting the cooling air also to enter the annular space between the inner and outer shaft sections at the lower part of the furnace. At about hearth 9 this annular space may be blocked off by a barrier 38, so that the cooling air which is to pass through the rabbling structure at burning hearths 4 to 9 inclusive, has to pass through inner shaft section 37, from which it is distributed through inner rabble arm conduits as at 40 to the various rabble arms at these hearths. That is, at hearths 4 to 9, inclusive, the rabble arms may be of the well-known air cooled type with which the cooling air from the inner shaft is conducted through inner rabble arm conduits to the outer ends of the rabble arms and thence back through annular spaces in the rabble arms to the annular space as at 41 inside shaft 14. At this stage the air will be considerably heated and it is this preheated air which is discharged through the apertures 23 in rabble arms 22 at the drying hearths.

The gases of combustion, any excess air, and mercury vapor may be discharged from the burning zone through an outlet as at 42 above hearth 4, which as indicated may be connected through a dust collector to a condenser for recovering the mercury.

The hot calcines passing through the discharge ports in hearth 11 to the cooling zone may be cooled in several ways. For example, cooling air may be introduced just above the bottom hearth, as through several air intake ports as at 43 similar to the air inlets 31 above referred to. Also the rabble arms 44 at the two cooling hearths may be of the same construction as the arms 22 and 33 above described, and therefore serve to discharge cold air from the bottom of the central shaft, from the trailing faces of these rabble arms, onto all of the hot calcines. Furthermore, if desired, the bottom hearth 13 comprising the bottom of the furnace, may be formed hollow and of metal as shown, and with inlet and outlet connections for circulating cooling water. The calcines may be finally discharged from hearth 13 through an outlet port 45 onto a conveyor of a suitable standard belt type 46 running to a dump. Some cooling air if desired may also be introduced through this outlet. In these various ways, sufficient cooling air and cooling effect may be applied to the calcines so that they may be

safely discharged onto the conveyor belt, even if of fabric or rubber, without injury to the latter.

The cooling air after becoming heated by passing over the cooling hearths may be conducted through a plurality of conduits, one of which is shown at 50 running up along the furnace wall inside the furnace outer shell, to the top of the furnace, and connected through suitably dampered openings as at 51 and 52 to the space over preheating hearths 2 and 3 as shown. For example, four or more conduits as at 50 may be provided at spaced positions around the walls of the furnace. Thus all of the air which has been heated in cooling the calcines, may be conducted up into the drying and preheating zone, thereby efficiently transferring heat from the hot calcines to the incoming ore. At the same time this expedient makes it possible to both preheat the ore and cool the calcines with streams of air which are kept apart from the mercury vapor, thereby permitting considerably greater concentration of mercury vapor largely free of water vapor, in the gases passing out to the condenser through outlet 42. This reduction in gas volume, and avoidance of moisture, running to the condenser, materially reduces the burden on the condensing system used for precipitation of the mercury. A substantially smaller condensing system per ton day plant capacity will be required, as compared with furnaces of the various types heretofore in use for mercury recovery. A number of factors contribute to this result. First, the avoidance of moisture makes possible a very rapid temperature fall in the condenser, since the condenser does not have to absorb the latent heat of vaporization of any substantial amount of water. Also the efficiency of the condenser system in terms of percent of total mercury precipitated is related to the degree of concentration of the mercury in the gases. The higher the concentration the greater the efficiency. And since a furnace arranged as above described will have an abnormally small exit gas volume, it follows that the concentration of the mercury in the furnace outlet gases will be higher and the efficiency with which the same may be condensed will be greater.

In order to provide adjustment of the air discharge apertures in rabble arms 22, 33 and 44, a construction may be used such as shown in Figs. 2 and 3, wherein the hollow rabble arms are indicated at 22 with the discharge ports at 23. An angle strip 60 extends along the arm and is formed with depending areas 61 for adjustably covering each port, these areas alternating with cut-out areas 62. At spaced points the strip may be formed with slots as at 63 for slidably receiving retaining bolts as at 64.

In operating the furnace, the burners and air inlets are preferably so adjusted that the ore upon discharge from the drying and preheating zone will be heated substantially, but not in excess of about 300° F. in case cinnabar ore is being treated. At such a temperature the ore will not be dissociated, and hence formation of mercury vapor in the upper zone will be avoided. With a typical example of mercury ore, the moisture content averages around 12%. With the invention, by utilizing the heat which would otherwise be wasted, from the rabbling structure and from the hot calcines, such ore may be dried in the upper zone to a moisture content of around 3%, with a consequent considerable saving of fuel consumption in the burning zone, as well as greatly reducing the moisture content of the mercury vapor. The invention in fact makes possible a fuel saving of some 40% in typical installations, as compared with the amount which would be required if all of the gases and vapors were free to flow up through the furnace to an outlet at the top.

At the various succeeding lower hearths in the burning zone, the temperature of the ore may be made higher until at about hearth No. 9 it reaches for example 1400°. Thereafter the ore and calcine temperature decreases for example to about 1000° F. on hearth 11. Thus it will be apparent that the air introduced through ports 31 and through the apertures in rabble arms 33 will serve to initiate the step of cooling the ore while concurrently allowing the ore to remain in this zone for a sufficient length of time to permit the mercury vapor to escape therefrom during continued rabbling. At the same time the air thus introduced at the bottom of the burning zone will be materially raised in temperature before it arrives at the higher temperature hearths where most of the fuel combustion takes place.

Under normal conditions the calcines may be cooled in the cooling zone to a temperature of about 300–500° F., depending upon the rate of feed and the air transferred. When the temperature of the discharge calcines tends to be too high, either the hearth 13 as above described may be water cooled, or water may be sprayed upon the calcines at the outlet before the same fall onto the conveyor belt. By either method the calcine rock falling on the conveyor may be kept at or below a safe temperature of 350° F.

The temperature of the cooling air after passing through the rabbling structure at hearths 4 to 9 may ordinarily be raised to about 375° F. This when mixed with air coming up through the ducts 50 at a temperature of about 250°, will supply sufficient heat in the drying zone without resorting to the burning of any fuel at that zone, and at the same time avoiding any danger of excess preheating of the ore in this zone. The drying will be quite thorough so that a surprisingly small amount of moisture will be present in the gases exhausted from the burning zone. In fact, the moisture passing out through conduit 42 will be largely confined to water of crystallization and moisture resulting from combustion of fuel oil. Hence the temperature fall through the condenser system may be made extremely rapid, and the final stack temperatures will be lower than otherwise obtainable with furnaces in the quicksilver industry, except with the use of water jacketed condensers, which are uneconomical at the hot, dry locations of many quicksilver mines. By using the features of this invention, it has been found possible to limit the mercury losses in the final stack gases to as low as one-half of one percent. Hence under prevailing conditions ores, including material bearing as little as 2 lbs. of mercury per ton, may be economically treated.

While the invention has been described in detail with respect to a particular preferred example, it will be understood by those skilled in the art after understanding the invention that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended therefore in the appended claims to cover all such changes and modifications.

What is claimed as new and desired to be secured by Letters Patent is:

1. Method for treating mercury ores to recover mercury therefrom which comprises, passing the

ore successively over a plurality of enclosed superposed hearths, including an upper enclosed hearth or hearths forming a drying and preheating zone, an intermediate plurality of hearths forming a burning zone, and a lower hearth or hearths forming a cooling zone, maintaining separation between said zones against the direct passage of gases between adjacent zones, applying to the ore in the upper zone, streams of heated air to substantially preheat the ore but to temperatures insufficient to expel mercury vapor, the time and temperature of the treatment in the upper zone being sufficient to drive off most of the free moisture from the ore, roasting the ore by burning sufficient fuel in the burning zone to expel the mercury vapor therefrom, discharging said vapor from the burning zone independently of gases from the other zones and conducting such vapor through a condenser, applying cooling air to the ore in the cooling zone and conducting the latter air after being heated in the cooling zone, into contact with the ore in the upper zone to provide said streams of heated air therein.

2. Method for treating mercury ores to expel mercury vapor therefrom, which comprises passing the ore successively over a plurality of enclosed superposed hearths by the use of rabbling means cooled internally by air, said hearths including an upper hearth or hearths forming a drying and preheating zone, an intermediate plurality of hearths forming a burning zone, and a lower hearth or hearths forming a cooling zone, maintaining separation between said zones against the direct passage of gases between adjacent zones, applying to the ore in the upper zone, streams of heated air to dry and substantially preheat the ore but to temperatures insufficient to expel mercury vapor, roasting the ore by burning sufficient fuel in the burning zone to expel the mercury vapor therefrom, discharging said vapor from the burning zone independently of gases from the other zones, applying cooling air to the ore in the cooling zone, conducting the latter air after being heated in the cooling zone, into the upper zone to provide said heated air therein, discharging some cool air from said rabbling means into said cooling zone, some into said burning zone, and most of the remainder into the upper zone after being heated by passing through the rabbling means of the burning zone.

3. A furnace for roasting mercury ores to expel mercury vapor, comprising a plurality of superposed hearths, rabbling structure for advancing the ore over each hearth and from hearth to hearth down through the furnace, said hearths including an upper hearth or hearths forming a drying and preheating zone, an intermediate plurality of hearths forming a burning zone, and a lower hearth or hearths forming a cooling zone, means separating said zones against the direct passage of gases between adjacent zones, said rabbling structure being constructed and arranged with internal cooling air conduits and outlets for discharging some cool air into said cooling zone, some air into said burning zone, and most of the remaining air from the rabbling structure into the upper zone after being heated by passage through the burning zone rabbling structure, and conduit means for conducting air which has been heated by passage through the cooling zone, into said upper zone.

4. A furnace for roasting mercury ores to expel mercury vapor, comprising a plurality of superposed hearths, rabbling structure for advancing the ore over each hearth and from hearth to hearth down through the furnace, said hearths including an upper hearth or hearths forming a drying and preheating zone, an intermediate plurality of hearths forming a burning zone, and a lower hearth or hearths forming a cooling zone, means separating said zones against the direct passage of gases between adjacent zones, said rabbling structure in the burning zone being constructed and arranged with internal cooling air conduits, said structure in the upper zone being formed with apertures for discharging such cooling air into the upper zone after being heated by passage through the burning zone rabbling structure, and conduit means for conducting air which has been heated by passage through the cooling zone, into said upper zone.

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