United States Patent

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[15] **3,658,309**

[45] **Apr. 25, 1972**

[54] TEMPERATURE CONTROL OF ORE IN MULTIPLE HEARTH FURNACE

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[22] Filed: **Aug. 3, 1970**

[21] Appl. No.: **60,668**

[52] **U.S. Cl.** **266/20,** 73/343, 263/26

[51] **Int. Cl.** **F27b 21/00**

[58] **Field of Search** 266/20; 73/343; 263/26

[56] **References Cited**

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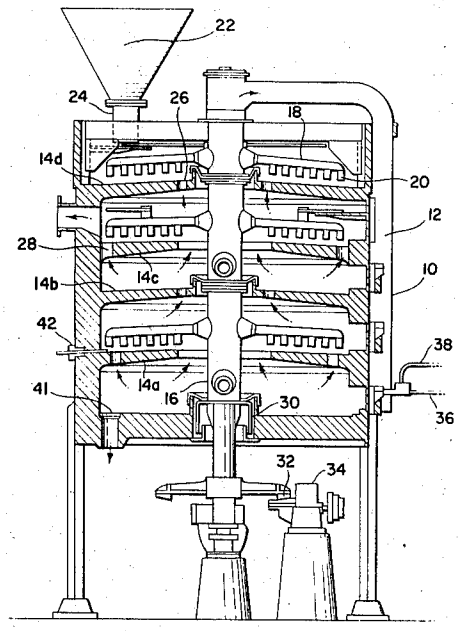
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[57] **ABSTRACT**

The temperature of ore on the hearth of a multiple hearth furnace is continuously monitored by means of a thermometer positioned in the undisturbed dead bed of the ore beneath the live bed which is being continuously raked. The temperature readings are used to control the roasting temperature in the live bed within a preselected range.

6 Claims, 2 Drawing Figures



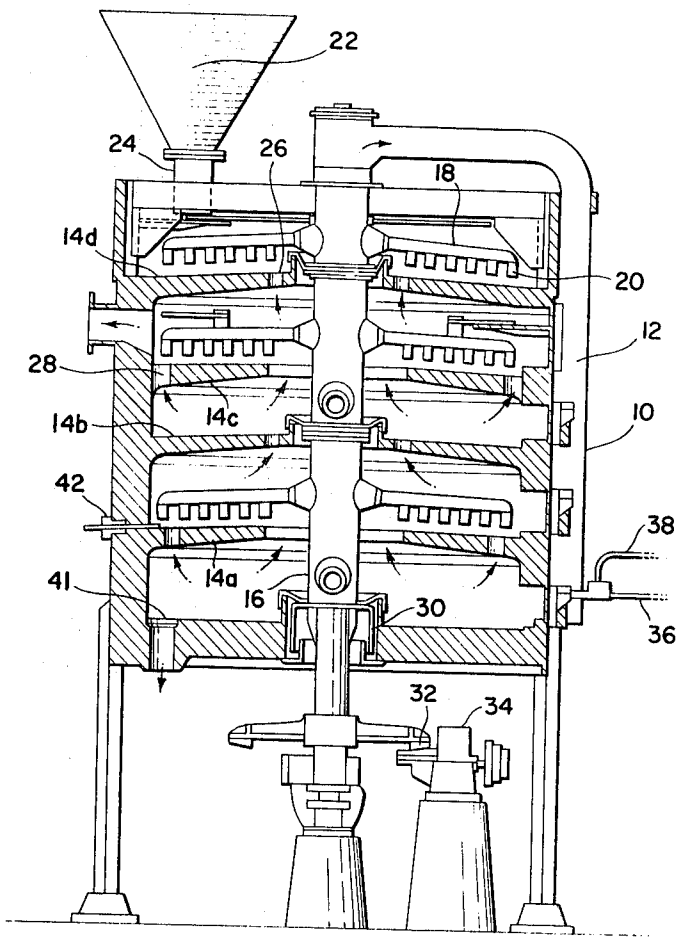


FIG. 1

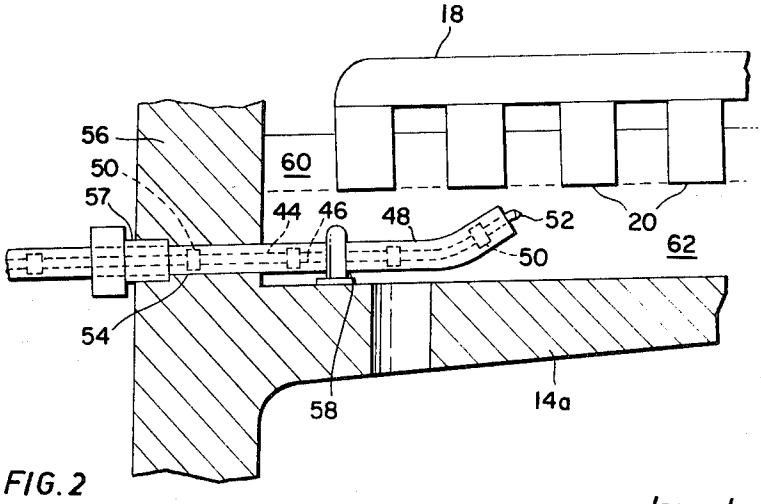


FIG. 2

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TEMPERATURE CONTROL OF ORE IN MULTIPLE HEARTH FURNACE

This invention relates to a method and apparatus for measuring ore temperature and more particularly to a method and apparatus for measuring the temperature of an ore disposed upon a hearth in a multiple hearth furnace.

Ores which are treated by hydrometallurgical or pyrometallurgical processes for the extraction of valuable metals are frequently subjected to a preliminary roasting operation in order to increase the amenability of the ores to the subsequent processes. The ores may be roasted to reduce certain or all metal values, to oxidize metal values or to adjust the moisture content. Roasting is commonly carried out in a multiple hearth furnace such as a Herreshoff furnace which consists of a series of superimposed circular hearths. A central rotating shaft turns rabble arms that extend out across the hearths. The rabbles are set at angles that work the ore outward or inward on alternate hearths, turning the ore over to bring new surfaces in contact with gas moving up through the furnace. The ore is fed into the top of the furnace and falls to the first hearth where it is moved inward and falls through a drop hole at the center of the hearth to the hearth below where it is moved outward to a drop hole near the perimeter of the hearth, inward on the next hearth and so on down. As the ore passes downward, it is heated by rising hot gases.

The ore on the hearths is heated by the rising hot gases evolved from the combustion of fuel used to fire the furnace. The temperature of the ore is controlled by regulating the quantity of fuel used or by regulating the flow of air into the furnace at the lower hearth levels.

It is essential that the temperature of the ore on the hearths be maintained within a preselected range to ensure satisfactory roasting. The temperature range will of course be dependent on the nature of the ore, its grain size, the metallurgical process which follows the roasting operation and other factors. For example, if 1 mm pyrrhotite grains are subjected to an oxidizing roast, the temperature of the grains must be sufficient to ignite the grains, generally 430° C. The temperature must however be below the fusing point of the pyrrhotite. Lateritic ores which are subjected to a preliminary reduction roast before being subjected to a conventional leaching operation in an aqueous ammoniacal ammonium carbonate solution also require close temperature control in the furnace. The temperature must be such that nickel and cobalt oxides in the ore reduce to a metallic state leachable in the carbonate solution with a minimum accompanying reduction of iron oxide in the ore to metallic iron and ferrous iron. If the grain size of the lateritic ore is substantially 100 percent minus 100 mesh standard Tyler screen, the temperature of the ore within the furnace should be maintained in the range of 500° to 750° C. and the temperature of the ore on each hearth within narrow predetermined limits, e.g., 575° ± 10° C. to bring about the desired reduction.

In order to maintain the temperature of the ore on the hearths within the desired range, means must be provided for determining the ore temperature. A number of methods for determining the ore temperature on a periodic basis are currently in use. One method involves measuring the temperature of the gas within the furnace. Such a measurement may be readily made but in most cases the gas temperature is significantly higher than the temperature of the ore on the hearths and the gas temperature can rarely be directly related to the temperature of the ore.

Another method involves the periodic taking of a sample of the ore and measuring the temperature of the sample. A cup is mounted in a drop hole through which the ore passes as the ore falls from one hearth to the hearth below. A sheathed thermocouple is mounted in the cup and the cup is connected to an elongated handle which projects through the wall of the furnace. The other end of the handle is outside the furnace and may be manually rotated in order to turn the cup from an upturned to a downturned position. Samples of ore falling through the drop hole in which the cup is positioned will be captured in the cup when the cup is in an upturned position. The temperature of the ore sample within the cup is measured by the thermocouple.

There are a number of problems associated with this method of measuring the temperature of the ore. When the cup is in a downturned position, its temperature will rise until it reaches the temperature of the gas to which it is exposed. As a sheathed thermocouple requires a minute or longer to arrive at a stabilized temperature, the stabilized temperature will be the same as or very close to the temperature of the gas. When the cup is turned over and a sample of ore falls into the cup, the temperature of the thermocouple will begin to drop because the ore is cooler than the gas. However, by the time the temperature reading approaches the temperature of the ore, the temperature of the ore sample will be about the same as the temperature of the gas because the sample is heat conductive and is surrounded by the hot gas. Thus the temperature at the thermocouple begins to rise again and will stabilize at the gas temperature. This method is therefore unsatisfactory for accurately measuring the temperature of the ore within the furnace.

It is accordingly an object of the present invention to provide a method and apparatus for determining accurately the temperature of ore on the hearths of a multiple hearth furnace.

Another object is to provide an economical and simple method and apparatus which permits the continuous monitoring of the temperature of ore on the hearths of a multiple hearth furnace.

Broadly, the present invention may be considered to involve an improvement in the method of heating an ore disposed on a hearth of a multi-hearth furnace wherein the temperature is controlled within a preselected range to effect roasting of the ore, the ore being disposed in two beds having a common interface and comprising a lower dead bed and an upper live bed, the dead bed remaining relatively undisturbed and the upper bed being continuously raked. The improvement in the method involves placing a thermometer in the dead bed and utilizing the temperature determination to control the roasting temperature of the ore in the live bed within the preselected temperature range.

According to an alternative aspect, the invention is for use in a furnace having a hearth disposed within the furnace for supporting an ore; a rabble arm disposed immediately above the hearth having a plurality of downwardly extending teeth for raking the ore. The apparatus of the invention comprises a thermometer having a temperature detecting element and connected to the hearth such that the detecting element is disposed above the hearth but beneath the teeth of the rabble arm.

The ore on the hearths of a multiple hearth furnace is divided into two beds, an upper 'live' bed and a lower 'dead' bed. The live bed is raked by means of rotating rabble teeth and is constantly in motion. The lower dead bed lies beneath the lowermost edges of the rabble teeth and remains relatively undisturbed. Ore from the live beds forms the bulk of the furnace discharge; insignificant amounts of charge from the dead beds are discharged from the furnace. Accordingly, the roasting temperature of the charge in the live beds must be controlled. It is however impractical to insert a temperature measuring device into the live bed because the device would be struck by a rabble tooth and rendered inoperative.

It has hitherto been believed that the temperatures of the charge forming the live and dead beds were very different. The live bed was being constantly turned over by the rabble teeth in order to expose all particles to the hot furnace gases whereas the particles of the dead bed remained stationary and out of contact with the gases. It was therefore believed that the temperature of the live bed was much different than the temperature of the dead bed. It has been discovered however that the temperature of the live and dead beds of most furnace ores are much the same. Metalliferous ores which are moderately to highly heat conductive form into live and dead beds of

much the same temperature in a multiple hearth furnace. Nickeliferous sulphide and oxide ores including garnieritic and sepentinic laterites are examples of such metalliferous ores. Non-metallic ores such as coal and calcium carbonate are also moderately to highly heat conductive and temperatures in the live and dead beds of such ores in a multiple hearth furnace are very similar.

Accordingly, the temperature of the live bed of an ore within a multiple hearth furnace can in most cases be obtained by measuring the temperature of the dead bed. Since the ore particles in the dead bed remain stationary, their temperature can be readily measured by means of conventional temperature measuring devices such as a thermocouple, dial thermometer, and resistance bulb.

A fuller understanding of the invention may be had by referring to the following description of a preferred embodiment of the present invention taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a view of a Herreshoff furnace and thermometer according to the invention partly in section and

FIG. 2 shows the thermometer in the furnace.

Like reference characters refer to like parts throughout the description of the drawing.

The furnace illustrated in FIG. 1 is a so-called multi-hearth furnace which consists of a cylindrical metal shell **10** that supports arches of firebrick **12** decked one above the other. A plurality of circular hearths **14***a*, *b*, *c*, and *d* are disposed in decks within the furnace. A vertical central rotating shaft **16** running through the center of the brick arches carries rabble arms **18** having a plurality of downwardly extending teeth **20**. The rabble arms are disposed above the hearths and the teeth attached thereto serve to take the furnace charge across the hearth upon rotation of shaft **16**.

A hopper **22** is secured to the furnace at the top. Charge to the furnace is fed to the hopper and passes downwardly through drop hole **24** to the periphery of hearth **14***d*. The charge is raked inwardly along the hearth to drop hole **26** where it falls downwardly to hearth **14***c*. The ore is raked outwardly along the hearth and falls through drop hole **28** and so on down.

Shaft **16** is carried on a heavy bearing **30** and is rotated by a bevel gear **32** at the bottom, further reduction being obtained by a gear reduction unit **34**. The speed of rotation of shaft **16** is determined largely by the required retention time in the furnace or the depth of bed of ore on the hearths.

In order to maintain a uniform bed on each hearth **14**, it is necessary that the ore be closely sized, 1¼ inches being about the maximum suitable size.

Fuel such as oil is fed to the furnace through conduit **36** and air is fed through conduit **38**. As the ore travels downward from hearth to hearth, it is thoroughly stirred and exposed to the hot gases evolved during combustion of the fuel. The roasted calcine is discharged through exit port **41** in the bottom of the furnace.

Thermometer **42** is secured to hearth **14***a* and like thermometers are secured to the remaining hearths.

With reference to FIG. **2**, the illustrated thermometer is a thermocouple composed of two legs **44** and **46** of dissimilar metals. The legs are maintained in a fixed spaced relation with one another within tubing **48** by means of ceramic rings **50**. The free ends of the legs project from the end of tubing **48** and are joined at temperature sensing junction **52**. Tubing **48** projects through an aperture **54** formed in wall **56** of the furnace. The tubing is expanded and ferruled to the aperture wall at **57** in order to produce a seal between the tubing and the furnace wall.

Preferably tubing **48** is contoured to the shape of the upper surface of hearth **14***a* so that the tubing is in contact therewith. A U-bolt **58**, anchored in hearth **14***a*, serves to prevent the tubing from swinging to either side or upward upon expansion and contraction of the tubing with changes in temperature.

Rabble teeth **20** are arranged on arm **18** so that substantially every point on the surface of hearth **14***a* is passed over by a tooth. To prevent the teeth from damaging the upper surface of the hearth as the rabble arm rotates, the lower edges of the teeth are spaced apart from the hearth upper surface. Changes in temperature within the furnace will produce vertical expansion and contraction of shaft **16** and a corresponding movement of teeth **20** away from and toward hearth **14***a*, thus the teeth and hearth must be arranged such that the teeth, when at their closest point to the hearth, do not make contact with the hearth.

The ore upon hearth **14***a* is divided into two layers, an upper live bed **60** which is raked by teeth **20** and a lower dead bed **62** which is not disturbed by the teeth. The thickness of the dead bed will be the distance between the lower edges of the teeth and the upper surface of the hearth when the teeth are closest to the hearth. Usually the thickness of the dead bed **62** is about 2 to 5 inches.

In many cases, the temperature of the ore in the live and dead beds is uniform and therefore junction **52** may be located anywhere in the dead bed. In some cases however, the temperature is not constant in the two beds. The gases within the furnace greatly influence the temperature of the upper surface of the live bed but have much less effect on the temperature of the head bed and the temperature will vary from the upper surface of the live bed to the lower surface of the dead bed.

The most suitable location of junction **52** is directly beneath the interface between beds **60** and **62** where the junction is not damaged by the rabble teeth. The temperature measured at the junction will be close to if not the same as the temperature of the lower zone of the live bed.

The thermometer must be capable of withstanding temperatures of the dead bed. Where the dead bed is corrosive to the thermometer, protection in the form of sheathing is required. The thermometer may be a thermocouple comprising a platinum wire and a wire of some other refractory metal such as iridium or an alloy of platinum and iridium, rhodium or chromium. Preferably the thermocouple is composed of platinum and an alloy composed of 87 percent platinum and 13 percent rhodium. These metals are capable of standing up to highly corrosive reducing atmospheres for long periods of time without appreciable deterioration. The thermocouple may or may not be shielded. When the temperature of the charge is subject to rapid changes, an exposed thermocouple is preferred since it is capable of reaching equilibrium at a new temperature more quickly than a shielded thermocouple.

The tubing may be constructed of stainless steel or other material which is not corroded by the furnace charge.

The improved roasting method of the present invention is especially applicable to lateritic ores. In order to reduce the nickel and cobalt oxides in the lateritic ore to metallic state with a minimum accompanying reduction of iron oxide to metallic iron and ferrous iron, the ore is roasted in the presence of reducing gases such as hydrogen or carbon monoxide or mixtures thereof. The temperature of the ore in the live beds within the furnace is continuously monitored by means of thermometers positioned in the dead beds. The temperature of the live bed on the hearth is maintained within narrow predetermined limits by regulating the quantity of fuel fed to the furnace or by regulating the flow of air into the furnace.

I claim:

1. In the method of heating an ore disposed on a hearth of a multi-hearth furnace wherein the temperature is controlled within a preselected range to effect roasting of said ore, said ore being disposed in two beds having a common interface and comprising a lower dead bed and an upper live bed, said dead bed remaining relatively undisturbed and said upper bed being continuously raked, the improved procedure for continuously determining the temperature of the ore in said live bed characterized in that a thermometer is placed in the dead bed and said temperature determination is utilized to control the roasting temperature of the ore in said live bed within said preselected temperature range.

2. The method as claimed in claim **1** wherein said thermometer is placed in the dead bed adjacent said interface.

3. The method as claimed in claims 1 or 2 wherein said ore is a lateritic ore.

4. In a furnace having a hearth disposed within said furnace for supporting an ore, a rabble arm disposed immediately above said hearth having a plurality of downwardly extending teeth for raking said ore the improvement comprising: a thermometer having a temperature detecting element and being connected to said hearth such that said detecting element is disposed above said hearth but beneath the teeth of said rabble arm.

5. In a furnace having a hearth disposed within said furnace for supporting an ore, a rabble arm disposed immediately above said hearth having a plurality of downwardly extending teeth for raking said ore, said ore when supported by said hearth being disposed in two beds, a lower dead bed and an upper live bed, said beds having a common interface and being at substantially the same temperature, said dead bed remaining relatively undisturbed and said live bed being raked by means of said teeth, the improvement comprising a thermometer having a temperature sensing element, said sensing element being maintained within said dead bed adjacent said interface.

6. The combination as claimed in claim 5 wherein said thermometer is a thermocouple composed of two dissimilar metals, one said metal being platinum and the other said metal being an alloy composed of about 87 percent platinum and the balance rhodium.

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