Jan. 29, 1935. P. E. BILLINGHURST 1,989,072

APPARATUS FOR TREATING ORES

Original Filed April 2, 1932

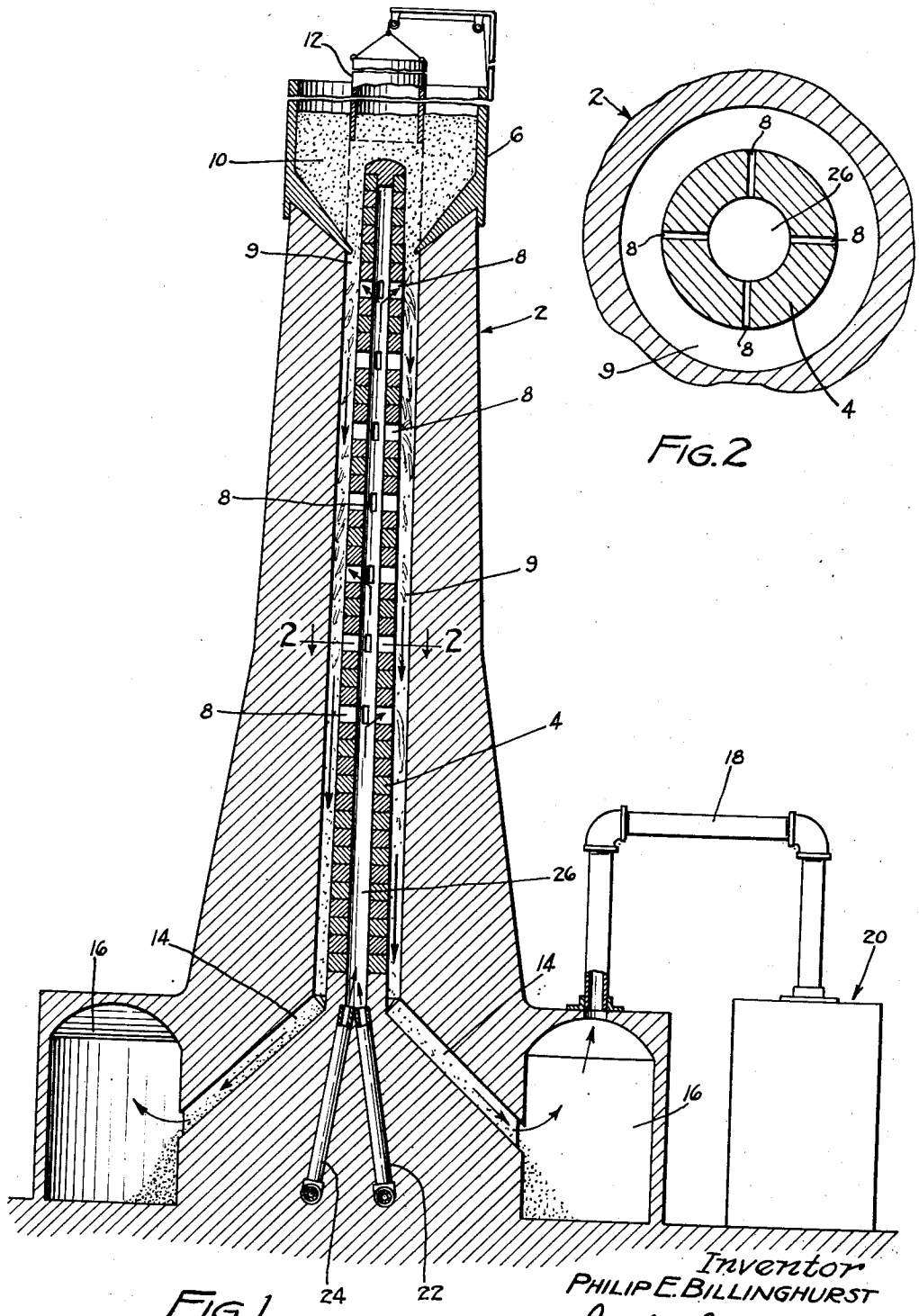

FIG. 1

FIG. 2

Inventor
PHILIP E. BILLINGHURST
By Paul, Paul & Moore
ATTORNEYS

Patented Jan. 29, 1935 1,989,072

UNITED STATES PATENT OFFICE

1,989,072

APPARATUS FOR TREATING ORES

Philip E. Billinghurst, Winnipeg, Manitoba, Canada

Original application April 2, 1932, Serial No. 602,741. Divided and this application June 29, 1933, Serial No. 678,142

5 Claims. (Cl. 266—17)

This application is divisional of my application Serial No. 602,741, filed April 2, 1932, and further relates to apparatus as described in my application Serial No. 602,742, filed April 2, 1932.

This invention relates to apparatus for the treatment of natural ores and rocks, and more particularly for the treatment of natural ores and rocks having silica and/or alumina in relatively large proportion.

It is a general purpose of the invention to provide apparatus which is applicable for use in readily and economically treating such silica and/or alumina bearing rocks or ores to produce fertilizers comprising nitrogen compounds of aluminum and/or silicon.

Another purpose of the invention is the provision of a novel apparatus for heat treating any natural rocks or ores containing alkali metals or their compounds, for the purpose of concentrating the same. Such ores consist principally of silica and/or alumina in admixture with alkali metals such as lithium, potassium, sodium, lepidolite, caesium, and their compounds. Among the better known ores of this type are those known as potash feldspars, microline, lepidolite, spodumens, emblygonite, beryl, lithium and potassium bearing micas. In the process contemplated by this invention, the alkali metals and/or their compounds are driven off as volatiles and collected by means of suitable apparatus for that purpose.

A more specific purpose of the invention is the provision of an apparatus for readily and economically treating natural alkali silicates for the dual purpose of concentrating alkali metals and/or their compounds which they contain, and simultaneously forming nitrogen compounds of aluminum and silicon.

In accordance with my invention, the natural ores or rocks to be treated are ground or pulverized to particles of relatively small size, i. e. approximately 150 to 200 mesh, and are dispersed in a highly heated chamber. Preferably the particles are allowed to drop through a highly heated furnace or reaction chamber which is elongated and of limited cross-section so that it may be maintained at a very high temperature, i. e. from approximately 1600° C. to 1900° C. or above. When these fine particles of ore are dispersed in the highly heated chamber, they readily give off their volatiles and may be made to react with other substances which may be introduced in the chamber.

When carrying out my process for the purpose of treating natural ores containing alkali metals and/or their compounds in order to concentrate the same, the chamber of the furnace in which the ore particles are dispersed is maintained at such a temperature that the alkali metals and/or their compounds will become volatile although the greater part of the ore remains in the solid or liquid state. In practice, the volatiles containing the alkali metals and their compounds are led off from the furnace and collected by means of suitable apparatus, and represent a product very rich in the alkali metals and alkali metal compounds contained in the natural ore. This concentrated product, while containing substantially all of the alkali metals and their compounds which were present in the starting material, weighs in most instances from about 5% to 15% of the natural ore, depending upon the richness of such ore in the alkali metals. It will thus be seen that the process provides a simple and effective way of concentrating ores containing alkali metals, and that the process may be employed very advantageously if it is desired or necessary to ship the ores for any appreciable distances for purposes of refining. The cost of shipping the concentrated product is greatly reduced. Moreover, the alkali metals can be recovered in commercial form from the concentrated product much more cheaply than they could be recovered directly from the natural ores by means of the usual processes.

The following is a typical example illustrating the carrying out of the process for the sole purpose of concentrating ore containing alkali metals:

Potash bearing feldspars such as microline were pulverized to a fineness of approximately from 150 to 200 mesh and dropped through a furnace chamber containing substantially only heated air at a temperature of approximately 1600 degrees C. The suspended particles gave off vapors which were led off from the furnace chamber and were found, upon condensation, to be very rich in potassium. They consisted principally of K_2O. The remainder of the ore dropped down to the bottom of the furnace where it was collected in molten form. This molten material, which consists principally of alumina and/or silica, was cast into bricks or blocks which were found to possess very good insulating qualities to be highly useful in building construction.

In my process for treating natural ores bearing silica and alumina in order to obtain fertilizer, I finely divide the ores, i. e. into particles from 150 to 200 mesh, and subject the particles to temperatures of from about 1700 degrees C. to 1900 de-

grees C. Instead of dispersing the particles in a medium consisting solely or principally of atmospheric air, however, I heat the particles in a medium containing nitrogen and some reducing agent. A good source of nitrogen is atmospheric air, and carbon monoxide serves as an efficient reducing gas. The reducing agent may be generated and admitted into the furnace chamber in the form of a gas, or, if desired, materials which will form a reducing gas in the course of the reaction may be mixed with the charge. For example, it is possible to mix carbon with the charge of ore to be treated. Any desired means for maintaining a reducing agent present may be utilized.

At temperatures of from 1700 degrees C. to 1900 degrees C., I have found that the oxygen in the silica (SiO_2) and alumina (Al_2O_3) leaves these compounds and unites with the carbon monoxide to form carbon dioxide, whereupon it is replaced by the nitrogen present with the result that nitrides of silicon (Si_2N_3) and aluminum (AlN) are formed and fall down as a white powder to be collected at the bottom of the heated furnace chamber. The above reaction results because of the fact that the affinity of nitrogen for silicon and aluminum rapidly increases with temperature.

It will be seen that the process lends itself readily to the treatment of natural alkali metal containing ores, for the dual purpose of concentrating the alkali metals and/or their compounds, and producing nitrides of silicon and aluminum which are extremely valuable fertilizers. Ores to be so treated are also finely divided and then suspended in a gaseous mixture of nitrogen or some mixture containing it as for instance air, together with a reducing gas, which mixture is maintained at a temperature sufficiently high to volatilize the alkali metals and their compounds and to further cause the oxygen in the alumina and silica to be replaced by the nitrogen present, as previously explained. The volatiles are led off from the furnace chamber and condensed, the condensate representing a concentrate of the alkali metals and their compounds. The nitrides of silicon and/or aluminum fall as a white powder to the bottom of the furnace where they are collected.

The following example will illustrate the carrying out of a process in which fertilizer is produced and in which alkali metal compound is concentrated.

Lepidolite ore was ground into fine particles having a size of from 150 to 200 mesh and dropped into a furnace chamber containing carbon monoxide and atmospheric air, and maintained at a temperature of from 1700 degrees C. to 1900 degrees. In the course of the resulting reaction the particles of the charge are broken down into lithium vapor, potassium vapor, alumina, silica, and fluorine, to produce lithium fluoride, potassium fluoride, lithium oxide, and potassium oxide. These compounds remain in the gaseous or vapor state and are led off from the furnace chamber and collected in suitable condensing apparatus. The collected product so obtained represents the concentrate which is very rich in the alkali metals and which represents only a very small fraction of the original natural ore.

Under the high temperature conditions prevailing during the reaction, the oxygen of the alumina and silica leaves these compounds and combines with the carbon monoxide to form carbon dioxide. Nitrogen in the air replaces the oxygen, combines with the aluminum and silicon to produce aluminum nitride and silicon nitride. These nitrides fall to the bottom of the furnace as a white powder.

The drawing illustrates one form of suitable apparatus for carrying out any of the processes described above, although it will be obvious to those skilled in the art that many modifications of the apparatus may be made for various working conditions.

Figure 1 shows a cross-section of the apparatus; and

Figure 2 is a transverse cross-section along line 2—2 of Figure 1.

Referring more particularly to the drawing, numeral 2 designates generally a tower which is formed of magnesium oxide fire-brick or other suitable insulating material. The tower is provided with a vertical central bore in which there is located a burner 4 which is also formed of similar fire-brick. The burner 4 extends from the base of the tower to a point adjacent the top thereof and into a charging hopper 6 which is formed at the top of the tower. Burner 4 is provided with a plurality of vertically spaced openings 8 communicating with the central bore of the tower. These openings cease at a point below the bottom of the charging hopper 6 and it will be observed that that portion of burner 4 which extends into the charging hopper 6 is completely closed. The outlet opening of the charging hopper 6 is round and is adapted to discharge the particles of finely divided ore 10 into the annular space 9 of restricted cross-section between the central burner 4 and the inner surfaces of the walls of the tower 2. Any suitable means may be provided for controlling the flow of ore particles from the hopper 6 into the aforementioned annular space 9. As here shown there is provided a cylindrical cut-off member 12 which cooperates with the lower wall of the hopper to regulate the flow of the charge, or if desired, cut off the same completely. The member 12 may be remotely controlled by means of a cable passing over suitable pulleys as shown.

The lower portion of the annular passageway 9 communicates with a series of radially disposed passageways 14 which lead to a sealed, annular chamber 16. A conduit 18 leads volatiles from the chamber 16 to a condenser generally designated at 20. The conduits 22 and 24 supply a combustible and oxygen, respectively, to the central bore 26 of the burner 4.

When the device is in operation, oxygen enters the burner through the pipe 22 and some combustible such as carbon monoxide enters the burner through pipe 24. Combustion takes place as the gases ascend in the bore 26. A part of the gases escapes through the lower holes or openings 8 whereas the remainder of the gases continues upwardly within the bore 26 and escapes through upper openings 8. As the gases leave the openings 8 they pass downwardly as shown by the arrows and continue in the annular passageway 9 to the radially disposed passages 14 which lead to the annular chamber 16. The conduit 18 conveys the gases to condenser 20. It will be observed that the gases within the bore 26 serve to heat the entire passageway 9 and also the upper portion of the burner 4 which lies within the charging hopper 6, whereby the material 10 is somewhat pre-heated before it passes to the annular passageway 9.

Assuming that the apparatus is to be used for the purpose of concentrating an alkali metal containing ore, such ore is placed in the charging

hopper 6 and allowed to drop into the annular passageway 9 while the burner 4 is thoroughly heated by the hot gases ascending therein. The vapors resulting from the ensuing reaction are collected and passed to the condenser from which the concentrated ore is obtained. The remainder of the ore drops down to the bottom of passageway 9 and is collected from the chamber 16 in molten form.

If the apparatus is to be used for the treatment of silica or alumina bearing ore to produce fertilizer, nitrogen, as well as oxygen, is admitted into the apparatus through pipe 24, and an excess of carbon monoxide is admitted through the pipe 22. Consequently, the passageway 9 will contain a highly heated medium comprising both a reducing agent and nitrogen. In such a medium, the ore particles will react to form the fertilizing nitrogen compounds which drop downwardly in the form of a powder as previously explained. This powder is collected from the chamber 16. The volatiles are again collected from chamber 16 and led to the condenser 20 by means of conduit 18.

Having now described my invention, what I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. An apparatus for heat treating finely divided ores, comprising a tower formed of insulating material, a burner within said tower extending substantially along the length thereof to form therewith an annular passageway of restricted cross-section, means for introducing a combustible substance and oxygen to said burner, means for introducing a charge of ore at the top of said annular passageway so that the same may drop therein, and means for collecting volatiles and non-volatiles from the passageway, said burner being provided with a plurality of vertically spaced openings permitting passage of gases therein to said annular passageway.

2. An apparatus for heat treating finely divided ores, comprising a tower, a charging hopper located at the top of the tower, a burner within said tower extending longitudinally thereof and forming therewith an annular passageway of restricted cross-section, said burner having a portion thereof extending into said charging hopper for the purpose of preheating the material contained therein, means for introducing fluid combustible material and oxygen to said burner, means for regulating the passage of the charge from said charging hopper to said annular passageway, and means for collecting volatiles and non-volatiles from said passageway, said burner being provided with a plurality of vertically spaced openings permitting passage of gases therein to said annular passageway.

3. An apparatus for heat treating finely divided ores, including a tower having an elongated passageway of limited cross-section extending longitudinally thereof, an elongated burner extending longitudinally of said passageway for heating the same, means for supplying a combustible mixture to said burner, means for introducing a charge of finely divided ore at the top of the passageway so that the same may drop therethrough, means for introducing steam into said passageway, means for collecting volatiles from said passageway, and means for collecting non-volatiles therefrom, said burner being provided with vertically spaced openings providing passages from the interior thereof to said elongated passageway.

4. An apparatus for heat treating finely divided ores and the like, including a burner having an elongated passageway of limited cross section extending longitudinally thereof, an elongated burner adjacent to and extending longitudinally of said burner for heating the same and being provided with a plurality of vertically spaced openings constituting passages from the interior thereof to said passageway, means for supplying said burner with a combustible mixture, means for dropping a finely divided charge of ore through said passageway from the top thereof, and means for collecting reaction products from said passageway.

5. An apparatus as defined in claim 4 wherein there are means for removing the mixed reaction products of the combustible mixture and the ore from the bottom of said passageway.

PHILIP E. BILLINGHURST.