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B. G. COBB

METHOD OF VOLATILIZING AND OXIDIZING MINERALS

Original Filed April 6, 1921

Fig. 1

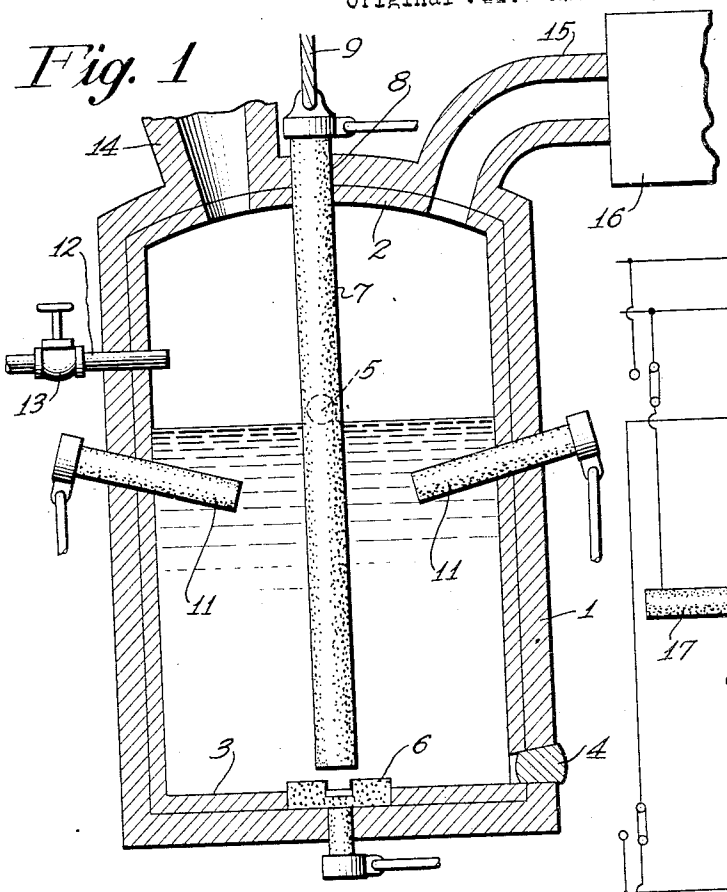


Fig. 3

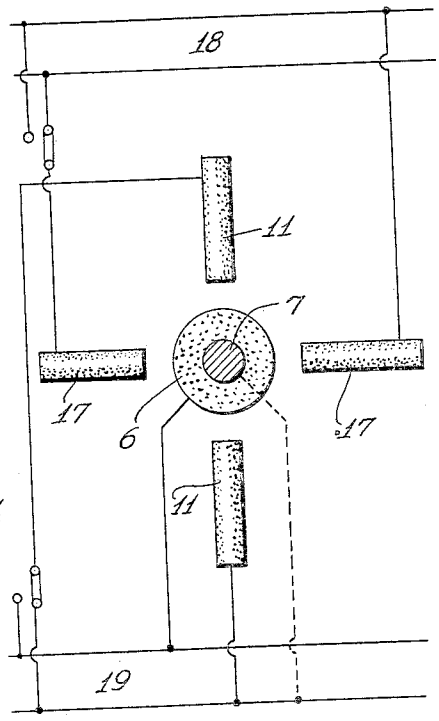
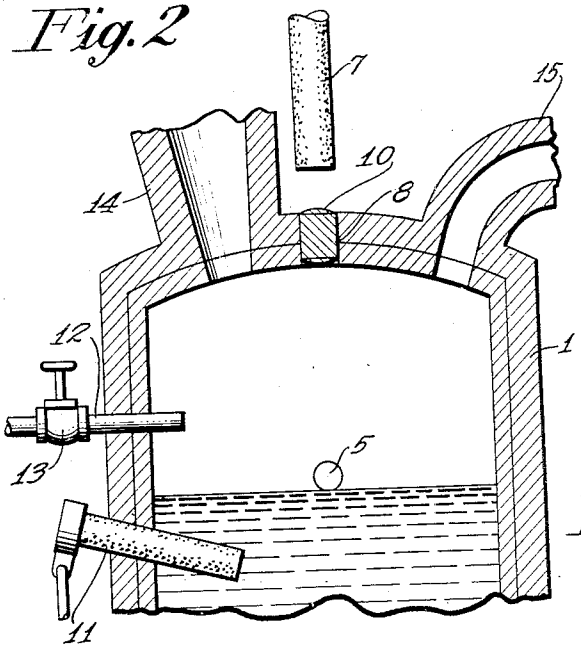


Fig. 2



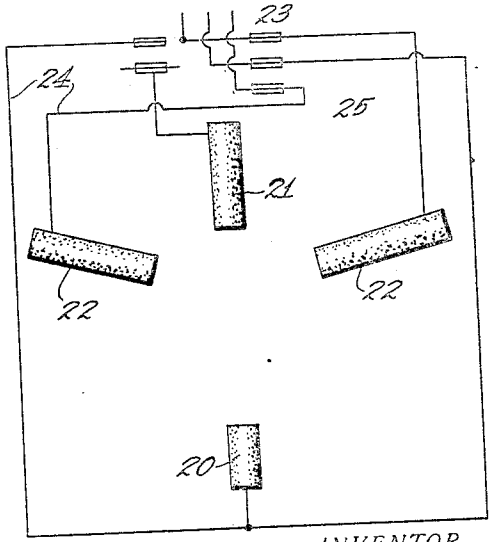


Fig. 4

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UNITED STATES PATENT OFFICE.

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METHOD OF VOLATILIZING AND OXIDIZING MINERALS.

Application filed April 6, 1921, Serial No. 458,960. Renewed March 1, 1927.

The invention relates to the concentration of ore by means of a thermo-electric apparatus, and has for its objects the method of volatilization of a mineral, capable of being volatilized, in an oxidizing atmosphere; to provide means for volatilizing the mineral in the absence of a draft or blast; to provide means for the admission of oxygen to the volatilizing zone; to provide means for preventing oxidation of the electrodes; to prevent the formation of objectionable gases in the oxidizing zone; to produce an apparatus in which the current consumption will be low; and to provide means for condensing the gases and recovering the mineral.

These and further objects will more fully appear in the following specification and accompanying drawings considered together or separately.

One embodiment of the invention is illustrated in the accompanying drawings in which like parts in all of the figures are designated by corresponding characters of reference, and in which

Fig. 1 is a sectional view of an electric furnace embodying the invention, the parts being in position to form the bath.

Fig. 2 is a similar view showing a portion of the apparatus, the parts being in position to receive the charge.

Fig. 3 is a diagrammatic plan view showing a modification, and

Fig. 4 is a diagrammatic view showing an arrangement for a three phase circuit.

A suitable apparatus for carrying out the process comprises a chamber or crucible 1 built of a material or materials capable of withstanding the high heat required to volatilize the material to be acted on, and to resist chemical action caused by the reactions taking place in the crucible.

The crucible is preferably provided with an arched roof 2 and a flat floor 3, and situated near the floor is a cinder monkey 4 and, if desired, a tap hole 5, normally closed, may be located at a point above the floor and below the roof.

Embedded in the floor, and preferably projecting slightly above the same is an electrode 6. This electrode may be a single block of conducting material, but preferably comprises a block having a plurality of protuberances which are symmetrically arranged and which are flush with or project slightly above the surface of the floor.

A movable electrode 7 extends downwardly through the roof 2 to within a short distance of the electrode 6 and in vertical alinement with the center of the same when a single electrode member 6 is employed, or in the center of the group when more than one is used. The electrode 7 is adapted to be moved vertically away from the electrode 6 and through an opening 8 in the roof 2 by any suitable means. The said electrode is, for convenience shown as suspended on a cable 9 by means of which it may be manipulated. When the electrode is removed from the apparatus the opening 8 is closed, as by means of a plug 10.

Extending through the side walls of the crucible at a suitable distance above the floor 3 is a plurality of electrodes 11 arranged in oppositely disposed pairs and projecting a considerable distance into the crucible. Each electrode 11 should preferably extend inward the same distance whereby their ends will be the same distance from the vertical center line of the celectrode 6, and the same distance above the same.

Projecting into the crucible above the slag monkey 4 and above the electrodes 11 is a nozzle 12 through which air may be admitted to the upper part of the crucible. The nozzle is provided with a cock 13 by means of which the air supply may be regulated. It is to be understood that if desired oxygen in any form, instead of atmospheric air may be admitted through the nozzle. It is also to be understood that instead of one any number of nozzles may be employed whereby air may, if desired, be distributed in desired quantities throughout the upper part of the crucible.

The crucible is provided with a charging shaft 14 by means of which the crucible may be charged, and with an outlet 15 by means of which gases generated in the apparatus may be conducted to a bag house or condenser 16 of any suitable and desired construction.

The electrical arrangement illustrated in Fig. 1 is adaptable to either direct current

or single phase. In using direct current the electrode 6 is the cathode and electrodes 7 and 11 are anodes.

In Fig. 3 is shown a modification in which a pair of supplemental electrodes 17 is employed in a separate circuit. The electrodes 17 are arranged at a greater distance from the electrode 6 than they are from each other whereby they will remain in the circuit 18 and not be influenced by the current in the circuit 19. It is to be understood that any number of pairs of electrodes 17 may be employed.

Fig. 4 illustrates a modification in which the process may be carried out with three phase current. Electrodes 20, 21 and 22 corresponding to the electrodes 6, 7 and 11 are arranged as in Fig. 1. A double throw switch 23 is employed in the line. One side of the switch is adapted to close two contacts in a circuit 24 which includes the electrodes 20 and 21. The other side of the switch is adapted to close a three phase circuit 25 which includes the electrodes 20 and 22.

The operation is as follows:

For convenience the operation herein described is carried out in the oxidation of molybdenite (MoS_2) the ore of molybdenum, which has been previously concentrated by gravity or otherwise and which has a relatively low percentage of gangue, but it is to be understood that the invention may be carried out with other minerals which are capable of volatilization and oxidation, such as zinc sulphide, lead sulphide, antimony sulphide, arsinides of various metals, for the recovery of arsenic, cobalt, etc., and instead of using a concentrate the ore in finely divided form may be used.

In starting the openings 4 and 5 are closed, and the bottom of the crucible is covered with a suitable flux. Such a flux may be composed of fluorspar, coke and old silica slag finely ground. The flux may be dropped through the charging shaft 14 until the floor and the electrode 6 are covered. The electrode 7 is lowered through the opening 8 and into the flux but not in contact with the electrode 6, and current sufficient to melt the flux, the resistance of which is high, is turned on and the flux is fused. Old silica slag, in finely divided form is now poured into the retort through the shaft and the electrode 7 is gradually raised as the slag is fused to form a bath. During the formation of the bath the carbon in the flux will pass out through the exit 15 in the form of carbon monoxide.

When the fused bath reaches the level of the opening 5, as indicated by a trial tap, and the electrodes 11 are submerged, the electrode 7 is removed through the opening 8 and the latter is closed, and a gentle current of air is admitted through the nozzle 12 into the zone above the surface of the bath. The bath is now kept molten by the passage of the current between the electrodes 6 and 11. The electrode 7 being removed, and the other electrodes being submerged in the bath there will be no carbon above the bath and the only oxygen above the bath will be the regulable amount admitted through the pipe 12.

The molybdenite concentrate, which consists of Mo and S, is fed through the shaft 14 into the space above the bath, is immediately volatilized and, in the gaseous state, is met by the oxygen of the air and is oxidized to MoO_3 and SO_2 both gases. The gentle air pressure carries the gases out of the retort into the bag house 16 whence the SO_2 escapes and the MoO_3 condenses and remains.

It will be seen that a perfect zone of oxidation may be maintained and controlled in the retort above the bath, and that the electrodes delivering current while the oxidizing zone is maintained are below the surface of the bath and not affected by the air or oxygen, whereby the life of the electrodes is greatly increased and the formation of objectionable gases in the oxidation zone will be prevented.

Since a good concentrate contains only about 2.5% to 3% of gangue it will be necessary to tap the slag from the cinder monkey only occasionally, to keep the bath at a fairly uniform level. Because of the infrequency of tapping the current consumption will be low, it being only necessary to hold the bath at the point of fusion, to replace heat energy lost by radiation etc., to remove the furnace gases and to overcome the drop in temperature caused by charging cold ore. The load is practically constant, and there is no loss in the slag as the MoS_2, volatilizes practically instantaneously.

The air current being only sufficient to supply the oxygen necessary to form the reaction, the MoO_3 being in the form of a fine, light fume may be readily condensed in the bag house, and not blown out into the atmosphere as would be the case if the retort were coal or gas fired with the inevitable high pressure or suction necessary in such processes.

The minerals are recovered in the form of oxides and may be readily reduced to metallic form.

The lining of the retort must be of such a character that it will withstand the heat necessary to carry out the process and must be lined at least with a material which will not be chemically affected by the bath or the ingredients thereof. If a basic slag is to be used a basic lining must be employed.

Instead of fusing the bath by means of an electric current passing between the electrodes 6 and 7, the electrode 7 may be omitted and the retort may be coal or gas

fired until the fused bath is high enough to submerge the electrodes 11. The firing may now cease, and current be turned on and the bath maintained in fusion by the passage of current between the electrodes 6 and 11. As the ore is not introduced into the retort until the bath is properly built up the draft or suction will not be objectionable.

It is to be understood that the direction of current flow before described is merely relative. The electrode 7 may, if desired, be the cathode, and electrodes 6 and 11 anodes, or the electrodes 11, 11 may be opposite polarity whereby current will flow between and transversely of the retort.

As shown in Fig. 3 the electrodes 11, 11 may be of like or unlike polarity, the electrodes 17, 17 may be of like or unlike polarity, and the electrodes 6 and 7 must be of opposite polarity but the current may flow in either direction in the circuits 18 and 19.

In operating the apparatus with the connections as first above described, current will be caused to flow between the electrodes 6 and 7 until the bath is built up, when the electrode 7 is removed. Current to electrode 6 is cut off and a current is caused to flow between the electrodes 11, 11. This will maintain the upper part of the bath at the proper temperature to volatilize the mineral of the charge and no current will be flowing through the main body of the bath. Should the temperature of the lower portion of the bath fall too low, the connections will be changed whereby electrodes 11 and 11 will be of the same polarity while electrode 6 will be of the opposite polarity whereby current will flow between 6 and 11, 11 to raise the temperature of the entire bath, after which the electrode 6 will be cut out and current caused to flow between 11 and 11 as before. This will result in a considerable economy of current as obviously more current will be required to maintain a high temperature in the entire molten mass than will be necessary to keep the upper portion of the mass at a temperature sufficient to volatilize the material which is acted on by the temperature of the space above the level of the bath.

The same operation may be carried out in the form of the apparatus shown in Fig. 3. The temperature of the upper part of the bath may be maintained by current flowing between the electrodes 11 and 11, and between the electrodes 17 and 17, or one pair may be cut out, or the said electrodes may be located on the same horizontal level and be of alternate polarities whereby the current will travel horizontally around the retort near the surface of the bath.

As before stated the bath may be fused in the retort by means other than the heat of an electric current. It will also be understood that the bath may, if desired, be fused in a separate apparatus and introduced into the retort in the fused state, and then maintained at the proper temperature by means of the heat of the electric current.

In accordance with the provisions of the patent statutes the principle of the invention has been described, together with the apparatus which is now considered to represent the best embodiment thereof, but it is desired to have it understood that the apparatus shown is merely illustrative, and that the invention may be carried out in other ways.

The invention having been described what is claimed as new and desired to be secured by Letters Patent is as follows:—

1. The process of treating ores containing metals having volatilizable oxides, which comprises forming a molten bath, forming an oxidizing atmosphere above the same, introducing the ore into the zone above the bath and maintaining the temperature of the bath sufficient to cause volatilization of the desired metallic components.

2. The process of treating volatile compounds of metals whose oxides are substantially volatile which comprises producing a non-reducing molten bath in a suitable receptacle, forming an oxidizing atmosphere thereabove, maintaining the temperature of the bath at least as high as the volatilization temperature of the compound to be oxidized, introducing said compound into the zone above the bath and collecting the products of the reaction.

3. The process of treating volatile metallic compounds to recover volatile oxides therefrom, which comprises employing closed retort having suitable outlets for gaseous reaction products, forming a fused neutral bath therein, providing an oxidizing atmosphere above the bath, maintaining the bath in a fused state, and introducing the material to be oxidized into the zone above the bath.

4. The process of treating minerals for recovery of volatilizable oxides which comprises producing an oxidizing atmosphere, heating the same to the volatilization temperature of the oxides by means of a non-reducing source of heat, subjecting the ore to the action of said oxidizing atmosphere, and maintaining the temperature of the latter at the volatilization temperature of the oxides.

5. The process of treating minerals for the production of volatile oxides which includes the steps of forming a non-reducing fused mineral bath, maintaining the same in a fused state, maintaining an oxidizing reaction zone above and in contact with the surface of the bath, directing the material in finely divided form into said zone to cause volatilization of the same and inter-

action of it with the atmosphere to produce the desired oxides, collecting the latter while in gaseous form and condensing the same.

6. The process of treating mineral ores for the recovery of those metals contained therein having volatilizable oxides which comprises providing a suitable receptacle having spaced electrodes for the application of an electric current, introducing a fusible non-reducing material, passing an electric current between the electrodes to produce a non-reducing molten bath, the electrodes being so located as to be submerged within the bath, forming an oxidizing atmosphere above the bath, introducing the mineral into said atmosphere and collecting the gaseous reaction products.

7. The method of treating molybdenite which comprises forming a non-reducing fused bath consisting essentially of solicates, maintaining the same in a fused state, providing a confined oxidizing zone above and in contact with the surface of the bath by continuously introducing a supply of oxygen thereto, introducing the molybdenite in finely divided form into said zone to cause volatilization thereof and production of molybdenum oxide, and drawing off the reaction products substantially as formed to recover the oxide.

8. The process of recovering volatilizable oxides, which comprises forming a fused bath in a receptacle by the passage of an electric current between two electrodes, removing one of said electrodes from the receptacle, maintaining the bath in a fused condition by the passage of an electric current between the remaining electrode and another electrode, said latter electrodes being immersed in the bath, forming an oxygenized zone within the receptacle and above the bath, directing the mineral into said zone whereby the same will be oxidized, and recovering the oxide.

9. The process of recovering volatilizable oxides, which comprises forming a fused bath in a receptacle by the passage of an electric current between two electrodes, removing one of said electrodes from the receptacle, maintaining the bath in a fused condition by the passage of an electric current between the remaining electrode and a plurality of other electrodes, said latter electrodes being immersed in the bath, forming an oxygenized zone within the receptacle and above the bath, directing the mineral into said zone whereby the same will be oxidized, and recovering the oxide.

This specification signed this 2nd day of April, 1921.

BAYARD GEEKIE COBB.