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METHOD OF REDUCING ZINC ORES

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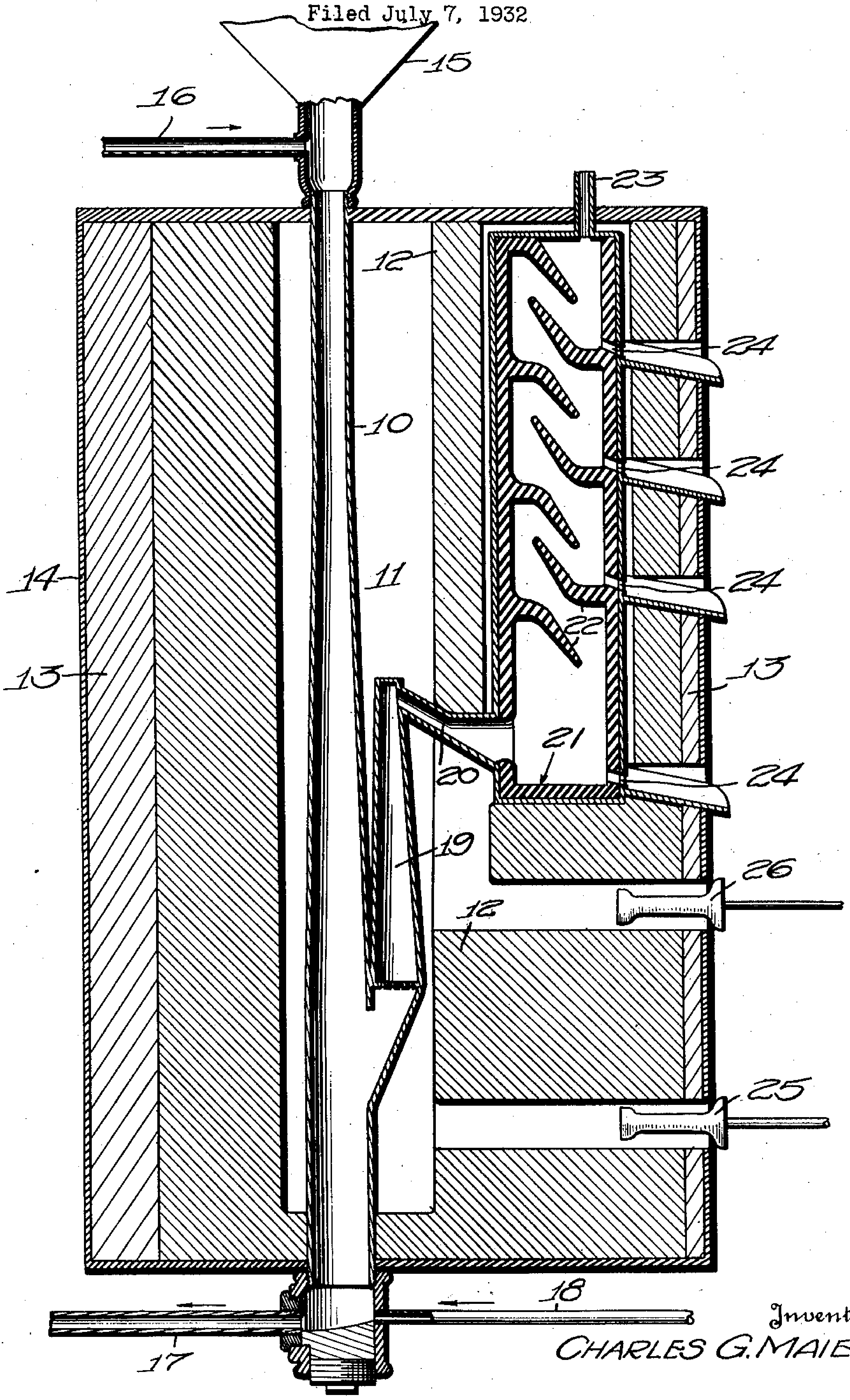

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METHOD OF REDUCING ZINC ORES

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9 Claims. (Cl. 75—28)

My invention relates in general to the reduction of zinc ores and in particular to decreasing the amount of partially oxidized zinc which is formed in the condensation of zinc vapor from its mixtures with gas containing oxides of carbon, water vapor and hydrocarbons.

It is well known in the art that this partial oxidation of the zinc is a principal source of the blue powder which is formed to a greater or less extent in all processes heretofore used for the production of zinc, and which is a source of loss and inconvenience in reducing zinc ores.

Various processes have been proposed for the prevention of this blue powder formation such as passing the exit gas through a bed of incandescent carbon. The use of such a process, however, involves expensive solid fuel and to insure a rapid and complete reduction, temperatures above 1100° C. must be employed, which increase the cost and upkeep of equipment.

The object of my invention is to prevent the formation of blue powder by the reduction of all oxidizing gases resulting from the reduction of zinc oxide, in a cheap and efficient manner.

A further object of my invention is to carry out this reduction of oxidizing gases at temperatures where metal containers may be used.

A further object of my invention is to carry out the methane reduction of zinc at higher temperatures than heretofore possible without blue powder formation.

I have discovered that if the products of reaction from the reduction of zinc oxide by carbonaceous material or hydrocarbons be mixed with methane or natural gas and passed over a catalyst, the resulting gas will be free from such oxidizing gases as carbon dioxide and water vapor and zinc may be condensed from them without any oxidation.

The catalysts which I have found most satisfactory for this purpose are alumina or zirconia impregnated with nickel, iron, chromium or thorium.

My process is preferably carried out in conjunction with methane or natural gas reduction of zinc such as described in my co-pending applications Serial Numbers 583,246 filed December 26th, 1931, and 513,458 filed February 4th, 1931. I shall, therefore, describe it in detail with references to its employment in this connection. Those skilled in the art will have no difficulty in applying my process to any zinc reduction method where the zinc is condensed from a gas containing oxides of carbon or water vapor.

While my process may be carried out in several different forms of apparatus, the apparatus shown diagrammatically in the accompanying drawing has been found to be particularly satisfactory. Referring to the drawing, the numeral 10 indicates an elongated retort vertically arranged in the chamber 11 which is lined with any suitable heat resisting material 12 which is surrounded with insulation 13 maintained in position by a casing 14. The upper end of the retort 10 is provided with an ore hopper 15 and a reducing gas inlet pipe 16, while the lower portion of the retort communicates with a spent ore discharge pipe 17 and an exit gas return pipe 18 through which a portion of the exit gases from the apparatus is returned to maintain a slight upward pressure in the retort 10. Intermediate its length the retort 10 communicates with an offset catalyst chamber 19, the upper portion of which communicates through the opening 20 with a zinc vapor condenser designated generally by the numeral 21. Throughout substantially the length of the interior of the condenser 21 a plurality of baffles 22 are arranged, as shown, to direct gases in a tortuous path through the condenser. The upper portion of the condenser is provided with an exit gas outlet pipe 23. As shown in the drawing, certain of the baffles extend upwardly and are so arranged as to act as collectors for condensed liquid metal which is discharged from the apparatus through tap holes 24. The retort 10 and the catalyst chamber 19 are heated by means of gas burners 25 and 26. As will be noted, the gas burner 26 is arranged in relative proximity to the catalyst chamber 19 so that the catalyst arranged in the chamber 19 may be heated to a somewhat higher temperature than the retort, if desired.

In applying my process in conjunction with natural gas reduction it is only necessary to insure that a sufficient excess of methane is present so that after the zinc oxide has been reduced the gaseous reaction products will contain enough methane to be stoichiometrically equivalent in reduction to the total oxidizing gases present as CO_2, H_2O, etc. This mixture is passed over the catalyst held at approximately the same or slightly higher temperature as the retort for reduction. In this catalytic chamber I find that all the carbon dioxide and water vapor react with methane to produce carbon monoxide and hydrogen from which the zinc can be condensed without oxidation.

The use of this catalytic process enables higher temperatures to be used in the reduction of zinc oxide by methane than could otherwise be used. It therefore broadens the usefulness of the method described in my co-pending applications.

Since the temperature I employ in the catalytic chamber may be less than 1100° C., metal containers may be used.

The catalyst may be prepared by impregnating alumina with nickel nitrate, igniting to the oxide and reducing in hydrogen. Other methods of preparing the catalyst may be employed, the essential feature being the presence of a finely divided high melting metal on an inert base.

I find that the activity of this catalyst is not affected by zinc vapor, however, if after exposure to zinc vapor the catalyst is for any reason exposed to oxidizing conditions its efficiency is lowered. When this happens I restore its activity by heating in a stream of hydrogen.

The process, as I prefer to employ it, consists of the reduction of a properly prepared charge by methane in accordance with the methods described in my co-pending applications already referred to, except that I use temperatures of 1000–1100° C. and an excess of methane. The gases resulting from this reduction are passed through a catalytic mass at the same or elevated temperatures.

I have found that the best results are obtained if the catalytic mass is contained in a vertically disposed container in the same furnace with the retort so that the gases pass upward or downward through the catalytic chamber to a vertically disposed condenser.

In the application of my process to other methods of reducing zinc oxide the gaseous products of reduction are led through the catalytic chamber and methane added at the entrance of the chamber. In the preferred practice of my process zinc oxide is introduced from the hopper 15 into the retort 10 where it is heated to the desired temperature by means of the gas burners 25 and 26 in contact with a reducing gas such as methane introduced into the retort from the inlet pipe 16. The gaseous reaction products, including zinc vapor are passed upwardly through a catalyst arranged in the chamber 19 and the resulting gas mixture, substantially free from oxidizing gases, is directed into the condenser 21 wherein the zinc vapor is condensed to liquid zinc and collected from the tap holes 24. The spent zinc oxide is discharged through the pipe 17. As indicated above it is preferable that a portion of the exit gases discharged from the pipe 23 be returned through the pipe 18 to the lower portion of the retort 10 in order to maintain a slight upward pressure in the lower portion of the retort. This assures the passage of the reaction gas mixture through the catalyst chamber 19 and serves to prevent the passage of any zinc vapor into the discharge pipe 17 where it would condense.

While I have described in detail the preferred practice of my invention and the preferred form of apparatus to be used in connection therewith it is to be understood that the details of procedure and the form of apparatus employed may be modified without departing from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. A process of producing metallic zinc which includes reduction of zinc oxide by a reducing agent selected from the group consisting of carbonaceous material and hydrocarbons, passing the resulting mixture of zinc vapor, carbon oxides and water vapor together with methane over a catalyst which will cause the methane to react with carbon dioxide and water vapor, and condensing the zinc vapor.

2. A process of producing metallic zinc which includes reducing zinc oxide by a reducing agent selected from the group consisting of carbonaceous material and hydrocarbons, passing the resulting mixture of zinc vapor, carbon oxide and water vapor together with methane over a catalyst composed of a high melting metal supported on an inert base, and condensing the zinc vapor.

3. The process of producing metallic zinc which includes reducing zinc oxide by a reducing agent selected from the group consisting of carbonaceous material and hydrocarbons, passing the resulting mixture of zinc vapor, carbon oxides and water vapor together with methane over a catalyst selected from the group consisting of metallic nickel, iron, chromium and thorium supported on an inert base, and condensing the zinc.

4. The process of producing zinc which includes supporting zinc oxide in a retort, heating the zinc oxide, passing sufficient methane into the retort and through the zinc oxide to cause the methane to contact intimately with the zinc oxide whereby zinc oxide and methane react to produce gaseous reaction products consisting of carbon oxides, water vapor and excess methane, passing the gaseous products over a catalyst whereby the carbon dioxide and water vapor react with the methane, and condensing the zinc vapor.

5. The process of producing zinc which includes supporting zinc oxide in a retort, heating the zinc oxide between 1000° C. and 1100° C., passing sufficient methane into the retort and through the zinc oxide to cause the methane to contact intimately with the zinc oxide whereby zinc oxide and methane react to produce gaseous reaction products consisting of carbon oxides, water vapor and excess methane, passing the gaseous products over a catalyst at at least the same temperature, whereby the carbon dioxide and water vapor react with the methane, and condensing the zinc vapor.

6. A process for producing zinc as described in claim 5 where the gaseous products of reaction pass through a catalytic mass supported in a vertically disposed container.

7. A process for producing zinc as described in claim 5 where the catalyst is selected from the group consisting of nickel, chromium, iron and thorium supported on an inert base.

8. The process of producing metallic zinc as described in claim 1 where the catalyst is kept active by intermittent heating in a stream of hydrogen.

9. In a process of reducing zinc oxide wherein the zinc oxide is heated with a reducing agent to produce gaseous reaction products including oxidizing gases, the improvement which comprises adding to the gaseous reaction products methane sufficient to be the stoichiometrical equivalent of the total oxidizing gases present, and passing the resulting mixture over a catalyst.

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