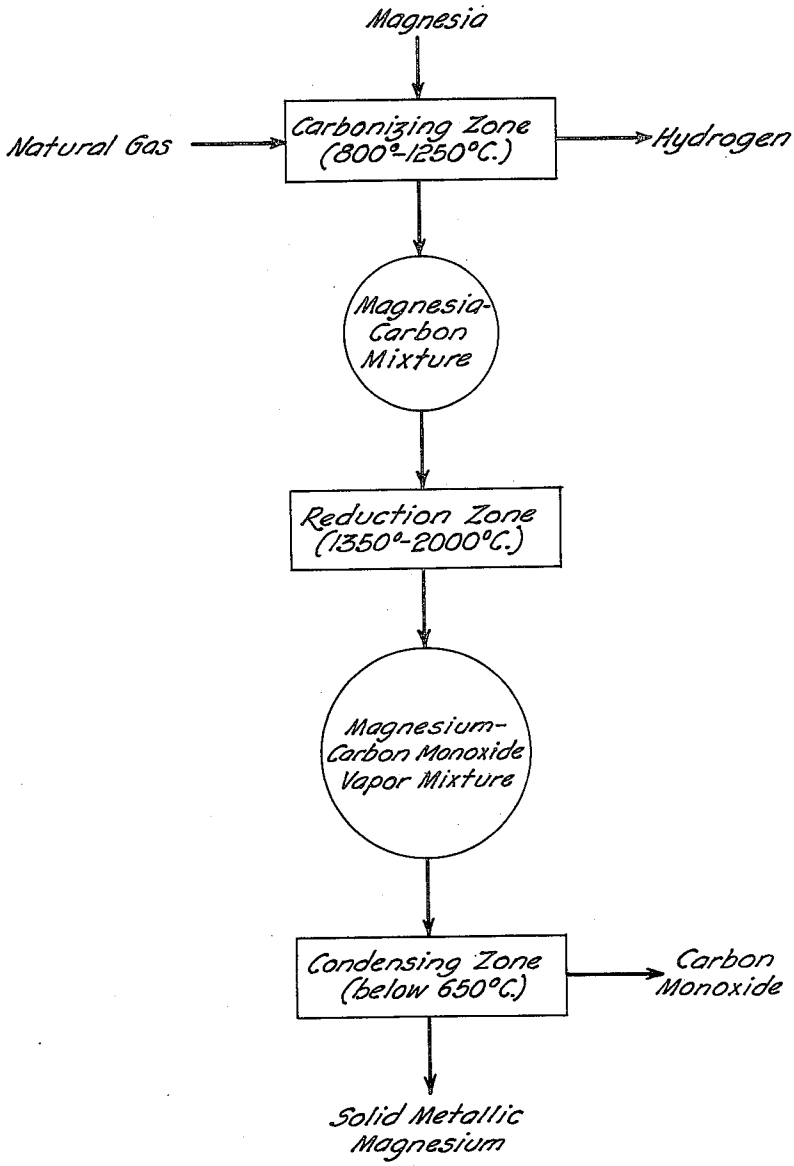
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PRODUCTION OF LIGHT METALS

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INVENTORS
Joseph D. Hanawalt
John S. Peake
BY Griswold & Burdick
ATTORNEYS

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PRODUCTION OF LIGHT METALS

Joseph D. Hanawalt and John S. Peake, Midland, Mich., assignors to The Dow Chemical Company, Midland, Mich., a corporation of Michigan

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This invention relates to an improved process for producing light metals, particularly magnesium, by the thermal reduction of their oxides, using carbon as a reducing agent.

In processes of the type mentioned, the reduction charge is usually prepared by separately grinding the metal oxide to be reduced and a carbonaceous reducing agent such as coke, mixing the ground material and forming the mixture into briquettes using a tar or pitch binder, and then baking the briquettes to carbonize the binder. Even after this elaborate preparation, however, except under unusual conditions the charge is rarely an intimate mixture of the oxide and the carbon. Accordingly, unless a considerable excess of carbon is employed in the charge, portions of the metal oxide may never be in actual contact with carbon, and the metal content of the charge may not be wholly recovered.

The principal object of the present invention, then, is to provide an improved method of preparing a reduction charge which permits the formation of an extremely intimate mixture of the oxide and carbon and at the same time eliminates the necessity of grinding and briquetting the ingredients of the charge.

According to the invention, a reduction charge is first prepared by subjecting a gaseous hydrocarbon to a carbonizing temperature while in contact with an oxide of magnesium, aluminum, beryllium, silicon, or one of the alkaline earth metals, barium, strontium, and calcium. The hydrocarbon decomposes into hydrogen and finely-divided carbon, and the latter deposits in the mass of oxide, forming an extremely intimate mixture. The resulting metal oxide-carbon reduction charge is then heated at a reaction temperature to reduce the oxide and to liberate the metal as a vapor, and the vapor is condensed to recover the metal in liquid or solid form.

The metal oxide used in the process may be derived from any desired source and need not be finely ground, but is ordinarily used in granular form, e. g. as half-inch lumps. The oxide is preferably in a porous state, to permit easy access of the gaseous hydrocarbon to the entire body of material. For instance, in preparing magnesium, the oxide is ordinarily provided in the form of coarse calcined natural magnesite or dolomite, but may also be prepared by drying and calcining a magnesium oxide slurry such as is obtained as a by-product in certain chemical processes. Any gaseous hydrocarbon alone or in admixture with other hydrocarbon or non-oxidizing gases may be employed in the process. Methane, usually in the form of natural gas, is particularly suitable.

In practice, the reduction charge is ordinarily prepared by passing a current of the gaseous hydrocarbon directly into contact with the granular or powdered metal oxide in a carbonizing zone maintained at a temperature above the minimum carbonization temperature of the hydrocarbon under the existing conditions but below the temperature at which the oxide is appreciably reduced by carbonaceous material. Carbonization of the hydrocarbon is catalyzed by the metal oxide, so that the carbon formed is substantially all liberated within the oxide mass, where it is retained tenaciously. Since, during carbonization, the hydrocarbon permeates the entire body of the porous oxide, even to the center of the individual granules, and is there converted to finely-divided carbon, a uniform and extremely intimate mixture of carbon and metal oxide results. Moreover, the oxide does not change form during the carbonization. It is therefore possible, by using relatively coarse granules or lumps of oxide in the carbonization, to prepare an equally coarse oxide-carbon reaction mixture which may be used directly in the reduction step without briquetting or other treatment.

Within limits, the carbon content of the mixture prepared in the carbonization step increases as long as the gaseous hydrocarbon is passed into contact with the oxide. Ordinarily, the treatment is carried out for a time sufficient to form a mixture in which the carbon is present in a proportion substantially equivalent chemically to the oxide, although other proportions may be used.

The hydrogen liberated in the carbonization treatment is ordinarily vented as formed.

After the oxide-carbon mixture has been prepared as described, it is heated at a reaction temperature to reduce the metal oxide and liberate the metal as a vapor which may be condensed. The reduction and condensation may be carried out according to any of a variety of processes well known in the art.

Although both the carbonization and thermal reduction steps of the process may be effected in a single zone merely by raising the temperature when carbonization is complete, it is preferable, especially in continuous operation, to employ two separate zones maintained at different temperatures. The carbonization is most suitably carried out in an apparatus lined with graphite, nickel, or other material which does not significantly catalyze decomposition of gaseous hydrocarbons

under the existing conditions. The thermal reduction step is ordinarily effected in a graphite-lined electric resistance furnace provided with a condenser for the metal vapor.

One form of the process of the invention may be further explained with reference to the accompanying drawing which illustrates diagrammatically the flow of materials in a method for producing magnesium from magnesia and natural gas.

In the process shown, the magnesia, preferably in lump form, is continuously charged into a carbonizing zone, e. g. a rotating drum, heated at a temperature of 800°–1250° C. A stream of natural gas is also passed into the zone and is directed into contact with the magnesia. The hydrocarbons present in the gas decompose forming finely-divided carbon which deposits within the mass of magnesia in intimate contact therewith, and liberating hydrogen which is withdrawn. The charge of magnesia is maintained in contact with the stream of natural gas until the carbon content of the resulting mixture is approximately 22 per cent by weight (the quantity theoretically necessary for complete reaction with the magnesia). This magnesia-carbon mixture is then transferred to a reduction zone maintained at a temperature of 1350°–2000° C., the exact temperature depending upon whether operation is under vacuum or at atmospheric pressure in the presence of an inert gas. In this zone, the carbon reacts with the magnesia, liberating metallic magnesium as a vapor and forming carbon monoxide. This vapor mixture is then passed into a condensing zone, in this case at a temperature below 650° C. The magnesium condenses as a solid which may be removed as product, and the carbon monoxide is exhausted.

It will be appreciated that the invention provides a method of producing magnesium, aluminum, silicon, beryllium, and the alkaline earth metals by the reduction of their oxides with carbon in which the carbon-oxide reduction charge is a more intimate mixture than has been possible heretofore and is obtained in readily usable form without the necessity of a grinding or briquetting operation.

It is to be understood that the foregoing description is illustrative rather than strictly limitative and that the invention is co-extensive in scope with the following claims.

We claim:

1. A method of producing a light metal which comprises: preparing a reduction charge by passing a stream of a gaseous hydrocarbon into intimate contact with a mass consisting essentially of a porous oxide of a metal selected from the class consisting of the alkaline earth metals, magnesium, aluminum, silicon and berryllium in a carbonizing zone maintained at such a temperature above the minimum carbonization temperature of the hydrocarbon but below the temperature at which the oxide is reduced appreciably by carbonaceous material that carbonization of the hydrocarbon occurs substantially all within the oxide mass, whereby hydrogen is liberated and there is obtained an intimate mixture of the oxide and finely divided carbon, and withdrawing the hydrogen as it is formed, said carbonizing operation being carried out for a time sufficient to form a reduction charge in which carbon is present in a proportion substantially equivalent chemically to the oxide; then heating the oxide-carbon reduction charge so formed in a reducing zone maintained at a reaction temperature to reduce the metal oxide and liberate the metal as a vapor; and condensing the vapor.

2. A method according to claim 1 in which the gaseous hydrocarbon is supplied in the form of natural gas.

3. A method according to claim 1 in which the metal oxide consists essentially of magnesia.

4. In a process of producing a light metal wherein a reduction charge consisting essentially of a mixture of carbon and an oxide of a metal selected from a class consisting of alkaline earth metals; magnesium, aluminum, silicon, and beryllium is heated to reduce the oxide and liberate the metal, the improved method of preparing the reduction charge which comprises passing a stream of a gaseous hydrocarbon into intimate contact with the said oxide in porous form in a carbonizing zone maintained at a temperature above the minimum carbonization temperature of the hydrocarbon but below the temperature at which the oxide is reduced appreciably by carbonaceous material, for a time sufficient to form a charge in which carbon is present in a quantity substantially equivalent chemically to the metal oxide.

5. A method according to claim 4 in which the gaseous hydrocarbon is supplied in the form of natural gas.

6. In a process of preparing magnesium wherein a reduction charge consisting essentially of a mixture of magnesia and carbon is prepared and then heated to reduce the magnesia and liberate magnesium, the improved method of preparing the reduction charge which comprises passing a stream of natural gas into intimate contact with a mass of porous magnesia in a carbonizing zone maintained at such a temperature above the minimum carbonization temperature of the hydrocarbon present in the gas but below the temperature at which magnesia is reduced by carbonaceous material that carbonization of the hydrocarbon occurs substantially all within the oxide mass, whereby hydrogen is liberated and there is obtained an intimate mixture of the oxide and finely divided carbon, said carbonizing operation being carried out for a time sufficient to form a charge in which carbon is present in a quantity substantially equivalent chemically to the oxide.

7. A method according to claim 6 wherein the carbonizing zone is maintained at a temperature between about 800° C. and about 1250° C.

JOSEPH D. HANAWALT.
JOHN S. PEAKE.