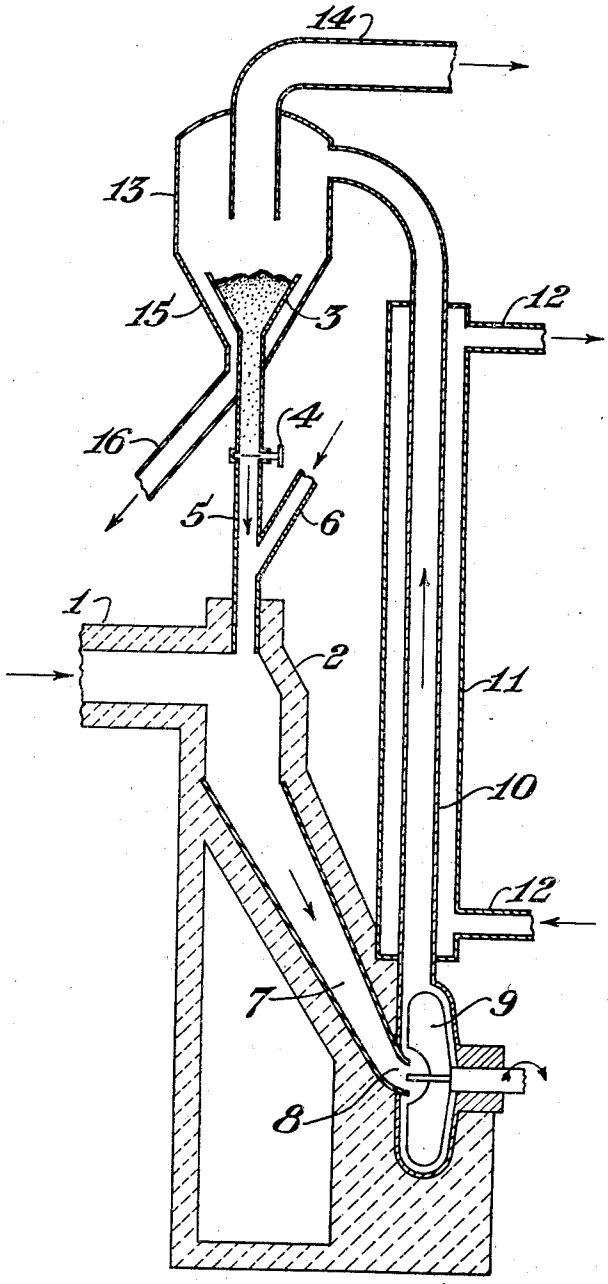
April 22, 1941. T. H. McCONICA, 3D., ET AL 2,238,907

CONDENSATION OF METAL VAPORS

Filed Jan. 31, 1940



INVENTORS
Thomas H. McConico III
BY Charles E. Nelson
Griswold & Burdick
ATTORNEYS

Patented Apr. 22, 1941

2,238,907

UNITED STATES PATENT OFFICE

2,238,907

CONDENSATION OF METAL VAPORS

Thomas H. McConica, III, and Charles E. Nelson, Midland, Mich., assignors to The Dow Chemical Company, Midland, Mich., a corporation of Michigan

Application January 31, 1940, Serial No. 316,628

12 Claims. (Cl. 75—67)

This invention concerns an improved method of condensing metal vapors. In its preferred form, it relates to condensing magnesium from vapor-phase mixtures also containing carbon monoxide.

In the production of metallic magnesium by the thermal reduction of magnesia-containing ores with carboniferous reducing agents, the magnesium is formed in the vapor phase in admixture with carbon monoxide, and is recovered as solid metal by condensation. As is well known, in the condensation step the magnesium vapors must be cooled to a low temperature as rapidly as possible in order to avoid interaction of the magnesium and carbon monoxide at the more elevated temperatures. It has been suggested that this rapid cooling be accomplished by contacting the magnesium-carbon monoxide mixture issuing from the reaction zone with a cold condenser surface, by injecting cold fluids such as hydrogen or kerosene into the metal-vapor mixture, and even by blowing finely-divided fusible salts into the vapor stream. However, because of inherent operating disadvantages, most of which are discussed in the art, none of these methods has met with widespread acceptance.

An object of the present invention, then, is to provide a simple method for cooling and condensing metal vapors, particularly magnesium vapors admixed with carbon monoxide, with high thermal efficiency and with minimum loss of product. Another object is to provide such a method wherein the volume of non-condensable vapor to be handled is at a minimum. A further object is to permit of the recovery of the condensed metal in the form of relatively large particles.

According to the invention, metal vapors are cooled rapidly and condensed by contacting them with relatively cool metal particles, preferably in a quantity sufficient to absorb the heat of condensation and cooling without themselves fusing.

The invention may best be understood by referring to the accompanying drawing, which illustrates in diagrammatic section one form of apparatus adapted to condensing metal vapors. The process will, for purpose of illustration, be explained with reference to the condensation of magnesium from vapor mixture thereof with carbon monoxide, using finely divided magnesium powder as condensing agent, although it will be appreciated that the invention is not thus limited.

The mixture of magnesium vapors and carbon monoxide resulting from the thermal reduction of magnesia-containing ores leaving the reaction zone enters the apparatus through a vapor tube 1 leading to a mixing chamber 2 constructed of brick or other refractory material. Cold finely-divided magnesium powder from a hopper 3, controlled by a valve 4, falls or is blown into the mixing zone from a chute 5, either by the force of gravity, the action of a suitable mechanical impeller (not shown), or the pressure of an inert gas, such as hydrogen, supplied in small quantities through an inlet 6. This inlet also serves to admit make-up magnesium powder, as hereinafter explained. In the chamber 2, the magnesium vapor and carbon monoxide are mixed intimately with the cold magnesium powder, which cools and condenses the vapor, leaving a suspension of solid magnesium particles in carbon monoxide. This suspension is withdrawn through a conduit 7 to the inlet 8 of a blower 9. This blower forces the gaseous suspension through a cooler 10 surrounded by a jacket 11, through which water can be circulated by way of nipples 12. The cold suspension from the cooler 10 is blown tangentially into a centrifugal separator 13, in which the metal particles are separated from the carbon monoxide, the latter escaping through a central gas outlet 14. The separator is of such design that the heavier particles of magnesium are thrown to the walls, fall into the conical bottom 15 of the separator, and are removed through the chute 16. The lighter or finer particles of magnesium collect in the hopper 3 near the center of the separator, and re-enter the process through the chute 5, together with make-up particles added through the inlet 6 to replace those withdrawn.

In operation, the magnesium vapor-carbon monoxide mixture leaves the reduction zone and enters the mixing chamber 2 at a temperature of 1000°–2000° C. and is condensed and cooled by contact with magnesium powder to a temperature below 650° C., and preferably much lower, say 200° C. To this end, the finely-divided magnesium powder is supplied preferably at about room temperature (25° C.) and preferably in a quantity sufficient to absorb the heat of condensation and cooling. In general, several parts by weight of magnesium powder are required per part of magnesium condensed. The cooler 10 serves to reduce the temperature of the magnesium powder-carbon monoxide sus-

pension leaving the mixing chamber back to room temperature or thereabouts.

By utilizing the cooling effect of solid magnesium powder according to the invention, it is possible to effect a considerable economy over known magnesium condensation processes. Thus, a given volume of magnesium powder has roughtly 1600 times the cooling capacity of an equal volume of a gaseous cooling agent, such as hydrogen, supplied at the same temperature. A marked reduction in apparatus size and in the cost of recirculating the cooling agent is achieved. In addition, in the process the cooling agent may effectively be separated from the gaseous products of the reduction, principally carbon monoxide, by simple mechanical means, e. g. a centrifugal separator, instead of by the expensive and complicated gas or liquid separation systems heretofore employed.

Another and perhaps the most significant advantage of the invention is the rapidity and ease of controlling the cooling and condensing operation. This advantage results principally from the fact that the magnesium vapors are condensed in the presence of discrete particles of solid magnesium. If these particles were not present, the magnesium on condensation would form an extremely fine powder or dust which is difficult to recover. However, in the presence of the solid magnesium particles, condensation of the vapor occurs principally on the surface of the existing particles, forming larger particles which are readily recoverable. In addition, because of the presence of the solid magnesium particles which serve as nuclei, condensation begins the instant the vapors and metal particles are mixed, and supercooling of the magnesium vapors is avoided; the rate of condensation can therefore be controlled more closely.

In its broader aspects, the invention is not limited to the condensation of magnesium vapors, but is applicable to the condensation of any metal vapor, using metal particles. It is not essential that the particles be of the same metal as the vapor being condensed, but, as will be appreciated from the foregoing, this is highly preferable. If desired, the metal particles may be mixed with an inert solid powdered material, such as magnesia, carbon black, and the like. In general, it is highly preferable that the metal particles employed be in finely-divided or powder form, e. g. as particles of 5–100 microns diameter, but for some purposes, particularly when operating at reduced pressures, particles of much greater size, say 10 millimeters or even larger, may be used. The metal particles being used as cooling agent need not be recirculated, although recirculation is a distinct process economy.

As shown in the drawing, the metal particles, when in powder form, are preferably, though not necessarily, blown into the mixing chamber while in suspension in a small proportion of a gas chemically inert to the powder. If the metal vapors to be condensed are not admixed with a large proportion of gas as, for instance, in the case of magnesium vapor liberated in the ferrosilicon reduction of magnesia-containing materials, in which operation no carbon monoxide is formed, it may be desirable to add a further small proportion of inert gas through the inlet 6 to serve as a carrier gas for transporting the metal particles; such gas may be recirculated in the process. Alternatively, and especially when using particles of larger diameter, the metal particles may be recirculated by mechanical means other than a carrier gas.

This application is a continuation-in-part of our co-pending application Serial No. 292,182, filed August 28, 1939.

Other modes of applying the principle of the invention may be employed instead of those explained, change being made as regards the details disclosed, provided the step or steps stated in any of the following claims or the equivalent thereof be employed.

We claim:

1. The process of condensing a metal from a vapor state which comprises contacting the metal vapors with relatively cool metal particles in a quantity at least sufficient to absorb the heat of condensation.

2. The process of condensing a metal from the vapor state which comprises injecting into the metal vapors relatively cool solid metal particles in a quantity at least sufficient to absorb the heat of condensation without themselves fusing.

3. The process of condensing a metal from the vapor state which comprises injecting into the said metal vapor a relatively cool solid finely-divided powder of the same metal in a quantity at least sufficient to absorb the heat of condensation.

4. The process of condensing magnesium vapors which comprises contacting the vapors with relatively cool solid magnesium particles in a quantity at least sufficient to absorb the heat of condensation.

5. The process of cooling and condensing magnesium from vapor phase admixture with carbon monoxide which comprises contacting said mixture with relatively cool magnesium particles in a quantity at least sufficient to absorb the heat of condensation and cooling.

6. The process of cooling and condensing magnesium from vapor phase admixture with carbon monoxide which comprises injecting into said mixture relatively cool finely-divided magnesium powder in a quantity at least sufficient to absorb the heat of condensation and cooling.

7. The process of cooling a mixture of magnesium and carbon monoxide from a temperature of at least 1000° C. to a temperature below 650° C., whereby the magnesium is condensed from the vapor to the solid state, which comprises injecting into the said mixture metal particles supplied in a quantity at least sufficient to absorb the heat of condensation and cooling.

8. The process of cooling a mixture of magnesium and carbon monoxide from a temperature of at least 1000° C. to a temperature below 650° C., whereby the magnesium is condensed from the vapor to the solid state, which comprises injecting into the said mixture finely-divided magnesium powder supplied at approximately room temperature and in a quantity at least sufficient to absorb the heat of condensation and cooling.

9. The process of cooling and condensing magnesium from vapor phase admixture with carbon monoxide at a temperature of at least 1000° C., which comprises injecting into said mixture finely-divided magnesium powder supplied at approximately room temperature and in a quantity at least sufficient to absorb the heat liberated in condensing the magnesium and cooling the mixture to below 650° C., whereby there is formed a suspension of solid magnesium particles in carbon monoxide at a temperature below 650° C., cooling the said suspension to approximately

room temperature, separating the magnesium particles from the carbon monoxide, and returning at least part of the particles so separated to the first step of the process.

10. The process of cooling and condensing magnesium from vapor phase admixture with carbon monoxide at a temperature of at least 1000° C., which comprises injecting into said mixture finely-divided magnesium powder supplied at approximately room temperature and in a quantity at least sufficient to absorb the heat liberated in condensing the magnesium and cooling the mixture to a temperature below 650° C., whereby the magnesium condenses on the surface of some of the particles of the powder and there is formed a suspension of fine and relatively coarse particles of magnesium in carbon monoxide at a temperature below 650° C., cooling the said suspension to approximately room temperature, simultaneously separating the magnesium particles from the carbon monoxide and the fine particles from the relatively coarse particles, withdrawing the coarse particles, and returning the fine particles to the first step of the process.

11. The process of condensing a metal from a vapor state which comprises injecting into the metal vapor a stream of relatively cool metal particles.

12. The process of condensing a metal from the vapor state which comprises injecting into the metal vapor a stream of relatively cool finely-divided metal powder suspended in a small proportion of a gas chemically inert to the powder.

THOMAS H. McCONICA, III.
CHARLES E. NELSON.