Feb. 18, 1947. T. K. HOLMEN 2,415,822

PRODUCTION OF MAGNESIUM AND NITRIC OXIDE

Filed June 21, 1943

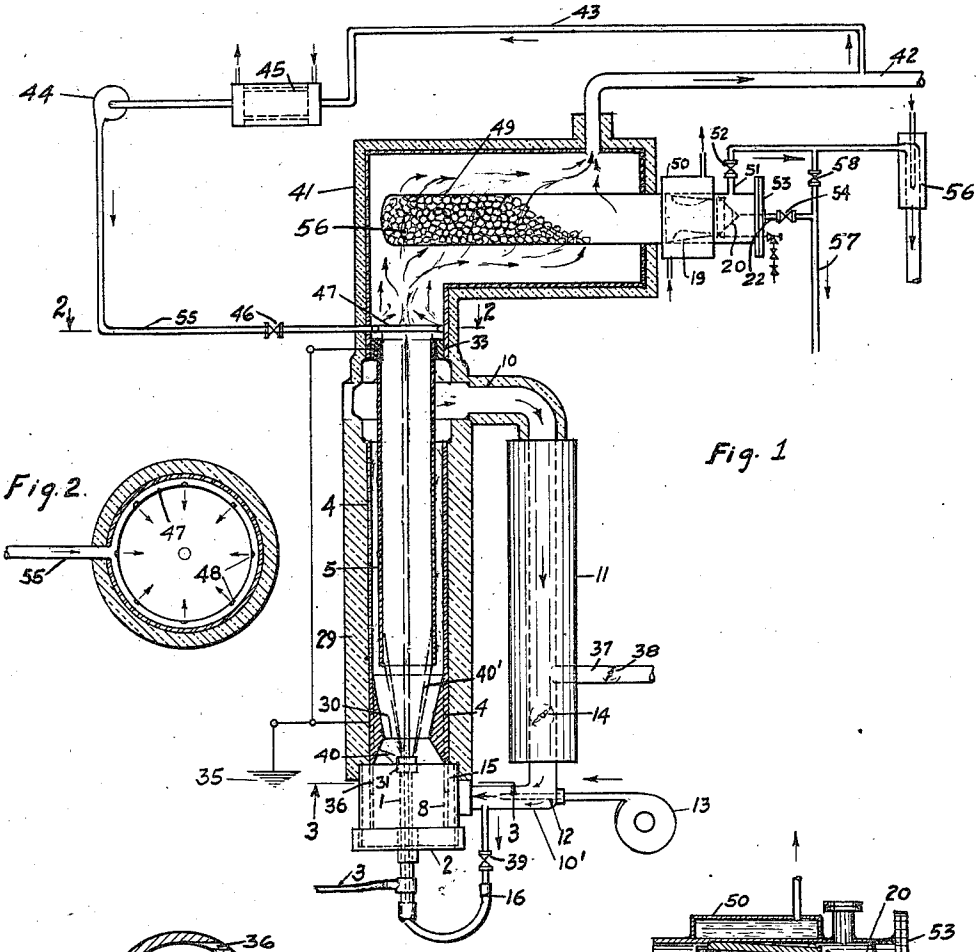

Fig. 1

Fig. 2.

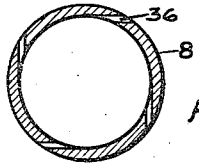

Fig. 3.

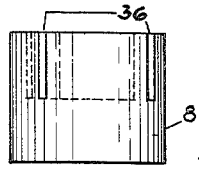

Fig. 4.

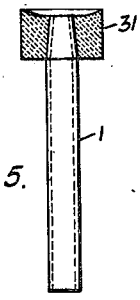

Fig. 5.

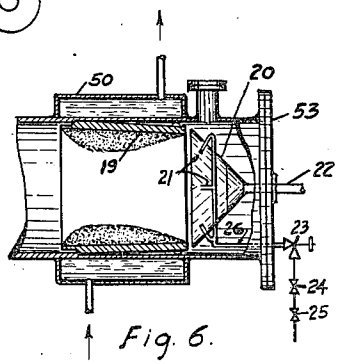

Fig. 6.

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PRODUCTION OF MAGNESIUM AND NITRIC OXIDE

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2 Claims. (Cl. 75—67)

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This invention relates to a method and apparatus for producing nitric oxide and magnesium.

The main object of the invention is to produce magnesium from magnesium oxide (MgO) or other mixtures containing the same, such as calcined lime (MgO+CaO) with which should also be mixed other substances adapted to absorb oxygen such as magnesium silicide, ferro silicon, etc., by the use of nitric oxide (NO) gas, the mixture containing the magnesium oxide being placed in a retort and subjected to the hot nitric oxide gas. The nitric oxide does not readily give up its oxygen and in fact has a tendency to pick up other oxygen to form NO_2. The nitric oxide is thus a reducing, rather than an oxidizing, agent so that if any of it should by any chance seep into or penetrate the retort wherein the magnesium is produced reoxidation of the magnesium would not occur such as would be the case if the heating gas would readily give up oxygen. The use of the nitric oxide makes it possible to use a non-metallic retort which may be to some extent porous. The entry of the nitric oxide into the magnesium producing retort might even be of advantage in facilitating the production of the magnesium by combining with oxygen in the retort to form NO_2 as referred to.

A further object of the invention is to utilize the heat for forming nitric oxide from air, for causing reduction of the magnesium oxide, the nitric oxide being obtained as a by-product of the production of the magnesium.

A further object of the invention is to provide an improved means for establishing and maintaining the electric arc employed in a producer of nitric oxide from air.

A further object of the invention is to provide a more efficient action of the electric arc upon the air in a producer of nitric oxide from air.

A further object of the invention is to provide an improved structure in a retort producing magnesium from its oxide which shall lessen or prevent the danger of burning of the magnesium and perhaps other products, at the mouth of the retort upon access of air thereto as when the retort is opened to remove the magnesium.

A further object of the invention is to provide an improved structure in a retort for producing magnesium from its oxide which shall facilitate the flow of vapors in the retort to the condensation zone.

A further object of the invention is to provide a structure upon which the magnesium is condensed in a retort for producing magnesium from its oxide which shall facilitate the removal of the magnesium from the structure upon which it is deposited.

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Other and ancillary objects of the invention will appear hereinafter.

In the accompanying drawing which illustrates the invention—

Fig. 1 is a diagrammatic view embodying the invention of means, and by which the method can be carried out;

Fig. 2 is a section, partly broken away, and on an enlarged scale, on the line 2—2 of Fig. 1;

Fig. 3 is a transverse sectional view on the line 3—3 of Fig. 1, and on an enlarged scale, of the sleeve through which air is admitted to the interior of the apparatus;

Fig. 4 is a side elevation of the sleeve of Fig. 3;

Fig. 5 is a side elevation, partly in section, and on an enlarged scale, of the lower electrode of Fig. 1; and

Fig. 6 is an axial section, and partly in side elevation, on an enlarged scale, of the exit end of the retort.

Referring to the drawing, the apparatus comprises an outer casing 29 of suitable refractory material within which the air is subjected to the electric arc. Lining said refractory casing is a metal sleeve 4 of which the inner wall tapers inwardly adjacent its lower end, the opposite walls approaching each other most closely at the circular line 30, the walls then tapering outwardly progressing downwardly from the line 30. Just below the line 30, and centrally located, is the end of the central electrode comprising the metal pipe 1, to the upper end of which is secured, in good electrical connection, the metal block 31. This electrode is suitably insulated and mounted in the cap 2 closing the lower end of the electric furnace.

At the upper portion of the casing 29 is mounted a metal ring 33 in which is supported the metal tube 5 extending downwardly within the metal lining 4 into proximity to the taper of the lower end thereof, the ring 33 closing the end of the space between the casing 29 and the tube 5. The ring 33 and the metal lining 4 are electrically connected to ground at 35. An alternating current generator of voltage and capacity appropriate to maintaining the arc under the conditions as hereinafter described, has one terminal connected with the ground while the other terminal is connected through the conductor 3 with the electrode 1.

A fan or blower 13 forces air from the atmosphere through an injector nozzle 12 in the intake

pipe 10' into the annular chamber 15 between the wall of the cap 2 and the sleeve 8 whence the air passes through the tangential slots 36 in the sleeve into the interior of the furnace about the electrode 1. Thence the air passes upwardly through the throat at the line 30. Thence, still passing upwardly, the air current divides, one portion passing between the lining 4 and the tube 5 and the other portion passing within the tube 5.

Adjacent the top of the furnace but below the upper end of the tube 5 there is connected with the area outside the tube 5, an outlet pipe 10 which passes through the cooler 11 and connects with the intake pipe 10' above referred to. The pipe 10 has an outlet 37 controlled by a valve or damper 38 and also has below the outlet 37, a valve or damper 14 whereby flow through the pipe 10 may be throttled. Connecting the pipe 10' with the tubular electrode 1 is a pipe 16 which may be more or less throttled, by adjusting the valve 39. At point 40 the distance between the electrode block 31 and the metal lining 4 is the shortest and short enough for an electric arc to form by the prevalent potential. The uprushing air will force the arc upwards until it connects with tube 5 an arc or flame of a cylindrical or conical shape at 40'. The flame will continue up the tube 5 for some distance as the air (N+O) is converted to (NO) and the ionized gas forms a conductor.

The gases within and about the tube 5 pass into a suitably heat insulating and refractory container chamber 41 whence they pass outwardly through the pipe 42. A portion of the gases are drawn from the pipe 42 through a pipe 43 by means of a rotary pump or blower 44, the pipe 43 passing through a cooler 45. The blower 44 impells the gases through a pipe 55, controlled by a valve 46, to a tubular ring 47 adjacent the upper end of the tube 5, the ring 47 having perforations 48 upon its inner side whereby the gases from the pipe 45 are sprayed into the gases passing out of the furnace.

The air passing from the pipe 10' through the tangential slots 36 will be given a swirling motion as it is forced upwardly within the producer, the swirling motion causing the air to more definitely seek the outside of the producer chamber. An arc having been established between the central electrode 1 and the electrode having the apex 30, the natural tendency for the arc to rise will be greatly added to by the upward current of air when the arc will travel upwardly along the electrode last referred to and passing its peak at the line 30 will then travel along its upper taper until it finally jumps to the bottom of the tube 5. The taper on the lower side of the electrode is of great importance. If this taper were not present, when the arc was originally initiated, and before it was well established, the upward current of air would tend to blow out the arc and it might be difficult to establish it. With the taper, however, the blowing upward of the arc does not materially increase the arc gap until the arc has been thoroughly establshed. There is a current of air entering through the electrode 1 which also tends to blow the arc upwardly, and the arc or flame travels up within the tube 5 for the greater part of the length of the tube thereby increasing the efficiency of the action in producing the desired nitric oxide. The upwardly moving air below the end of the tube 5 divides into two portions, one portion passing within the tube and upon which the arc acts to produce the nitric oxide. The other portion

passes between the casing 29 and the tube 5 thereby cooling the tube so as to prevent it from injury, the gases between the casing and the tube finding an outlet into the pipe 10 whence they may be suitably disposed of. In this case, as before described, a certain amount of these gases may pass through a cooler 11 and return into the producer along with outside air. The air which enters the producer through the electrode 1 tends to balance the pressure in the furnace so that the cooling air traveling upward near the inner wall of the casing has less tendency to travel over towards the center and thereby form any currents that will mix the cooling air with that in the arc. Furthermore the air from this central tubular electrode will travel into the center of the arc so as to be surrounded thereby and thus cause the heating of the air by the arc to be more efficient and therefore better results be obtained in the production of the nitric oxide. The extended and intimate contact of the air with the arc within the tube 5 is productive of the greatest efficiency in producing the nitric oxide.

On emerging from the upper end of the tube 5, gases produced by the production of nitric oxide in the tube 5 described, will be cooled by the cooler gases sprayed into them from the ring 47 and thus the gases are cooled down to a temperature at which the nitric oxide is almost, if not entirely, non-reacting and which temperature is also suitable for the purposes of producing the magnesium. The temperature of the gases within the tube 5 is very high, probably 3600° F. to 4000° F., and they are cooled as described on leaving the tube to a temperature of approximately 2000° F.

Within the chamber 41 extends a retort 49 within which the magnesium oxide is distilled by the heat of the gases surrounding it in the chamber. The retort extends outside the chamber where it is provided with a jacket 50 through which is circulated cooling water or other suitable liquid, this cooling causing condensation of the vapor of magnesium or other materials which may be present. The vapors of magnesium are drawn into the outer and cool end of the retort by applying suction to the outer end of the retort by means of a pipe 51 controlled by a valve 52. The outer end of the retort is closed by a removable cover plate 53. The mixture 56 of the material containing the magnesium oxide is charged into the heated end of the retort 49. The retort is then evacuated to a high degree of vacuum by applying suction to the outer end of the retort through the pipe 51 controlled by a pipe 52 by means of evacuating means 56 adapted to exhaust relatively large quantities of air quickly and means adapted to evacuate the small amount of remaining air to produce a higher vacuum, the last means being connected to a pipe 57 controlled by a valve 58.

The tapered collector sleeve 19 for the magnesium is made tapering for the reason that when the magnesium condenses and deposits on the sleeve the mass traveling toward the retort outlet is reduced and tends to form a higher vacuum at that point which will retard the forward motion of the other gases. The decrease in diameter due to the taper will offset that effect and the deposit on the sleeve will be more uniform. Also after the removal of the sleeve from the retort, the removal of the deposited magnesium is facilitated, this being accomplished by pushing or

knocking the magnesium out of the sleeve through its larger end.

When the outlet end of the retort is opened, by removing the plate 53, for the removal of the magnesium and residue, the influx of air is liable to cause the magnesium to catch fire with undesirable consequences. To avoid this the inflammable substances are removed during the process of forming the magnesium and before the retort is opened. This is accomplished by providing a funnel-shaped hood 20 adjacent the end of the collector sleeve 19, the apex being connected by a pipe 22 passing through the cover plate, connected with a source of suction and controlled by means of the valve 54. The funnel is provided with one or more pipe connections 21 opening into its interior and connected with a pipe line 26. This pipe line leads to the atmosphere and is provided with three valves 23, 24 and 25. The valves 24 and 25 are located a certain distance apart so that the pipe between them contains a certain and limited quantity of air. If now the valve 24 is opened a small quantity of air will be sucked into the hood 20 through the valve 23 which may be a needle valve or of other type which can be finely and accurately adjusted. The chemicals within the hood 20 will combine with the air thus admitted and be drawn out through the suction or vacuum pipe 22. By closing the valve 24 and opening valve 25 a fresh charge of air may be admitted between the valves 24 and 25 when the valve 25 may be closed, the valve 24 opened and the process repeated as often as necessary to remove the inflammable materials collecting within the hood 20 so that upon opening the retort there will be no catching fire as before referred to. The method of admitting the air to the funnel through the pipe 20 for the purpose as indicated, insures that there will be only a limited supply of air admitted to the hood and that the injurious consequences of an inrush of excess air are prevented.

The magnesium of a charge having been deposited on the collector sleeve, this is removed by removing the closure plate at the outer end of the retort and then removing the collector sleeve. The magnesium is then removed from the sleeve, another charge may be placed in the retort, the collector sleeve and end closure plate be placed in position and the operation repeated. This repetition may continue indefinitely.

While the invention has been illustrated in what is considered its best application it may have other embodiments without departing from its spirit and is not therefore limited to the structure shown in the drawing.

What I claim is:

1. A method of producing magnesium as a by-product in the production of nitric oxide from air by the electric arc method comprising the steps of introducing the air under pressure through a hollow electrode, heating the air by means of an electric arc to a high temperature, ionizing the air by means of thermal agitation as well as by the potential field of the arc, conducting the air from the arc to a magnesium retort and cooling the air by contact with said retort whereby sufficient heat for producing magnesium is obtained from the waste heat of the nitric oxide process.

2. A method of producing magnesium as a by-product in the production of nitric oxide from air by the electric arc method comprising the steps of introducing the air through a hollow electrode, heating the air by means of an electric arc to a high temperature, ionizing the air by thermal agitation as well as by the potential field of the arc, conducting the resulting gases from the arc, controlling the temperature of said gases and letting said hot gases impinge upon a magnesium retort thereby utilizing the heat of said gases and cooling same for the stabilization of their nitric oxide content.

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