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HENRY SPENCER BLACKMORE, OF MOUNT VERNON, NEW YORK.

ART OF REDUCING ALUMINIUM OR OTHER METALS.

SPECIFICATION forming part of Letters Patent No. 778,100, dated December 20, 1904.

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To all whom it may concern:

Be it known that I, HENRY SPENCER BLACKMORE, a citizen of the United States, residing at Mount Vernon, in the county of Westchester and State of New York, have invented certain new and useful Improvements in the Art of Reducing Aluminium or other Metals; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The object of my invention is to reduce metals from their salts or combinations in a simple and economical manner; and it consists in extracting the desired metal from its associated elements by action of substances for which the associated elements have greater affinity and maintaining the composition at a reacting temperature largely by action of heat liberated within the mass by chemical reaction.

It is well known that in the formation of many compounds—such, for instance, as aluminium oxid by the union of aluminium with oxygen—a great amount of heat is evolved, which heat must be resupplied before the aluminium oxid or similar substance can be reduced or transformed to a metallic condition again, and for this reason great difficulties have been encountered in the extraction of many metals from their associated elements because of the high temperature required and the means at hand for applying it to advantage without loss of metal by volatilization or corrosion or destruction of apparatus in which the transformation or reduction is performed.

My invention therefore relates to a class of reduction of exothermic nature whereby reaction between materials which ordinarily require considerable externally-applied heat, either by conduction, convection, or electrical resistance, may be carried on at much lower-applied heat or wholly by heat liberated within the mass in juxtaposition with the ingredients by chemical action of more energetic substances. By the application of heat evolved within the mass of materials to be reduced the loss of heat which ordinarily occurs in furnaces from products of combustion and resistance of materials and contaminations are avoided and the heat liberated at points where utilized without loss. This is particularly applicable in such cases where the ingredients are of high resistance to heat, as are many of the aluminium compounds and similar refractory substances.

As an illustration of my invention I will take, for example, the reduction of aluminium from its oxid by action of acetylene and magnesium. It is well known that acetylene will reduce aluminium oxid at high temperatures provided it can be prevented from dissociating into free carbon and hydrogen before bringing in contact with the heated aluminium oxid. This reaction, therefore, is only practical when the oxid is heated to the required temperature and heated acetylene conveyed in contact therewith. The maintenance of the refractory aluminium oxid at the required temperature has also been a serious factor in performing reduction from this standpoint. I have found, however, that the heat may be readily supplied by chemical action within the mass of aluminium oxid by introducing with the acetylene gas vaporized magnesium, which magnesium, having greater affinity for the oxygen content of the aluminium oxid, abstracts it, liberating aluminium and generating an excess of heat whereby the temperature necessary to perform the reduction of aluminium oxid with acetylene may be attained within the mass, and it is found that the employment of a small amount of magnesium thus renders the reduction of the refractory aluminium oxid by carbon practically feasible, especially when the heat liberated by dissociation of the endothermic acetylene also assists the reaction. The reaction which takes place may be illustrated by the following formula or equation:

$$Al_2O_3+C_2H_2+Mg=2Al+2CO+MgO+H_2+heat$$

The heat evolved in this reaction is sufficient to render available the reaction as illustrated in the following equation:

$$2Al_2O_3+3C_2H_2=4Al+6CO+6H,$$

so that the magnesium required to perform and maintain the heat necessary for practical

reduction of aluminium oxid with acetylene is only in small proportion and may be illustrated in chemical formula as a whole by the following equation:

$$3Al_2O_3+4C_2H_2+Mg=6Al+8CO+MgO+8H.$$

In carrying out my invention I prefer to employ porous aluminium oxid, place it in a retort or container preferably lined with carbon, and heat the oxid to bright redness. I then pass a current of acetylene through molten magnesium, regulated so that it will carry in suspension the magnesium vapor in about equivalent proportions and introduce the acetylized magnesium into and through the heated aluminium oxid, whereupon a reaction ensues, liberating metallic aluminium, which can be withdrawn from the reduction-chamber from time to time as desired. A part of the magnesium in the acetylene is transformed into magnesium acetylide, which is carried along in suspension in the magnesium vapor.

Instead of exposing the porous aluminium oxid to the action of the acetylene and magnesium in its dry-heated condition I can employ it in any form, such as dissolved or suspended in molten bath or combined with other materials which merely render it fusible, or I can bring the ingredients together in any convenient or practical manner. I can also employ other reducing agents with the magnesium, such as hydrogen. Neither do I desire to confine myself to the reduction of aluminium oxid, as my process may be applied to the reduction of many other metals and substances. I can also employ other heat-generating materials instead of magnesium, which materials need not enter directly in the reduction as part of metal yield and may even be of non-metallic nature so long as heat sufficient to maintain reduction of desired metal is produced within the mass of ingredients or in juxtaposition thereto by chemical action. I can also employ any practical compound or compounds of the metal which it is desired to reduce and any reducing agent so long as the reacting ingredients contain as a part of their composition substances which evolve heat on reaction, which substances may either enter directly into the chemical reduction of the desired metal or may be exclusive and inert to the same so long as the heat is liberated in juxtaposition to the reacting ingredients.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The process of reducing metals which consists in exposing a compound of the metal to be reduced to the action of a substance having such superior affinity for the electronegative constituent of the compound that heat is evolved in the said reduction and simultaneously employing the said heat to elevate other ingredients capable of reducing the metal by endothermic reaction to a temperature at which reduction is accomplished, and carrying on the reduction by the action of such ingredients.

2. The process of reducing metals which consists in exposing compounds of the metal desired to the action of a reducing agent capable of liberating heat during the said reduction while in the presence of ingredients requiring the external application of heat to reduce the same and utilizing the heat liberated in the first reaction to maintain the reduction in the second.

3. The process of reducing metal oxy compounds which consists in exposing said oxy compounds to the action of a reducing agent capable of liberating heat during reduction and utilizing the heat so liberated by the employment of reducing agents absorbing heat during reduction, the said endothermic and exothermic reduction processes being so proportioned that the heat evolved by exothermic reduction will be sufficient or in excess of that required to maintain the endothermic reduction.

4. The process of reducing metals which consists in exposing a compound containing metal and oxygen to the action of reducing agents one of which evolves heat while reducing the metal by abstracting the oxygen therefrom and the other which requires the addition of heat to perform and maintain reduction and proportioning the amount of reducing agent of exothermic nature to that of endothermic nature so that the metal will be reduced by both reducing agents, the heat evolved by one being sufficient or in excess to maintain the other.

5. The process of reducing metal oxids which consists in exposing the metal oxid to the action of a deoxidizing agent capable of liberating heat and the action of a deoxidizing agent requiring the application of heat the said deoxidizing agents being so proportioned that the amount of reducing agent liberating heat will supply sufficient or excess heat to perform the reduction by the reducing agent requiring the application of heat.

6. The process of reducing metals which consists in exposing a metallic oxid to the action of magnesium and a reducing agent requiring the application of heat to perform reduction and proportioning the amount of magnesium and other reducing agent so that the heat evolved by the reduction with magnesium will be sufficient or in excess of that required to reduce the metallic oxid by the reducing agent requiring the application of heat.

7. The process of reducing metals which consists in exposing a metal oxid to the action of magnesium and acetylene, at a reacting temperature.

8. The process of reducing aluminium which consists in exposing an aluminium oxy com-

pound to the action of magnesium and acetylene, at a reacting temperature.

9. The process of reducing aluminium oxid which consists in exposing it to the action of a reducing agent capable of liberating heat and a reducing agent requiring the application of heat, the said reducing agents being so proportioned that the heat evolved by one will be sufficient or in excess of that required to produce and maintain the reduction by the other.

10. The process of reducing aluminium oxid which consists in exposing aluminium oxid to the action of magnesium and acetylene, at a reacting temperature.

In testimony whereof I affix my signature in presence of two witnesses.

HENRY SPENCER BLACKMORE.

Witnesses:
C. C. WRIGHT,
H. N. JENKINS.