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PROCESS AND APPARATUS FOR PRODUCING NITROGEN COMPOUNDS, ESPECIALLY NITRIDS.

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Fig. 1.

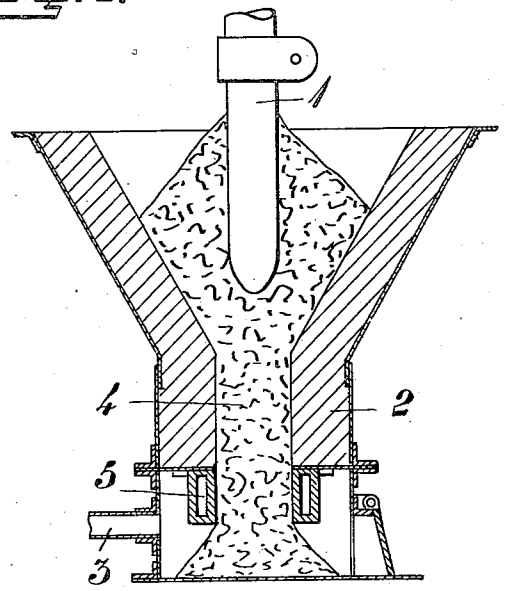
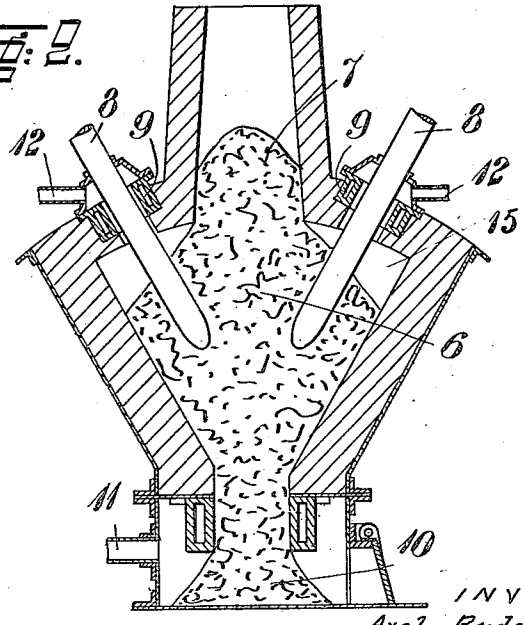


Fig. 2.



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To all whom it may concern:

Be it known that I, AXEL RUDOLF LINDBLAD, subject of the King of Sweden, residing in Hamngatan 1A, Stockholm, in the Kingdom of Sweden, have invented certain new and useful Improvements in Processes and Apparatus for Producing Nitrogen Compounds, Especially Nitrids, of which the following is a specification.

Among the compounds of nitrogen with other substances, the nitrids have long been the object of great interest. Many attempts to produce nitrids on an industrial scale have in fact been made, but without satisfactory results. The chief reason of this seems to be that the peculiar characteristics of these compounds have not been sufficiently observed. A fact which above all must be taken into consideration is that the nitrids are non-fusible; when heated to a very high temperature, they become decomposed before they have yet melted. Therefore, if continuous working is to be maintained, arrangements must be made which render it possible to remove from the furnace the resulting product in an unmelted condition. Further, all nitrids require a high temperature for their formation; as a rule about 2000 degrees centigrade, sometimes a slightly lower, but sometimes, on the other hand, a still higher temperature. From this it ensues that satisfactory results can hardly be attained otherwise than with the aid of an electric furnace.

Proceeding from these points of view, the problem, in accordance with the present invention, has been solved by heating the charge in an electric furnace and simultaneously injecting nitrogen or nitrogenous gases into the same. The electric current is supplied to the furnace by means of electrodes hanging down into the furnace, or introduced through openings in the walls of the furnace. These electrodes enter into the charge in places where the latter forms a free spreading or sliding surface, and are so arranged that the charge itself forms a greater or lesser part of the resistance of the circuit. The resulting product is thereupon removed from the furnace, in an unmelted condition, through an opening in the lower part of the furnace, continuously or at suitable intervals.

In the accompanying drawings, Figures 1 and 2 are views showing in vertical section two forms of furnaces embodying my invention for performing the process in question.

Fig. 1 shows an electric furnace of ordinary shaft-furnace type, open at the top. The current is supplied through the electrode 1 which is suspended in the shaft as shown. The other electrode consists of the conductive furnace lining 2. The raw material is charged into the furnace around the electrode 1, and is heated by the electric current passing through it. Nitrogen is blown in through the pipe 3. The reaction gases thus generated, are allowed to pass out at the top, whereas the resulting nitrid is removed in an unmelted condition through the opening or outlet 4, which is prolonged at its lower end by the water-cooled ring-shaped tube or pipe 5. If continuous removal of the nitrid produced is desired, this can be effected by arranging a mechanical extraction device, for example a transporting screw, or the like.

Fig. 2 illustrates another furnace of the closed type suitable for the same purpose. The internal contour of the furnace chamber is such that one or more free spaces 15 always exist between the charge sinking down and the masonry of the furnace. 6 represents the actual smelting chamber, above which a feeding shaft 7 is arranged. 8 are the electrodes for supplying the current, and are surrounded by water-cooled jackets 9 at the point where they pass through the masonry of the furnace. In the bottom of the furnace is arranged the discharge opening 10. Finally there is a pipe 11 for blowing-in nitrogen through the bottom of the furnace. If it is considered suitable, the shaft may be provided with a closed charging device of suitable construction.

By the use of a furnace as above described all the electrodes required for supplying and leading off the current pass through free spaces 15, formed between the charge and the masonry of the furnace. It is, how-

ever, also possible to arrange only one of the electrodes in this manner, whereas the other is placed in contact with the charge in some other manner.

With the use of these furnaces, the process, which is the object of the present invention is as follows: assuming that the intention is to produce silicon nitrid Si_3N_4:

Silicon dioxid, for example in the form of crushed quartz, together with carbon is charged into the electric furnace and is heated by the action of an electric current.

As a result SiO_2 is reduced to Si, which combines with the nitrogen simultaneously introduced, into nitrid. The reaction may be expressed by the following formula:

$$3SiO_2+6C+4N=Si_3N_4+6CO.$$

The process will be analogous in case of other nitrids, for example aluminium nitrid, magnesium nitrid, boric nitrid, etc.

It is obvious that a number of variations in the process can be made without departing from the principle of the invention. In the form of furnace shown in Fig. 2, the nitrogen or nitrogenous gases can be blown into the pipes 12 and into the free spaces 15. In furnaces according to Fig. 1 the furnace lining obviously need not necessarily be a conductor as has been assumed to be the case in the example given here. The furnace may instead be provided with two or more electrodes hanging down into the furnace. The number of electrodes moreover in both open and closed furnaces, may be varied according to the circumstances.

Having thus described my invention, I declare that what I claim is:

1. An electric furnace for producing nitrogen compounds such as nitrids and the like, comprising a furnace chamber, having an opening for introducing a charge into the same, said chamber being of such a form that a free space exists between certain portions of the chamber and the charge in the chamber, electrodes extending through the wall of the furnace chamber and into the same at places where the charge is not in contact with the chamber, said chamber being formed with an outlet at its lower end, and means for supplying nitrogenous gases to said chamber.

2. An electric furnace comprising a chamber of inverted frusto-conical formation and having an axially disposed inlet at the upper end thereof, electrodes extending into the same chamber between the side walls of the chamber and the outlet, and means for supplying nitrogenous gases to said chamber.

3. Process for producing nitrid comprising the charging of the raw material into an electrical furnace and there heating the same by means of electric current supplied and carried off through an electrode or electrodes entering into the charge in places where this has a free surface, nitrogen or nitrogenous gases being simultaneously introduced into the lower part of the furnace chamber, and the resulting product being removed from the furnace in an unmelted condition through openings in the lower part of the furnace.

4. Process for producing nitrids comprising the charging of the raw material into an electric shaft furnace of inverted frusto-conical shape and open at the top, there heating the material by means of electric current supplied through electrodes entering from above into the charge through the free surface of the same, nitrogen or nitrogenous gases being simultaneously introduced into the lower part of the furnace chamber, and the resulting product being removed from the furnace in an unmelted condition through openings in the lower part of the furnace.

5. Process for producing nitrids comprising the charging of the raw material into an electric furnace, and there heating the same by means of electric current supplied and carried off through an electrode or electrodes entering into the charge in places where this has a free surface and through the lining of the furnace, nitrogen or nitrogenous gases being simultaneously introduced into the lower part of the furnace chamber, and the resulting product being removed from the furnace in an unmelted condition through openings in the lower part of the furnace.

6. Process for producing nitrids comprising charging of the raw material into an electric furnace at the top provided with opening for introducing the charge while the furnace has such an internal form that free spaces always are formed between the brickwork of the furnace and the charge sinking down into the same through the charging opening, heating the charge by means of electric current supplied through electrodes, one or several of which enters into the charge through said free spaces, nitrogen or nitrogenous gases being simultaneously introduced into the lower part of the furnace chamber, and the resulting product being removed from the furnace in an unmelted condition through openings in the lower part of the furnace.

7. Process for producing nitrids comprising charging of the raw material into an electric furnace at the top provided with opening for introducing the charge, while the furnace has such an internal form that free spaces always are formed between the brickwork of the furnace and the charge sinking down into the same through the charging opening, heating the charge by means of electric current supplied through electrodes, one or several of which enters

into the charge through said free spaces, nitrogen or nitrogenous gases being simultaneously introduced into the said free spaces within the furnace chamber, the resulting product being removed from the furnace in an unmelted condition through openings in the lower part of the furnace.

In witness whereof I have hereunto affixed my signature in presence of two witnesses.

AXEL RUDOLF LINDBLAD.

Witnesses:

JENS SOELBERG,

ELSA HELLSTRÖM.