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ELECTRIC FURNACE FOR FIXING NITROGEN FROM THE AIR.

APPLICATION FILED JAN. 19, 1916.

1,232,179. Patented July 3, 1917.

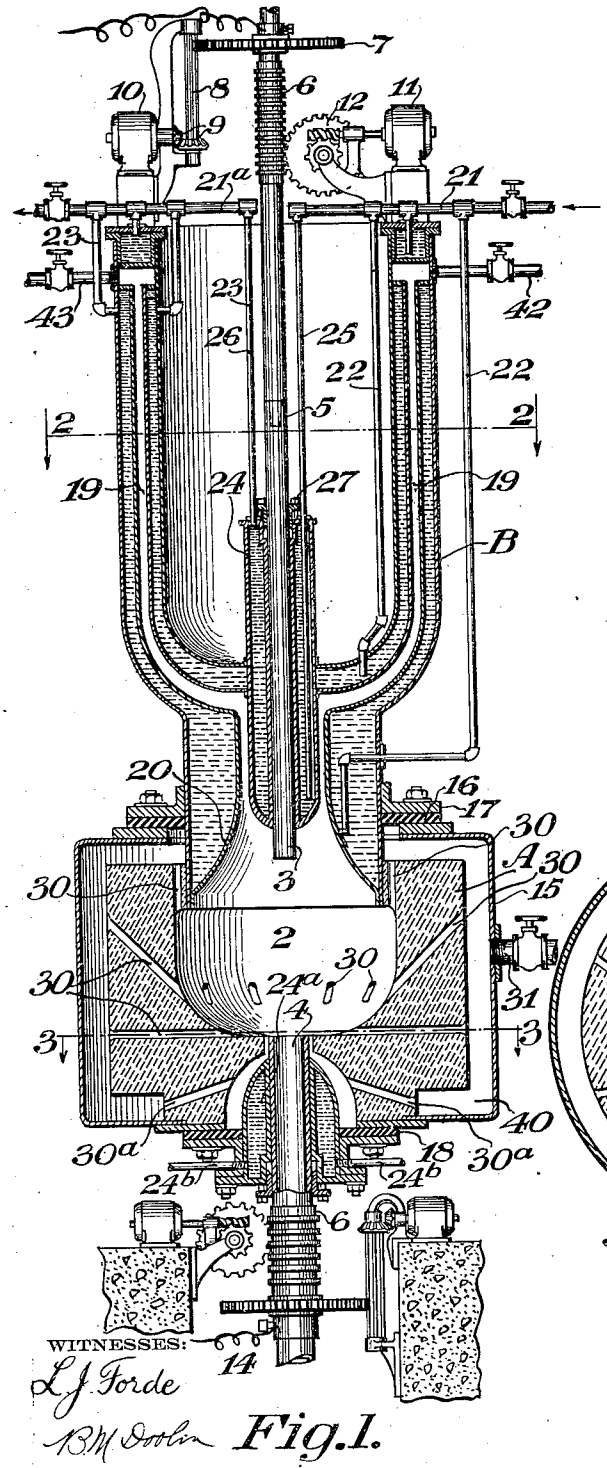


Fig.1.

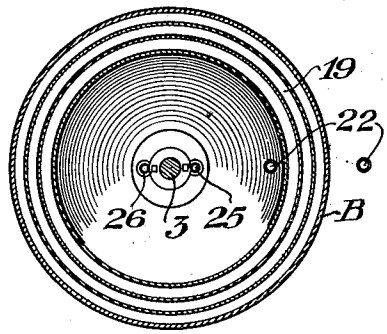


Fig.2.

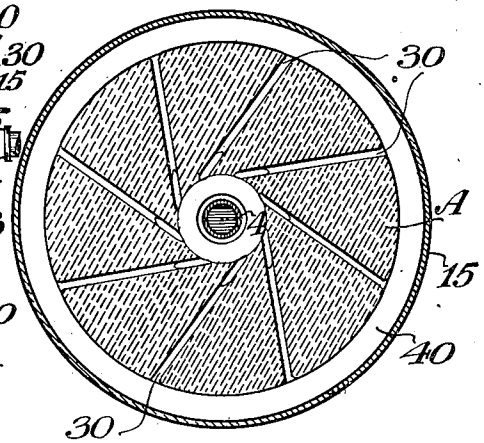


Fig.3.

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ELECTRIC FURNACE FOR FIXING NITROGEN FROM THE AIR.

1,232,179. Specification of Letters Patent. Patented July 3, 1917.

Application filed January 19, 1916. Serial No. 72,939.

To all whom it may concern:

Be it known that I, SVEND BARFOED, a citizen of the United States, residing at Oakland, in the county of Alameda and State of California, have invented new and useful Improvements in Electric Furnaces for Fixing Nitrogen from the Air, of which the following is a specification.

This invention relates to an electric furnace particularly constructed for use in connection with the fixation of atmospheric nitrogen, for combining oxygen and nitrogen, or for the treatment of other gases by means of an electric arc.

It is known that certain gaseous chemical compounds, such as oxids of nitrogen, are formed by passing air through or into immediate contact with an electric arc. Many attempts have been made to produce compounds of this nature, such as nitrogen, nitric-acid, etc., on a commercial scale, but these attempts have proved more or less unsuccessful, the main difficulties encountered being as follows:

No furnace has seemingly been produced which is capable of continuous operation, nor has any furnace been produced in which the air or gases when heated to a high temperature by the arc is sufficiently rapidly cooled. It is known that the gaseous chemical compounds formed at high temperatures easily decompose if they are not rapidly cooled from the high temperature at which they are formed, to a comparatively low temperature. Practical experience and operation of furnaces heretofore in use have also brought out many mechanical difficulties which further renders the process or apparatus used impracticable and commercially unsuccessful.

The object of the present invention is to provide a furnace which is so constructed that continuous operation during extended periods of time, for instance, thirty days, will be possible, and that the objections previously referred to will be entirely overcome.

The invention consists of the parts and the construction and combination of parts as hereinafter more fully described and claimed, having reference to the accompanying drawings in which—

Figure 1 is a central vertical section through the furnace.

Fig. 2 is a cross-section on line 2—2 of Fig. 1.

Fig. 3 is a cross section on line 3—3 of Fig. 1.

Referring to the drawings in detail, A indicates the furnace proper constructed of any suitable make of fire brick or other refractory material. Formed interior of the refractory lining A is a furnace chamber 2 into which projects a pair of electrodes 3 and 4. The electrode 3 is preferably solid and constructed of copper, steel or any other metal desired. The electrode is preferably made in sections which are adapted to be joined together by a connection similar to the one indicated at 5 and means have furthermore been provided for rotating the electrode and simultaneously forcing it into the furnace chamber 2 at a rate which is just sufficient to maintain a fixed spacing between electrodes as burning away or consumption of the electrodes takes place. One form of mechanism is here shown for the purpose of rotating and feeding the electrode, said mechanism comprises a hollow sleeve on the exterior surface of which is formed an annular rack bar 6. Secured on the upper end of the sleeve is a spur gear 7 which intermeshes with an elongated pinion 8, continuously driven by means of a pair of connected beveled gears 9 and a motor 10. The motor 10 with connected gear train, transmits a rotary motion to the sleeve through which the electrode 3 passes, and the second motor 11 forces the sleeve and electrode in a downward direction through means of the gear train 12 which intermeshes with the annular rack bar 6. By referring to Fig. 1, it will be seen that the lower electrode 4 is similarly controlled and that a pit 14 has been provided, to permit insertion of the lower electrode through the sleeve 6. The lower electrode may be constructed in a manner similar to the upper electrode 3 or may consist of metallic oxids compressed into a metal tube which may be constructed so that it can be handled or inserted through the sleeve 6. While both electrodes are here shown as provided, with means for rotating and forcing same into the furnace, it is obvious that both or either may remain stationary.

Surrounding the furnace A and spaced from same to form a surrounding air chamber, is a metal casing 15. This casing supports the refractory material of which the furnace proper is constructed and is itself in turn supported in any suitable manner or as here shown by a plurality of foot-extensions. Centrally disposed with relation to the furnace A and supported on the upper end of the casing 15 is a gas cooler

generally indicated at B. This cooler is insulated from the casing 15, by interposing a fiber or asbestos plate 16 between a flange 17 formed on the lower end of the cooler and the casing proper. The upper electrode 3 passing through the center of the cooler is therefore insulated from the casing 15 and from the lower electrode 4 as this is in turn insulated from the casing 15 by means of an insulating plate 18 similar to that indicated by plate 16. The cooler employed in the present instance is cup-shaped as shown, for reasons hereinafter to be described and is provided with an annular discharge passage 19, which communicates with the furnace chamber 2 by means of a centrally disposed downwardly turned cone-shaped neck 20. The annular passage 19 is completely surrounded or water-jacketed on both sides and a constant circulation in the jacket is maintained, through pipes 22 and 23, which are connected with a source of water supply by means of pipe 21. By referring to Fig. 1, it will also be seen that the annular discharge passage 19 gradually tapers from one end to the other, being smallest in area at the upper end. This forms one of the important features of the present invention and will later be more fully described. Centrally disposed in the lower portion of the cooler B, and projecting into the neck 20 or lower end of the discharge passage 19, is a waterjacketed tube 24, through which the electrode 3 passes. This tube is provided for the purpose of guiding the electrode 3 and also for the purpose of cooling same. Pipes 25 and 26 connected with the main supply pipe 21 and the return 21^a provide means for keeping a constant circulation in the tube. The tube is furthermore provided with a stuffing box 27 at its upper end, which positively prevents any escape of gases between the electrode and the tube 24. The lower electrode is also provided with a cooling tube 24^a and a constant circulation of water is maintained through pipes 24^b.

Formed in the refractory lining A of the furnace is a plurality of air passages 30 which communicate at one end with the interior of the furnace and at the other end with the space formed between the casing 15 and the exterior of the furnace. Said passages are all tangentially disposed and some of the passages are arranged in a horizontal, others in a vertical, and still others in an angular, position. Air admitted to the space between the casing 15 and the furnace proper, passes through the several passages 30 just described, directly into the furnace chamber 2 and are here given a swirling motion as all the passages are tangentially disposed. The air may be supplied by any suitable means such as a compressor, fan, etc., said air being admitted through pipe 31. The provision of the exterior air chamber 40 formed between the casing 15 and the furnace and the arrangement of the several air passages 30, also forms one of the important features of the present invention as will hereinafter be described.

The operation of the furnace as a whole will be as follows:

The entering air or gas to be treated delivered through pipe 31 by means of a compressor or fan, first enters the space 40 between the furnace A and the casing 15. It then passes through the furnace lining, that is, through the numerous air passages formed therein, the position of which are such that the entering gas or air stream is set into a helical motion over the entire inner surface of the lining, preferably this helical motion is downward and inward toward the center of the furnace until the air or gas stream reaches the circumference of the lower electrode where an upward stream of air or gas from the lower air passages 30^a meets the downward-inward stream and deflects it in an upward-inward direction; to facilitate the motion or direction of the air or gas in this manner, the furnace walls are designed with the object in view to create as little disturbance in the air or gas stream as possible. The upward-inward deflection forces the air or gas into the sphere of action of the electric arc and is thus heated to a sufficiently high temperature to cause fixation of the nitrogen contained therein.

It is now necessary to cool the resultant product as rapidly as possible to prevent decomposition. This is readily accomplished in the present instance by the arrangement and construction of the cooler B. The cooler is so designed and arranged that the air or gas under high temperature after passing through or leaving the arc formed between the electrodes is directed into the neck 20 of the annular discharge passage 19 and as this is cone-shaped and flared as shown, but small resistance is offered to the passage of the hot gases. The gas products impinging with a swirling motion against the metal surfaces of the water-cooled cooler will consequently rapidly decrease in temperature and volume. The velocity is however, kept constant as the annual passage 19 gradually decreases in area as previously described, toward its upper end in proportion to the contraction of the gases, thus maintaining a constant velocity, both of incoming and outgoing gases. This condition is desirable for rapid cooling as the rate of heat transfer from a hot gas to a metallic and cooled surface, being almost directly proportional to the velocity of the gas over this surface is thereby greatly increased. The control and direction of the air currents entering the furnace is of great benefit as it prevents gases already fixed, from decomposing by contacting with the excessively

hot furnace walls. These excessive hot walls are however, eliminated in the present instance as the refractory lining is kept comparatively cool by the numerous air passages formed herein, and also by the swirling action of the incoming air between the arc and the surface lining. The gases passing through the annular passage 19 are finally permitted to escape through a pair of pipes indicated at 42 and 43, which are connected with apparatus not necessarily described, where the gases are further treated. The cup-shaped construction of the cooler is of great importance as it forms a compact unit which at the same time permits the provision of a large cooling surface employed for the purpose of rapidly reducing the temperature of the gases treated in the furnace. In actual practice with furnaces heretofore constructed, it has been found that the best results are obtained where continuous operation is possible. The provision and arrangement of the solid electrodes here shown that can be joined to new ones, permits these to be continuously fed into the furnace as they are consumed, without interrupting the operation of the furnace. The operation may therefore extend over, practically speaking, an indefinite period of time, and all danger of puncturing or burning the electrodes unevenly is entirely eliminated. In several of the furnaces now used, it is common practice to employ hollow metal tube electrodes, closed at the lower ends by means of metal caps. These tubes are cooled by water entering through a pipe which is centrally disposed in the tube and reaches nearly to the cap for the purpose of permitting the cooling fluid to impinge on same, thereby producing the greatest cooling efficiency possible. This cap is however, gradually consumed by the action of the electric arc and it is only a matter of time before it becomes so thin that it punctures, thus not only destroying the action of the arc but also permitting water to enter the furnace with consequent detrimental action. In my furnace this objection is entirely eliminated as the solid electrodes employed are easily cooled by means of the tubes 24 instead of internally, as described. The solid metal electrode, preferably constructed of copper, is passed through the fluid cooled tube 24, which is sufficiently long to guide the electrode and to produce the desired cooling surface required. This, together with the means for joining one electrode to the other, and the means for rotating and forcing the electrodes inwardly as they are being consumed, not only permits continuous operation over indefinite periods of time, but also prevents the ends of the electrodes from burning unevenly, which is objectionable as it often deflects the air stream, causing excessive heating of one side of the stream and not sufficient heating of the other side, resulting in inefficient fixation.

The helical air stream passing over the furnace walls also keeps the refractory lining at such a temperature that its insulating value against the passage of the electric current is maintained, permitting the use of higher voltages in furnaces of large capacity where it becomes important to work with as low amperage as practicable in order to reduce the dimensions of the current carrying parts of the furnace.

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

1. The combination with an electric furnace having a pair of electrodes mounted therein and a source of current supply for maintaining an arc between the electrodes, of means for delivering air or gas to the furnace and directing it through the sphere of action of the arc and a cooler having an annular cooler discharge passage of large area compared to its volume formed therein directly connected with the furnace to rapidly decrease the temperature of the air or gas after it leaves the electric arc.

2. The combination with an electric furnace having a pair of electrodes mounted therein and a source of current supply for maintaining an arc between the electrodes, of means for delivering air or gas to the furnace and directing it through the sphere of action of the arc, and a cup-shaped cooler having an annular discharge passage of large area compared to its volume formed therein directly connected with the furnace to rapidly decrease the temperature of the air or gas after it leaves the electric arc.

3. The combination with an electric furnace having a pair of electrodes mounted therein of means for delivering air or gas to the furnace and directing it through the sphere of action of the arc, a cup-shaped cooler having a water-jacketed discharge passage of large area compared to its volume formed therein directly connected with the furnace to rapidly decrease the temperature of the air or gas after it leaves the electric arc, and means for maintaining a circulation of water in the jacket.

4. The combination with an electric furnace and the electrodes mounted therein, of means for rotating one of the electrodes, and simultaneously feeding it into the furnace as it is being consumed by the arc to maintain a uniform heating and reaction in said furnace.

5. The combination with an electric furnace and the electrodes mounted therein, of means for rotating both electrodes to maintain a uniform heating and reaction in said furnace.

6. The combination with an electric fur-

nace and the electrodes mounted therein, of means for rotating both electrodes and simultaneously feeding same into the furnace as they are being consumed by the arc to maintain a uniform heating and reaction in said furnace.

7. The combination with an electric furnace having means for delivering air or gas thereto and an outlet for the gases, of a cup-shaped cooler having a water-jacketed annular discharge passage of large area formed therein directly connected with the outlet in the furnace, a water-cooled tube centrally disposed and extending through the lower end of the cooler, an electrode extending through said tube into the furnace and adapted to be cooled and guided by the tube, and a second electrode extending into the furnace.

8. The combination with an electric furnace having means for delivering air or gas thereto and an outlet for the gases, of a cup-shaped cooler having a water-jacketed annular discharge passage of large area formed therein directly connected with the outlet in the furnace, a water-cooled tube centrally disposed and extending through the lower end of the cooler, an electrode extending through said tube into the furnace and adapted to be cooled and guided by the tube, a second water-cooled tube entering through the furnace, and an electrode extending through said tube into the furnace.

9. The combination with an electric furnace having means for delivering air or gas thereto and an outlet for the gases, of a cup-shaped cooler having a water-jacketed annular discharge passage of large area formed therein directly connected with the outlet in the furnace, a water-cooled tube centrally disposed and extending through the lower end of the cooler, an electrode extending through said tube into the furnace and adapted to be cooled and guided by the tube, another electrode extending into said furnace, and means for rotating the first named electrode.

10. The combination with an electric furnace having means for delivering air or gas thereto and an outlet for the gases, of a cup-shaped cooler having a water-jacketed annular discharge passage of large area formed therein directly connected with the outlet in the furnace, a water-cooled tube centrally disposed and extending through the lower end of the cooler, an electrode extending through said tube into the furnace and adapted to be cooled and guided by the tube, a second water-cooled tube entering through the furnace, and an electrode extending through said tube into the furnace.

11. The combination with an electric furnace having a plurality of vertically, horizontally and angularly disposed air inlet passages into a furnace chamber, of a casing surrounding the furnace and spaced from same to form a surrounding air passage which communicates with said chamber through the air inlet passage in the furnace, and means for delivering air to be treated to said surrounding air passage.

12. An electric furnace for effecting gas reactions comprising a furnace chamber having a substantially concave bottom, an electrode extending into said chamber near the center of the concavity, and means for distributing incoming gases over the concave surface of the chamber and directing them generally toward said electrode.

13. An electric furnace for effecting gas reactions comprising a furnace chamber, electrodes extending into said chamber, said chamber being provided with an outlet and a plurality of inlets for gases so disposed as to cause part of the incoming gases to move first away from said outlet and subsequently toward said outlet in contact with the arc maintained between the electrodes.

14. An electric furnace for effecting gas reactions comprising a furnace chamber provided with an outlet for gases, an electrode extending into said chamber near said outlet, another electrode extending into said chamber, and means for causing gases to move first near the surface of said chamber and subsequently through the center of said chamber in the general direction of the line joining said electrodes.

15. In an electric furnace for effecting gas reactions the combination with a furnace chamber provided with an outlet for gases and an electrode extending into said chamber, of means for introducing a portion of the reaction gases directly into said chamber and means for causing another portion of the gases to contact with said electrode just prior to entering said chamber.

16. In an electric furnace for effecting gas reactions the combination with a furnace chamber provided with an outlet for gases and an electrode extending into said chamber, of means for introducing a portion of the reaction gases at intermediate parts of said chamber and means for causing another portion of the gases to contact with said electrode just prior to entering said chamber at one end thereof.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

SVEND BARFOED.

Witnesses:
JOHN H. HERRING,
W. W. HEALEY.