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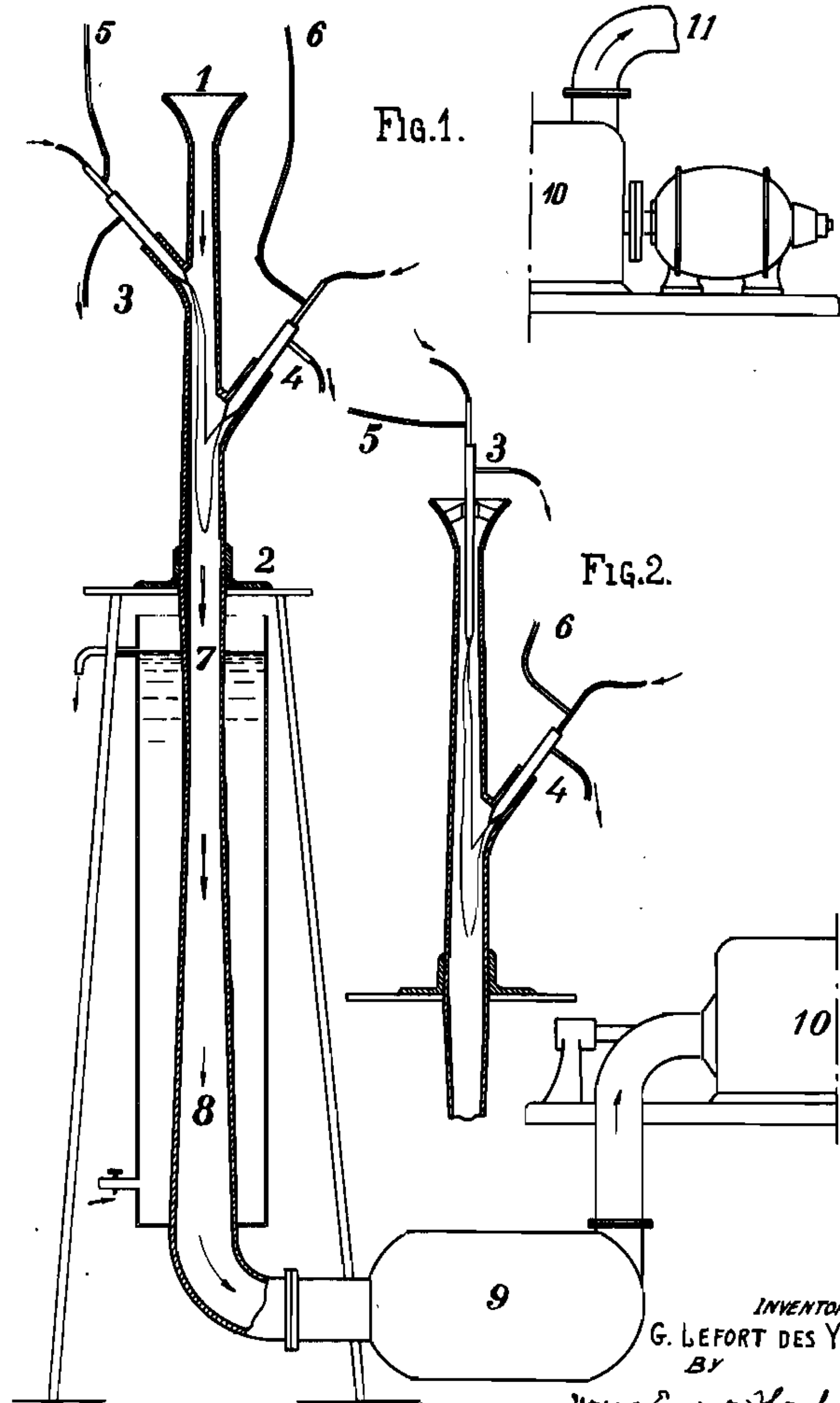

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HIGH FREQUENCY ELECTRIC FURNACE FOR THE PRODUCTION OF OXIDES OF NITROGEN

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This invention relates to a high frequency electric furnace for the production of oxides of nitrogen.

In electric arc furnaces intended for the production of oxides of nitrogen, the simultaneous use of high frequency currents and reduced pressure give much increased outputs, but a sufficiently low pressure is expensive to produce, and can hardly be considered unless a means can be found of recovering the necessary energy.

Experience shows that high blowing speeds do not harm the production of oxides of nitrogen, any more than the stability of the arc, when high frequency current is used. This fact renders possible the use of a diverging compression tuyere after the arc, and consequently a considerable raising of the pressure to the suction of the air pump, which means considerable economy.

In order to obtain the greatest possible recovery of pressure, it is important to produce the reduced pressure by passage into an expansion tuyere, allowing the speeds to attain very high values—higher, in principle, than the speed of sound and, for example, ranging between 400 and 700 metres per second. The pressure is thus low, for example of the order of 100 grams residual pressure, while the temperature is very low, for example from −100° to −150° C.

This air of high velocity, low pressure and very low temperature, arrives on the electric arc. The high speed leads to a small section. The distance between the electrodes and the axis of the furnace is thus necessarily small.

In order to avoid the effect of shock, the loss of speed and the abrupt rise of pressure which would be produced by a short arc, the arc is lengthened, so that the supply of heat may be progressive.

The lengthened arc also has the advantage of taking a lower intensity, for an equal power. As the wear on the electrodes and the energy lost by their cooling are, above all, a function of the intensity, the lessening of the latter is very advantageous.

A short arc would lead to a high intensity, particularly as the ohmic resistance of air is greatly diminished by reduced pressure.

In the present invention, this lengthening of the arc may advantageously be effected by the use of two staggered electrodes. The first of these electrodes may be disposed in the axis of the current of gas. Said current of gas is then annular ahead of the arc, and fills the reaction chamber from the tip of the electrode. This arrangement has the advantage of better protecting the walls of the furnace against the heat of the arc, and also of facilitating the establishing of a correct profile for the furnace.

The pressure must, above all, be very low along and at the end of the are, in order to lessen the decomposition of NO into N+O, which is very greatly diminished by the lowering of the pressure. It is thus important to prevent the pressure from rising on passage of the air into the arc. Now, the air expands on being heated in the arc, so that it is essential to see that this expansion does not result in an increase of pressure.

When the speed of the gas exceeds that of sound, a cylindrical reaction chamber provides a reduction of the speed, and an increase of pressure at the rear. An appropriate divergence enables this increase of pressure to be avoided, and even enables a reduction of the pressure along the arc to be obtained.

The profile is so designed that the pressure remains constant, or falls a little, between the first and second electrode, from 100 to 80 grams residual pressure, for example.

The particles of air heated by the arc to the temperature of the latter are immediately cooled by mixture with the very cold air arriving.

Finally, at the outlet of the zone where the arc develops, the temperature of the gaseous mixture is lowered by 100° to 160° by comparison with what it would be if the arc were developed in quiescent air and, in consequence, at ordinary temperature. This is highly conducive to a good yield of oxides of nitrogen.

The air leaving the arc at a speed of the order of 400 to 900 metres per second, and at a temperature of several hundred degrees centrigrade, passes into a compression tuyere. The latter is preferably slightly converging at first and then diverging, the angle at the vertex of the cone being, at the maximum, from 7 to 8°.

It is thus possible to raise the pressure beyond half an atmosphere, which renders the construction of the vacuum pump very simple, while the power consumed is relatively low.

It is advantageous to cool the compression tuyere from the outside, which lessens the decomposition and, at the same time, increases the specific gravity of the gas. This increase of specific gravity permits better recovery of pressure.

The high or very high frequency arc—for example a frequency of 10^7 to 10^8 cycles per second—resists perfectly wind of supersonic velocity and, despite what might be believed, the reactance N+O=NO has time to be effected, particularly if a substantially cylindrical chamber be disposed between the furnace and the compression tuyere, where the pressure remains constant, although appreciable, for a short while. The decomposition is very low and the yield of NO is very high, being of the order of from ten to fifteen times what is obtained at low frequency and ordinary pressure, per kilowatt hour.

The high frequency currents give rise to losses through capacity in the neighbouring metallic members, thus causing not only a loss of power, but also troubles in operation, so that it is advantageous is reduce such members to a minimum.

To this end, the furnace constructed in accordance with the present invention is essentially composed of a tubular portion of tight and solid refractory material, which does not heat up to any substantial extent in a high frequency electric field.

Quartz or fused silica give excellent results and enable all external members to be dispensed with, together with all joints in the reaction chamber. Resistance to wear through dust is considerable and enables the internal surface to be kept polished, which is very important in order not to cause losses of charges.

At the same time, the expansion is almost nil and causes no cracks.

On account of the high yields obtained, the energy expended per kilo of gas is low, and an important part of this energy is absorbed by the reaction N+O=NO, which is endothermic. It follows that the temperature, at the outlet of the arc, is relatively low, from 100° to 400° C., for example. Under these circumstances, the quartz resists perfectly, the metallic electrode dusts do not attack it, and no fusible silicate is formed, as would be formed at higher temperatures, of the order of 1000° C., habitually used in electric arc furnaces.

After the recuperating tuyere the gases, under a pressure raised to several hundred grams, traverse a cooler and arrive in a cooled state at a vacuum pump which delivers them, either at atmospheric pressure or at a higher pressure, into absorption towers where the nitric acid derived from the oxides of nitrogen contained in the gases is collected.

In order more clearly to understand the invention, reference is made to the accompanying drawings, which illustrate diagrammatically and by way of example, a preferred embodiment thereof, and in which:

Fig. 1 is a side elevation, partly in section, of the apparatus; and

Fig. 2 is a detail of a modification.

The air arrives in the quartz furnace at 1 and leaves the same at 2 (Fig. 1).

The high frequency electric current arrives at the electrodes 3 and 4 at 5 and 6 respectively.

The gases pass into a cylindrical space 7, and then into the compression tuyere 8. They pass into the cooler 9, and are taken by the vacuum pump 10, being discharged at 11.

The metallic electrodes are of the water cooled type.

Fig. 2 represents a modification in which the first electrode is axial.

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