Oct. 27, 1942. T. ELLEFSEN 2,300,355

PROCESS FOR THE PRODUCTION OF CARBIDES AND FERRO-ALLOYS

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Fig. 1.

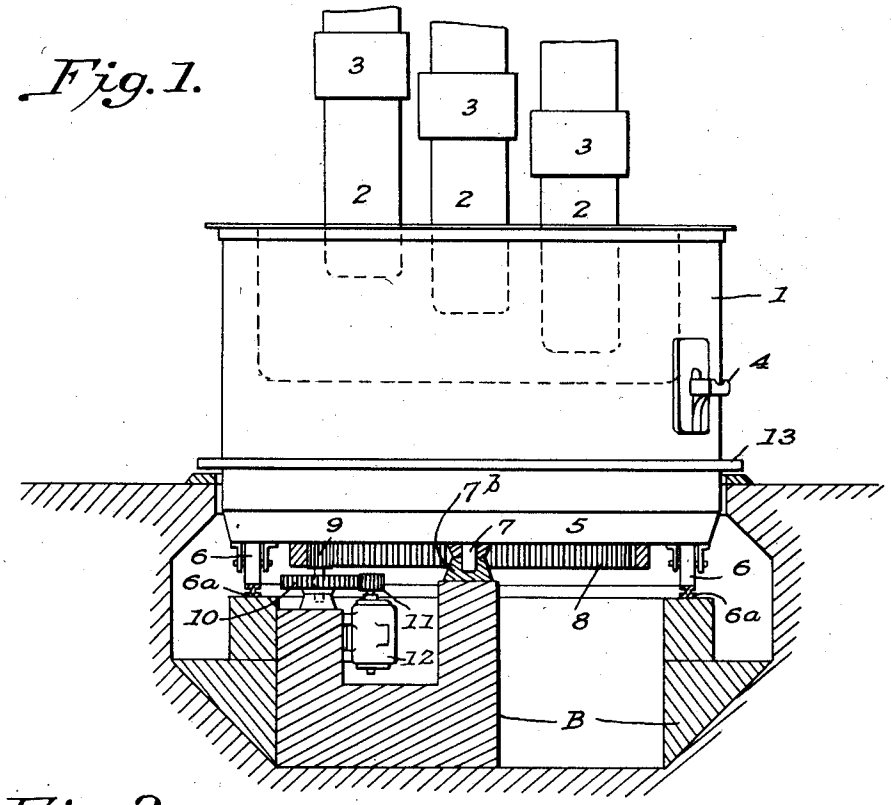
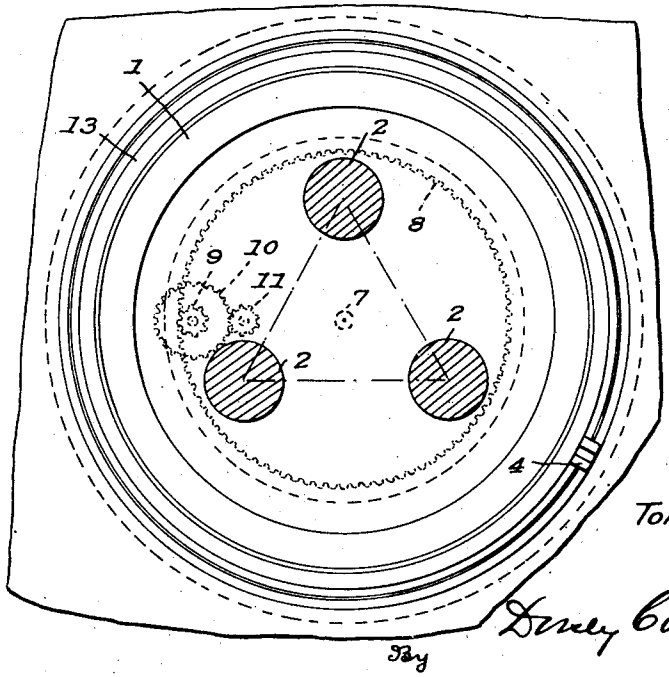


Fig. 2.



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Fig. 3.

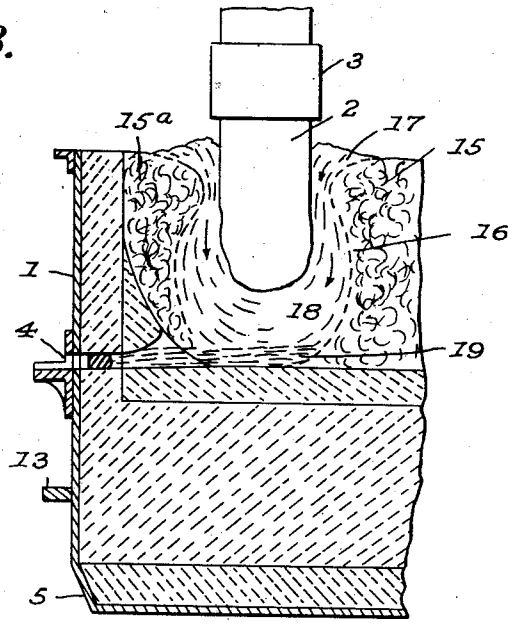
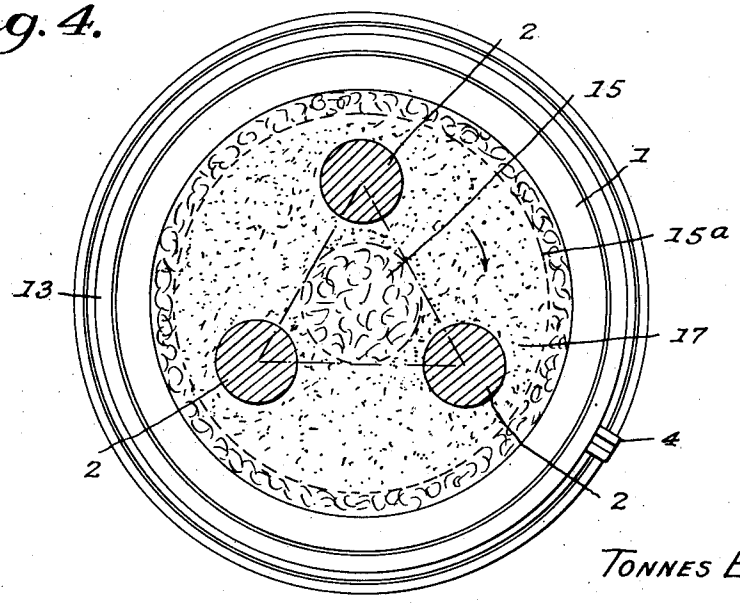


Fig. 4.



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PROCESS FOR THE PRODUCTION OF CARBIDES AND FERRO-ALLOYS

Tönnes Ellefsen, Porsgrunn, Norway

Application May 1, 1941, Serial No. 391,416
In Norway July 3, 1935

6 Claims. (Cl. 13—34)

The present invention relates to electric resistance furnaces where the supply of energy is effected by means of electrodes and is especially directed to electrothermic metallurgical processes more particularly in the production of carbides and ferro-alloys in which alternating current is employed.

In such furnaces the electrodes generally hang vertically into the charge and the development of heat takes place at the lower end of the electrode point dipping into the charge. The supply of energy to such furnaces is commonly regulated by varying the electrical resistance in the furnace by raising or lowering the electrodes in the charge. In such furnaces the experience has been that the operation is effected more efficiently at the beginning than at a later stage of the process. This may be easily explained by the fact that at the beginning of the process the charge is porous so that the reaction gases may easily escape therethrough and be dispersed in a greater part of the furnace surface.

After some time fusion craters are formed around the electrodes. These craters take the form of incrusted pockets around the lower ends of the electrodes and contain the fresh charge which is being electrothermically acted upon. The openings between the materials in the charge forming the crater walls are gradually clogged with sintered materials, flying dust, etc. By reason of this the spreading of the gases and their even distribution over a greater part of the surface is prevented. Instead they are driven out in greater quantities, often quite locally on very small areas between the crater wall and the electrode. The operators call this "blowing" of the furnace. This results in uneven operation of the furnace, great losses through evaporation, heat loss, varying electric load, etc. As the condition proceeds the operation of the furnace becomes increasingly difficult.

Also the tapping of the furnace is rendered difficult and the craters themselves become smaller so that it is often necessary to clean out the furnace. This happens for instance when producing metallic silicon whereby it is ordinarily necessary from time to time to change the operation into production of lower alloys containing more iron in order to wash away the impurities which have accumulated and thereby again widen out the craters.

One object of the present invention is to avoid these drawbacks by giving the electrode an opportunity always to operate in newly formed craters. It is intended to effect this by displacing the electrode and the charge relatively to each other in such a way that there will be no time or opportunity for formation of craters with sintered walls which prevent evolution of gases, new fresh craters being continuously formed while the relative displacement is effected. The movement should preferably take place continuously and may be effected by moving the furnace relatively to the electrodes or the electrodes relatively to the furnace. The movement may be adjusted according to speed of reaction and load. Facilities must be provided whereby the movement necessary to displace the craters relatively to the charge may be effected independently of the motion necessary for regulating the load on the electrodes. As the surface of the charge in such a furnace is approximately horizontal and the electrodes hang vertically into this charge an especially convenient arrangement will be attained by arranging the electrodes eccentrically in the furnace and then rotating the furnace in such a way that the electrodes pass through practically the total charge during the rotation.

A further object of the invention is to increase the efficiency of the prior methods by conserving and dispersing the heat developed in the furnace and employing such heat in preheating the charge prior to the smelting action. The timing of the relative movement between the electrodes and the charge is so regulated that the movement between the electrodes and the charge is such that the electrodes surrounded by newly formed craters, as it were, burn their way through the charge. This relieves the electrodes of lateral strain which might result in breakage and permits the charge to be supplied to points high up on the sides of the electrodes. With the electrodes thus buried deep in the charge above the smelting area, when the charge reaches the smelting area it has attained a high temperature and the smelting is more quickly and economically effected.

Other objects of the invention will become apparent as this description proceeds.

As an alternative to the relative rotary movement between the electrodes and furnace above set forth the furnace or electrodes may be given an oscillating movement so as to bring the electrodes in operating contact with as much as possible of the charge. Also a combined oscillating and rotating movement of the furnace and/or electrodes may be possible within the scope of the invention.

In cases where the relative movement is affected by rotation of the furnace, by feeding

the raw materials into the furnace through tubes which do not follow the movement of the furnace this movement may also be utilized for obtaining an even distribution of the raw materials in the furnace with a minimum of charging tubes.

Furthermore, in such cases it should be noted that it may be of advantage in connection with the present method to arrange the smelting furnace at an angle relative to the horizontal plane. This may in many instances facilitate the tapping of the furnace and contribute towards keeping the furnace bottom clean. The reason for this is that the bottom of the furnace during the rotation of the furnace at periodic intervals will approach one of the electrodes.

Another advantage of the rotation of the furnace is that it is possible in a three-phase furnace to tap all three craters at one side of the furnace. Ordinarily, though not of necessity, it will be preferable to arrest the rotation during the tapping. It should be mentioned that the rotation makes it easier to tap all three craters through one tapping hole, the reason for this being that the product from the different craters flows together more easily and forms a common bath.

In the accompanying drawings I have illustrated a suitable furnace in which my process may be carried out and have illustrated certain characteristics of the process carried on in such furnace. I have selected for illustration a horizontal three-phase furnace which is rotated about its vertical axis and have shown means for effecting this rotation. It should be understood, however, that the said drawings are purely for illustrative purposes and are not limitative upon the scope of my invention.

In the said drawings Fig. 1 illustrates in elevation an electric furnace (broken away) supplied with three electrodes, and in vertical cross-section the supporting and rotating parts for the furnace;

Fig. 2 is a top view of the furnace illustrated in Fig. 1, the electrodes being shown in horizontal cross-section;

Fig. 3 is a vertical cross-section of a portion of the furnace of Fig. 1 illustrating the tap hole thereof and showing the raw material, the solid charge, the crater, the melt, and one electrode as herein above recited; and

Fig. 4 is a top view of the furnace corresponding with Fig. 2 but with the raw material in the furnace.

The furnace 1 is provided with a bank of three centrally positioned electrodes 2 suitably supported in holders 3. By way of illustration of the various vertical positions in which the electrodes may be placed in the varying conditions of operation of the furnace as herein set forth, I have shown three positions of the electrodes as illustrative of the raising and lowering of the electrodes in varying the resistance of the furnace to maintain the proper smelting temperature. The furnace is suitably lined and is provided with a tap hole 4.

At the bottom the furnace is formed with a ground plate 5. This ground plate carries near its periphery rollers 6 which travel on tracks 6a mounted on the supporting bed B for the furnace. The furnace rotates about a vertical pin 7 located in the axis of the furnace and mounted on the ground plate 5 centrally of thrust bearings 7b which are suitably mounted between the ground plate 5 and the bed B.

An inwardly gear-toothed annular flange 8 is mounted on the bottom of the ground plate 5, its teeth registering with a spur gear 9 driven by reducing gearing 10, 11, from an electric motor 12.

A flange 13 may be supplied around the bottom of the furnace to prevent loose material from dropping into the pit in which the supporting bed B is located.

The electrical connections with the electrodes 2 and furnace 3 are well known in the art and are not specifically illustrated. The furnace operates on A. C. current. The furnace may be continuously rotated about its centrally positioned bank of electrodes which are continuously energized.

Reference being had to Figs. 3 and 4 it can be seen that the furnace is partially filled with raw material 15, 15a which by reason of partial sintering and reduction, while porous, is more or less solid and is herein referred to as the "solid charge." At the center this solid charge is more or less circular as shown at 15 in Fig. 4, and at the sides it is formed more or less as a shell 15a. The amount of this solid charge is greatly reduced by the movement of the furnace 1 in respect to its bank of electrodes 2.

The craters around the electrodes 2 are illustrated at 18. These are newly and continuously formed around each electrode as the charge carried by the furnace is moved in relation to the electrodes. The crater which surrounds the lower part of each electrode has its outer edges formed by the partially sintered boundary layer 16 of the solid charge.

Into the space between this boundary layer 16 and the electrodes, the raw material 17 to be smelted is charged into the furnace preferably continuously by suitable means not specifically illustrated. It will be observed that the charge is so fed to the furnace that the lower part of the electrode is entirely buried therein to a depth which extends nearly to the electrode holder as illustrated in Fig. 3, and that the top of the charge is substantially level with the top of the furnace. In some furnaces, for example, the charge may extend up the sides of the electrode for a distance of approximately from three to five feet. This charge in the case of carbides, as is well known, is composed of a suitable proportion of coke and lime. By keeping the charge well up on the electrodes, as just stated, it attains a high temperature prior to reaching the smelting zone and the smelting is greatly expedited.

As the smelting takes place the calcium carbide (or ferro-alloy) formed drops to the bottom of the furnace hearth as a liquid and constitutes the melt 19; the gases escape through the pores of the solid charge and upward out of the crater through the raw material being supplied thus contributing to the preheating thereof; and blowing of the furnace is prevented, the porosity of the solid charge more particularly in the boundary layers of the craters being maintained by the relative movement between the charge and the electrodes.

As illustrated in the drawings the bottoms of the electrodes in the regular operation of the furnace are kept above the level of the melt in the furnace hearth, the melt being tapped off from the furnace through tap hole 4 in well-known manner, preferably though not necessarily, periodically.

It is evident that the speed of the rotation should be adjusted according to the process em-

ployed. For each process there exists a certain maximum speed, where the movement takes place without development of appreciable side pressure on the electrodes. This speed is probably dependent upon the rapidity of the vertical descent of the materials in the craters. If this maximum speed is surpassed, the electrodes will press against the materials in the walls of the craters, particularly in the upper part of the charge, and the danger exists that the electrodes will break off.

The relative speed between the charge and the electrodes may thus be varied according to the nature of the process from the speed at which blowing is initially prevented upward until the speed, which corresponds to the descent of the materials in the craters, is reached. In calcium carbide and ferro-alloy three-phase furnaces of about 10,000 kva. capacity speeds ranging from twenty-four to eighty-five hours for one complete rotation of the furnace have given excellent results. Stated in another way, it takes from about one to nearly four full days for such a furnace to turn around once. If in such a furnace the electrodes were positioned with their centers about 5 feet from the axis of rotation, this would mean that the electrodes were moving through the charge at a rate of between about 4 inches and 15 inches per hour. Such slow speeds as these are necessary in order that the electrodes will not plow through the charge, because as has already been stated, if the relative movement of the electrodes and charge is such that the electrodes press against the charge, the danger exists that the electrodes will break off. On the contrary, when the relative speed is very slow, the electrodes substantially burn their way through the charge without the development of side pressure. The material adjacent the arc is fused and runs down to the bottom of the furnace. This removes the support for the material and crust above the crater which in turn falls down into the melting zone. By this procedure new crater walls are continually being formed even though no agitation of the charge takes place. It is these new walls which permit the escape of gases and prevent the furnace from blowing.

An important advantage of the process hereinabove set forth is that a much greater part of the charge of the furnace will take part in the reaction than has heretofore been possible so that the dead part of the charge will become very much reduced.

This application is a continuation in part of my application Ser. No. 87,115, filed June 24, 1936.

The foregoing detailed description is given for illustration only and no undue limitation is to be inferred therefrom.

I claim:

1. In the production of carbides and ferro-alloys by smelting a suitable charge in an electric furnace adapted for continuous operation and provided with one or more electrodes, the electrothermic process which includes during the continuous operation of the furnace the steps of energizing each electrode with alternating current, supplying the furnace with the raw material to be smelted, effecting relative movement between the charge and each electrode by relative movement between each electrode and the furnace hearth, regulating and positioning each electrode so that each electrode extends through and is surrounded by the charge for a substantial portion of its length above the smelting zone and is held out of contact with the melt at the bottom of the furnace hearth, preventing the clogging of the pores of the new craters continuously formed around the lower end of each electrode by suitably regulating the speed differential between the electrode and the charge so that each electrode travels very slowly through the charge at a speed depending upon the rapidity of the vertical descent of the materials in the craters so that such electrode can form a path through the charge without the development of appreciable side pressure on the electrode and thereby tending to prevent blowing of the furnace, and tapping off the liquid smelted product directly from the furnace hearth as the smelting is completed, substantially as described.

2. In the production of carbides and ferro-alloys by smelting a suitable charge in an electric furnace adapted for continuous operation and provided with one or more electrodes, the electrothermic process which includes during the continuous operation of the furnace the steps of energizing each electrode with alternating current, supplying the furnace with such quantity of the raw material to be smelted that such raw material extends substantially to the top of the furnace, effecting continuous relative movement between the charge and each electrode by continuous relative movement between each electrode and the furnace hearth, regulating and positioning each electrode so that each electrode extends through and is surrounded by the charge for a substantial portion of its length above the smelting zone and is held out of contact with the melt at the bottom of the furnace hearth, preventing the clogging of the pores of the new craters continuously formed around the lower end of each electrode by suitably regulating the speed differential between the electrode and the charge so that each electrode travels very slowly through the charge at a speed depending upon the rapidity of the vertical descent of the materials in the craters so that such electrode can form a path through the charge without the development of appreciable side pressure on the electrode and thereby tending to prevent blowing of the furnace, and periodically tapping off the liquid smelted product directly from the furnace hearth as the smelting is completed, substantially as described.

3. In the production of carbides and ferro-alloys by smelting a suitable charge in an electric furnace adapted for continuous operation and provided with one or more electrodes, the electrothermic process which includes during the continuous operation of the furnace the steps of energizing each electrode with alternating current, supplying the furnace with such quantity of the raw material to be smelted that such raw material extends substantially to the top of the furnace, effecting sidewise movement between the charge and each electrode by relative sidewise movement between each electrode and the furnace hearth, regulating and positioning each electrode so that each electrode extends through and is surrounded by the charge for a substantial portion of its length above the smelting zone and is held out of contact with the melt at the bottom of the furnace hearth, preventing the clogging of the pores of the new craters continuously formed around the lower end of each electrode by suitably regulating the speed differential between the electrode and the charge so that each electrode travels very slowly through the charge at a speed depending upon the rapidity of the

vertical descent of the materials in the craters so that such electrode can form a path through the charge without the development of appreciable side pressure on the electrode and thereby tending to prevent blowing of the furnace, and periodically tapping off the liquid smelted product directly from the furnace hearth as the smelting is completed, substantially as described.

4. In the production of carbides and ferro-alloys by smelting a suitable charge in a three-phase electric furnace adapted for continuous operation and provided with three electrodes, the electrothermic process which includes during the continuous operation of the furnace the steps of energizing each electrode with alternating current, supplying the furnace with such quantity of the raw material to be smelted that such raw material extends substantially to the top of the furnace, effecting relative movement between the charge and the electrodes by rotating the furnace hearth around the electrodes, regulating and positioning each electrode so that each electrode extends through and is surrounded by the charge for a substantial portion of its length above the smelting zone and is held out of contact with the melt at the bottom of the furnace hearth, preventing the clogging of the pores of the new craters continuously formed around the lower end of each electrode by suitably regulating the speed differential between the electrode and the charge to accord with the rate of descent of the raw material around each electrode so that each electrode can form a path through the charge without the development of appreciable side pressure upon it but so that the craters will move through the charge to form continually changing crater walls and thereby tending to prevent blowing of the furnace, and periodically tapping off the liquid smelted product directly from the furnace hearth as the smelting is completed, substantially as described.

5. In the production of carbides and ferro alloys by smelting a suitable charge in an electric furnace adapted for continuous operation and provided with one or more electrodes, the electrothermic process which includes during the continuous operation of the furnace the steps of energizing each electrode with alternating current, supplying the furnace with the raw material to be smelted so that each electrode extends through and is surrounded by the charge for a substantial portion of its length above the smelting zone, and very slowly moving each electrode sideways through the charge at such a speed that no appreciable side pressure will develop on the electrode but the craters will move through the charge to form continually changing crater walls and thus prevent the furnace from blowing.

6. A process as specified in claim 5 in which the relative movement between the electrodes and the furnace follows an approximately circular path and each electrode takes from 24 to 85 hours to make a single rotation.

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