June 16, 1942. J. A. HARDIN 2,286,732

ELECTRIC FURNACE

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Fig. 2

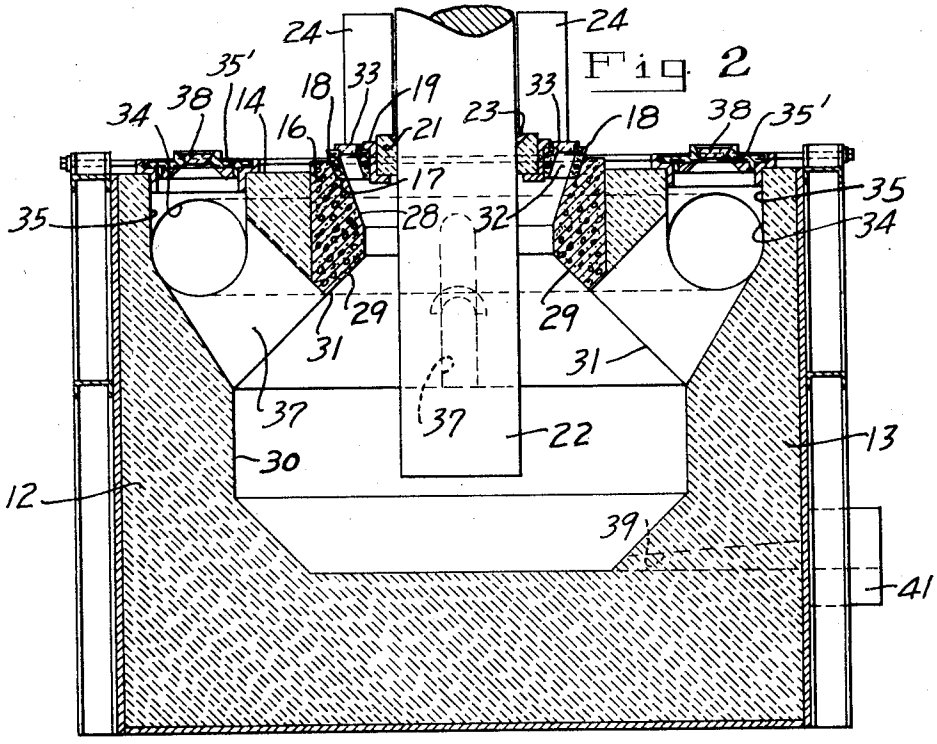
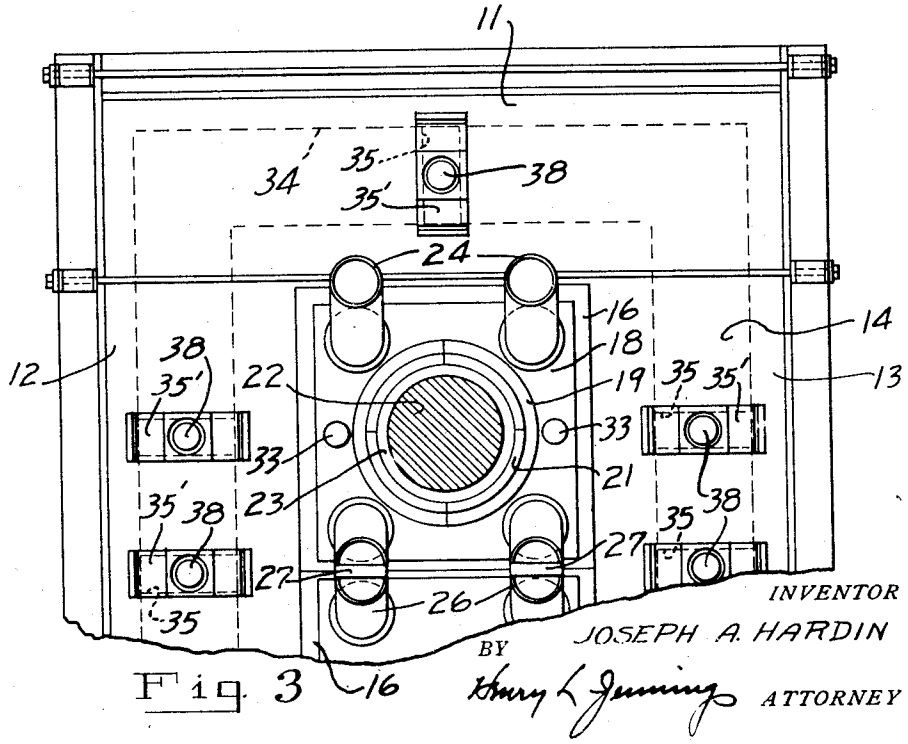


Fig. 3



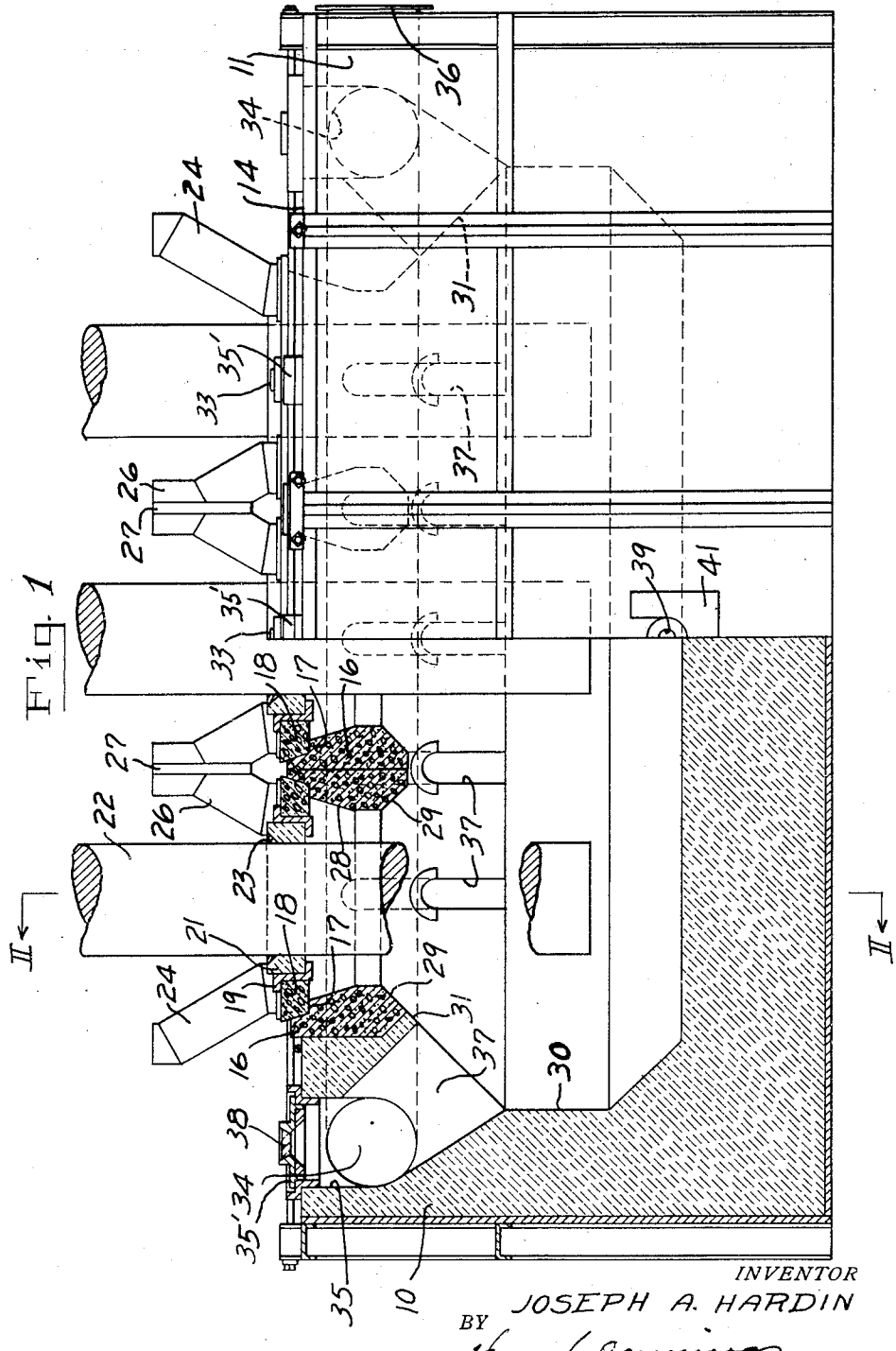
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ELECTRIC FURNACE

Filed March 20, 1941 2 Sheets-Sheet 1

Fig. 1



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2,286,732

ELECTRIC FURNACE

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9 Claims. (Cl. 13—9)

This invention relates to an electric smelting furnace, particularly to a furnace for smelting phosphate rock, and has for one of its objects the provision of such a furnace with means for feeding the stock downwardly through the roof, and with inner walls so designed that, in cooperation with the stock feeding means, the furnace in operation is completely filled with stock at all times, and there is no gas space or pocket formed in the upper part of the furnace.

A further object of my invention is to provide an electric smelting furnace having stock feed openings in the roof extending downwardly into a hopper section, with the under side of the roof inclined toward and merging with the hopper section, and gas offtake means including ducts extending downwardly to connect with the furnace below the stock.

A still further object of my invention is to provide an electric smelting furnace for phosphate rock, together with means to filter the gases developed during the smelting operation through the coarser part of the stock charge, and means to withdraw the gases from a point below the stock.

Another object of my invention is to provide an electric furnace having stock feeding means which effectively seals the furnace against the ingress of air or outward leakage of gas during operation.

As is well known in the art to which my invention relates, one of the major problems encountered in the production of phosphoric acid and elemental phosphorus in an electric furnace process is the carrying over of dust by the gases developed during the smelting operation, which dust contaminates the acid or elemental phosphorus collected and is difficult of separation. This difficulty is particularly hard to overcome in the production of elemental phosphorus, due in part to its highly combustible nature and low igniting point. The separation of dust from phosphorus thus collected has been found to be well nigh impossible.

I have found, in the operation of electric furnaces as heretofore constructed, that the dust is formed and carried over with the gases principally because the gas offtake means have been located in the furnace above the stock line. Also the furnaces have been so constructed that the gases collect in the upper part and the dust from each fresh dry charge of rock is free to pass out with the stream of phosphorus bearing gas formed in the smelting operation. Furthermore, in event of a slip in the furnace, which frequently occurs, there is always a large volume of dust formed which passes out with the gases. This dust is collected with the phosphorus and contaminates it, as heretofore described.

In accordance with my invention, I provide a furnace with a feed hopper in the roof and with an electrode extending downwardly through the feed hopper, with the stock forming a seal around the electrode. I incline the under side of the furnace roof toward the feed hopper at an angle greater than the angle of repose of the stock. The side walls of the furnace may be vertical, or substantially so. In operation, the fine particles of stock move downwardly toward the center of the furnace, and the coarser particles roll to the outside against the side walls and the inclined under side of the furnace roof. The furnace is thus maintained full of stock at all times during operation and no gas pockets can form in the upper part of the furnace, as has been possible with all furnaces heretofore known to me. I construct a gas header in the roof extending around the upper part of the furnace, and connect the gas header with the interior of the furnace by means of downwardly inclined ducts communicating with the furnace through the inclined under side of the roof at a point below the normal stock line. The gas header being formed in the roof of the furnace is maintained at a temperature above the dew point of phosphorus when the furnace is in operation, thus preventing condensation of phosphorus.

In my improved furnace the gas formed in the bottom around the arc filters upwardly through the stock into the ducts and out through the gas header to the offtake. In this way, more than 95% of the dust in the stock is filtered out of the gases by passing through the coarse stock bed, and I overcome the dust difficulty by so constructing the furnace as to inhibit dust being carried over with the gases.

A furnace embodying features of my invention is illustrated in the accompanying drawings forming a part of this application, in which

Fig. 1 is a view partly in section and partly in elevation, of said furnace;

Fig. 2 is a sectional view taken along the line II—II of Fig. 1; and

Fig. 3 is a partial plan view of the furnace showing the arrangement of the feed hopper, feed chutes, and poke holes in the top of the furnace.

Referring to the drawings for a better un-

derstanding of my invention, I show a furnace having end walls 10 and 11, side walls 12 and 13, and roof 14. The general support and staying of the furnace follows conventional lines, and need not be described. Also, the inner side and end walls are constructed of the usual refractory materials employed in such furnaces, which forms no part of my present invention.

Located centrally from side to side, and set into the roof of the furnace at regular intervals, are precast concrete feed hoppers 16, which may be made of high temperature cement and crushed fire brick in order to withstand the heat. The hoppers 16 are formed with an inner shoulder 17 near the top, on which rests a precast concrete hopper top 18 made of the same materials as the hopper. Fitting within the hopper top 18 is a circular cast iron seal ring support 19, which is preferably made of two pieces and is of Z-shape in cross section to support a refractory seal ring 21. The seal ring 21 is preferably cast in four segments, as shown in Fig. 3, which rest on the lower flange of the seal ring support 19. Extending downwardly through the seal ring 21 is an electrode 22, and an asbestos air seal packing 23 is interposed between the electrode and the seal ring 21. In Fig. 1 of the drawings I show a three-electrode furnace with three feed hoppers constructed as just described, but it will be apparent that my invention is applicable to a furnace having one or more electrodes.

Each of the feed hoppers 16 has a plurality of feed chutes 24 and 26 connected thereto. The end chutes 24 are single chutes, while the intermediate chutes 26 may be arranged as double chutes, with insulators 27 between them. It will be seen by reference to the drawings that the hoppers form a solid covering for the furnace except for the feed chutes and electrode openings. Immediately within the furnace, the feed hoppers 16 have inwardly converging walls 28 forming a constricted hopper section to insure that the stock being fed through the feed chutes 24 and 26 will effectively fill and seal the space between the electrode 22 and the feed hopper. The lower portion of the feed hoppers 16 diverge outwardly at 29 to merge with the converging under side 31 of the furnace roof. Poke holes 32 are provided in the hopper top 18, whereby to dislodge stock in event it should hang in the hopper or the furnace. As is understood, these poke holes are usually covered by caps 33 when the furnace is in operation. As will be seen in Figs. 1 and 3, the feed hoppers 16 abut each other along the length of the furnace and form a part of the furnace roof. The inner side walls 30 which join to the under side 31 of the furnace roof are preferably vertical or substantially so.

Built into the upper part of the end and side walls of the furnace is a header 34 terminating on the outside at one end of the furnace in an offtake 36, where an offtake flue, not shown, may be connected.

As already pointed out, the under side of the furnace roof, both at the sides and the ends, inclines towards and merges with the diverging under sides 29 of the feed hoppers. The angle of inclination is important and should be greater than the angle of repose of the rock being smelted. As the stock is fed down through the hoppers 16 it naturally assumes a position against the inclined under surface of the roof, and thus effectively precludes the formation of gas pockets in the upper part of the furnace. Extending through the inclined under side 31 of the furnace roof, below the stock line, are a plurality of gas ducts 37 connecting the interior of the furnace to the gas header 34. The gas ducts 37, as may be seen in Fig. 1, are spaced at regular intervals around the furnace whereby the gas formed in the smelting operation may find a ready exit to the gas duct 34. Poke holes 35 having relatively large cleanout covers 35', which in turn have relatively small covered openings 38 therein for the insertion of rods, are provided over the gas header above each of the ducts 37 to give access to the interior of the furnace when necessary for loosening a hanging charge or cleaning out. Slag is removed from the furnace through a tap hole 39 and trough 41. Any showing of the electrode supports and electrical connections has been omitted for the reason that they are well understood and form no part of the present invention.

In operation, the furnace charge of phosphate rock, coke and silica is fed downwardly into the feed hoppers 16 around the electrodes 22. The stock forms an effective air seal around the electrodes and prevents the escape of gas from the furnace or the ingress of air into the furnace, thus permitting the furnace to be operated either above or below atmospheric pressure. Also, the effective seal provided by the feed hopper and the stock prevents the oxidation of the electrode 22 around the feed opening.

As the stock passes into the furnace, the fines which constitute the main dust forming portion of the charge tend to move straight down, while the coarser portions of the charge roll to the outside and against the converging under side 31 of the furnace roof. The smelting zone of the furnace is in the lower part below the electrode 22, and the gases formed in the smelting operation pass upwardly through the stock, being filtered through the slowly moving charge into and through the gas ducts 37 into the gas header 34 leading to the gas offtake. The chutes 24 and 26 are kept full of stock, so that there is always stock against the inclined under side 31 of the furnace roof to provide the filtering action just described.

From the foregoing it will be apparent that I have devised an improved electric smelting furnace which is so constructed as to be completely filled with stock during operation, and no gas space is formed in the upper part of the furnace; and one in which the gases generated are filtered through the slowly moving stock charge before entering the gas outlet ducts.

While I have described my improved furnace in particularity in connection with the smelting of phosphate rock, it will be apparent that it is adapted for any smelting operation in which such a furnace has heretofore been employed, and that it is of particular value in smelting operations in which the dust carried over with the gases produced is a problem. I wish it to be further understood that I do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

What I claim is:

1. In an electric furnace for the continuous smelting of phosphate rock comprising side and end walls and a roof with an electrode mounted to feed downwardly through the roof, a feed hopper surrounding the electrode and having a constricted portion therein to cause the stock to

form a gas seal around the electrode, feed chutes connected to the hopper to maintain the furnace full at all times, the under side of the roof of the furnace being inclined toward the electrode for the stock to lie thereagainst, and a gas header formed in the roof with openings into the furnace located below the stock line.

2. In an electric furnace for the continuous smelting of phosphate rock having side and end walls, a roof, and an electrode extending downwardly through the roof, a feed hopper surrounding the electrode, means to feed stock into the hopper and maintain it full at all times, the under side of the roof converging toward and merging with the side of the feed hopper in the upper part of the furnace, a gas header formed in the roof and extending around the furnace, and gas ducts in the roof connected to the header and opening into the furnace below the stock line, to give access to the interior of the furnace.

3. In an electric furnace for the continuous smelting of phosphate rock having substantially vertical side and end walls, a roof, and an electrode mounted for free movement downwardly through the roof, a feed hopper surrounding the electrode, means to feed stock continuously into the feed hopper, the under side of the roof converging in the upper part of the furnace toward the feed hopper at an angle greater than the angle of repose of the stock being smelted, gas offtake ducts formed in the roof and communicating with the furnace through the converging walls, and a gas header in the roof extending around the furnace and connecting with the gas offtake ducts.

4. In an electric furnace for the continuous smelting of phosphate rock, side and end walls and a roof, a feed hopper in the roof, an electrode mounted to move freely downwardly through the feed hopper in a position for the stock to form a seal therearound, means for feeding stock into the hopper to maintain it full at all times, the under side of the roof converging inwardly at the top at an angle greater than the angle of repose of phosphate rock, a gas header in the roof, and gas ducts formed in the roof and extending downwardly from the gas header to open into the furnace at a point below the stock line.

5. In an electric furnace for smelting phosphate rock, a roof, a feed hopper in the roof having downwardly contracting inner wall portions, an electrode disposed centrally of the feed hopper and extending downwardly into the furnace in a position for the stock to form a seal around the electrode, the under side of the roof converging toward and merging with the lower end of the feed hopper, gas ducts communicating with the interior of the furnace through the converging walls, a gas header formed in the roof and connected to the gas ducts, and a plurality of feed chutes connected to the hopper and disposed to feed stock downwardly thereinto to maintain the hopper and furnace full of stock at all times and form an effective seal about the electrode.

6. In an electric furnace for smelting phosphate rock, a roof, a plurality of feed hoppers in the roof disposed one adjoining another at regular intervals in the roof, feed chutes connected to the hoppers to maintain them full at all times, an electrode extending centrally downward through each of the feed hoppers in a position for the stock to form a gas seal around the electrode, the under side of the roof converging toward the hoppers at an angle greater than the angle of repose of phosphate rock to cause the charge to roll against the under side of the roof and fill the furnace completely, a gas header formed in the roof, and gas ducts communicating with the header and the furnace through the roof below the stock.

7. In an electric furnace for smelting phosphate rock, a roof, a plurality of feed hoppers in the roof disposed one adjoining another at regular intervals in the roof, feed chutes connected to the hoppers to maintain them full at all times, an electrode extending centrally downward through each of the feed hoppers and so disposed in relation to the hopper that the stock forms a gas seal therearound, the under side of the roof converging toward the electrodes and merging with the lower ends of the hoppers at an angle greater than the angle of repose of phosphate rock to cause the charge to roll against the under side of the roof and fill the furnace completely, a gas header formed in the roof and gas ducts in the roof communicating with the header and the furnace below the stock.

8. In an electric smelting furnace for the continuous smelting of phosphate rock embodying side and end walls and a roof, a feed hopper located centrally between the side walls, an electrode extending centrally downward through the feed hopper and spaced therefrom for the stock to form a gas seal in the hopper, feed chutes connected to the feed hopper, said hopper being closed at the top except for the feed chute connections and electrode opening, the under side of the roof inclining from opposite sides of the furnace towards the feed hopper at an angle greater than the angle of repose of the stock being smelted and merging with the lower end of the hopper to cause the stock to move from the feed hopper against the roof and fill the furnace completely.

9. In an electric smelting furnace embodying side and end walls and a roof, a feed hopper located centrally between the side walls, an electrode extending centrally downward through the feed hopper and spaced therefrom to cause the stock to form a gas seal therearound, means to feed stock into the hoppers and maintain them full at all times, the under side of the roof being inclined from opposite sides of the furnace toward the feed hopper at an angle greater than the angle of repose of the stock being smelted and merging with the lower end of the feed hopper to cause the stock to move from the feed hopper against the under side of the roof and fill the furnace completely, a gas header formed in the roof around the upper part of the furnace, a plurality of gas ducts formed in the roof and connecting the header with the furnace below the stock, and means giving access to the interior of the furnace through the gas header and the gas ducts.

JOSEPH A. HARDIN.