Nov. 13, 1956 L. H. ALMOND 2,770,451

FURNACE FOR DEFLUORINATING PHOSPHATE ROCK

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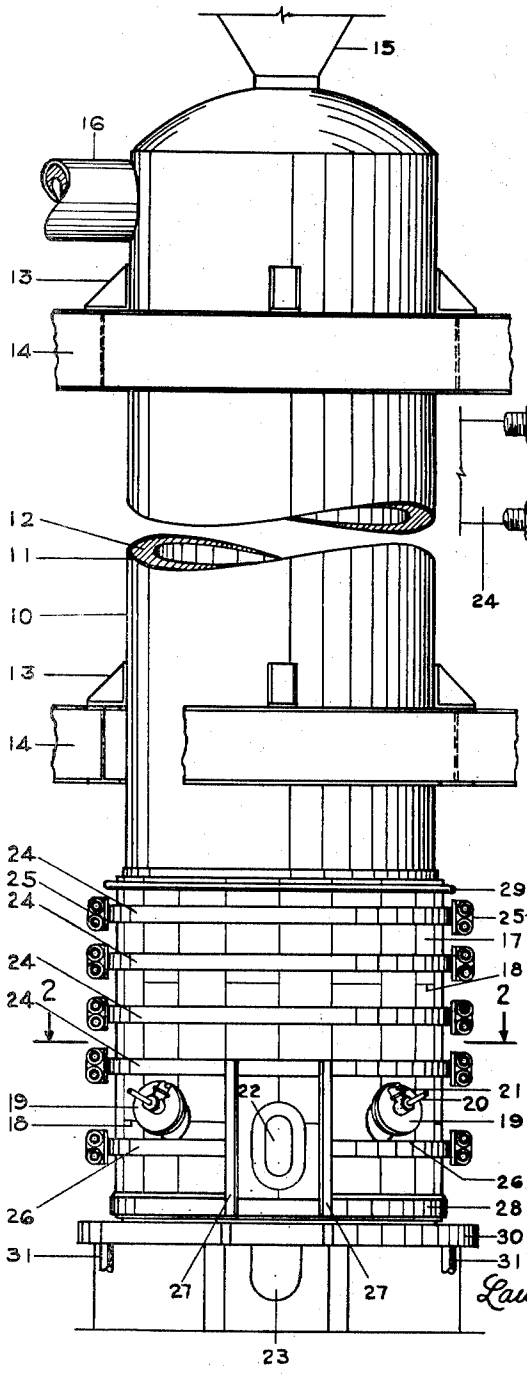


Fig. 1

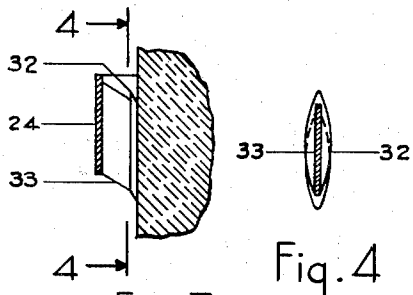


Fig. 3

Fig. 4

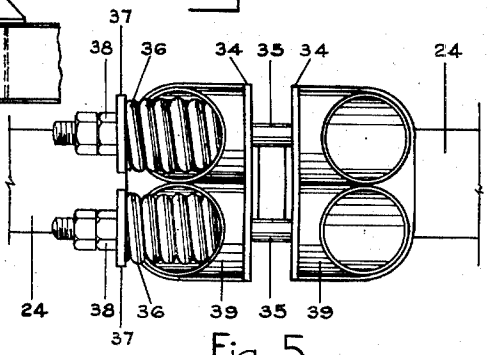


Fig. 5

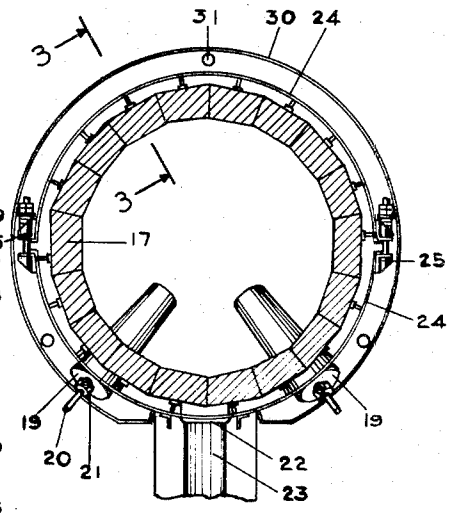


Fig. 2

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FURNACE FOR DEFLUORINATING PHOSPHATE ROCK

Lawrence H. Almond, Florence, Ala., assignor to Tennessee Valley Authority, a corporation of the United States

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2 Claims. (Cl. 263—29)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention herein described may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to improved furnaces for the defluorination of phosphate rock by a fusion process.

Defluorinated phosphate rock produced by a fusion process is commonly termed "fused tricalcium phosphate." Its production in a shaft furnace has been described in U. S. Patent 2,474,831, issued July 5, 1949, and in U. S. Patent 2,499,385, issued March 7, 1950. A description of the process has been published by Hignett and Hubbuch [Ind. Eng. Chem. 38, 1208–16 (December 1946)]. A detailed account of the development of the process has been published by the Tennessee Valley Authority in Chemical Engineering Report No. 7 [U. S. Government Printing Office (1953)].

The Tennessee Valley Authority has been operating two experimental fused tricalcium phosphate furnaces since 1946. The furnaces have a nominal capacity of 60 tons per day each. Corrosion of the furnace hearth has been one of the principal difficulties encountered in operation of furnaces constructed and operated as described in U. S. Patent 2,499,385, although that furnace construction and method of operation are adequate to control corrosion in the upper part of the furnace.

Various types of hearth construction were tried, prior to my invention, without much success. The longest period any of these previous types of construction was operated without a shutdown for major repairs was about six months.

Conditions in the hearth section of a fused tricalcium phosphate furnace are particularly severe. Temperatures range from about 2500° to 2700° F. The atmosphere in the furnace is oxidizing. The molten phosphate readily attacks many refractories, and fluorine compounds are present which are corrosive to siliceous materials and to metals. The hearth structure must not only be capable of withstanding these severe conditions, it must have sufficient mechanical strength to withstand the shocks of stock slides. It must also withstand thermal shocks that occur when the furnace is shut down and started up.

A principal object of my invention is to provide an improved furnace for the production of fused tricalcium phosphate in which corrosion in the hearth section is minimized.

Another object of this invention is to provide a hearth structure for a fused tricalcium phosphate furnace that has a long service life.

Another object is to provide a hearth structure that is capable of withstanding the effects of high temperature and chemical action that obtain in the furnace.

Still another object is to provide a hearth structure that has sufficient strength to withstand mechanical and thermal shocks.

Other objects and advantages of my invention will become apparent as this disclosure proceeds.

The type of furnace with which my invention is concerned has a vertical hearth section surmounted by a

vertical shaft section. Means for charging phosphate to the furnace are provided at the top of the shaft section. A gas offtake is provided near the top of the shaft section. At least one fluid fuel burner or preferably two such burners are located in the hearth section, and a taphole is provided to drain molten phosphate from the furnace.

The improved structure of my invention comprises a vertical-walled section supported independently of the hearth section; a vertical-walled hearth section having walls constructed of graphite blocks bonded together, each of said blocks constituting the full thickness of the hearth wall, the internal diameter of the hearth section being substantially the same as that of the shaft section; means for preventing dislocation of said blocks comprising a plurality of tensioned bands disposed around the hearth wall spaced apart from said wall, and members so disposed upon said bands as to bear firmly against the graphite blocks, there being at least one such member on each band for each of the blocks at the level of the band, and means for distributing a film of cooling liquid of substantial thickness over substantially the entire surface of said hearth section.

I have found that it is unnecessary to provide a tapered bosh section in a furnace of this kind. A film of cooling water flowing down over the outside of the graphite wall of the hearth section is sufficient to cool both that wall and a layer of charge in immediate contact therewith, below the melting point of phosphate rock. Thus the interior of the hearth wall becomes coated with a layer of frozen or semi-frozen tricalcium phosphate which not only prevents ignition of the graphite in the oxidizing atmosphere and high temperature present in the hearth section but also transmits sufficient cooling effect to the charge at some little distance from the wall near the upper part of the hearth to cause such cooled material to perform the charge-supporting function heretofore performed by a bosh.

I have also found that it is essential that the weight of the shaft section be carried by independent means of support, since the graphite hearth section does not have sufficient mechanical strength to carry the great weight of the shaft and charge under the conditions of vibration encountered in operation.

In the attached drawing,

Figure 1 shows an elevation of a fused tricalcium phosphate furnace embodying principles of my invention.

Figure 2 is a horizontal sectional view of the hearth section taken on line 2—2 of Figure 1.

Figure 3 shows a detail of an element used to hold the graphite blocks in place.

Figure 4 is another view showing details of a holding element.

Figure 5 is a detail view showing means for applying tension to bands that encircle the hearth section.

Referring now to the figures, in which like numbers refer to like parts, the numeral **10** designates the vertical shaft section of a fused tricalcium phosphate furnace. The shaft section consists of a metal shell **11** and a refractory lining **12**. The shaft section is supported by brackets **13**, which rest on beams **14** in such a manner that the entire weight of the shaft section is carried by these supports. At the top of the shaft section is a hopper **15** into which phosphatic material is charged. A gas offtake **16** carries off the furnace gases.

Below the shaft section **10** is the hearth section. This section is constructed of graphite blocks **17**. These blocks are assembled to form a vertical, multisided, approximately cylindrical section. The blocks are bonded together with a suitable carbonaceous cement. Each of the graphite blocks **17** is of the full thickness of the

hearth wall. For greatest mechanical strength, it is desirable that the blocks 17 be as long as possible. It is not necessary that they extend the full height of the hearth section, but there should be a minimum of horizontal joints, and these joints should be staggered. As shown in Figure 1, the longest blocks may be about two-thirds as long as the height of the hearth section. The horizontal joints are indicated by numeral 18.

Positioned near the bottom of the hearth section are two burners 19, having fuel inlets 20 and air inlets 21. Located at the bottom of the hearth section is tapping slot 22, through which molten phosphate is withdrawn. Molten phosphate withdrawn via tapping slot 22 flows into trench 23, where it is quenched and granulated by jets of water (not shown).

Encircling the hearth section at several levels are pairs of semicircular bands 24. The pairs of bands are held together and tension is applied to them by tensioning members 25. These members are shown in detail in Figure 4 and will be described later.

Band segments 26, together with a semicircular band 24 which does not appear in Figure 1, provide clearance for tapping slot 22. The ends of band segments 26 are fastened to angles 27.

Band 28 forms a complete circle around the bottom of the hearth section. The space between band 28 and the graphite blocks is packed with carbon paste.

Water is distributed over the hearth section for cooling purposes by spray ring 29. The water is collected in catch pan 30, which is fitted with drains 31. The bottom of the hearth section is a steel plate (not shown) to which the bottom edge of band 28 is welded. This plate rests on beams (not shown) placed in catch pan 30; the beams support the bottom plate above the water level in pan 30. Inside the hearth section the bottom is covered with several courses of firebrick, which in turn are covered by a layer of concrete made from heat-resistant cement and limestone aggregate.

Details of the holding elements which bear against the graphite blocks are shown in Figures 3 and 4. The numeral 32 designates a beveled, streamlined plate which is connected to band 24 by means of spacer 33. The plate 32 is shaped so as to present minimum resistance to the flow of water down the hearth wall. This minimizes the chances for the development of a "hot spot" in the graphite wall. There is at least one of these plates at each block at the level of each of the bands.

In order that the plates 32 will exert a moderate pressure against the graphite blocks, tension is applied to the bands by means of tensioning elements. These elements are designated in Figures 1 and 2 by numeral 25 and are shown in detail in Figure 5.

As shown in Figure 5, angle members are welded to the end of bands 24. The angle members 34 are connected together by bolts 35, the heads of which do not appear in the drawing. The bolts are spring-loaded by springs 36. The springs bear against washers 37, and the tension on the bolts 35 is varied by adjusting the nuts 38. Tubular segments 39 serve to keep the bolt-spring assembly in proper alignment and also to brace the angle members 34.

It has been found that the structure shown in the drawing and described above gives excellent services. This structure has been embodied in one of the experimental furnaces operated by the Tennessee Valley Authority. It was placed in operation in January 1953. Since that time the furnace has been in practically continuous operation. The few, brief interruptions in operation were caused by breakdowns of auxiliary equipment rather than by failure of the furnace structure itself.

The use of graphite blocks in the hearth section of a fused tricalcium phosphate furnace is advantageous in several respects. Carbon is one of the few construction materials that resist corrosion by molten phosphate and fluorine compounds. Amorphous carbon blocks, however, are not suitable. The atmosphere within the hearth section is oxidizing, and there is no satisfactory method for keeping amorphous carbon blocks cool enough to keep them from igniting in this atmosphere. Graphite, on the other hand, is a better conductor of heat. By flowing a film of water over the exterior of the graphite blocks the inside surface can be kept cool enough to prevent igniition and to freeze a layer of fused phosphate on the surface. This frozen layer of phosphate, which ranges in thickness up to about 3½ inches, affords protection against corrosive and erosive attack on the blocks.

The bonded graphite structure does not possess sufficient strength by itself to withstand the stresses imposed upon it by thermal and mechanical shock. Additional support is needed. The supporting structure, however, must not be such as to interfere greatly with the flow of water over the graphite structure. The supporting structure I employ imposes a minimum of interference to the flow of water over the graphite surface. In the time the furnace has been operated, no hot spots have appeared on the graphite blocks.

Of the two experimental fused tricalcium phosphate furnaces operated by the Tennessee Valley Authority, the No. 1 furnace is fitted with the graphite hearth described herein. The No. 2 furnace is similar to the No. 1 furnace except that its hearth is constructed of panels made of ¼-inch and ½-inch thick copper plate. The copper hearth of No. 2 furnace is cooled by flowing a film of water over the hearth exterior. With the exception of the present hearth of No. 1 furnace, the structure of the No. 2 furnace hearth has given better service than any of the previous hearth structures used on these two furnaces.

During the calendar year 1953, No. 1 furnace was out of service for repairs 7.8 percent of the time. None of this down-time was caused by a need for repairs to the hearth section. During the same period, No. 2 furnace was out of service for repairs 10.7 percent of the time. Of the total down-time, 2 percent was for repairs to the copper hearth section. No. 2 furnace had to be shut down four times for such repairs, for periods ranging from 3 hours to 125 hours.

After 8 months of operation, inspection of the No. 1 furnace hearth revealed substantially no deterioration.

I claim as my invention:

1. In a furnace for the production of molten defluorinated phosphate rock having a hearth section surmounted by a shaft section, means for charging phosphate rock located at the top of the shaft section, at least one fluid fuel burner in the hearth section and a taphole at the bottom of the hearth section, that improvement which comprises a substantially round vertical-walled hearth section constructed of a single layer of graphite blocks; a vertical-walled shaft section surmounting said hearth section and having an internal diameter substantially the same as that of the hearth section; supporting members independent of the hearth section, disposed to bear substantially the entire weight of the shaft section; means for exerting uniform pressure upon a small part of each graphite block of the hearth section toward the vertical axis of the furnace disposed around said hearth section; and means for flowing a film of cooling liquid of substantial thickness over substantially the entire external surface of the hearth section in direct contact with the graphite blocks.

2. In a furnace for the production of molten defluorinated phosphate rock having a hearth section surmounted by a shaft section, means for charging phosphate rock located at the top of the shaft section, at least one fluid fuel burner in the hearth section and a taphole at the bottom of the hearth section, that improvement which comprises a substantially round vertical-walled hearth section constructed of a single layer of graphite blocks having their greatest length disposed vertically; a vertical-walled shaft section surmounting said hearth section and

having an internal diameter substantially the same as that of the hearth section; supporting members independent of the hearth section, disposed to bear substantially the entire weight of the shaft section; a plurality of tensioned bands disposed around the exterior of the hearth wall, spaced from said wall; a plurality of small streamlined pressure members disposed upon each of said bands in contact with each of the blocks at the level of each band; and means for flowing a film of cooling liquid of substantial thickness over substantially the entire exterior surface of said hearth section in direct contact with the graphite blocks.

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