March 30, 1937. C. L. LEVERMORE ET AL 2,075,212

MANUFACTURE OF PHOSPHORIC ACID

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Fig. 1.

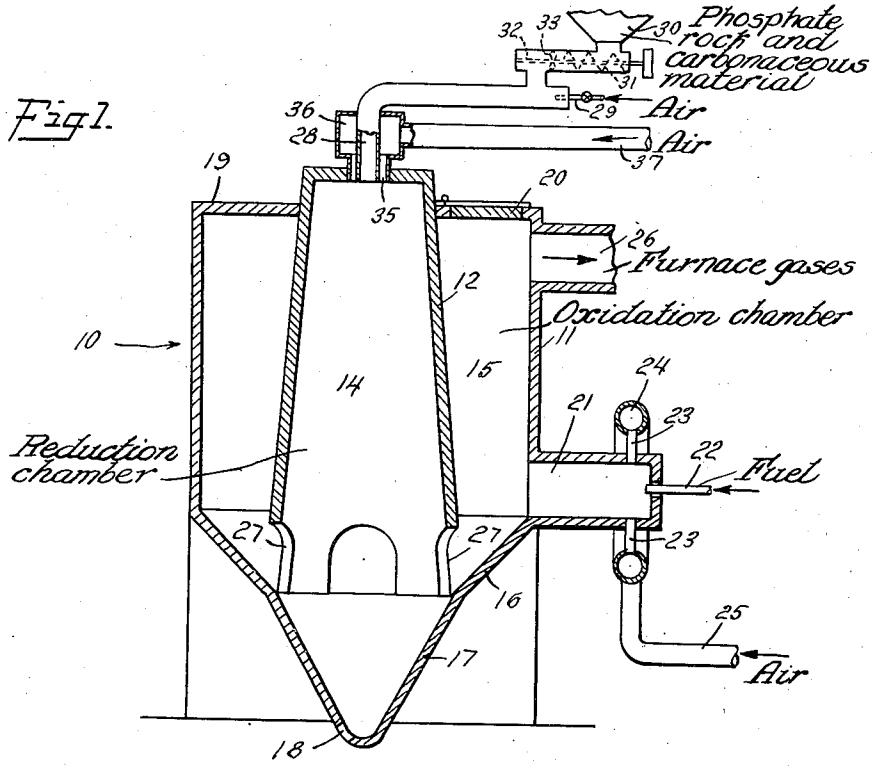
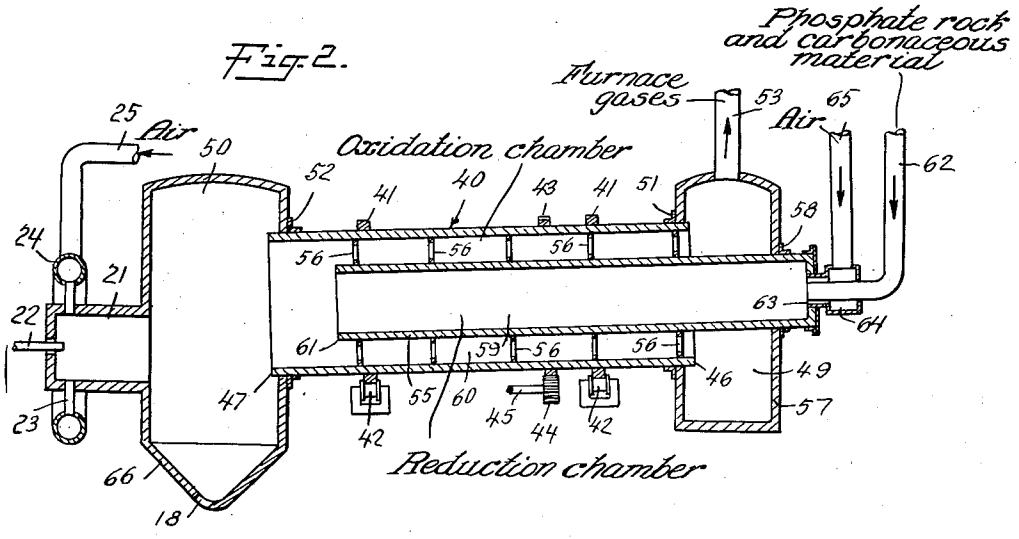


Fig. 2.



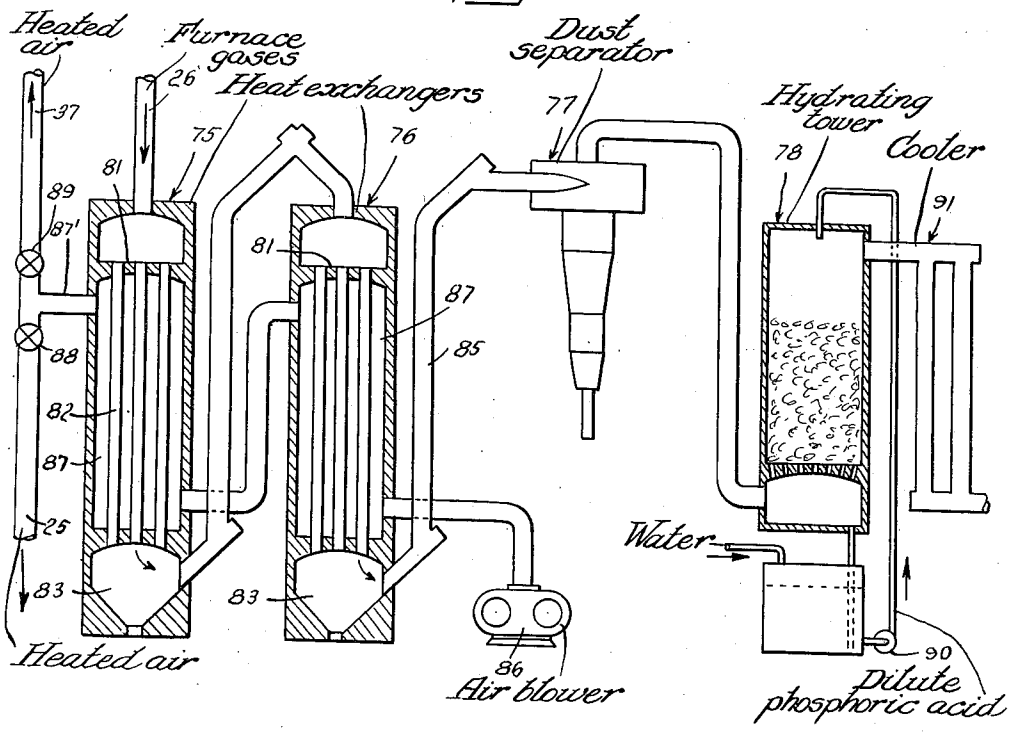
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Fig. 3.



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2,075,212

MANUFACTURE OF PHOSPHORIC ACID

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6 Claims. (Cl. 23—165)

This invention relates to methods and apparatus for the recovery of phosphorus from phosphate rock, and more particularly to the manufacture of phosphoric acid.

The process of the invention involves primarily reduction of phosphates contained in phosphate rock by means of carbonaceous reducing material to produce elemental phosphorus, and subsequent oxidation of the phosphorus to form phosphoric acid. As one of the chief objects thereof, the invention contemplates a process by which the reduction of the phosphate, contained in the phosphate rock, to phosphorus and oxidation of the latter may be effected in a relatively short period of time. To this end, the invention provides, in the preferred embodiments, a process by which phosphates of phosphate rock are reduced while the rock, in finely divided condition, is in suspension in a reducing atmosphere.

As another object, the invention aims to provide a process for the production of elemental phosphorus from phosphate rock by reduction of phosphates thereof in which process part of the fuel required to maintain proper temperature conditions during the reaction is burned in the reducing zone. For this purpose, phosphates of the rock are reduced in the presence of an excess of reducing material over that required to effect reduction of the phosphates of the rock to phosphorus and in the presence of sufficient oxygen to support partial oxidation of the excess of reducing material, thus generating heat directly within the reduction zone.

In the preferred embodiments, the invention includes a procedure carried out in two relatively well defined zones, an initial reduction zone in which phosphate of the rock is reduced, part of the fuel needed in the process is burned, producing carbon monoxide and phosphorus, and a subsequent oxidation zone in which the phosphorus and carbon monoxide from the reduction zone, together with an added amount of extraneous fuel if desired, are burned. Another object of the invention lies in the provision of a process by which the heat generated in the oxidation zone by the oxidation of phosphorus and carbon monoxide may be advantageously utilized to aid in maintaining proper temperatures in the reduction zone. It is still another important object of the invention to provide a process by which substantial economies in fuel requirements may be effected.

The invention accordingly comprises the several steps of the improved processes and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combination of elements and arrangement of parts adapted to carry out the processes of the invention.

A fuller understanding of the objects and advantages of the invention may be had from the following description taken in connection with the accompanying drawings, in which—

Fig. 1 is a vertical section of a furnace in which the preferred embodiments of the process may be effectively carried out,

Fig. 2 is a longitudinal, vertical section of a modified furnace construction, and

Fig. 3 represents a gas purification and absorption system.

Refering to Fig. 1, the furnace indicated generally by reference numeral 10 comprises a vertically disposed outer shell 11, and an inner shell 12 preferably tapering toward the top end. Both shells are preferably circular in cross-section, shell 12 having therein a reduction chamber or zone 14. The outer surface of shell 12 and the inner surface of shell 11 form an annular oxidizing zone or chamber 15. Shell 12 may be made of suitable refractory material such as carborundum, and shell 11 may be made of or lined with similar material to withstand high temperatures and the corrosive action of the reacting materials.

The lower end of shell 11 is provided with a frusto-conical shaped portion 16, and an adjoining cone-shaped section 17, together forming, for the furnace, a hopper bottom terminating in an opening 18 through which slag may be tapped off from time to time. Under some operating conditions, the residue in the bottom of the furnace may be in the dry granular state, in which case provision may be made for discharging material of this nature from the apparatus.

The top of the oxidizing chamber 15 is closed off by an annular crown 19 including one or more outwardly opening doors or valves 20 which operate to open automatically in case of explosion in the furnace. Opening into the oxidizing chamber 15, near the base thereof, is a combustion chamber 21, having a burner nozzle 22 by means of which additional required amounts of fuel may be introduced into chambers 21 and 15. Though combustion chamber 21 is shown for convenience opening radially into chamber 15, it will be understood, in practice, combustion chamber 21 opens tangentially into chamber 15 to afford better mixing of gases therein. Air or other oxidizing gas, for purposes hereinafter noted, may be fed into chambers 21 and 15 through pipes 23 from a bustle 24 connected through pipe 25 with heat

exchangers shown in Fig. 3. Gaseous products formed during the reaction taking place in the furnace are withdrawn therefrom through an outlet pipe 26 opening into the upper end of the oxidizing chamber 15, and communicating at the opposite end with a purification and absorption system represented in Fig. 3.

As indicated on the drawings, the inner shell 12 is cone-shaped, the bottom terminating at about the elevation of the upper end of bottom section 17. The bottom of shell 12 is of substantially the same diameter as the top of section 17, so that fused, partially fused or solid materials drop from chamber 14 into the hopper bottom of the furnace and may be discharged through the opening 18. The bottom of the reduction chamber 14 communicates with the oxidizing chamber 15 by means of openings 27 in the lower end of shell 12. By this construction, it will be seen that fumes and gases on the one hand and fused or solid materials on the other hand are separated at the base of the reduction zone, the latter materials dropping into section 17, while fumes and gases pass through openings 27 into the lower end of the oxidizing zone 15.

A stream of finely divided phosphate rock, carbonaceous material such as coal or coke, and a relatively small amount of air is fed into the reduction zone through an inlet conduit 28, opening at one end into the top of chamber 14 and having a valve controlled air jet 29 in the opposite end. Rock and coal are fed into conduit 28 from a hopper 30 by a screw conveyor 31 the shaft 32 of which carries propellor-like blades 33 acting to feed rock and coal into conduit 28 in a relatively steady stream. Further quantities of air, preferably preheated, are introduced into chamber 14 through annular inlet 35, chamber 36 and pipe 37 communicating with an air preheater in the purification system of Fig. 3.

In Fig. 2 there is illustrated another type of apparatus in which the process of the invention may be carried out. Reference numeral 40 indicates a rotary shell having near the ends annular tires 41 resting in supporting rollers 42. A gear 43, fixed to the outside of the shell, meshes with a pinion 44 keyed to a shaft 45 through which drum 40 is rotated from a source of power not shown.

The ends 46 and 47 of the drum project into chambers 49 and 50, suitable joints being provided at 51 and 52 to substantially prevent gas leakage between the exterior of shell 40 and the adjacent edges of the walls of chambers 49 and 50. Chamber 49 acts as a gas outlet header, and has at the upper end an outlet pipe 53, corresponding with pipe 26 of Fig. 1, through which gases are conducted to the purification and absorption system of Fig. 3.

Carried rigidly by shell 40 is a second rotary shell 55, supported in the position shown in the drawing within shell 40, by spiders 56. The inlet end of shell 55 extends completely through chamber 49 and projects through the outer wall 57 thereof. As shell 55 rotates with the outer shell 40, a suitable gas-tight joint connection is made at 58 to prevent gas leakage.

The interior of the inner drum 55 constitutes a reduction zone or chamber 59, the outer surface of drum 55 and the inner surface of drum 40 forming an oxidizing zone or chamber 60. The reduction zone communicates with the oxidizing zone at the inner end 61 of drum 55, the latter terminating at a point within the outer shell 40. The opposite end of oxidizing zone 60 opens into chamber 49. A mixture of powdered phosphate rock and coal may be injected, in a relatively small stream of carrying air, into the inlet end of drum 55 through a fixed pipe 62, corresponding with pipe 28 of Fig. 1, and connected to a rock-coal feed mechanism similar to that shown in Fig. 1. Also, as in Fig. 1, additional air is introduced into reduction zone 59 through annular inlet 63, chamber 64, and pipe 65, corresponding with pipe 37 (Fig. 1), and connected to the preheaters of Fig. 3.

As indicated on the drawings, the end of shell 40 in chamber 49 is raised to facilitate movement of semi-fluid or solid materials through the reduction chamber 59 toward the outlet end 61 thereof. In operation, fluid or solid material is discharged from the reduction chamber 59 into the lower end of shell 40, and thence into chamber 50. The latter is formed with a hopper-shaped bottom 66 to facilitate discharge of material from the apparatus through tap 18.

Opening into chamber 50 is a combustion chamber 21, equipped with a burner 22, bustle 24 and pipe connections 23 and 25 as in Fig. 1.

Fig. 3 illustrates the gas purification and phosphoric acid collection system. Such system comprises heat exchangers 75 and 76, a dust separator 77 and hydration tower 78. The exchangers 75 and 76 may be constructed of refractory material, and the internal parts exposed to the action of the furnace gases may be lined with more resistant material such as carborundum. The tube header arches 81 and the tubes 82 are also preferably of resistant material such as carborundum. Each exchanger is formed with a relatively large chamber 83 in the lower end which acts as dust chamber and facilitates removal of dust from the gas stream. Furnace gases pass from pipe 26 into the upper end of cooler 75, in series through exchangers 75 and 76, and thence flow through a pipe connection 85 into one or more dust separators 77, preferably of the cyclone type.

Air, for use in oxidizing chambers 15 and 60 of the furnaces of Figs. 1 and 2, is pumped by blower 86 through the chambers 87 surrounding the tubes 82 in exchangers 76 and 75. The air, thus preheated by heat transfer with the hot furnace gases flowing through the tubes of coolers 75 and 76, passes through pipe 87' into conduits 25 and 37 controlled by valves 88 and 89 respectively.

Gases discharged from dust collector 77, made for example of nichrome steel, are conducted into the bottom of hydrating tower 78, preferably lined with carbonaceous block and packed, if desired, with preferably coarse coke. In tower 78 gases rise against a downwardly flowing stream of phosphoric acid circulated over the hydrating tower by means of a circulating system indicated generally by reference numeral 90. Exit gases and mist leaving the top of tower 78 flow through a cooler 91, and into a suitable phosphoric acid collector, not shown. Gas flow, at a suitable rate, through the apparatus is maintained by a blower, not shown, interposed between the cooler 91 and the phosphoric acid collector, or located at the end of the system.

In carrying out the process of the invention, phosphate rock and coal or coke may be crushed separately and subsequently admixed in proper proportions, or may be ground together in proper proportions in a mill. The latter procedure is preferred since this operation effects a more

intimate admixture of rock and coal which in turn promotes rapid and complete reaction during the relatively short time of travel of the materials through the reduction zone in the furnace. The rock and coal are ground to pass, for example, 100 mesh, and proper proportions thereof are fed into hopper 30 by conveyor mechanism not shown. On operation of conveyor 31, a steady stream of finely divided rock and coal is fed into conduit 28. Just enough air is admitted through jet 29 to float the mixture into chamber 14, cool air being preferably used for this purpose to avoid premature ignition in pipe 28. At the beginning of operations, it will be understood the furnace 10 may be heated up to initial reaction temperature by any convenient means such as burner 22.

In accordance with the present invention, it is not essential, and in the preferred embodiments not desirable, that all the extraneous fuel, as distinguished from the carbonaceous material involved as reducing material, required in the process be introduced into the reduction zone with the phosphate rock as part of the carbonaceous material. Preferably, however, an excess of carbonaceous material, over that theoretically required for reduction of phosphate, is charged into the furnace with the rock, and the heat generated by partial oxidation to carbon monoxide of this excess, which may be considered as extraneous fuel, is advantageously liberated directly within the reduction zone to aid in maintaining therein the desired high temperatures. As great an excess of carbonaceous material as practicably possible is desirably introduced into the furnace with the rock, the excess of fuel being limited, preferably, so that it is unnecessary to unduly speed up the passage of material through the reduction zone, because of increased volume of material, and in this way unduly decrease the time during which the reacting materials are in the rduction zone. Hence, when operating in accordance with the more desirable embodiments of the process, the amount of finely divided coal fed into the furnace with the powdered rock is that required to bring about reduction of phosphates plus as large an excess as may be convenient, taking into account the size of the furnace and the particular operating conditions.

Substantially all of the air needed for the reaction in chamber 14 is introduced through pipe 37, chamber 36 and inlet 35, having been preheated to temperatures of, say, about 1500–1800° F. in heat exchangers 75 and 76. The volume of air thus entering the furnace may be regulated by valve 89 (Fig. 3) in pipe 37, and should be sufficient to burn to carbon monoxide the coal or coke in excess of that needed for reduction of the phosphate in the reduction chamber 14. Annular inlet 35 has an injector action, and hence, a suspension of finely divided phosphate rock and coal in air is introduced into the reduction chamber 14. By introducing the major portion of the air directly into the top of the reduction zone, such air may be highly preheated, and as mixing of hot air and coal outside the furnace chamber is prevented, premature ignition of coal is avoided.

The temperature maintained in the reduction zone 14 is not desirably less than about 2400° F. and is preferably within the range of about 2600–3000° F. With such temperatures prevailing, the reduction of the phosphate of the rock, by the coal, to elemental phosphorus takes place. Carbon monoxide is produced by the burning fuel which reacts with the phosphate rock in accordance with the following equation:

$$Ca_3P_2O_8+5CO+Heat=3CaO+P_2+5CO_2$$

the carbon dioxide reacting with the excess carbon present to regenerate carbon monoxide as follows:

$$5CO_2+5C+Heat=10CO$$

As the time of travel of the reacting materials through the vertical chamber 14 is comparatively short, it will be seen the reduction of the phosphate to phosphorus, during co-current flow of reactant materials through the reduction zone, is substantially a flash reaction.

A reducing atmposhere is maintained in the chamber 14 to the bottom thereof, and at the base of the shell 12, the fused, partially fused or solid materials are separated from the stream of gas and phosphorus fume. Fume and gases leaving the reduction chamber through openings 27 comprise principally nitrogen, carbon monoxide and phosphorus, and materials dropping into the bottom 17 include chiefly calcium oxide, with incidental amounts of coal ash and of calcium silicate, resulting from the silica content of most varieties of phosphate rock and coal.

This silica content of the phosphate rock or coal or both fed into the top of the reduction chamber may be high enough so that the residue in the base of the furnace has the consistency of a semi-fluid slag, or the residue particles at least tend to stick together. If the latter condition prevails, such residue may be made fluid by the addition of silica to the residue while in the base of the furnace, thus facilitating discharge through tap hole 18. Where the residue is fused or partly fused, in this situation the mass also acts to catch solid particles impinged against the surface thereof by the gas stream from chamber 14. However, in order to avoid as much as possible the presence in the reduction chamber of molten material, which tends to shorten the life of shell 12, it is preferred that the silica content of the rock and coal should be low. In cases where the rock and coal contain substantially no silica, the residue in the furnace bottom may be in the solid condition. The base of the furnace is large enough to permit most of the normally fluid particles to drop out of the gas stream, or to impinge upon the surface of the pool of molten slag. The stream of gas and fume, substantially free of dust, after passing through openings 27 in shell 12, rises through the oxidizing chamber 15 into the base of which preheated air, hot combustion gases, and unburned fuel are fed from combustion chamber 21.

Air from bustle 24 is introduced into combustion chamber 21 in quantities sufficient to support combustion of fuel introduced through burner 22, and combustion of phosphorus and carbon monoxide in chamber 15. As fume and gases from the reduction zone rise through chamber 15, the elemental phosphorus and carbon monoxide are oxidized respectively to phosphorus pentoxide and carbon dioxide. The oxidation of phosphorus to phosphorus pentoxide and of carbon monoxide to carbon dioxide liberates large quantities of heat. In accordance with one of the important features of the invention, the heat generated during this oxidation operation is utilized economically to aid in maintaining the

proper temperatures in the reduction zone. To accomplish this purpose, oxidation of phosphorus and carbon monoxide is effected in annular oxidizing zone 15, and heat generated is transferred through the walls of shell 12 to the reducing reaction taking place in chamber 14. The invention thus provides procedure by which heat of the oxidation reaction is advantageously employed to sustain the reducing reaction, and in this way, bring about substantial saving in the amount of fuel needed in the process.

The balance of the amount of extraneous fuel, in any suitable liquid, solid or gaseous form, required to maintain the desired reaction temperature in the furnace is charged into combustion chamber 21 through burner 22. Under usual conditions, about one-third of the quantity of extraneous fuel needed in the process is fed, with the rock and coal, into chamber 14. In this situation, about two-thirds of extraneous fuel requirements are provided for by regulation of burner 22. Air for burning such fuel is introduced through bustle 24, and combustion of the fuel may take place principally in chamber 21 and burning completed in chamber 15. According to particular operating conditions, the amounts of extraneous fuel introduced into reduction zone 14 and combustion chamber 21 may vary considerably. Preferably, however, it is desirable to introduce into the reduction zone less than a major portion of the total amount of extraneous fuel utilized in the process.

To further raise the temperatures reached in the oxidizing chamber 15 and in the reduction chamber 14, and thereby increase the efficiency of the operation, the air introduced through bustle 24, and employed in combustion chamber 21 and in oxidizing zone 15 for burning phosphorus to phosphorus pentoxide and carbon monoxide to carbon dioxide is preferably preheated. Preheating of the air to the desired degree, for example to about 1500–1800° F., or higher may be advantageously effected by passing such air through heat exchangers 76 and 75, the air outlet pipe 87′ of the latter being connected through pipe 25 with bustle 24. The quantity of air introduced into chamber 15 from bustle 24 may be controlled by valve 88 in pipe 25.

The gases leaving the top of oxidizing chamber 15, consisting principally of nitrogen, carbon dioxide and phosphorus pentoxide, are conducted by pipe 26 to the gas purification and absorption system shown in Fig. 3 of the drawings. The hot furnace gases flow through the heat exchangers 75 and 76 in series and are cooled by air passing countercurrent through chambers 87 around the tubes 82. The furnace gases are thus cooled, and the air employed in furnace 10 is preheated. This feature presents another substantial advantage of the invention, in that heat of the furnace gases, after discharge from the furnace, is recovered to a large degree and utilized to further the reduction reaction in the furnace. While passing through the heat exchangers, dust particles settle out of the gas stream and are recovered in dust chambers 83 provided in the base of both heat transferrers. After having passed through the latter, the gases are then introduced into a separator 77, preferably of the cyclone type, and remaining dust is removed from the gas stream. Any calcium oxide dust leaving the oxidizing chamber 15 with the gaseous phosphorus pentoxide may combine therewith to some extent. Thus, it may well be of advantage to return dust recovered from transferrers 75 and 76, and separator 77 to the furnace along with the fresh quantites of rock and coal fed thereto.

The gas stream, substantially free of dust, leaving the top of separator 77, is fed into the bottom of hydrating tower 78, the latter being preferably lined with carbonaceous material and packed preferably with very coarse coke. The ascending gases are contacted with a downwardly flowing stream of phosphoric acid maintained in circulation through the tower by suitable pumps and pipe connections. In the hydrating tower, the gas is cooled to or below hydrating temperature, e. g. about 400° F., and part of the water, in the preferably weak circulated phosphoric acid, is flashed to water vapor which reacts with P_2O_5 to form $H_3PO_4 \cdot H_2O$ mist, some of the acid thus formed being absorbed in the acid of the circulating system. From time to time, water may be added to the acid circulation system in the usual manner.

In cooler 91, the mixture of phosphoric acid mist, water vapor and gases is cooled to temperatures suitable for collection of acid mist, and the latter is collected by mechanical or electrical means, or in any desired manner. If desired, the exit gas of the phosphoric acid collector may be scrubbed for recovery of SiF_4 vapors as H_2SiF_6.

The process when carried out in the apparatus of Fig. 2 is, to a large degree, substantially the same as already described in connection with the apparatus of Figs. 1 and 3. In the furnace of Fig. 2, powdered rock and coal, in a stream of carrying air, is fed into the inlet end of the inner drum 55, through pipe 62, and, because of the rotation and pitch of drum 55, the materials are gradually worked toward the outlet end 61, and residues are discharged into the chamber 50. The atmosphere is reducing throughout the length of chamber 59, and phosphates are reduced to form phosphorus, and the excess fuel above that necessary for reduction of the rock is burned with the limited amount of oxygen present to form carbon monoxide. The air required in reduction zone 59 is introduced, in preheated condition through pipe 65, connected to pipe 37, Fig. 3. As in the apparatus of Fig. 1, additional air and fuel are introduced, through bustle 24 and combustion chamber 21, into chamber 50, and oxidation of phosphorus and carbon monoxide is effected in oxidizing zone 60. The fume and gaseous products of the reaction are discharged from the furnace into chamber 49, and flow through conduit 53 to the purification and absorption system shown in Fig. 3.

Because of the rotation of drum 55, it will be seen the finely divided rock and coal are dispersed in a reducing atmosphere. As the passage of material through reduction zone 59 is relatively slow, under some circumstances, the process of the invention may be carried out to advantage in apparatus of this type, where it is desired to maintain a relatively longer period of contact between finely divided phosphate rock and the fuel.

We claim:

1. The method of producing phosphoric acid which comprises introducing finely divided phosphate rock and an excess carbonaceous reducing material in suspension in air into a reduction zone, reducing the phosphate at elevated temperatures to phosphorous while passing the re-

acting materials co-current through the reduction zone, regulating the amount of air fed into the zone to afford oxygen sufficient to oxidize the excess of reducing material to carbon monoxide thereby supplying heat to the reducing reaction, separating gases containing phosphorus and carbon monoxide from non-gaseous residue of the reduction reaction, introducing into an oxidizing zone phosphorus, carbon monoxide and preheated air to support oxidation thereof together with sufficient extraneous heat to maintain reaction temperatures, oxidizing the phosphorus and carbon monoxide to phosphorous pentoxide and carbon dioxide while in heat transfer relation with the reduction zone, thereby utilizing the heat generated by the oxidation reaction to further the reduction reaction, and recovering phosphoric acid.

2. The method of producing phosphoric acid which comprises passing a suspension of phosphate rock, carbonaceous material, and a gas containing free oxygen through a reduction zone maintained at elevated temperatures, the carbonaceous material in the suspension being in excess of the amount necessary to convert the phosphate rock to phosphorous and the amount of gas containing free oxygen being regulated so as to convert the excess of carbonaceous material to carbon monoxide and supply heat for the reaction, oxidizing the resulting phosphorus and carbon monoxide to oxides of phosphorus and carbon dioxide in the presence of a heated gas containing free oxygen in an oxidation zone maintained in indirect heat exchange relationship with said reducing zone whereby the heat of oxidation is utilized in the reducing reaction, withdrawing the gaseous oxides of phosphorus and carbon from the oxidizing zone, and passing said gaseous mixture in heat exchange relationship with the gas containing free oxygen being supplied to said oxidation zone to preheat said gas.

3. A method of producing phosphorus pentoxide which comprises reacting a suspension of phosphate rock, carbonaceous material and a gas containing free oxygen at elevated temperatures in a reduction zone, the proportions of carbonaceous material and oxygen being adjusted so as to maintain reducing conditions in said reducing zone to release elemental phosphorus and to form carbon monoxide, separating gases containing phosphorus and carbon monoxide from the non-gaseous residue of the reduction reaction, introducing said phosphorus and carbon monoxide together with oxygen into an oxidation zone maintained in indirect heat exchange relationship with said reduction zone, oxidizing the phosphorus to phosphorus pentoxide and carbon monoxide to carbon dioxide in said oxidation zone, whereby the heat generated by the oxidation reaction is utilized in effecting the reduction reaction, and recovering phosphorus pentoxide.

4. A method of producing phosphorus pentoxide which comprises reacting a suspension of phosphate rock, carbonaceous material and a gas containing free oxygen at elevated temperatures in a reduction zone, the amount of carbonaceous material in said suspension being in excess of that necessary to convert the phosphate rock to elemental phosphorus and the amount of oxygen being regulated so as to maintain reducing conditions in said zone, to release elemental phosphorous and to convert the excess carbonaceous material to carbon monoxide to supply heat for the reducing reaction, separating gases containing phosphorus and carbon monoxide from the non-gaseous residue of the reduction reaction, introducing said phosphorous and carbon monoxide along with extraneous fuel and free oxygen into an oxidation zone maintained in indirect heat exchange relationship with said reduction zone, oxidizing the phosphorus to phosphorus pentoxide and carbon monoxide to carbon dioxide and burning the fuel in said oxidation zone, whereby the heat generated in the oxidation zone is utilized in effecting the reduction reaction, and recovering phosphorus pentoxide.

5. The method of producing phosphorus pentoxide which comprises introducing relatively finely divided phosphate rock and relatively finely divided carbonaceous material into a reduction zone, reducing the phosphate rock at elevated temperatures while in suspension in a reducing gaseous atmosphere to release elemental phosphorus from the phosphate rock, separating the gaseous products containing phosphorus from the non-gaseous residue of the reduction reaction, introducing said gaseous products together with oxygen into an oxidation zone maintained in indirect heat exchange relation with said reduction zone, oxidizing the phosphorus to phosphorus pentoxide in said oxidation zone whereby the heat generated by the oxidation reaction is utilized in effecting the reduction reaction, and recovering phosphorus pentoxide.

6. The method of producing phosphorus pentoxide which comprises reacting a suspension of phosphate rock, carbonaceous material and oxidizing gas at elevated temperatures in a reduction zone, the amount of carbonaceous material in said suspension being in excess of that necessary to convert the phosphate rock to elemental phosphorus and the amount of oxygen being regulated so as to maintain reducing conditions in said zone, to release elemental phosphorus and to convert excess carbonaceous material to carbon monoxide to thereby supply heat for the reduction reaction, separating gases containing phosphorus and carbon monoxide from the non-gaseous residue of the reduction reaction, introducing said phosphorus and carbon monoxide together with oxygen into an oxidation zone maintained in indirect heat exchange relation with said reduction zone, oxidizing the phosphorus to phosphorus pentoxide and the carbon monoxide to carbon dioxide in said oxidation zone whereby the heat generated in the oxidation zone is utilized in effecting the reduction reaction, and recovering phosphorus pentoxide.

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