June 17, 1924. 1,497,727

B. G. KLUGH

PROCESS AND APPARATUS FOR THE PRODUCTION OF PHOSPHORIC ACID

Filed Dec. 7, 1920 2 Sheets-Sheet 1

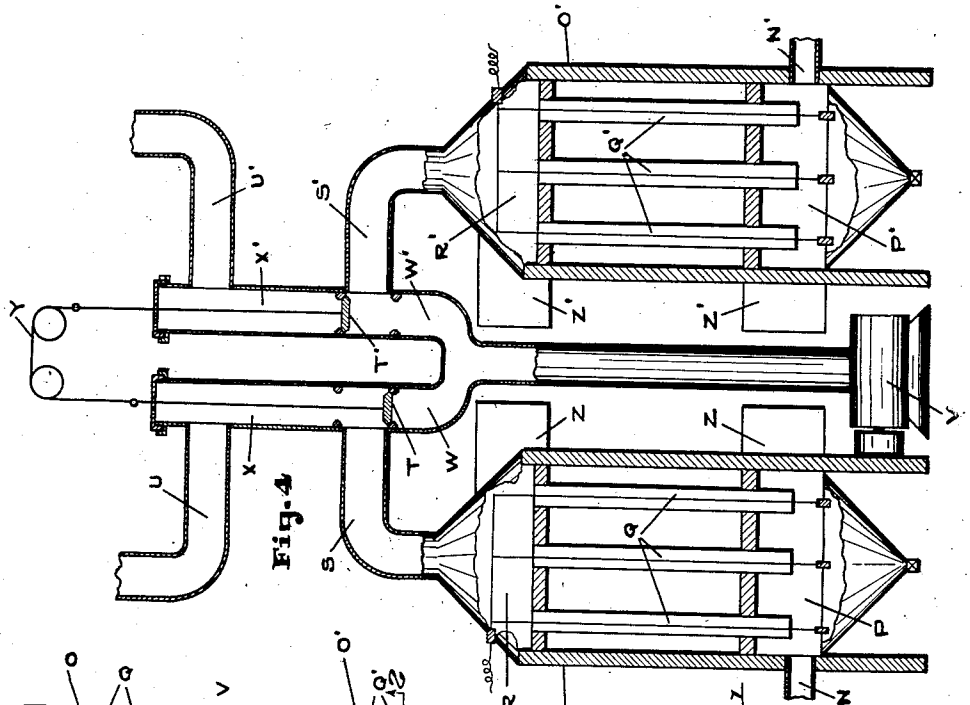


Fig. 4

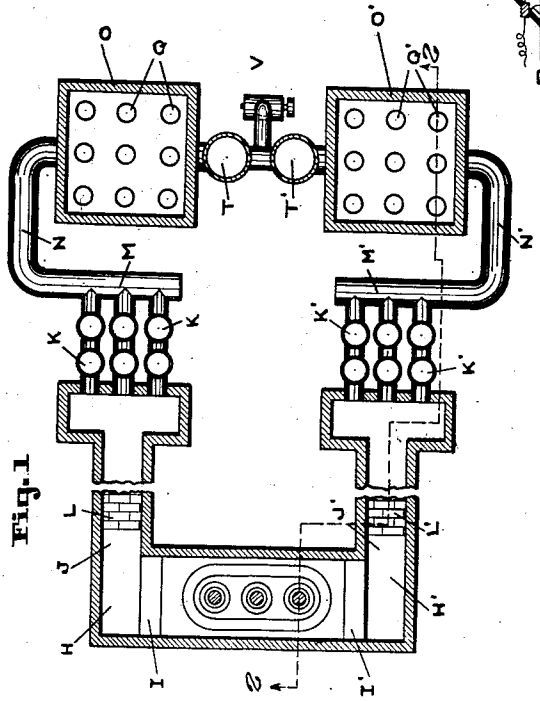


Fig. 1

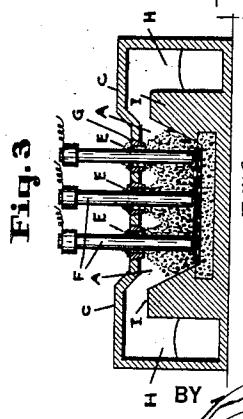


Fig. 3

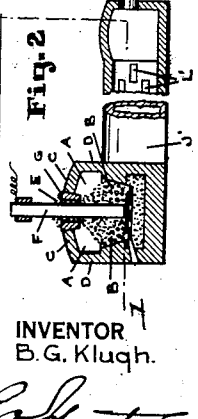


Fig. 2

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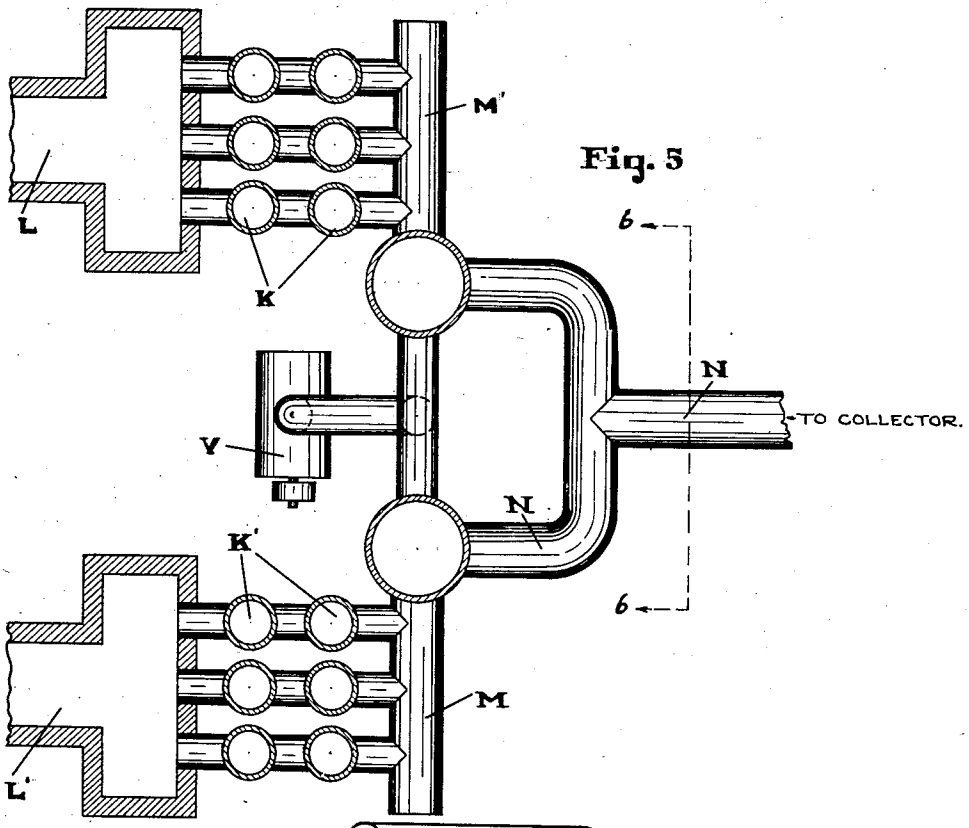


Fig. 5

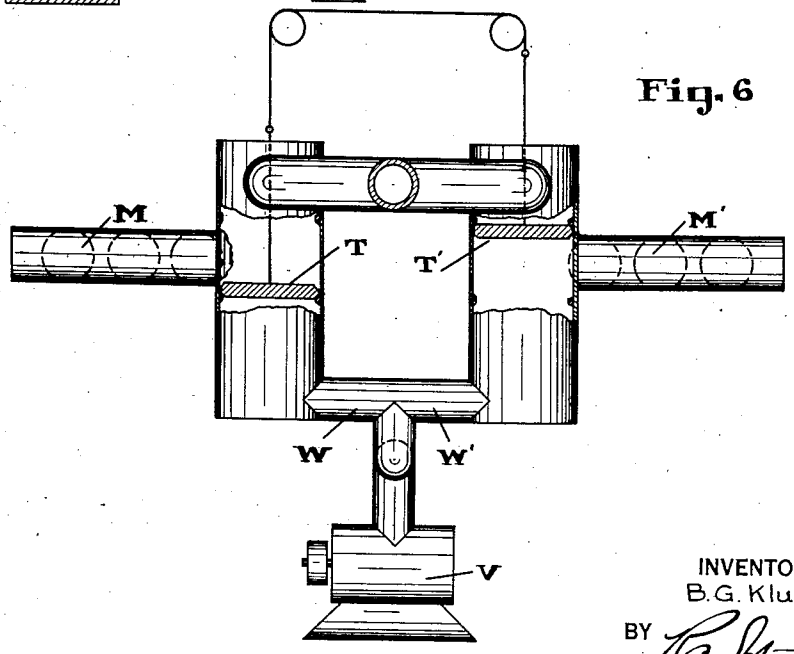


Fig. 6

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Patented June 17, 1924. 1,497,727

UNITED STATES PATENT OFFICE.

BETHUNE G. KLUGH, OF ANNISTON, ALABAMA, ASSIGNOR TO FEDERAL PHOSPHORUS COMPANY, OF BIRMINGHAM, ALABAMA, A CORPORATION OF ALABAMA.

PROCESS AND APPARATUS FOR THE PRODUCTION OF PHOSPHORIC ACID.

Application filed December 7, 1920. Serial No. 429,016.

To all whom it may concern:

Be it known that I, BETHUNE G. KLUGH, a citizen of the United States of America, residing at Anniston, in the county of Calhoun and State of Alabama, have invented certain new and useful Improvements in Processes and Apparatus for the Production of Phosphoric Acid, of which the following is a specification.

This invention relates to improvements in the production of phosphoric acid by the electric smelting of phosphatic materials with carbonaceous reducing agents and silicious flux, oxidation of the elemental phosphorus and the collection of the resultant acid from the gases by electrical precipitation or other suitable means.

It has for its object the smelting of each unit of phosphorus involved with less electrical energy, hence lower cost, than is possible in the present state of the art, and the provision of means for effecting such saving in a practical manner while at the same time facilitating the essential steps in the process.

I will illustrate by thermal calculations the heat units involved in the electrical smelting of an assumed quantity of materials in the process. The chemical reaction which fulfills the conditions involved in such smelting operation is as follows:

$$(CaO)_3P_2O_5+2SiO_2+5C= P_2+5CO+(3CaO)(2SiO_2).$$

The relative weights of hypothetically pure materials involved in this equation per pound of phosphorus is as follows:

	Lbs.
Phosphorus	1
$(CaO)_3P_2O_5$	5
Carbon	.967
$3(CaO)2(SiO_2)$	4.645
CO	2.250

The phosphorus is evolved as elemental phosphorus and the CO. as such in gaseous state.

The thermal balance of the above equation and weights involved, based upon well accepted factors, shows that the net heat to be supplied for all the heat requirements is equivalent to 3966 calories. On the other hand the heat given out in the oxidation of the above weights of phosphorus and carbon monoxide evolved is equivalent to 4929 calories, or 1.24 times as much heat as is required to be furnished by electrical energy. It is obvious that any of the calories (usually wasted) from the combustion of the phosphorus and carbon monoxide, that can be absorbed by the stock in the smelting zone will replace an equivalent amount of electrical energy, and thereby result in equivalent saving in smelting costs. The theoretical temperature of combustion with cold air without excess of the relative quantities of phosphorus and carbon monoxide from the hereinbefore described charge, is about 2400° C., that with the air without excess for combustion heated to 600° C., is about 2700° C., and that with air without excess for combustion heated to 1000° C., about 2900° C. It is obvious that the rate of heat absorption by the stock from the heat of combustion of the gases will be increased many times by the higher temperature of combustion of the gases in contact therewith.

The herein described invention discloses a practical means of causing the stock to absorb a maximum quantity of said heat from the combustion of the phosphorus and carbon monoxide, and furthermore gives advantages in the conducting of all the features of the operation. Attempts have been made to absorb a portion of this combustion heat in the stock by passing the burning and heated gases over and through the stock in transit to the electric furnace through revolving tubes and inclined or vertical shafts. All involve a clumsy and impractical mechanical equipment, interfere with the proper distribution of the stock in the furnace, and entrain quantities of dust in the gases, as well as present many other undesirable features of operation.

I will now describe my invention so that those skilled in the art may clearly understand and practice it.

Referring to the drawings, like symbols in the different figures indicate like parts:

Fig. 1 is a horizontal sectional view taken on the line 1—1 of Fig. 2.

Fig. 2 is a longitudinal sectional view on the line 2—2 of Fig. 1.

Fig. 3 is a transverse vertical sectional view through the furnace.

Fig. 4 is an enlarged cross sectional view taken on the line 4—4 of Fig 2.

Fig. 5 is an enlarged cross sectional view

corresponding to Fig. 1 of a discharge end of the piping system delivering to one collector.

Fig. 6 is a view partly broken away on the line 6—6 of Fig. 5.

Similar reference numerals refer to similar parts throughout the drawings.

In this furnace I provide a tightly enclosed combustion chamber between the stock B within the furnace and the enclosing arch roof C, and the side walls D. The fresh stock is continuously supplied to the furnace through the annular spaces E, which exist between the electrodes F and their respective inwardly projecting stock feed refractory rings G. The stock within this space seals the gases within the combustion chamber against their outward passage. The furnace is further provided with gas passages H, H′ at either end with which combustion chamber A communicates. These passages are constructed with an elevation of the arch roof C, and of bridge-wall I, I′, so that the incoming combustion air from one end, as hereinafter described, will be projected downwardly upon the stock adjacent thereto, and effect direct combustion of the gases emanating from the surface of said stock. The gas passages H and H′ comunicate directly and continue into respective gas mains J, J′, which are constructed respectively in duplicate as shown, and connect directly into regenerative checker work L and L′, through which the gas passes respectively to the batteries of multiple coolers K and K′ and then through their respective manifolds M and M′, and through pipes N, N′, into the respective electrical precipitators O, O′, shown in vertical section in Fig. 4. The two respective precipitators in Fig. 4 show the lower gas chambers P, P′ with pipes Q, Q′ communicating to the upper gas chamber R, R′ and thence through pipes S, S′. The reversing valves T, T′ jointly control the flow of the gases (or air) so that as the valves are set in the figures, the gases from precipitator O, from which the phosphoric acid has been removed therein, pass out through waste stack U. The air blower V delivers air under pressure through manifold W, W′, and with the valves T, T′ set as shown, is closed against gas pipe S and open to pipe S′. The reversal of the gas and air movement is then entirely controlled by means of the valves T, T′, whose respective stems X, X′ are actuated reciprocally through the common connecting cable Y.

Having explained the apparatus through the figures I will briefly discuss the operation of the process therewith with attention to advantages gained thereby.

The gases consisting of elemental phosphorus and carbon monoxide are evolved in the smelting zone within the stock and pass out uniformly over the entire top surface of the stock within the furnace. At the same time fresh cold stock is being constantly supplied through the stock feed openings surrounding the electrodes, and responsive to the continuous demands of the fusion zone, is automatically delivered and distributed over the said top surface of the stock within the furnace.

If the phosphorus and carbon monoxide be burned with a large excess of air or if the combustion of said gases is completed other than in direct contact with the top surface of the freshly supplied stock, or if the gases pass out from said surface of the stock too quickly, there will be very little of the heat evolved from said combustion absorbed by said stock within the furnace.

In producing my invention, I cause the combustion of the evolved elemental phosphorus and carbon monoxide to be completed directly as evolved from and in direct contact with the top surface of the freshly supplied cold stock in the furnace, and further cause said combustion to produce the highest possible temperature of combustion. By raising the temperature of combustion to the highest attainable degree, I cause the greatest flow of heat units evolved in said combustion of gas to the incoming stock, and hence provide the greatest possible amount of heat in said stock to replace that required to be supplied by electrical energy.

In the construction of the furnace herein described, I provide the greatest possible area of the top surface of the stock within the furnace, and said area is further so placed in the furnace as to cause the gas combustion to proceed over the said entire surface. The said stock being delivered uniformly and in a thin layer over said surface presents contact to the largest possible volume of burning gases therewith which is most conducive to absorption of the heat therefrom.

In the operation of the hereindescribed invention, the products of combustion, after passing out one end of the furnace, have their sensible heat absorbed progressively by the refractory materials in the regenerative chamber through which they pass. The flow of the gases is maintained in this direction until the temperature rise in the farther end of said regenerative chamber shows that the maximum absorption of heat has been reached, whereupon the direction of the gases from the combustion chamber A is reversed and the air for combustion forced through the regenerative chambers to be heated therein and passed at a high temperature into the combustion chamber, thus coming in direct contact with the evolved phosphorus and carbon monoxide, and ef-

fecting their combustion with the highest practicably attainable temperature of combustion. I do not confine myself to the horizontal type of regenerative furnace, or to the proportionate dimension shown in the drawing, but wish my herein described invention to include any arrangement of regenerative chamber, in which the materials of construction present the best design as to size, area, weight, or volume for absorbing the heat from gases passing thereover, or thereabout, and for storing up said heat for disbursement to lower temperature gases subsequently passed thereover or thereabout.

As shown in the drawings, the air for combustion as it is reversed passes alternately through the entire passage last traversed by the gas and thus its heat absorbing capacity will take up the heat which has been stored up in the passage by the gases. Furthermore, by forcing the air for combustion through the electrical precipitator in which the stream of gas was last treated, and through the entire length of the gas passage before reversion, all of the P_2O_5 left in the precipitator and passage is conducted back with the stream of combustion air and forced through the furnace combustion chamber and then back into the stream of gases passing in the opposite direction to the other precipitator. In this way my invention presents a distinct advantage in that no P_2O_5 is lost in the operation of recuperating the sensible heat of the gases and utilizing it in raising the combustion temperature of the gases above the stock within the furnace.

A further advantage exists in this complete reversal of the gas cycle in that the electrical precipitator under best operating conditions requires cleaning of insulators, wires and pipes periodically in order to maintain its efficiency in its precipitating functions. Thus during the period in which the combustion air is being driven through the precipitator as a part of its cycle of operation, the air within presents ideal conditions for workmen to perform all cleaning or repairing desired without interruption of the continuous operation of the acid production and collection. I propose to provide air locks Z, Z′ for entry and exits in the upper and lower chambers of the precipitators without interference with the current of combustion air being passed therethrough.

The exact volume of air required for combustion of the gases in the furnace is governed by the speed of the blower V. My system as shown in the herein described invention corrects certain very troublesome conditions prevailing in the usually practiced methods of handling the gases under suction, or under pressures below atmospheric pressure. The objections to such procedure, which are corrected by producing my invention as hereindescribed, are:—

(1) Under reduced pressure air leakage, which increases greatly the volume of gas to be handled, occurs through vents that are scarcely detectable, while under pressure, such leaks become obvious, and only result in a loss of gas or air without proportionately overloading the capacity of the handling and collecting apparatus.

(2) The passing of the P_2O_5 bearing gases through a fan or suction pump is very objectionable on account of the condensing and corrosive characteristics thereof, which shorten the life and efficiency of the fan, whereas in placing the entire cycle under pressure by means of forcing the combustion air through the entire cycle, I cause only air to be handled through the pump, thus obviating all the difficulties mentioned.

(3) In the hereinbefore mentioned proportions of phosphorus and carbon monoxide combustion, the weight of products of combustion is 13.9 while the weight of air required for said combustion is 10.7. Moreover, the air is cool and relatively dense, whereas the gases are hot and greatly expanded. By handling only the air I have a medium of less heat and greater density. Thus the smaller quantity to be handled as well as its better handling qualities is decidedly in favor of the hereindescribed procedure.

(4) I avoid passing the P_2O_5 gases through any valves, as none are interposed in the system except between an air intake and the precipitators. On account of the tendency of the P_2O_5 to condense on and corrode or render sticky all parts of operating mechanism with which it comes in contact, this advantage, from an operating view point, has great value.

In case I collect the P_2O_5 or derivatives thereof by means other than by the electrical precipitator or in case it is not practicable to use the duplicate precipitators, and it is desirable to unite the alternative mains into one prior to conducting the cooled P_2O_5 bearing gases into the final collecting apparatus, I change the location of the air blower and reversing valves as shown in Figs. 5 and 6. The apparatus then remains the same as shown in Figs. 1 to 4 up to the manifold pipes M, M′. These pipes are connected respectively to the interposed valve chambers W, W′, containing respectively the reversing valves T, T′ and connected overhead by the manifold N″ to a pipe N‴ leading to any collector. The blower V delivers air at the required pressure to the valve chamber W and W′ and according to which of the valves T, T′ is open, the air flows through one course to the combustion chamber while the gases return through the other course to manifold M or M′ and flow

past the valve T or T', whichever is closed to the air, and thence pass through manifold N'' and pipe N''' to the collector. In all other respects except the use of one collector and the loss of the feature of flowing the air through the collector not in use, this alternative process is similar in its functions to that already described.

The method of utilizing the heat of the gases to highly preheat the stock in the furnace is the essential basis of my invention. By preheating the air supply I can greatly raise the temperature of combustion of the gases and thereby, notwithstanding their short stay in the presence of the stock, I can succeed in transferring a maximum quantity of heat units into the stock. To avoid excessive waste of heat in the high temperature attained by the gases in my process it is desirable to recover as much of this heat as possible and this is done by recuperating it by a regenerative apparatus in which the combustion air supply is heated. These higher combustion temperatures in the furnace necessitate great care for the protection of the electrodes against oxidation by the combustion air and this I accomplish by surrounding each with an entering column of cold stock which flows continuously responsive to the demands of the fusion zone.

The carbon which is added to the smelting stock for reduction in the smelting is most effective therefor, when in a finely divided state, say not over one-eighth of an inch in size. The phosphate rock and silicious fluxing materials being of larger size and the proportioned mixture being fed through the stock feed opening as shown, into the furnace, and the stock assuming in its natural angle of repose within said furnace, viz, a sloping section, will cause the coarser materials to roll toward the outer sides of the furnace or away from the electrodes, while the finely divided carbon tends to cling near the electrodes, especially in a sectional column formed about the lower edge of the internally projecting stock feed ring. In this way the carbon for reduction in the stock is protected from oxidation by the highly heated combustion air within the combustion chamber by the non-combustible coarser portion of the stock covering it during its passage to the smelting zone.

I have found this tendency of segregation of the reducing carbon in the descending column of stock within the furnace is advantageous in the construction of furnace shown, because its descent in a column about the electrode, protects said electrode from direct oxidation from the reducible oxides in the stock, by preventing direct contact therewith, and furthermore the said reducing carbon comes into contact with the reducible oxides of the charge near the bottom of the said furnace just above the slagging zone, which is the natural zone in which said reducing carbon performs its function.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. A process for the smelting of phosphatic material in an enclosed electric furnace, which consists in admitting air for the oxidation of gases as evolved in said smelting operation, and preheating said air to raise the temperature of combustion of said gases in the furnace.

2. A process for the smelting of phosphatic material in an enclosed electric furnace, which consists in regulating the volume of air admitted to that requisite for the oxidation of the gases as evolved in said smelting operation, and preheating said air to raise the temperature of combustion of said gases in the furnace.

3. A process for the smelting of phosphatic material in an enclosed electric furnace, which consists in admitting air for the oxidation of gases as evolved in said smelting operation, and utilizing the heat in the outflowing gases to preheat the air admitted to the furnace and raise the point of combustion of the gases therein.

4. A process for the smelting of phosphatic material in an enclosed electric furnace, which consists in regulating the volume of air admitted to that requisite for the oxidation of the gases as evolved in said smelting operation, and utilizing the heat in the outflowing gases to preheat the air admitted to the furnace and raise the point of combustion of the gases therein.

5. A process for the smelting of phosphatic and carbonaceous material in an enclosed electric furnace, which consists in regulating the volume of air admitted to that requisite for the oxidation in the furnace of the phosphorus fumes and carbon monoxide gases as evolved, and transferring heat from the waste gases to the air supply to thereby reduce the gases to the requisite temperature for the recovery of phosphoric acid and to raise the air to a high temperature to thereby increase the temperature of combustion of the gases in the furnace.

6. A process for the smelting of phosphatic material in an enclosed electric furnace, which consists in forcing into the furnace an air current under a predetermined pressure which will admit the requisite volume of air to oxidize the gases as evolved in the furnace, and utilizing said air current to expel the gases from the furnace into a collector.

7. A process for the smelting of phosphatic material in an enclosed electric furnace, which consists in forcing into the furnace an air current under a predetermined pres-

sure which will admit the requisite volume of air to oxidize the gases as evolved in the furnace, utilizing said air current to expel the gases from the furnace into a collector, and regulating and controlling the flow of the gases entirely by a regulation of the pressure and volume of said air current.

8. A process for the smelting of phosphatic material in an enclosed electric furnace having alternative regenerative passages for conducting the gases to respective electric precipitators, which consists in causing the air supply for the furnace to flow thereto through the precipitator and gas passage not at the time containing the evolved gases.

9. A process for the production of phosphoric acid by an electric furnace, which consists in providing regenerative gas passages and respective electric precipitators therefor, forcing an air blast alternatively through a passage and its precipitator to preheat the air, oxidize the evolved gases in the furnace and expel them through the other passage and precipitator.

10. A process for the smelting of phosphatic material in an electric furnace, which consists in preheating the air supply for the furnace, admitting the preheated air alternatively at opposite ends of the furnace in volume sufficient for the oxidation of the gases as evolved in the furnace, and causing the gases while burning with an increased temperature of combustion to flow slowly through the furnace and about the entering stock to preheat the latter.

11. A process for the smelting of phosphatic material in an enclosed electric furnace, which consists in feeding fresh stock continuously responsive to the demands of the fusion zone, providing ample space above the stock for the combustion of the evolved gases about the entering columns of stock, admitting air in the approximate volume requisite for the oxidation of only the gases as evolved, preheating said air to greatly increase the temperature of combustion of the gases in the furnace, causing the burning gases to pass slowly over and about the entering columns of stock as the gases pass out of the furnace, and transferring heat from the abnormally heated gases leaving the furnace to preheat the entering air supply.

12. A process for the smelting of phosphatic material in an enclosed electric furnace, which consists in providing a continuous feed of stock responsive to the demands of the fusion zone, providing a combustion space for the burning of the gases above the stock, utilizing the stock to surround and protect the electrodes, preheating the air entering the furnace to raise the temperature of combustion of the evolved gases, regulating the volume of air admitted approximately to that required for the oxidation of said gases as evolved, and causing the burning gases to pass slowly over and around the entering stock columns to radiate a high percentage of their heat to the stock before it enters the fusion zone.

13. An apparatus for the smelting of phosphatic material in an enclosed electric furnace which comprises regenerative chambers connected with the furnace, phosphoric acid recovery apparatus to which the gases are conducted through said chambers alternatively, and means to admit the air supply for the furnace to the regenerative chamber not at the time conducting gases, to preheat said air supply.

14. An apparatus for the smelting of phosphatic material, which comprises an enclosed electric furnace, a pair of regenerative chambers connected thereto, an acid collector for each chamber, means to cause the air supply for the furnace to flow through the collector and chamber not receiving the gases, and valve means to reverse the flow of the gases.

15. An apparatus for the smelting of phosphatic material, which comprises an enclosed electric furnace, a pair of regenerative chambers connected therewith, a collector means for the gases flowing through said chambers, air ducts connected to the gas discharge ends of said chambers, reversing valves to alternatively admit air to one chamber and exclude it from the other, and a blower to induce a forced current of air to flow through a chamber and enter the furnace in a preheated condition.

16. An apparatus for the smelting of phosphatic material, comprising an enclosed electric furnace, a pair of regenerative chambers connected thereto, a collector for each chamber, an air manifold connected to said collectors, a blower to force a current of air into the manifold, and reversing valve means to direct the air through said collectors and chambers alternatively to reverse the direction of flow of the gases independently of valves exposed to such gases and to preheat the air supply to the furnace.

17. The process for electrically smelting phosphatic material with a reducing agent, which consists in mingling the reducing agent in a finely divided state with coarser particles of phosphatic material and feeding said mixture by gravity flow into an electric furnace responsive to the demands of the fusion zone through an overhead opening, causing the coarser particles to overlie the finer particles which collect in and descend to the fusion zone through the center of the stock column.

18. The process for electrically smelting phosphatic material with a reducing agent, which consists in mingling the reducing

agent in a finely divided state with coarser particles of phosphatic material and feeding said mixture by gravity flow into an electric furnace responsive to the demands of the fusion zone through an overhead opening, causing the coarser particles to overlie the finer particles which collect in and descend to the fusion zone through the center of the stock column, and admitting preheated air to the combustion chamber surrounding the stock column in the furnace.

In testimony whereof I affix my signature.

BETHUNE G. KLUGH.

Witness:

NOMIE WELSH.