UNITED STATES PATENT OFFICE.

FREDERICK W. YOST, OF CHICAGO, ILLINOIS.

PROCESS OF TREATING MATERIALS.

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To all whom it may concern:

Be it known that I, FREDERICK W. YOST, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Processes of Treating Materials, of which the following is a specification.

My invention relates to the treatment of materials; and it comprises a process wherein a reaction-producing gas is conducted through the interior of a mass of material and by its aid one reaction is propagated through the mass toward the surface of gas entrance and another reaction is propagated through the mass toward the surface of gas exit; and it comprises more particularly, but not exclusively, the calcining, roasting, or reducing and clinkering of finely divided material in a stationary or movable mass; all as more fully hereinafter set forth and as claimed.

One of the chief objects attained by my invention is the high efficiency of the process, because the gaseous element is brought to the zones of reaction uncontaminated by the products of reaction, since the reaction-supporting gas is conducted through the material toward the surface of initial re action. And since the waste products of reaction are not conducted through the untreated material both reactions are susceptible of full control, because the untreated material is acted upon only by the energy developed at the zone of initial reaction.

Another important object attained is the lengthened life of any apparatus employed, because in my process the volatile products escape from the interior of the mass at the same surface at which the first reaction is initiated; therefore, the destructive agencies are all confined to one region of the apparatus and that part of the apparatus may be formed of material largely uninfluenced by such agencies.

A further attainment is the independent control of the various stages of the process due to the separate propagation of the two reactions.

My process can be carried on intermittently in the well known forms of pot roasting apparatus or in any reverberatory roasting furnace provided with a perforated hearth, or it can be carried on continuously in well known forms of chain grate stoker furnaces.

My process may be used for clinkering finely divided oxid ores. Such material may be in a finely divided state as found in nature, or it may be finely divided as the result of treatment by concentration, or it may be a finely subdivided metallurgical waste such as blast furnace flue dust. The finely divided ore to be clinkered is intimately mixed with powdered coal, coke, charcoal or other combustible material and is charged into one of the types of furnace referred to. The upper surface of the charge is heated by contact with the hot furnace gases; air is introduced at the lower surface of the charge and is conducted upward through the interior of the mass of ore; the heat, applied to the upper surface of the charge, is propagated by internal combustion downward through the mass to the lower surface of the charge; when the zone of combustion reaches the lower surface of the charge a clinkering reaction is propagated upward through the mass, from the lower to the upper surface, by the continued blowing of air through the charge; and the volatile products of combustion escape at the upper surface and join the furnace gases. When my process is carried on in a reverberatory furnace, provided with a fixed perforated hearth, the heat is first propagated downward through the charge and the clinkering reaction follows the conclusion of the heating stage. When the material is clinkered in a chain grate stoker furnace the various stages of the process take place simultaneously, one portion of the charge being heated while another portion of the charge is being clinkered. It will be evident that an important feature in the economy of the treatment is in maintaining, in the interior of the charge, the least degree of reduction that will initiate the agglomerating reaction and this condition necessitates the use of the minimum amount of combustible material in the charge. The carbonaceous component in the charge may be still further reduced in quantity by adding combustible gas to the air, conducted through the mass, or by substituting hot air for cold air. When it is desired to produce clinker containing the lower oxids of more or less reduced metal it will be necessary to maintain, in the interior

of the charge, conditions that are more highly reducing than those required for the production of high oxid clinker. Such highly reducing conditions may be secured by the use of larger proportions of carbonaceous material in the charge; or by the addition of combustible gas to the air used for the propagation of both reactions; or by the use of air for the propagation of the initial reaction and combustible gas for the propagation of the second reaction. The finished product may be made into large and relatively dense blocks of clinker, such as are desirable for open hearth furnace use, or into highly porous and relatively small pieces of clinker, such as are desirable for blast furnace use, by varying the amount of air blown through the charge during the progress of and after the completion of the clinkering reaction.

My process may also be used for roasting and clinkering finely divided sulfid ores, concentrates or flue dust. The finely divided ore is charged into any suitable apparatus; air is introduced at the lower surface of the charge and is conducted upward through the interior of the mass; the opposite surface of the charge is ignited and the heat is propagated downward by internal combustion; when the plane of ignition reaches the lower surface, the clinkering reaction is propagated upward, from the lower to the upper surface, by the continued blowing of the air through the charge; and the volatile products of combustion escape at the upper surface. If there is sufficient sulfur in the material for self-supporting combustion, after ignition, the process can be carried on in an open top receptacle; if there is not sufficient sulfur to support combustion, after ignition, the process may be carried on in a reverberatory furnace with a perforated hearth, or in a suitable form of chain grate stoker furnace, where a moving body of hot gases, generated by the combustion of extraneous fuel, can be maintained in contact with the upper surface of the charge. Material containing the maximum amount of sulfur, found in ores and concentrates, may be treated in one of the types of furnace referred to without the use of an igniting flame generated from the combustion of extraneous fuel; because, when the brickwork of the furnace has once been heated to a high temperature, the radiated heat will ignite the sulfur of the ore and the combustion of the sulfur will maintain the temperature of the hot brickwork; therefore, the waste gases, escaping from the charge, may be used for sulfuric acid manufacture or other by-product purpose. When the sulfur in the charge is too low for self-ignition and when, nevertheless, it is desirable to use the waste sulfur gases for by-product purposes, the heat from the combustion of extraneous fuel may be transmitted to the charge through muffle walls, thereby separating the heating gases from the sulfur gases. The air, conducted through the mass, reaches the zones of reaction uncontaminated by the products of reaction, hence the air acts with great efficiency and only the minimum volume need be used; therefore, the waste sulfur gases are highly concentrated and are very valuable for by-product use. Where the material is too low in sulfur for the propagation of internal combustion it will be necessary to add other combustible elements to the charge. The heating and clinkering functions are divided into separate stages, each of which is subject to independent control, thus making it possible to produce at will clinker of either high or low sulfur content to suit the requirements of the subsequent smelting operation.

My process is also well adapted for the clinkering of cement materials. The finely ground raw mix is intimately mixed with finely divided carbonaceous material and is charged into one of the types of furnace referred to. The upper surface of the charge is heated by contact with the moving body of hot furnace gases, generated by the combustion of extraneous fuel, air is introduced at the lower surface of the charge and is conducted upward through the interior of the mass; the heat, applied to the upper surface, is conducted downward through the mass by internal combustion from the upper to the lower surface; when the plane of combustion reaches the lower surface the clinkering reaction is propagated upward, from the lower to the upper surface, by the continued blowing of air through the interior of the mass; and the volatile products and gases formed from the components of the charge escape at the upper surface and join the furnace gases. The carbonates of the charge are decomposed during the first or heating stage of the process and the clinker is formed during the second stage. The intermixed fuel in any region is consumed by the internal reaction only when the hot combustion zone, in its initial and downward progress, or in its second and upward progress, reaches that region; therefore, the small particles of fuel release their heat only at the time and at the place when and where it is needed. Small clinker with a highly porous structure is more readily crushed and ground into finished cement than is dense clinker of large size, and this desirable physical quality may be obtained by a suitable variation in the amount of air conducted through the charge during the progress of and after the completion of the clinkering reaction.

In the treatment of any of the materials described in these examples various modifi-

cations will suggest themselves to those skilled in the art. It may be desirable to moisten the charge to form interstices for the uniform distribution of the combustion-supporting gas through the mass. The temperature in the zone of reaction may be regulated, or the character of the reaction may be varied, by the addition of steam, volatile products of combustion or other modifying elements to the air conducted through the interior of the mass. When the material to be clinkered is of a highly refractory nature it may be desirable to add a flux to lower the clinkering temperature whereby the fuel consumption may be lessened. The combustible components of the charge may be lessened in amount, or wholly eliminated, by the use of highly heated air conducted through the mass with or without an admixture of combustible gases. Where the ash from the combustion of solid fuel is an undesirable ingredient of the clinkered product liquid or semi-liquid fuel may be used as the heat developing component of the charge.

This process requires that the conditions relating to the composition of the charge, the composition and temperature of the igniting or heating gases, and the composition, temperature and pressure of the combustion-supporting gas, be properly correlated, so that a heating zone unaccompanied by a clinkering reaction will be propagated downward through the charge to the lower surface during the first stage of the process, and so that during the second stage the additional air conducted through the charge and acting upon the heated material, will initiate a clinkering reaction at the lower surface and will aid in propagating this clinkering reaction upward through the charge to the upper surface. During the first stage of the present process, the charge must be maintained in a loose, granular condition, so that the material of the charge can be properly calcined, roasted or otherwise treated before it is clinkered; and in this respect, the present process differs essentially from that described in my co-pending application, Serial No. 516,306, filed September 4, 1909, (renewed Jan. 16, 1911, Serial No. 602,980) wherein there must be such a change of correlations of the controllable conditions that during the first stage a clinkering reaction will be initiated at the upper surface, and will be propagated downward through the upper portion of the charge, coincidentally with the heating of the charge from the upper to the lower surface; and that during the second stage a clinkering reaction will also be initiated at the lower surface, and will be propagated upward through the unclinkered portion of the charge.

I do not wish to be limited to treatment of the specific materials described in the examples, nor do I wish to be limited to the specific details of treatment there described, nor merely to the specific process of treating iron oxids as herein described, since it will be evident to those skilled in the art that this invention applies to the treatment of any material, or any mixture of materials, of such a nature that an initial reaction can be propagated through a mass in one direction, and a second reaction can be propagated through the mass in another direction, by the means described. It will be further evident that the kinds of treatment accorded the material are not limited to calcining, roasting, or reducing and clinkering, but may include any treatment which can be carried on in separate stages, as described. It will be also evident that the gaseous element can vary widely as to composition, and may be either an oxidizing or reducing agent, provided, that under suitable control of conditions, it has the property of aiding in propagating one reaction toward the surface of gas entrance and another reaction toward the surface of gas exit. Neither do I wish to be limited to the use of one kind of gas for the propagation of both reactions, since it will be evident that for some purposes it may be desirable to use an oxidizing gas to propagate one reaction and a reducing gas to propagate the other reaction. In all of the examples, I have described a downward propagation of the initial reaction and an upward course for the reaction-supporting gas; but for different conditions, I may prefer to propagate the initial reaction upward, or in any other direction, provided the gaseous element is conducted in a direction other than the course of initial reaction. I also have described, in the examples, conditions which result in the formation of volatile products of reaction, but it will be evident that non-volatile products of reaction will be formed when the reactions are of such a character that the gaseous element, conducted through the interior of the mass, is absorbed by the material of the charge.

It is to be understood that the words, "finely divided," as herein used, have reference to any degree of subdivision that best adapts the material to treatment by my process, as some materials respond to treatment better when in a relatively coarse condition while other materials respond to treatment only when in a finely divided state. It is to be also understood that, where the material is described in the claims as containing various components, the various components may be originally contained in the material, or they may be added to the material to prepare it for treatment.

In my co-pending application, Serial Number 516,306, filed September 4th, 1909, (renewed Jan. 16, 1911, Serial No. 602,980)

I have described and claimed a specific embodiment of this invention wherein, by proper control of thermal and other conditions, one clinkering reaction proceeds through the mass in a direction other than the course of the gas current and another clinkering reaction proceeds in a different direction, and this specific embodiment of my invention I do not claim herein; in the embodiment which is specifically claimed in the present application, the clinkering reaction proceeds through the mass in one direction only.

What I claim is:

1. The process of treating finely divided material capable of undergoing propagative reaction, which comprises initiating a propagative reaction at a surface of a mass of the material, transmitting a current of reaction-supporting gas toward the surface of initial reaction, causing the initial reaction to travel through the mass in a direction other than the flow of the reaction-supporting gas, and propagating a second reaction through the mass toward the surface of initial reaction, substantially as described.

2. The process of treating finely divided material containing heat developing components, which comprises initiating a reaction in a region of a mass of the material, conducting a reaction-supporting gas through the mass toward the region of initial reaction, propagating the initial reaction through the mass in a direction other than the flow of the reaction-supporting gas, and propagating a second reaction through the mass in the direction of flow of the reaction-supporting gas, substantially as described.

3. The process of treating finely divided material containing heat developing components, which comprises initiating a reaction at a surface of a mass of the material, introducing a reaction-supporting gas at another surface of the mass, conducting the reaction-supporting gas through the mass, propagating the initial reaction through the mass in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

4. The process of treating finely divided material containing gas forming components, which comprises initiating a reaction in a region of a mass of the material, conducting a reaction-supporting gas through the mass toward the region of initial reaction, propagating the initial reaction through the mass in a direction other than the flow of the reaction-supporting gas, and propagating a second reaction through the mass in the direction of flow of the reaction-supporting gas, substantially as described.

5. The process of treating finely divided material containing gas forming components, which comprises initiating a reaction at a surface of a mass of the material, introducing a reaction-supporting gas at another surface of the mass, conducting the reaction-supporting gas through the mass, propagating the initial reaction through the mass in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

6. The process of treating finely divided material containing heat developing components, which comprises heating a surface of a mass of the material, introducing a reaction-producing gas at another surface of the mass, conducting the reaction-producing gas through the mass, propagating the heat through the mass by internal reaction in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

7. The process of treating finely divided material containing heat developing components, which comprises heating the upper surface of a mass of the material, introducing a reaction-producing gas at the lower surface of the mass, conducting the reaction-producing gas upward through the mass, propagating the heat downward through the mass by internal reaction, and propagating a second reaction upward through the mass, substantially as described.

8. The process of treating finely divided material containing gas forming components, which comprises heating a surface of a mass of the material, introducing a reaction-producing gas at another surface of the mass, conducting the reaction-producing gas through the mass, propagating the heat through the mass by internal reaction in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

9. The process of treating finely divided material containing gas forming components, which comprises heating the upper surface of a mass of the material, introducing a reaction-producing gas at the lower surface of the mass, conducting the reaction-producing gas upward through the mass, propagating the heat downward through the mass by internal reaction, and propagating a second reaction upward through the mass, substantially as described.

10. The process of treating finely divided material containing combustible components, which comprises heating a surface of a mass of the material, introducing a combustion-supporting gas at another surface of the mass, conducting the combustion-supporting gas through the mass, propagating the heat through the mass by internal combustion in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

11. The process of treating finely divided material containing combustible compo-

nents, which comprises heating the upper surface of a mass of the material, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a second reaction upward through the mass, substantially as described.

12. The process of treating finely divided material containing carbonaceous components, which comprises heating a surface of a mass of the material, introducing a combustion-supporting gas at another surface of the mass, conducting the combustion-supporting gas through the mass, propagating the heat through the mass by internal combustion in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

13. The process of treating finely divided material containing carbonaceous components, which comprises heating the upper surface of a mass of the material, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a second reaction upward through the mass, substantially as described.

14. The process of treating finely divided material containing combustible components, which comprises producing ignition in a mass of the material, feeding a gas current through the mass, causing a backward propagation of the plane of ignition against the flow of the gas current by means of a reaction internal to the mass, and propagating a clinkering reaction forward with the flow of the gas current, substantially as described.

15. The process of treating finely divided material containing heat developing components, which comprises transmitting heat from a body of hot gases to a surface of a mass of the material, introducing a reaction-producing gas at another surface of the mass, conducting the reaction-producing gas through the mass, propagating the heat through the mass by internal reaction in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

16. The process of treating finely divided material containing heat developing components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the material, introducing a reaction-producing gas at the lower surface of the mass, conducting the reaction-producing gas upward through the mass, propagating the heat downward through the mass by internal reaction, and propagating a second reaction upward through the mass, substantially as described.

17. The process of treating finely divided material containing gas forming components, which comprises transmitting heat from a body of hot gases to a surface of a mass of the material, introducing a reaction-producing gas at another surface of the mass, conducting the reaction-producing gas through the mass, propagating the heat through the mass by internal reaction in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

18. The process of treating finely divided material containing gas forming components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the material, introducing a reaction-producing gas at the lower surface of the mass, conducting the reaction-producing gas upward through the mass, propagating the heat downward through the mass by internal reaction, and propagating a second reaction upward through the mass, substantially as described.

19. The process of treating finely divided material containing combustible components, which comprises transmitting heat from a body of hot gases to a surface of a mass of the material, introducing a combustion-supporting gas at another surface of the mass, conducting the combustion-supporting gas through the mass, propagating the heat through the mass by internal combustion in one direction, and propagating a second reaction through the mass in another direction, substantially as described.

20. The process of treating finely divided material containing combustible components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the material, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a second reaction upward through the mass, substantially as described.

21. The process of treating finely divided material containing combustible components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the material, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a clinkering reaction upward through the mass, substantially as described.

22. The process of treating finely divided

material containing combustible components, which comprises transmitting heat from a body of hot gases to the upper surface of a movable mass of the material, introducing a combustion-supporting gas at the lower surface of the movable mass, conducting the combustion-supporting gas upward through the movable mass, propagating the heat downward through the movable mass by internal combustion, and propagating a clinkering reaction upward through the movable mass, substantially as described.

23. The process of treating finely divided material containing carbonaceous components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the material, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a clinkering reaction upward through the mass, substantially as described.

24. The process of treating finely divided material containing carbonaceous components, which comprises transmitting heat from a body of hot gases to the upper surface of a movable mass of the material, introducing a combustion-supporting gas at the lower surface of the movable mass, conducting the combustion-supporting gas upward through the movable mass, propagating the heat downward through the movable mass by internal combustion, and propagating a clinkering reaction upward through the movable mass, substantially as described.

25. The process of treating finely divided material containing combustion-supporting and other components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the material, introducing a gas (which is reactive with some of the components of the material) at the lower surface of the mass, conducting the reactive gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a second reaction upward through the mass, substantially as described.

26. The process of treating finely divided metal-bearing material containing combustible components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the material, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a clinkering reaction upward through the mass, substantially as described.

27. The process of treating finely divided metal-bearing material containing combustible components, which comprises transmitting heat from a body of hot gases to the upper surface of a movable mass of the material, introducing a combustion-supporting gas at the lower surface of the movable mass, conducting the combustion supporting gas upward through the movable mass, propagating the heat downward through the movable mass by internal combustion, and propagating a clinkering reaction upward through the movable mass, substantially as described.

28. The process of treating finely divided metal-bearing material containing carbonaceous components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the material, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a clinkering reaction upward through the mass, substantially as described.

29. The process of treating finely divided metal-bearing material containing carbonaceous components, which comprises transmitting heat from a body of hot gases to the upper surface of a movable mass of the material, introducing a combustion-supporting gas at the lower surface of the movable mass, conducting the combustion-supporting gas upward through the movable mass, propagating the heat downward through the movable mass by internal combustion, and propagating a clinkering reaction upward through the movable mass, substantially as described.

30. The process of treating a finely divided oxid-ore mixture containing combustible components, which comprises transmitting heat from a body of hot gases to the upper surface of a mass of the mixture, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a clinkering reaction upward through the mass, substantially as described.

31. The process of treating a finely divided oxid-ore mixture containing combustible components, which comprises transmitting heat from a body of hot gases to the upper surface of a movable mass of the mixture, introducing a combustion-supporting gas at the lower surface of the movable mass, conducting the combustion-supporting gas upward through the movable mass, propagating the heat downward through the movable mass by internal combustion, and propagating a clinkering reaction upward

through the movable mass, substantially as described.

32. The process of treating a finely divided oxid-ore mixture containing carbonaceous components, which comprises transmitting heat from a body of hot gases to the lower surface of a mass of the mixture, introducing a combustion-supporting gas at the lower surface of the mass, conducting the combustion-supporting gas upward through the mass, propagating the heat downward through the mass by internal combustion, and propagating a clinkering reaction upward through the mass, substantially as described.

33. The process of treating a finely divided oxid-ore mixture containing carbonaceous components, which comprises transmitting heat from a body of hot gases to the upper surface of a movable mass of the mixture, introducing a combustion-supporting gas at the lower surface of the movable mass, conducting the combustion-supporting gas upward through the movable mass, propagating the heat downward through the movable mass by internal combustion, and propagating a clinkering reaction upward through the movable mass, substantially as described.

34. The process of continuously treating finely divided material containing combustible components, which comprises continuously feeding the material to the moving perforated hearth of a reverberatory furnace to form a moving mass of the material, continuously transmitting heat from a body of hot gases to the upper surface of the moving mass, continuously introducing a combustion-supporting gas at the lower surface of the moving mass, continuously conducting the combustion-supporting gas upward through the moving mass, continuously propagating the heat downward through the moving mass in one part of the furnace by internal combustion, and continuously propagating a clinkering reaction upward only through the moving mass in another part of the furnace, substantially as described.

35. The process of continuously treating finely divided material containing carbonaceous components, which comprises continuously feeding the material to the moving perforated hearth of a reverberatory furnace to form a moving mass of the material, continuously transmitting heat from a body of hot gases to the upper surface of the moving mass, continuously introducing a combustion-supporting gas at the lower surface of the moving mass, continuously conducting the combustion-supporting gas upward through the moving mass, continuously propagating the heat downward through the moving mass in one part of the furnace by internal combustion, and continuously propagating a clinkering reaction upward only through the moving mass in another part of the furnace, substantially as described.

36. The process of continuously treating finely divided metal-bearing material containing combustible components, which comprises continuously feeding the material to the moving perforated hearth of a reverberatory furnace to form a moving mass of the material, continuously transmitting heat from a body of hot gases to the upper surface of the moving mass, continuously introducing a combustion-supporting gas at the lower surface of the moving mass, continuously conducting the combustion-supporting gas upward through the moving mass, continuously propagating the heat downward through the moving mass in one part of the furnace by internal combustion, and continuously propagating a clinkering reaction upward only through the moving mass in another part of the furnace, substantially as described.

37. The process of continuously treating finely divided metal-bearing material containing carbonaceous components, which comprises continuously feeding the material to the moving perforated hearth of a reverberatory furnace to form a moving mass of the material, continuously transmitting heat from a body of hot gases to the upper surface of the moving mass, continuously introducing a combustion-supporting gas at the lower surface of the moving mass, continuously conducting the combustion-supporting gas upward through the moving mass, continuously propagating the heat downward through the moving mass in one part of the furnace by internal combustion, and continuously propagating a clinkering reaction upward only through the moving mass in another part of the furnace, substantially as described.

38. The process of continuously treating a finely divided oxid-ore mixture containing combustible components, which comprises continuously feeding the mixture to the moving perforated hearth of a reverberatory furnace to form a moving mass of the mixture, continuously transmitting heat from a body of hot gases to the upper surface of the moving mass, continuously introducing a combustion-supporting gas at the lower surface of the moving mass, continuously conducting the combustion-supporting gas upward through the moving mass, continuously propagating the heat downward through the moving mass in one part of the furnace by internal combustion, and continuously propagating a clinkering reaction upward only through the moving mass in another part of the furnace, substantially as described.

39. The process of continuously treating a finely divided oxid-ore mixture containing

carbonaceous components, which comprises continuously feeding the mixture to the moving perforated hearth of a reverberatory furnace to form a moving mass of the mixture, continuously transmitting heat from a body of hot gases to the upper surface of the moving mass, continuously introducing a combustion-supporting gas at the lower surface of the moving mass, continuously conducting the combustion-supporting gas upward through the moving mass, continuously propagating the heat downward through the moving mass in one part of the furnace by internal combustion, and continuously propagating a clinkering reaction upward only through the moving mass in another part of the furnace, substantially as described.

40. The process of continuously treating finely divided iron oxid, which comprises mixing with the iron oxid finely divided fuel to form a mixture capable of being clinkered; continuously feeding the mixture to the moving perforated hearth of a reverberatory furnace to form a moving mass; continuously transmitting heat from a body of hot gases to the upper surface of the moving mass; and continuously conducting a combustion-supporting gas upward through the moving mass; the conditions relating to the composition of the iron oxid mixture, the composition and temperature of the hot gases, and the composition, temperature and pressure of the combustion-supporting gas being so correlated that heat unaccompanied by a clinkering reaction, is caused to continuously propagate downward from the upper surface and through the moving mass in one part of the furnace, while a clinkering reaction initiated at the lower surface is caused to continuously propagate upward through the moving mass in another part of the furnace.

In testimony whereof, I affix my signature in the presence of witnesses.

FREDERICK W. YOST.

Witnesses:
C. W. FOWLER,
EDWARD A. BERN.