UNITED STATES PATENT OFFICE.

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PROCESS OF TREATING MATERIALS.

1,003,684. Specification of Letters Patent. Patented Sept. 19, 1911.

No Drawing. Application filed September 4, 1909, Serial No. 516,306. Renewed January 16, 1911. Serial No. 602,980.

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 whereby one portion of the mass is clinkered and another reaction is propagated through the mass toward the surface of gas exit, whereby another portion of the mass is clinkered; 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; and it further comprises an improvement in the process presented in the application, Serial Number 516,305, filed by me on the fourth day of September, 1909 (renewed Jan. 16, 1911, Serial No. 602,979); 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 reaction. 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 increased speed of operation due to clinkering a portion of the mass while the initial reaction is being propagated.

My process can be carried on intermittently 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 agglomerated by contact with 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 of ore; the heat, applied to the upper surface, is propagated downward through the mass to the lower surface by internal combustion and the upper portion of the charge is thereby clinkered; another clinkering reaction is propagated upward from the lower surface by the continued blowing of air through the mass thereby clinkering the lower portion of the charge; and the volatile products of combustion escape at the upper surface and join the furnace gases. The furnace gases must be sufficiently reducing to partly deoxidize the material at the upper surface of the charge so as to initiate the agglomerating reaction which is propagated downward through the upper portion of the mass. The formation of a fused layer, at the upper surface of the mass, has the incidental advantage of preventing the waste gases from carrying away the finely subdivided particles of the charge. In a reverberatory furnace, with a fixed perforated hearth, the clinkering of the upper portion of the charge proceeds while the plane of combustion is being propagated downward, but the clinkering of the lower portion of the charge does not begin until the plane of combustion reaches the lower surface. When the material is treated in a chain grate stoker furnace the various stages of the

process take place simultaneously; the clinkering of the upper portion of the charge proceeds downward and the plane of combustion is propagated downward through the mass, in one part of the furnace, while the previously heated lower portion of the charge is being clinkered in another part of the furnace.

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 permit the propagation of the agglomerating reaction and this condition necessitates the use of the minimum amount of combustible material in the charge. The carbonaceous components 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 or 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 sulfid ore is charged into one of the types of furnace referred to; 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 agglomerated by contact with the hot furnace gases; and the heat is propagated downward to the lower surface by internal combustion thereby clinkering the upper portion of the charge; another clinkering reaction is propagated upward from the lower surface by the continued blowing of air through the mass thereby clinkering the lower portion of the charge; and the volatile products of combustion escape at the upper surface. The fusion of the upper surface of the charge initiates the agglomerating reaction which is propagated downward through the upper portion of the mass. 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 with a suitable air blast will fuse the surface of the charge and 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. 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.

My process is 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 agglomerated by contact with 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 propagated downward through the mass to the lower surface by internal combustion and the upper portion of the charge is thereby clinkered; another clinkering reaction is propagated upward from the lower surface by the continued blowing of air through the mass thereby clinkering the lower portion of the charge; and the volatile products and gases formed from the components of the charge escape at the upper surface and join the furnace gases. The successful conduct of the process requires the blowing of air through the mass during the formation of the fused layer at the upper surface so that the escape of the volatile products from the charge will not be hindered by a non-porous layer. 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 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 the materials described in these examples various modifications 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 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 which progresses from the upper to the lower surface, and so that during the second stage the additional air conducted through the charge and acting upon the heated material, will also initiate a clinkering reaction at the lower surface and will aid in propagating this clinkering reaction upward through the unclinkered portion of the charge. In the present process increased speed of operation is attained by clinkering a portion of the charge during the first stage and another portion of the charge during the second stage; and in this respect, the present process differs essentially from that described in my co-pending application above referred to, wherein there must be such a change of the correlations of the controllable conditions that a heating zone unaccompanied by a clinkering reaction, will propagate downward through the charge to the lower surface, thereby maintaining the charge in a loose, granular condition during the first stage of the process; and that during the second stage, a clinkering reaction initiated at the lower surface, will be propagated upward through the charge to the upper surface.

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 to clinker a portion of the mass, and a second reaction can be propagated through the mass in another direction to clinker another portion of the mass, 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.

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 another and co-pending application, Serial Number 516,305, filed September 4th, 1909, I have described and claimed a specific embodiment of this invention wherein, by proper control of thermal and other conditions, the clinkering reaction proceeds through the mass in one direction only; in the embodiment which is specifically claimed in the present application, 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.

What I claim is:

1. The process of treating finely divided material containing heat developing components, which comprises heating a surface of a mass of the material under conditions which initiate a clinkering reaction at that surface, 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 in one direction by internal combustion to clinker a portion of the mass, and propagating a second reaction through the mass in another direction to clinker another portion of the mass, substantially as described.

2. The process of treating finely divided material containing heat developing components, which comprises heating the upper surface of a mass of the material under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

3. The process of treating finely divided material containing gas forming components, which comprises heating a surface of a mass of the material under conditions which initiate a clinkering reaction at that surface, 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 in one direction by internal combustion to clinker a portion of the mass, and propagating a second reaction through the mass in another direction to clinker another portion of the mass, substantially as described.

4. The process of treating finely divided material containing gas forming components, which comprises heating the upper surface of a mass of the material under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

5. The process of treating finely divided material containing combustible components, which comprises heating a surface of a mass of the material under conditions which initiate a clinkering reaction at that surface, 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 in one direction by internal combustion to clinker a portion of the mass, and propagating a second reaction through the mass in another direction to clinker another portion of the mass, substantially as described.

6. The process of treating finely divided material containing combustible components, which comprises heating the upper surface of a mass of the material under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

7. The process of treating finely divided material containing combustion-supporting and other components, which comprises heating a surface of a mass of the material under conditions which initiate a clinkering reaction at that surface, introducing a gas (which is reactive with some of the components of the material) at another surface of the mass, conducting the reactive gas through the mass, propagating the heat through the mass in one direction by internal combustion to agglomerate a portion of the mass, and propagating a second reaction through the mass in another direction to agglomerate another portion of the mass, substantially as described.

8. The process of treating finely divided material containing heat developing components, which comprises producing ignition in a mass of the material under conditions which initiate a clinkering reaction at a surface of the mass, feeding a gas current through the mass, propagating the plane of ignition backward against the flow of the

gas current by means of an internal reaction to clinker a portion of the mass, and propagating a clinkering reaction forward with the flow of the gas current to clinker another portion of the mass, substantially as described.

9. The process of treating finely divided material containing gas forming components, which comprises producing ignition in a mass of the material under conditions which initiate a clinkering reaction at a surface of the mass, feeding a gas current through the mass, propagating the plane of ignition backward against the flow of the gas current by means of an internal reaction to clinker a portion of the mass, and propagating a clinkering reaction forward with the flow of the gas current to clinker another portion of the mass, substantially as described.

10. The process of treating finely divided material containing combustible components, which comprises producing ignition in a mass of the material under conditions which initiate a clinkering reaction at a surface of the mass, feeding a gas current through the mass, propagating the plane of ignition backward against the flow of the gas current by means of an internal reaction to clinker a portion of the mass, and propagating a clinkering reaction forward with the flow of the gas current to clinker another portion of the mass, substantially as described.

11. 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 under conditions which initiate a clinkering reaction at that surface, 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 in one direction by internal combustion to clinker a portion of the mass, and propagating a second reaction through the mass in another direction to clinker another portion of the mass, substantially as described.

12. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

13. 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 under conditions which initiate a clinkering reaction at that surface, 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 in one direction by internal combustion to clinker a portion of the mass, and propagating a second reaction through the mass in another direction to clinker another portion of the mass, substantially as described.

14. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

15. 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 under conditions which initiate a clinkering reaction at that surface, 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 in one direction by internal combustion to clinker a portion of the mass, and propagating a second reaction through the mass in another direction to clinker another portion of the mass, substantially as described.

16. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker

the lower portion of the mass, substantially as described.

17. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the movable mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the movable mass, substantially as described.

18. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the movable mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the movable mass, substantially as described.

19. 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 movable mass of the material under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to agglomerate the upper portion of the mass, and propagating a second reaction upward from the lower surface to agglomerate the lower portion of the mass, substantially as described.

20. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

21. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the movable mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the movable mass, substantially as described.

22. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

23. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the movable mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the movable mass, substantially as described.

24. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

25. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the movable mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the movable mass, substantially as described.

26. 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 mass of the mixture under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the mass, substantially as described.

27. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the movable mass, and propagating a clinkering reaction upward from the lower surface to clinker the lower portion of the movable mass, substantially as described.

28. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the moving mass in one part of the furnace, and continuously propagating a clinkering reaction upward from the lower surface of the moving mass to clinker the lower portion of the moving mass in another part of the furnace, substantially as described.

29. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the moving mass in one part of the furnace, and continuously propagating a clinkering reaction upward from the lower surface of the moving mass to clinker the lower portion of the moving mass in another part of the furnace, substantially as described.

30. The process of continuously treating finely divided material containing combustion-supporting and other 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 under conditions which initiate a clinkering reaction at that surface, continuously introducing a gas (which is reactive with some of the com-

ponents of the material) at the lower surface of the moving mass, continuously conducting the reactive gas upward through the moving mass, continuously propagating the heat downward through the moving mass from the upper to the lower surface by internal combustion to agglomerate the upper portion of the moving mass in one part of the furnace, and continuously propagating a second reaction upward from the lower surface of the moving mass to agglomerate the lower portion of the moving mass in another part of the furnace, substantially as described.

31. 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 under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the moving mass in one part of the furnace, and continuously propagating a clinkering reaction upward from the lower surface of the moving mass to clinker the lower portion of the moving mass in another part of the furnace, substantially as described.

32. 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, under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the moving mass in one part of the furnace, and continuously propagating a clinkering reaction upward from the lower surface of the moving mass to clinker the lower portion of the moving mass in another part of the furnace, substantially as described.

33. 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 material, continuously transmitting heat from a body of hot gases to the upper surface of the moving mass under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the moving mass in one part of the furnace, and continuously propagating a clinkering reaction upward from the lower surface of the moving mass to clinker the lower portion of the moving mass in another part of the furnace, substantially as described.

34. 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 material, continuously transmitting heat from a body of hot gases to the upper surface of the moving mass under conditions which initiate a clinkering reaction at that surface, 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 from the upper to the lower surface by internal combustion to clinker the upper portion of the moving mass in one part of the furnace, and continuously propagating a clinkering reaction upward from the lower surface of the moving mass to clinker the lower portion of the moving mass in another part of the furnace, substantially as described.

35. 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 in one part of the furnace heat is caused to continuously propagate downward through the moving mass from the upper to the lower surface, and clinkering reaction initiated at the upper surface of the moving mass is caused to continuously propagate downward through the upper portion of the moving mass, while in another part of the furnace a clinkering reaction initiated at the lower surface of the moving mass is caused to continuously propagate upward through the unclinkered portion of the moving mass.

In testimony whereof I have hereunto set my hand this 25th day of August, 1909, in the presence of two witnesses.

FREDERICK W. YOST.

Witnesses:
H. J. STEGEMANN,
EDWARD A. BERN.