April 28, 1931. F. M. SIMONDS 1,802,959

PROCESS AND APPARATUS FOR THE GASEOUS TREATMENT OF FINELY DIVIDED MATERIAL

Filed March 20, 1929 6 Sheets-Sheet 1

Fig. 1.

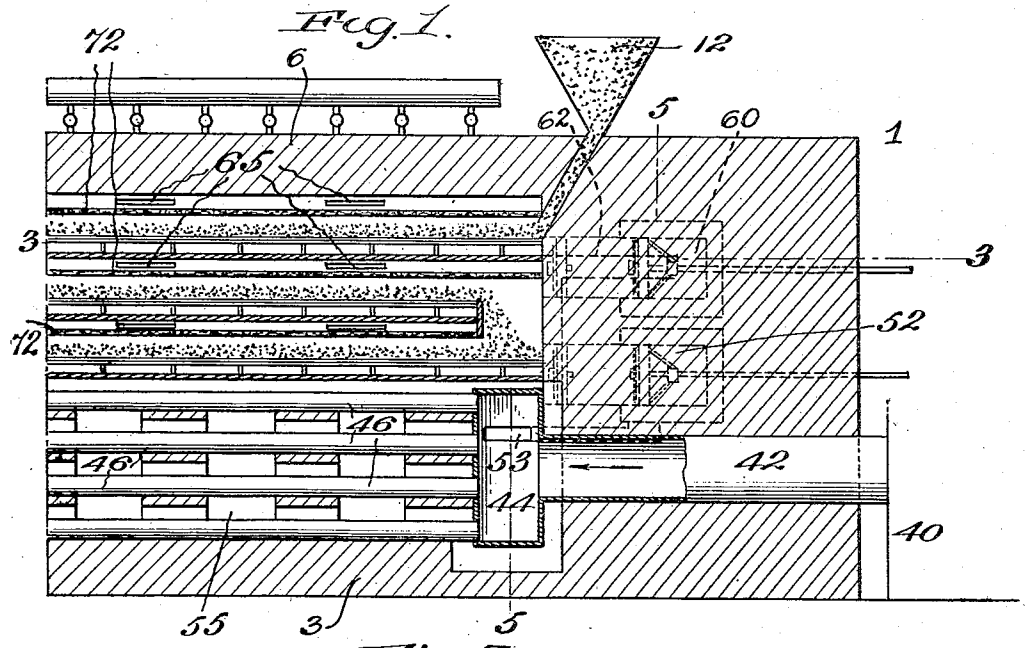
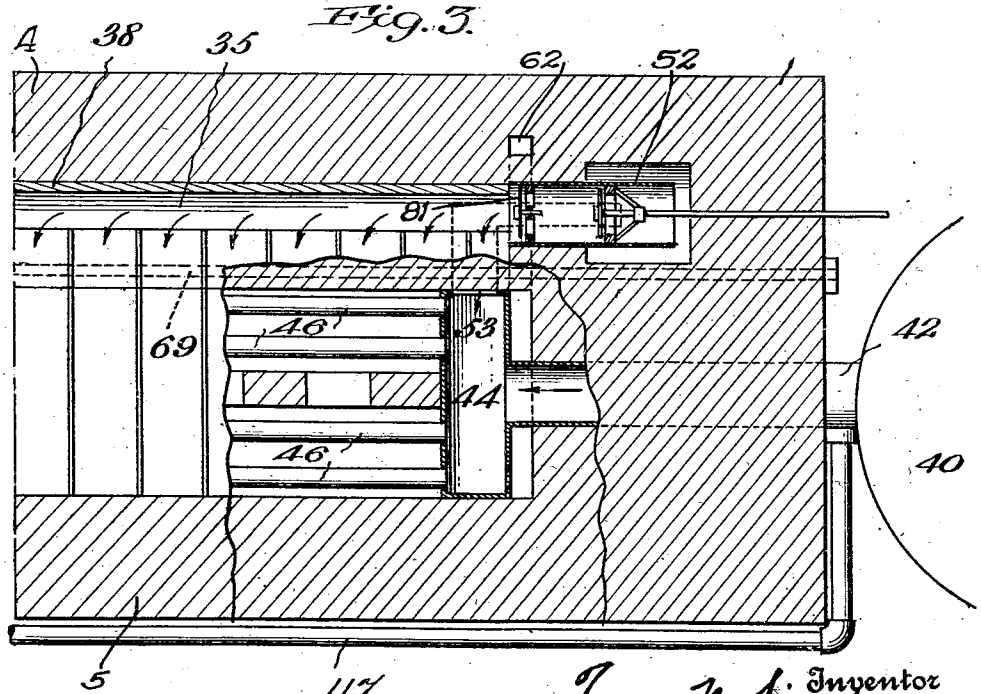


Fig. 3.



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PROCESS AND APPARATUS FOR THE GASEOUS TREATMENT OF FINELY DIVIDED MATERIAL

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Fig. 2.

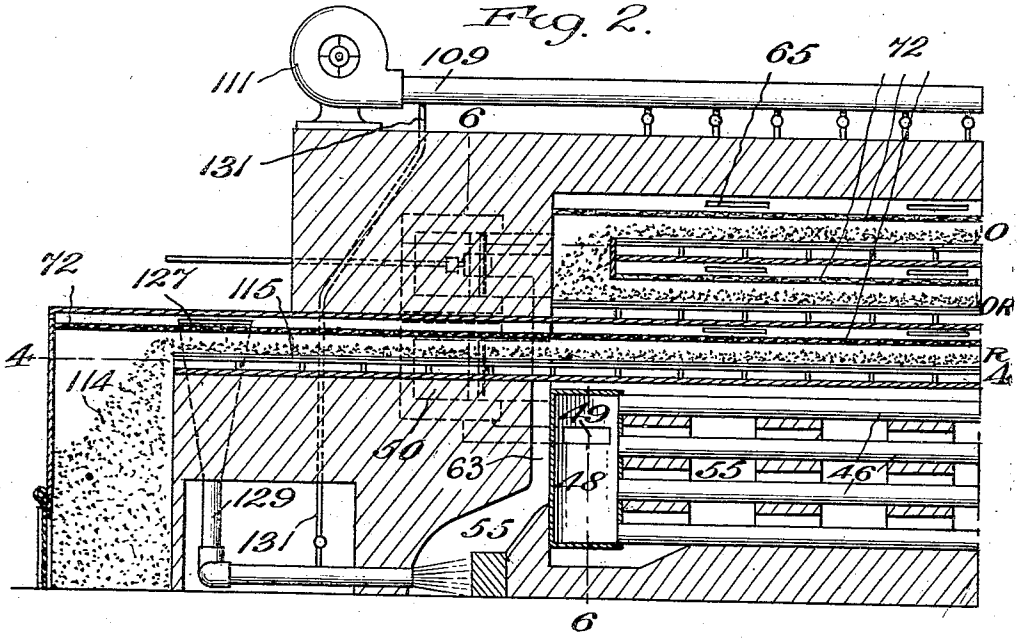


Fig. 4.

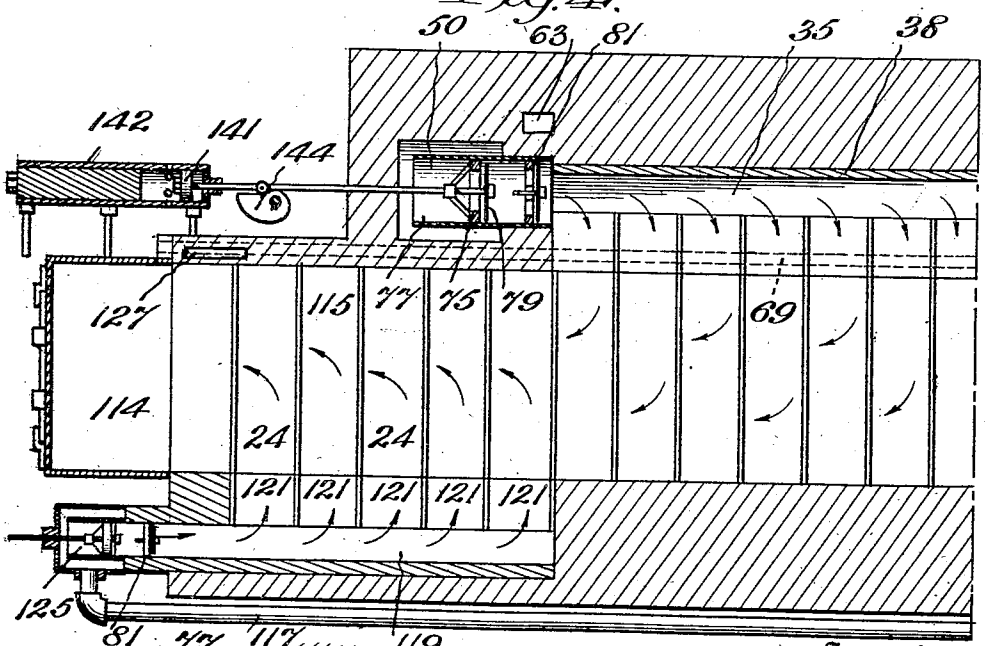
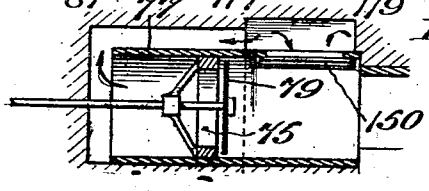


Fig. 12.



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PROCESS AND APPARATUS FOR THE GASEOUS TREATMENT OF FINELY DIVIDED MATERIAL

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Fig. 5.

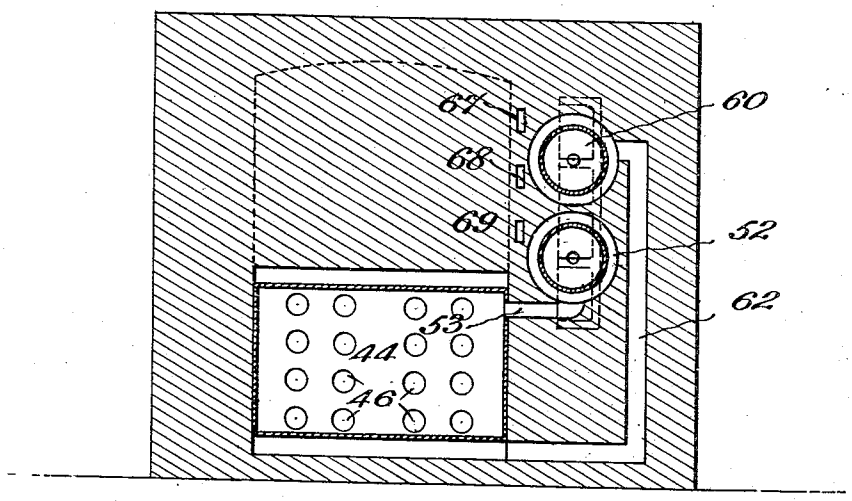
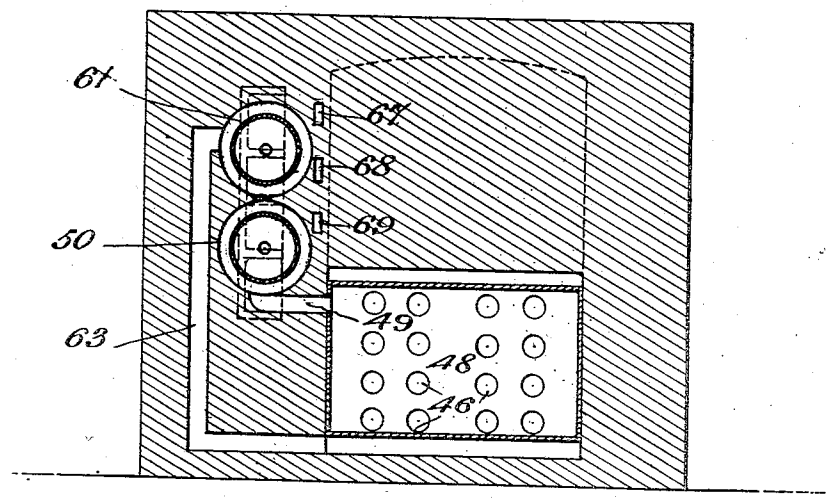


Fig. 6.



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PROCESS AND APPARATUS FOR THE GASEOUS TREATMENT OF FINELY DIVIDED MATERIAL

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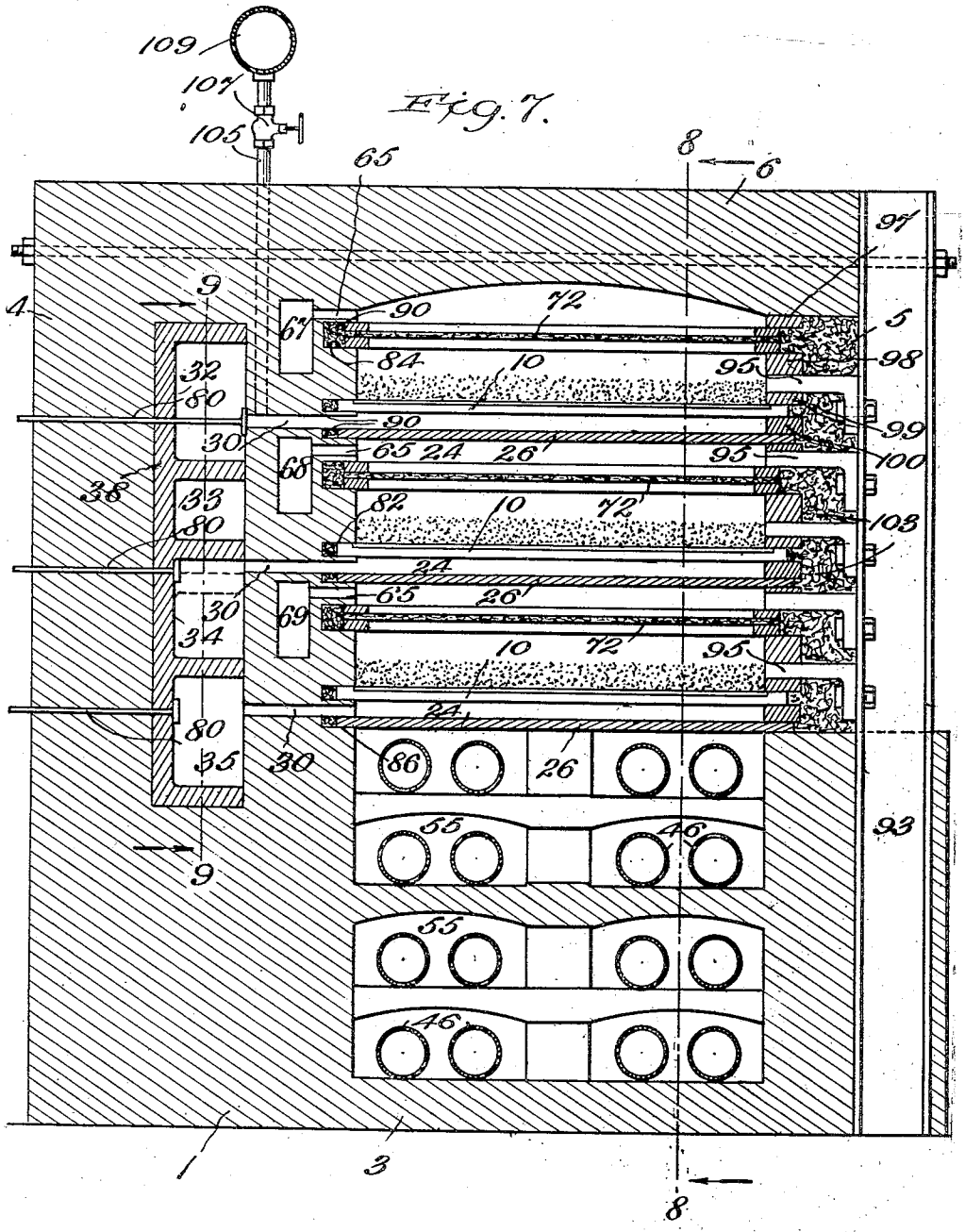
Fig. 7.



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PROCESS AND APPARATUS FOR THE GASEOUS TREATMENT OF FINELY DIVIDED MATERIAL

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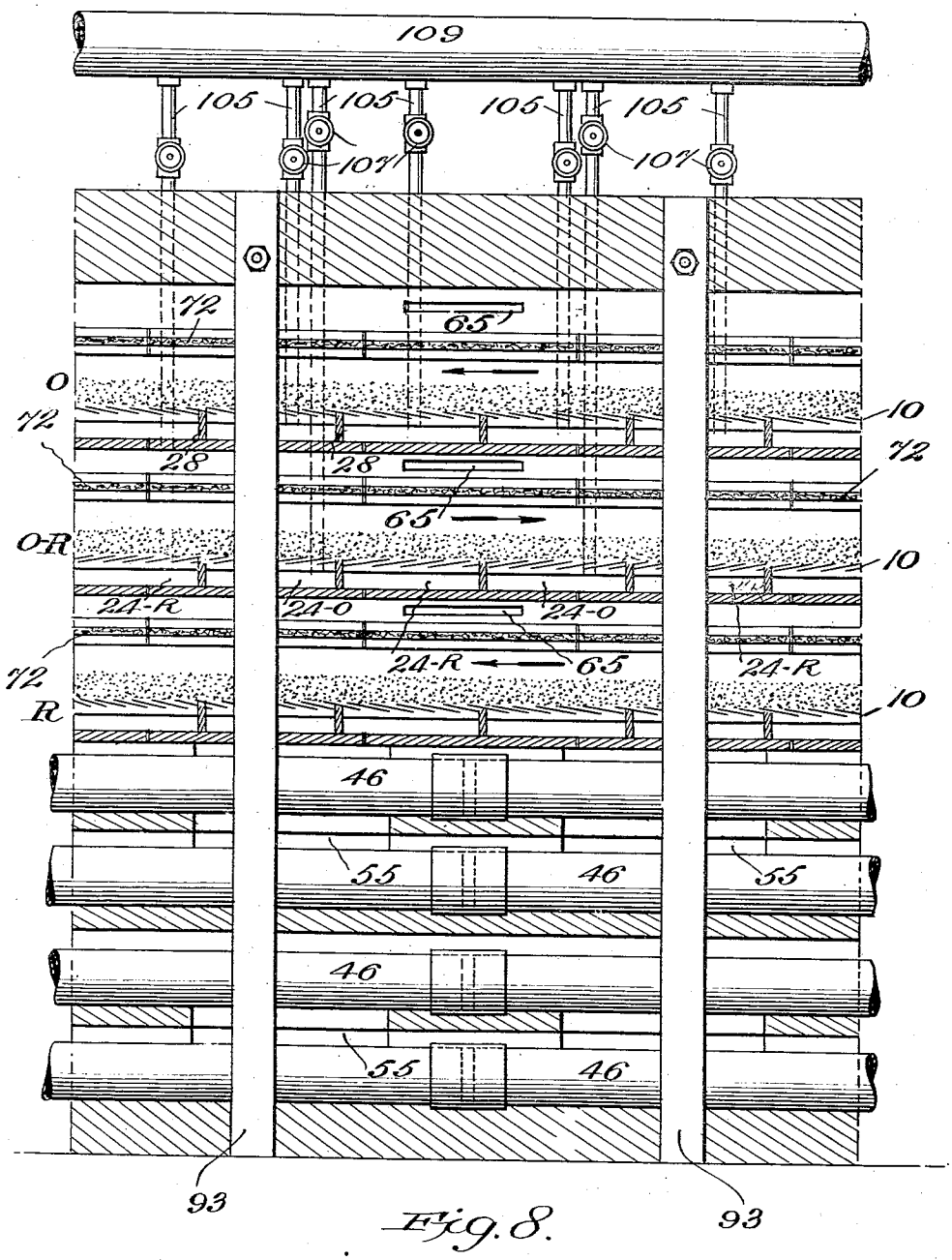

Fig. 8.

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PROCESS AND APPARATUS FOR THE GASEOUS TREATMENT OF FINELY DIVIDED MATERIAL

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Fig. 9.

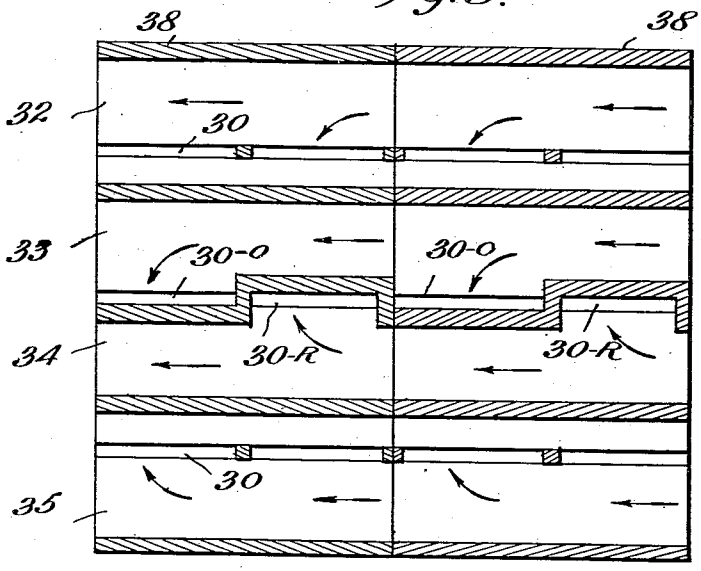


Fig. 10.

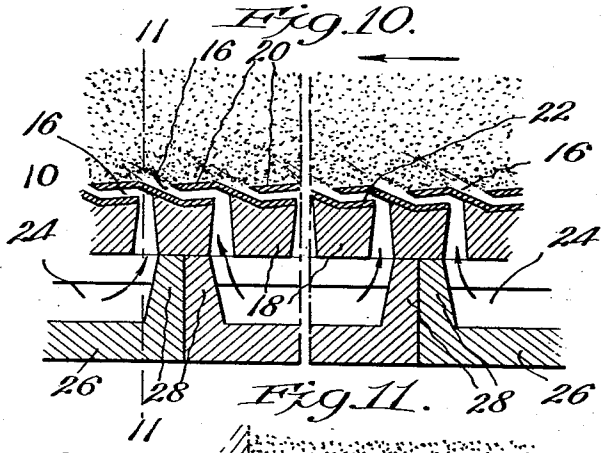
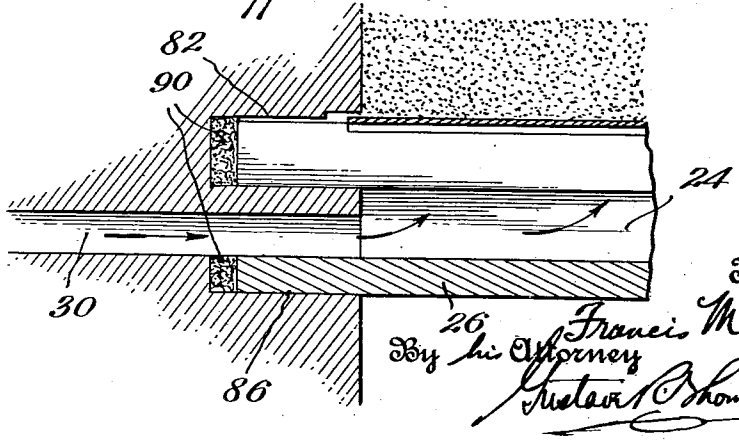


Fig. 11.



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UNITED STATES PATENT OFFICE

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PROCESS AND APPARATUS FOR THE GASEOUS TREATMENT OF FINELY-DIVIDED MATERIAL

Application filed March 20, 1929, Serial No. 348,632, and in Canada March 18, 1927.

This invention relates to a process and apparatus for gaseous treatment of granulated or finely divided material, and more particularly to the treatment of ores, and provides improvements therein.

This application is in part a continuation of my application Serial No. 135,440, filed September 14, 1926.

In the treatment of finely divided material, such as ground ores, pulverized ores, flotation concentrates, and admixtures, the desirability of bringing gases, and especially hot gases and corrosive gases, into intimate contact with the ores or other material has been recognized (see for instance Bureau of Mines Bulletin #72—1927), but great difficulties have been encountered in obtaining an intimate contact of the gas with all parts of the ore, in treating material on a large scale, in efficiently using large volumes of gas in closely regulating the temperatures of the gases and reactions, and in avoiding reverse and undesired reactions. Furthermore, great difficulties have been encountered in carrying out such treatment in a continuous manner, owing to limitations upon the use of apparatus comprising moving conveyors, particularly in the presence of hot or corrosive gases.

The present invention provides a method and apparatus for the gaseous treatment of finely divided material, (such as ores) in which movement of the material through the furnace is effected by impacts of gas against the underside of a layer of material on the furnace hearth, thereby avoiding the use of moving parts within the furnace, and is hence particularly adapted for gaseous treatment of material carried out at relatively high temperatures (red heat for example). The gas or gases pass through the layer of material on said hearth and an intimate and efficient use of the gas is thereby provided.

The invention further provides a method and means for closely regulating the temperatures of the gases and reactions; and for withdrawing said gases after passing through said ore, whereby reverse and undesired reactions in the material on the hearth are avoided.

The invention further provides a process and apparatus for carrying out a number of gas treatments upon the material, whereby to effect within the furnace one or more complete steps in the treatment of such material. For example, in the treatment of complex ores, the steps of roasting, reduction, or of roasting and reduction, or in some cases of selective roasting or reduction, or both, may be carried out.

The invention further provides improvements in the construction of a furnace, whereby replacements are facilitated, heat conserved, space economized, and a simple and serviceable structure provided.

The invention provides other features of advantage which will appear in connection with the description which follows:

An embodiment of the invention is illustrated in the accompanying drawings, wherein:

Figures 1 and 2 are vertical sectional views of said embodiment, Fig. 1 being a section at the feed end of the furnace, and Fig. 2 being a sectional view at the discharge end of the furnace.

Figs. 3 and 4 are related views, showing a horizontal section of the part shown in Figs. 1 and 2, the section being on the lines 3—3, Fig. 1, and 4—4, Fig. 2.

Fig. 5 is a transverse sectional view on the line 5—5, Fig. 1.

Fig. 6 is a transverse sectional view on the line 6—6, Fig. 2.

Fig. 7 is an enlarged transverse sectional view through the furnace at an intermediate part.

Fig. 8 is a view on the same scale as Fig. 7, being a transverse sectional view on the line 8—8, Fig. 7, looking in the direction of the arrows, the steel posts in front of the line of section, however, being shown.

Fig. 9 is a section through a part of the structure shown in Fig. 7, being on the line 9—9, looking in the direction of the arrows.

Fig. 10 is a longitudinal vertical section through a portion of the hearth;

Fig. 11 is a transverse sectional view through the hearth at the left-hand side of the furnace, Fig. 7; and

Fig. 12 is a vertical sectional view showing

a modification of the impeller and ducts, shown at the upper side of Fig. 4.

Referring to said drawings, numeral 1 designates the furnace, comprising base 3, side walls 4 and 5, and roof 6.

Numeral 10 designates the hearth. For conservation of space and also of heat, the hearth is conveniently divided into a plurality of superposed sections, here shown as three.

Numeral 12 designates a hopper for feeding finely divided material onto the hearth, and numeral 114 designates a bin, which is preferably a closed bin, as shown, for receiving the treated material at the discharge end of the furnace.

The divided material is moved along the hearth by means of a succession of impacts of gas against the underside of the layer of material on the hearth. The hearth is preferably level or approximately level.

Beneath the layer of material on the hearth there are arranged gas passages 16, Fig. 10, which gas passages 16 are upwardly inclined with relation to the ore layer, and are adapted to direct impacts of gas against the underside of the ore layer in such manner as to move or push the ore layer along the hearth in a direction to move it toward the discharge end of the furnace. The inclination of the passages 16 is preferably such as to direct the impacts at a small angle to the underside of the layer of material on the hearth.

The passages 16 are conveniently formed in the hearth itself. The hearth for this purpose may be composed of a number of bars 18 extending across the inside of the furnace, and spaced slightly apart, so as to allow an opening between adjacent bars. Each of the bars 18 is provided with an extension 20 (a plate for example), the extension on one bar extending over an extension on an adjacent bar and leaving a narrow space (for example, one-eighth of an inch between the plates), the said overlapping extensions 20, together with the top side of the bars 18, constituting the walls of the passages 16. The extensions 20 preferably extend across the furnace and thereby provide narrow gas-passages 16 running from side to side of the furnace.

Inasmuch as the material being treated is usually considerably smaller than the width of the passages 16, and furthermore inasmuch as at elevated temperatures, as for example 500 or 600° C., the material has a mobility very similar to dry talc, the passages 16 are formed throughout, or at least with a part, so little inclined that the finely divided material will not run down through the same. As shown in Fig. 10, the bars 18 are provided with such a portion 22 for preventing the material running through the said passages. As shown, this portion 22 has a slight inclination in the reverse direction to the upper portion of the said passage 16.

Gas chambers 24 are preferably arranged beneath the bars 18, with which the passages 16 communicate. The chambers 24 are conveniently formed of blocks or plates 26 which extend across the furnace and constitute the bottom of the gas-chamber 24. In case of breakage of one or more of the bars 18, the material would be caught by the said blocks or plates 26.

The hearth is preferably divided longitudinally into zones for carrying out different treatments of the material. For this purpose, among others, the chambers 24 are divided transversely, as shown at 28, so as to admit of gases of different composition being introduced to the hearth at different longitudinal zones. The gases are introduced to the chambers preferably through lateral passages 30 in one of the side walls of the furnace, as for example in the side wall 4, and these passages 30 preferably communicate with the ducts 32, 33, 34, 35 running longitudinally of the furnace, and preferably arranged in one of the side walls, as for example the side wall 4. Four of these ducts are shown, and these ducts may carry gases of different composition. For example, the duct 32 may carry an inert gas. The duct 33 may carry a similar gas, and ducts 34 and 35, a reducing gas, as for example producer gas, water gas, etc. The ducts may be conveniently and advantageously formed as channels in a block or blocks 38 laid up in the side wall 4, so that the open sides communicate with the lateral passages 30. Gas to the ducts 34 and 35 is conveniently supplied from producer 40, or other similar source, the gas from the said producer conveniently flowing to the said duct 34, through a main 42, manifold 44, pipes 46, manifold 48, opening 49, impeller 50, and thence into said duct 34.

The producer gas may also be supplied to the opposite ends of the duct 35, by an impeller 52 in communication therewith and taking producer gas from the manifold 44 through the opening 53.

The pipes 46 containing the producer gas are preferably arranged in a heating chamber in the bottom 3 of the said furnace, the pipes being supported in spaced relationship in a chamber 55, to which space is delivered products of combustion, as for example producer gas which is burned to supply hot combustion products to heat said chamber. As here shown, producer gas which has been previously utilized for cooling the ore, and thereby preheated, may be burned in said chamber 55.

The inert gas from the chamber 55 is conveniently delivered to the passages 32, 33 by impellers 60, 61, arranged at each end of the furnace in communication with the ends of the said ducts 32, 33 and in communication

with the said chamber 55 through ducts 62, 63 (see Figs. 5 and 6).

As the gases in the chamber 55 are at a higher temperature than the producer gas entering through pipes 46, the said producer gas will be heated to approximately the temperature of said chamber.

The gas passing through the hearth 10, and the layer of material thereon, is carried away in any suitable manner, as through lateral ducts 65 communicating with longitudinal ducts 67, 68, 69 preferably arranged in the side wall 4 of the furnace.

Above the layer of material on the hearth and between it and said ducts 65 there is preferably arranged a filter 72 of any suitable construction, as for example asbestos. The fine dust caught by said filter 72 falls back onto and mixes with material on the hearth which has received the same degree of treatment as it has.

The ducts 65 serve to carry off the gases immediately after passing through the layer of material on the hearth (and through the filter) and thereby carry them away from said material where they might otherwise react undesirably or reversely.

The ducts 67, 68, 69 may lead to a stack, or to a recovering apparatus for recovering such products from the gas as may be of value, and also for returning to the system, gas which may be again used in the process with or without regeneration, as may be necessary or desired.

The impeller 52 is conveniently of similar construction to the impeller 50. The action of these impellers is to produce sharp quick impacts of gas against the underside of the layer of material on the hearth, through the inclined passages 16 (by way of chambers 24, lateral passages 30 and channels 32, 33, 34, 35 in the illustrated construction). Any suitable impellers for effecting this action may be used. As here shown, the impellers comprise a reciprocating part or piston 75, working in a cylinder or sleeve 77, the parts 75 and 77 preferably being slightly spaced so as to avoid rubbing action at high temperatures. The front of the piston 75 is preferably provided with a valve disk 79 adapted to open when the piston 75 is pulled back, and to close when it is shot forward. The disk 79 on the back movement of the piston, opens and allows gas to pass to the front side of the piston, and also avoids suction or drawing back of the gases by the piston. In order to further avoid drawing back of the gases by the piston 75, a valve 81, opening toward the passage 35, may be placed in the cylinder 77 or other suitable location ahead of the said piston 75. Or, as shown in Fig. 12, a valve 150 (such for example as a so-called "flutter valve") may be placed in said sleeve or cylinder 77, ahead of the piston 75, and adapted to open on the backstroke of said piston and admit gas from the supply duct to the front of the piston. The piston 75 is reciprocated in any suitable manner so as to strike sharply against the gas, as by means of a crank or by means of a piston operated by compressed air or steam in such manner that the return stroke is relatively slow compared to the forward stroke, or by mechanical means, whereby the piston rod is shot forward by compressed air as in an air gun or by a spring, the return stroke being made by cams at a relatively slow speed. Other mechanical devices could be used. The object to be attained is a rapid forward stroke to give the shock to the air and a relatively slow return to avoid back suction and also to allow gas to continually pass through the ore. For example, the piston 75 may be driven by a piston 141 working in an air cylinder 142 (Fig. 4). A rotating cam 144 serves to force the piston 141 toward the back of the cylinder 142, compressing air, which, when the piston is released by the cam 144, shoots the piston 141 forward, and likewise the piston 75, thereby delivering a quick sharp impact to the gas in cylinder 77. I have obtained good results within the range of one to six impacts per second of the piston 75 against the gas. The impacts of the gas are such that momentarily, during such impacts, the passage of the gas through the layer of material is choked, in such manner that the resultant pressure of the gas against the underside of said material acts to impart movement to the layer of material along the hearth. Moreover, the pressure of the gas against the underside of the layer of material on the hearth is higher than that above the hearth, so that there is normally a constant or steady flow of gas through the material. The impacts of gas against the underside of the material are moreover effected in such a way as to avoid a jigging action on the material, which would result in a separation of the fines from the coarser material. It is preferable, particularly in ore treatment, to maintain a nearly homogeneous mixture of the fines and coarser material. Separation of the fines from the coarse material on the hearth is avoided by my invention, and I attribute this largely to the arrangement of the passages 16 in the hearth, whereby the impacts are delivered against the underside of the ore at a relatively small angle to the plane of the hearth. I have found that when the impacts are directed perpendicularly against the underside of a layer of material on the hearth, or at angles approximating the perpendicular, that separation of the fines and coarse particles occurs. Angles from 10° to 30° I have found most suitable for my purposes; that is, of maintaining a high degree of homogeneity of the coarse and the fine material, and that up to about 45° fair results may be obtained.

The maintenance of a good mixture of the fines and the coarse is of importance where

interactions take place between the particles, as for example in the treatment of complex ores, in using materials which are mixed together expressly for interaction, etc.

To facilitate feeding of the material on the hearth at the start, means are provided for closing off the gas to those portions of the hearth not covered by the material to be treated. For this purpose dampers 80 are provided for controlling the passages 30 leading to the gas-chambers 24 which communicate with the passages 16 in the hearth. In starting to feed material from hopper 12 to the hearth, all dampers 80 are closed except that controlling the flow of gas to the first gas-chamber 24, and as the material is fed forward, successive dampers are opened until the layer reaches the discharge end of the hearth.

As heretofore described, the passages 30 and 65 and also the channels or ducts 32, 33, 34, 35, 67, 68, 69 are preferably arranged in one side wall (4) of the furnace, leaving the opposite side wall (5) free of passages and adaptable for removal in whole or in part for making replacements of parts within the furnace, particularly the parts constituting the hearth 10 and filter 72.

To further adapt and facilitate the construction to the ready replacement of parts, the bars 18 are made of a length to extend across the furnace, and a recess 82 is provided in the side wall 4 for receiving and supporting an end of the bars 18. The filter 72 is also preferably made in transverse sections (see Fig. 8) extending across the furnace, and a recess 84 is provided inside wall 4 for receiving and supporting an edge portion of each filter section. Similarly, the plates or blocks 26 are constructed in transverse sections, and a recess 86 provided in the side wall 4 for receiving and supporting an edge of said sectional plates 26. Asbestos wool may be placed in said recesses 82 and 84, as indicated at 90, to pack the joint between the walls of the recesses and the parts fitting therein.

With a stationary hearth, as described, a snug joint can be made with the side walls of the furnace, and all gas forced to pass through the material, thereby securing greater efficiency and economy than possible with a moving hearth.

The side wall 5 is conveniently provided with a plurality of vertical columns 93 of steel or the like, and brackets 95 fastened thereto, project inwardly and support the adjacent edges of the sectional filter 72, and hearth parts 18 and 26. Suitable blocks or bars such as the blocks 97, 98, 99, 100 may be inserted between the brackets to support the parts 10, 26 and 72 at the proper level, and to fill the side of the furnace. Suitable packing and lagging material, as asbestos wool 103 may be placed outside of said blocks 97, etc., to seal, insulate and fill out the wall 5. The material 103 is readily removable, and after removal, the blocks 97, 98, 99, 100 may be easily removed, and a section or sections of the filter or hearth removed and replaced with very taking down of the furnace or loss of time.

The ducts 32 and 33 have been described as conveying hot inert gas to the hearth, which gas may be used for decomposing material on the hearth or for heating the material preliminary to other treatment.

If it be desired to oxidize material, as for example to roast sulphide ores, means are provided for introducing air into said inert gas, and preferably in independently controllable quantities into the gas introduced into the several gas-chambers 24. For this purpose pipes 105, controlled by valves 107 may be provided, communicating conveniently with the lateral passages 30 leading into the gas-chambers 24. The several pipes 105 may connect with a main 109 supplied with air under pressure, as from a low-pressure blower 111. Letter O, Figs. 2 and 8, designates a part of the oxidizing zone in the embodiment shown.

In order to break up compounds which at the temperature used do not dissociate under continued oxidation, it is desirable to alternately subject such compounds to alternate reduction and oxidation. For example, in the process of roasting sulphide ores, it is sometimes desired to subject the ores during a stage of the roasting, alternately to oxidation and reduction in order to break up sulphur-oxygen compounds with the metal of the ore. For this purpose the hearth (an intermediate portion designated by letters O—R, Figs. 2 and 8, in the embodiment shown) may be constructed to receive in alternate gas-chambers 24, oxidizing and reducing gases. Referring to Figs. 7 and 8, each of the gas-chambers 24—R are shown as communicating with the duct 34 containing reducing gas through lateral passages 30—R (Figs. 7 and 9), and each of the chambers 24—O are shown as communicating with the duct 33 (through lateral passages 30—O, Fig. 9) and with an air pipe 105, whereby an oxidizing gas is introduced to the chambers 24—O. The pipes 105 may be used for introducing other gas than air into the gas-chambers 24, where other treatment of the material than that effected by air is desired, and the valves 107 may be used for closely regulating the temperature and character of the reactions taking place at various parts of the hearth.

The after part of the hearth, in the illustrated embodiment a part of which is designated by letter R, may be used for reduction of the roasted ores, for which purpose reducing gas is supplied from the duct 35 to the

gas-chambers 24 in said after part of the hearth.

Before discharging reduced ores, and many other kinds of material into the air, it will frequently be desirable to reduce the temperature of the material after the treatment with hot gas has been finished. For this purpose the hearth 10 may have a prolongation 115 extending into the closed discharge bin 114 in which prolongation cool or relatively cool gas is used for moving the ore layer. As shown, relatively cool gas from the gas producer 40 is led through a pipe 117 to a duct 119 communicating through lateral passages 121 with gas-chambers 24 in the hearth at said prolongation 115 thereof, and an impeller 125, similar for example to the impeller 50, is provided for producing impacts of the gas admitted through pipe 117 on the material on the hearth for moving said material along said prolongation 115 of the hearth. The gas may be led off and burned to produce hot products of combustion for the heating chamber 55. The said gas from the prolongation 115 may pass off through lateral openings 127 above the filter 72 and pipe 129, and be mixed with air from a pipe 131, and burned as it issues from said pipe 129.

A description of the process of my invention and of a mode of procedure in which said process is carried out, has been given in connection with the foregoing description of the apparatus and its operation.

The apparatus of my invention may receive other embodiments than that herein specifically illustrated and described, and the process of my invention may be carried out in other modes of procedure than that herein specifically described.

What is claimed is:—

1. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material may lie, and means for moving said layer of finely divided material along said hearth, comprising a source of hot gas, and means for imparting a succession of sharp impacts of said hot gas against the underside of said layer of material, said gas under the pressure of said impacts being momentarily choked in its passage through said layer of material and by the resultant pressure against the underside of said material effecting said movement of said layer along said hearth.

2. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material may lie, and means for moving said layer of finely divided material along said hearth, comprising a source of hot gas, and means for imparting a succession of sharp impacts of said hot gas against the underside of said layer of material said gas under the pressure of said impacts being momentarily choked in its passage through said layer of material and by the resultant pressure against the underside of said material effecting said movement of said layer along said hearth, and means for maintaining a flow of gas through said layer of material between said impacts.

3. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material may lie, said hearth being divided into a plurality of zones, and means for moving said layer of finely divided material along said hearth, comprising a plurality of means for imparting a succession of sharp impacts of gas against the underside of said layer of material at said plurality of zones, and means for supplying gases of different composition to said zones.

4. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material may lie, and means for moving said layer of finely divided material along said hearth, comprising means for imparting a succession of sharp impacts of inert gas against the underside of said layer of material, and means for furnishing to said inert gas a limited quantity of a constituent active upon said material the proportion of which active constituent is such that reaction thereof on said material does not produce such an increase of temperature as to produce sintering.

5. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material may lie, and means for moving said layer of finely divided material along said hearth, comprising means for imparting a succession of sharp impacts of hot gas against the underside of said layer of material, and means at the discharge end of said hearth for supplying cooling inert gas to said material whereby said material is made inactive on meeting the air.

6. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material may lie, and means for moving said layer of finely divided material along said hearth, comprising means for imparting a succession of sharp impacts of gas against the underside of said layer of material, and a filter above said layer of material on the hearth for the gas which has passed through said material whereby to catch fine dust and allow it to drop back upon the layer on the hearth and means for drawing gas through the filter whereby to permit all the gas to immediately pass off and thereby avoid counter-reactions.

7. Apparatus for the gaseous treatment of finely divided material comprising a hearth on which a layer of finely divided material

may lie, and means for moving said layer of finely divided material along said hearth, said means comprising upwardly inclined gas-passages and means for imparting through said passages a succession of impacts of gas against the underside of said layer of material, said passages having at least a part so little inclined that the finely divided material will not flow downwardly through said gas passages.

8. Apparatus for the gaseous treatment of finely divided material comprising a hearth on which a layer of finely divided material may lie, and means for moving said layer of finely divided material along said hearth, said means comprising gas-passages and means for imparting through said passages a succession of impacts of gas against the underside of said layer of material, said gas-passages having a relatively small upward inclination not exceeding 30°, whereby stratification of said material under the action of said impacts of gas is prevented.

9. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material may lie, a source of gas inactive toward the material on said hearth, separate gas chambers for different portions of said hearth, means for moving said layer of finely divided material along said hearth comprising means for imparting a succession of sharp impacts of said inert gas through said chambers against the underside of said layer of material, means for admitting limited quantities of gas reactive toward said material to said chambers, and means for regulating the amount of said reactive gas admitted to individual chambers.

10. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material may lie, a source of gas, separate gas chambers for different portions of said hearth, means for moving said layer of finely divided material along said hearth comprising means for imparting a succession of sharp impacts of said gas through said chambers against the underside of said layer of material, and means for individually opening and closing said chambers, said latter means being independent of said means for imparting said impacts.

11. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which said finely divided material may lie, a source of reducing gas, a heating chamber, pipes for said reducing gas passing through said heating chamber, means for supplying hot combustion products to said heating chamber to heat said pipes, and means for supplying said heated reducing gas and said hot combustion products to the underside of said layer of material on said hearth, whereby said gases may pass through and in intimate contact with said material.

12. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which said finely divided material may lie, a source of reducing gas, a heating chamber, pipes for said reducing gas passing through said heating chamber, means for supplying hot combustion products to said heating chamber to heat said pipes, and means for supplying said heated reducing gas and said hot combustion products to the underside of said layer of material on said hearth, whereby said gases may pass through and in intimate contact with said material, and means for admitting regulated quantities of air to combustion products supplied to the underside of said layer.

13. Apparatus for the gaseous treatment of finely divided material comprising a hearth on which said finely divided material may lie, a source of reducing gas, a heating chamber, pipes for said reducing gas passing through said heating chamber, means for supplying hot combustion products to said heating chamber to heat said pipes, separate gas chambers for different portions of said hearth, and means for conducting said heated reducing gas to selected gas chambers, and means for conducting said hot combustion products to other of said separate gas-chambers, and passages between said chambers and the underside of said layer of material on said hearth, whereby said gases may pass through and in intimate contact with said material.

14. Apparatus for the gaseous treatment of finely divided material, comprising a hearth on which a layer of said finely divided material is adapted to lie, and through which gas is adapted to pass to the underside thereof, said hearth being made in replaceable sections, ducts for conveying gas to said hearth and for leading it off after passing through said layer of material, said apparatus having a side wall through which said ducts pass, and another side wall of readily removable construction, permitting of lateral access to said hearth for replacement of sections without necessitating the removal of the side wall or parts thereof containing said ducts.

15. In a furnace for the treatment of ore, a hearth constructed to permit the passage of gas thereto, means for projecting puffs of gas through said hearth, and a filter above the space for the passage of ore over the hearth.

16. In a furnace for the treatment of ore, a hearth constructed to permit the passage of gas thereto, means for projecting puffs of gas through said hearth, and means for supplying a plurality of different kinds of such gas.

17. In a furnace for the treatment of ore,

a perforated hearth, a series of chambers under the same, ducts leading into said chambers, adapted to admit gas in puffs simultaneously into said chambers.

18. In a furnace for the treatment of ores, a hearth adapted to permit the passage of gas therethrough, means for supplying a plurality of hot gases of different composition to the underside of said hearth, means for effecting passage of the hot gases through said hearth and the ore body thereon, and means for producing variations in the pressure of said hot gases to produce propelling impulses on the ore body to feed it along said hearth.

19. In a furnace according to claim 18, said hearth having a long chamber beneath the same, and means for admitting gases of different composition to said chamber at different points along said hearth, whereby to effect different chemical actions upon said ore.

20. In a furnace for the treatment of ore, a hearth constructed to permit the passage of a gas thereto, means for projecting puffs of aeriform material through said hearth, said means for propulsion of aeriform material comprising means for supplying a plurality of different kinds of such material.

21. In a furnace for the treatment of ores, a hearth adapted to permit the passage of a gas therethrough, means for supplying a hot gas to the underside of said hearth, means for effecting passage of said hot gas through said hearth and the ore body thereon, and means for producing variations in the pressure of said hot gas to produce propelling impulses on the ore body to feed it along said hearth, said latter means comprising a valve made with a sufficiently loose fit to permit even when the valve is closed, an effective passage of gas at all times for the treatment of the ore.

22. Process of treating finely divided material, comprising feeding said material along a hearth by impacts of gas against the underside of said body, said impacts being delivered sharply so as to avoid stratification of said material.

23. Process of treating finely divided material, comprising feeding said material along a hearth by impacts of gas against the underside of said body, said gas being an inert gas.

24. Process of treating finely divided material comprising feeding said material along a hearth by impacts of gas against the underside of said body, said gas being a hot inert gas.

25. Process of treating finely divided material, comprising feeding said material along said hearth by impacts of gas against the underside of said body, said gas being an inert gas, and admitting limited quantities of active gas to said material at different parts of said hearth.

26. Process of treating finely divided material, comprising feeding said material along a hearth by impacts of gas against the underside of said body, and withdrawing said gas from the upperside of said material whereby said gas after passing through said material moves directly away therefrom, and counter-reactions prevented.

27. Process of treating finely divided material with gases of different composition, comprising passing gases of different composition to different parts of said material spread out in a layer upon a hearth, and moving said layer of material along said hearth by impacts of said gases against the underside of said material.

28. Process of treating finely divided material with gases of different composition, comprising passing gases of different composition to different parts of said material spread out in a layer upon a hearth, and moving said layer of material along said hearth by impacts of said gases against the underside of said material, said gases being principally inert and reducing gases.

29. Process of treating finely divided material with gases of different composition, comprising passing gases of different composition to different parts of said material spread out in a layer upon a hearth, and moving said layer of material along said hearth by impacts of said gases against the underside of said material, said gases being principally inert and reducing gases, and admitting active gas to the inert gases at different parts of said hearth to effect desired degrees of oxidation.

In witness whereof, I have hereunto signed my name.

FRANCIS M. SIMONDS.