

April 19, 1938.

G. R. LEWERS

2,114,566

INCINERATION

Filed Nov. 21, 1936

2 Sheets-Sheet 1

FIG. 1.

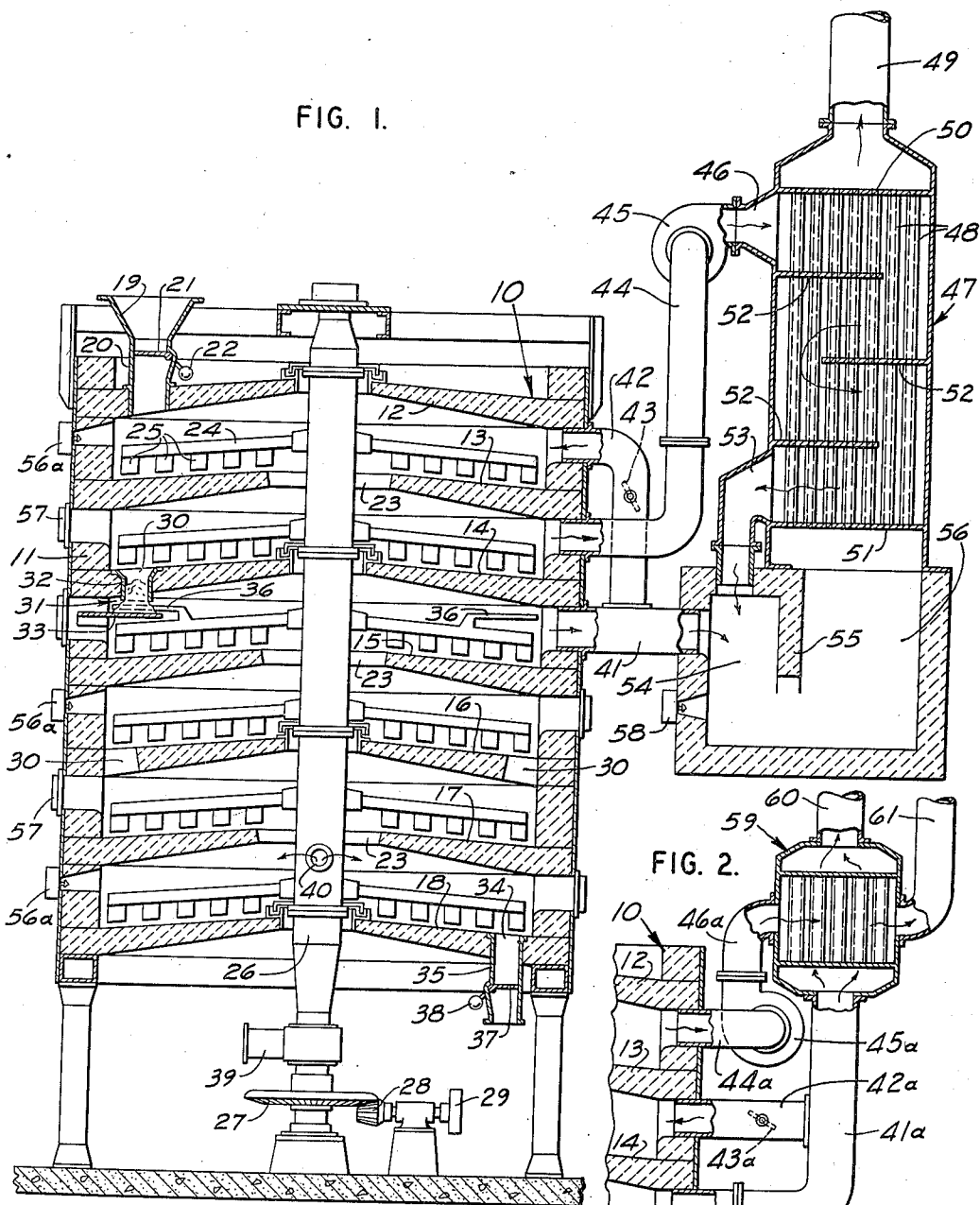
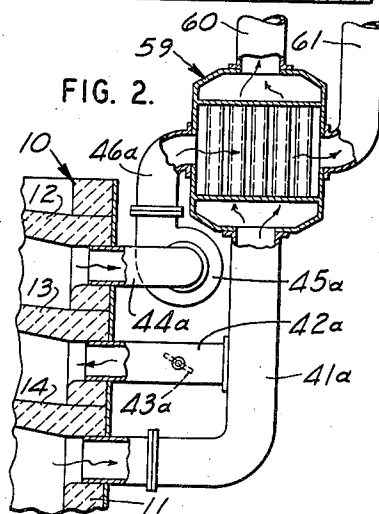


FIG. 2.



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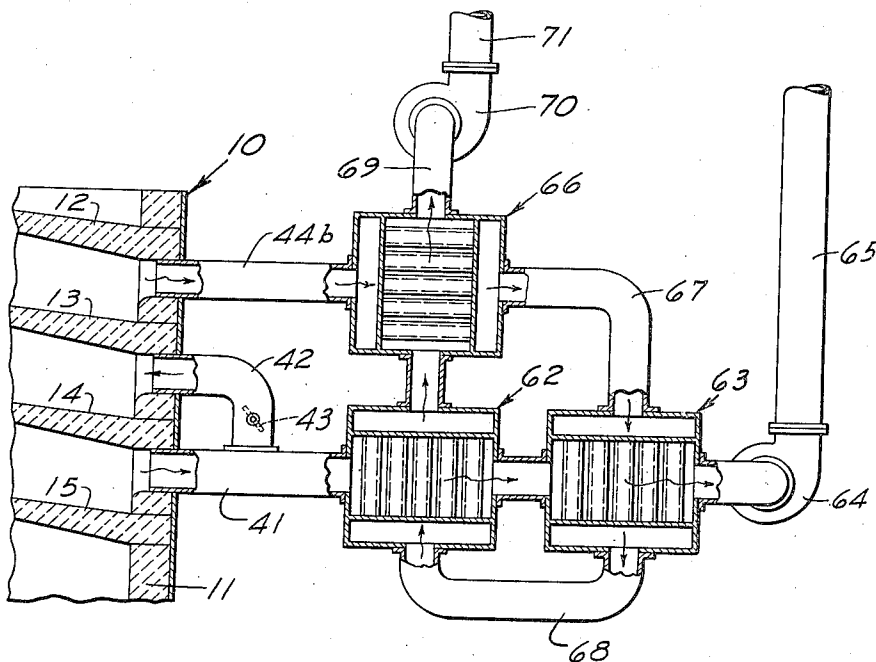
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2 Sheets-Sheet 2

FIG. 3.



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2,114,566

INCINERATION

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Application November 21, 1936, Serial No. 112,002

19 Claims. (Cl. 110—12)

This invention relates to incineration and more particularly to improvements in tiered multiple hearth furnaces and to improvements in processes for drying and burning material by passing it downwardly through a plurality of zones, gradually drying it in upper zones and then burning it in lower zones.

Although the apparatus and process of the present invention are suitable for use with many kinds of material, they are of particular value in drying and burning waste material such as garbage and sewage material including sewage sludge and sewage screenings both of which have a substantial moisture content.

The principal objects of the invention are to provide novel, advantageous and effective forms of apparatus and processes for treatment of material of the general character specified. Another object of the invention relates to improvements in tiered multiple hearth furnaces divided into separate drying and burning sections by intermediate hearths with gas seals, whereby part of the hot gases of combustion from the burning section is brought into contact with material in the drying section and, when passed out of the drying section at a lower temperature laden with gases and other material resulting from the drying, is heated by the remaining portion of the hot gases of combustion from the burning section to eliminate noxious odors. A further feature of the invention relates to the heating of hot gases from the drying section by heat interchange with the remaining gases from the burning section, the mixing of gases discharged from the burning section with the reheated exhaust gases and the subsequent combustion of combustible gases in said mixture. A further feature of the invention relates to the heating of the hot gases of combustion from the drying section by heat exchange with gases discharged directly from the burning section and the use of the gases thus reheated in heating the gases discharged from the drying section.

In carrying out the invention, use may be made of a tiered multiple-hearth furnace in which an intermediate hearth is provided with a gas seal to divide the furnace into an upper drying section and a lower burning section. In a furnace of this kind, the material introduced at the top of the furnace may be worked downwardly from hearth to hearth through central outlets for every other hearth and peripheral outlets for the remaining hearths, and material on the hearths may be agitated and moved towards the outlets of said hearths by suitable rabbling devices. Part of the hot gases of combustion discharged from the burning section may be passed through the drying section in contact with the material on the hearths thereof and, when discharged from the drying section laden with gases

and vapors produced in drying, may be passed in heat interchanging relation with hot gases passing directly from the burning section and later mixed with the hot gases discharged from the burning section and burned. The proportion of the hot gases of combustion passed through the drying section may be varied, for example as required to maintain the desired temperature. In this way all noxious odors produced in the drying operation may be eliminated by the high temperatures. It should be understood that the hot gases may be introduced into the drying section at the upper part and discharged therefrom at another level.

According to another way of carrying out the invention, the reheated gases from the drying section may be heated sufficiently to remove the noxious odors by fresh hot gases from the burning section without mixing therewith. In another way of carrying out the invention, the gases passing from the hot burning section may be utilized to heat the gases discharged from the drying section by use of one or more heat exchangers and the gas from the drying section thus reheated may be used to raise the temperature of the gases discharged from the drying section before they are subjected to the heat exchange from hot gases discharged directly from the burning section.

Further objects, features and advantages will appear upon consideration of the following description and of the drawings in which:

Figure 1 is a view in vertical section of a preferred embodiment of the apparatus of the present invention;

Figure 2 is a fragmentary section of a modification providing for the elimination of odors from the gases exhausted from the drying section by heat exchange with gases passing directly from the burning section, without being mixed therewith; and

Figure 3 is another modification.

Referring to Figure 1 of the drawings, there is disclosed an apparatus including a multiple-hearth furnace 10 having a peripheral wall 11, a top 12, and hearths 13, 14, 15, 16, 17 and 18 of which the hearth 18 serves as the bottom of the furnace. Material may be supplied at the top of the furnace by means of a hopper 19 and a chute 20 extending through the top 12, the chute being provided with a gas seal which may be in the form of a pivoted door or gate 21 normally held in closed position by weighted arm 22 as herein disclosed.

As herein disclosed, material introduced through the chute 20 passes into the upper compartment of the furnace and falls on the hearth 13 near its periphery. The material thus deposited on the hearth 13 is agitated and moved inwardly to a central outlet 23 by one or more

rabbling devices each of which comprises a radial arm 24 and inclined blades 25 extending downwardly therefrom, the arm 24 being supported and actuated by a hollow vertical shaft 26 passing through the central part of the outlet 23. Actuation of the shaft 26 may be effected by means of a bevel gear 27 thereon, a bevel gear 28 meshing with the bevel gear 27 and a pulley 29 connected with the bevel gear 28 and actuated from any suitable source of power.

The shaft 26 is provided above each of the hearths 14, 15, 16, 17 and 18 with rabbling devices similar to those above the hearth 13, but above the hearths 14, 16 and 18, the blades are inclined in the opposite direction so as to work the material to peripheral outlets. The hearth 14 is shown as provided with one outlet 30 provided with a gas seal 31 including a tube 32 in the outlet 30 and extending downwardly to within a short distance of a platform 33 on which the material passing downwardly through the outlet 30 piles up and maintains the tube 32 closed, the hearth 16 is provided with two or more outlets 30, and the hearth 18 is provided with a single outlet 34 in the form of a chute 35. Feeding of the material downwardly through the gas seal 31 to the hearth 18 may be effected by sweeps or sweep arms 36, each of which removes at each revolution some of the material from the shelf or platform 33 and allows other material to settle down through the tube or chute 32. The apparatus just described constitutes one form of means for feeding solid material through the hearth 14 while preventing the flow of gases. The hearths 15 and 17 are provided with central outlets 23 corresponding to that in the hearth 13. The top 12, and the hearths 14, 16 and 18 are provided with gas seals around the vertical shaft 26. The discharge chute 35 at the periphery of the hearth 18 is sealed against the passage of gas by means of a gate or door 37 normally held in closed position by a weighted arm 38.

Air may be supplied to the interior of the burning section through a duct 39 connected to the interior of the hollow vertical shaft 25 and one or more openings or nozzles 40 connecting the interior of the shaft 20 with the interior burning section. As illustrated, air is supplied from the hollow shaft 26 to the lower compartment of the burning section. From the upper part of the burning section, preferably from the uppermost compartment, the hot gases of combustion are discharged through a duct 41. The drying of the material in the drying section by direct use of hot combustion gases may be effected by means of a branch duct 42 connected with the duct 41 and regulated by a damper 43. As here shown the branch duct 42 may communicate with the interior of the uppermost compartment of the drying section and the cooled combustion gases laden with gases and vapors taken up in the drying operation may be discharged from the lowermost compartment of the drying section through a duct 44 and a suction fan 45 which draws the hot gases from the duct 41 through a duct 42 and the drying section.

The gases thus withdrawn through the duct 44 and fan 45 may contain combustible gases and may have noxious odors which may be removed by subjecting the mixture to sufficient heat to burn the combustible gases. Preferably, as illustrated in Figure 1, these results may be attained by passing the gases from the fan 45 through a duct 46 to the upper part of a heat exchanger 47. The heat exchanger 47 may comprise a compart-

ment receiving the gases from the duct 46 and containing a plurality of tubes 48 through which hot gases of combustion pass to a stack or discharge duct 49. The tubes are supported at their upper and lower ends in partitions 50 and 51 respectively and the gases are directed back and forth through the compartment by baffles 52, the gases from the duct 46 finally being discharged from the lower part of the heat exchanger through a duct 53 leading the gases to a mixer or mixing chamber 54 into which the duct 41 discharges. The mixture of gases thus produced passes from the mixing chamber 54 downwardly around the lower edge of a downwardly extending wall 55 and into a combustion chamber 56 in which the combustible gases are burned and the noxious odors eliminated. The hot gases of combustion pass from the combustion chamber 56 upwardly through the tubes 48 to the upper part of the heat exchanger and out through the duct 49.

In order to assist in starting the furnace and to maintain proper temperatures the different compartments of the furnace may be provided with burners 56* and in order to provide for access to the interior of the compartments, there may be supplied, wherever desired, doors 57. To assure proper temperatures in the gases passing into and through the combustion chamber 56 there may be provided a burner 58 at the lower part of the mixing chamber.

As illustrated in Figure 2, the mixing of the gases of combustion from the drying section and from the burning section may be omitted and the gases discharged from the drying zone may be raised to a sufficient temperature by heat exchange with the hot gases passing directly from the burning zone. This result may be attained by apparatus in which the hot gases of combustion discharged from the upper part of the burning section through a duct 41a may be divided into two parts, the main flow passing through a heat exchanger 59 to a discharge duct or stack 60 and a portion of the hot gases being diverted through a branch duct 42a supplied with a damper 43a to the lowermost compartment of the furnace and the gases cooled in drying the material in the drying section and containing combustible gases and noxious odors may be withdrawn from the uppermost compartment of the drying section through a duct 44a by a fan 45a and forced through a duct 46a to the heat exchanger 59. In passing through the heat exchanger 59 the combustible gases from the drying section are burned and the noxious odors eliminated, the resulting gases being discharged through a duct or stack 61.

According to another modification illustrated in Figure 3, not only are the gases from the drying section burned and the noxious odors eliminated by heat exchange with the gases of combustion discharged directly from the burning section, but the heat exchange is carried to a greater extent so that the temperatures of the discharge gases of combustion are lower than would otherwise be the case.

In this form, the main flow of hot combustion gases from the burning section through duct 41 to heat-exchanger 62 and from this heat-exchanger is passed through a second heat-exchanger 63 to an induced-draft fan 64 which discharges the gas to a flue 65 which may be a stack. Part of the hot gases of combustion discharged from the burning section are diverted from the duct 41 through branch 42, controlled

by damper 43, to the lower part of the drying section. From the upper part of the drying section the gases, cooled in the drying operation and laden with moisture and gases with noxious odors are passed through the heat-receiving part of a heat exchanger 66. The gases thus heated are passed through a duct 67 to the heat receiving part of the heat exchanger 63 where the gases are heated still more. Passing from the heat exchanger 63, the temperature of the gases thus heated is again raised by passing them through a duct 68 to the heat receiving part of the heat exchanger 62 where the noxious odors are eliminated. The gases thus reheated are then passed through the heat-imparting side or portion of the heat exchanger 66 and a duct 69 to a fan 70 discharging them to a duct 71 which may be a stack.

It should be understood that it has been a common practice in the disposal of sewage sludge to reduce the water content thereof by filtration and then to burn the filter cake either immediately after stripping from the filter or after the drying period. The apparatus of the present invention is particularly adapted for handling the filter cake as fast as it is stripped from the filter in that the filter cake can be suitably dried in the drying compartment of the apparatus shown in Figure 1 and the dried solids may then be burned in the burning section. By varying the amount of hot gases passing from the discharge duct 41 through the branch duct 42 to the drying section, the temperature in the drying section can be controlled as desired so that substantially uniform drying of the solids may be attained before discharging them into the burning section. Furthermore by passing the hot gases and vapors from the drying section through the heat receiving portion of the heat exchanger 47 they may be mixed with the remaining hot gases from the duct 41 in the mixing chamber 54 without unnecessary chilling and the mixture may then be passed around the bottom of the partition 55 into the combustion chamber 56 where the combustible gases will be burned and noxious odors eliminated. From the combustion chamber 56, the hot gases will pass upwardly through the tubes 48 constituting the heat imparting part of the heat exchanger 47 to the stack 49, the passage of the gases through the tubes 48 serving to produce a great drop of temperature between the gas combustion chamber 56 and the stack 49.

It should be understood that changes may be made and that certain features may be used without others without departing from the true scope and spirit of the invention.

Having thus described my invention, I claim:

1. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, means for withdrawing hot gases of combustion from the burning section, means for directing a part of said hot gases to the drying section, means for withdrawing the combustion gases from the drying section and means for heating the cooled gases withdrawn from the drying section by heat exchange with hot gases flowing directly from the burning section, for the elimination of noxious odors produced in the drying section.

2. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, means for withdrawing hot gases of combustion from the burning section, means for directing a part of said hot gases to the drying section, means for varying the proportional part of the hot gases directed to the drying section, means for withdrawing the combustion gases from the drying section and means for heating the cooled gases withdrawn from the drying section by heat exchange with hot gases flowing directly from the burning section, for the elimination of noxious odors produced in the drying section.

3. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, means for withdrawing hot gases of combustion from the burning section, means for directing a part of said hot gases to the drying section, means for withdrawing from the drying section combustion gases laden with gases and vapors evolved in the drying section, means for mixing the cooled gases withdrawn from the drying section with the hot gases withdrawn directly from the burning section, and means for burning combustible gases in the mixture and eliminating noxious odors acquired in the drying section.

4. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, means for withdrawing hot gases of combustion from the burning section, means for directing a part of said hot gases to the drying section, means for withdrawing from the drying section combustion gases laden with gases and vapors evolved in the drying section, means for mixing the cooled gases withdrawn from the drying section with the hot gases withdrawn directly from the burning section, means for burning combustible gases in the mixture and eliminating noxious odors acquired in the drying section, and means for passing hot gases from the last mentioned burning means into heat-exchanging relationship with the gases passing from the drying-section to the mixing means.

5. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the lower part of the burning section, means for withdrawing hot gases from the upper part of the burning section, means for directing a part of said hot gases to the drying section at one level, means for withdrawing gases and vapors from the drying section at another level, and means for controlling the drying op-

eration in the drying section by varying the amount of hot gases supplied thereto.

6. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, means for withdrawing hot gases from the burning section, means for directing a part of said hot gases to the drying section at one level, means for withdrawing gases and vapors from the drying section at another level, means for controlling the drying operation in the drying section by varying the amount of hot gases directed thereto, and means for utilizing the rest of the hot gases from the burning section in eliminating noxious odors acquired in the drying operation.

7. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, a duct receiving hot gases from the burning section, a branch duct leading from the first duct to the drying section, damper means for varying the flow through the branch duct, a combustion chamber receiving gases passed through the first duct, a heat exchanger receiving in its heat-imparting portion hot gases from the combustion chamber, and means for withdrawing hot gases and vapors from the drying section and passing them through the heat-receiving portion of said heat exchanger into said combustion chamber.

8. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, a duct receiving hot gases from the burning section, a branch duct leading from the first duct to the drying section, damper means for varying the flow through the branch duct, a mixer receiving the hot gases discharged from the drying section and the gases from the first duct, and a combustion chamber receiving the mixture from said mixer.

9. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, a duct receiving hot gases from the burning section, a branch duct leading from the first duct to the drying section, damper means for varying the flow through the branch duct, a mixer receiving the hot gases discharged from the drying section and the gases from the first duct, a combustion chamber receiving the mixture from said mixer, and a heat exchanger utilizing the hot gases from the combustion chamber to heat the gases passing from the drying section to the mixer.

10. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower

burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the lower part of the burning section, a duct receiving hot gases from the upper part of the burning section, a branch duct leading from the first duct to the upper part of the drying section, a third duct to receive gas from the upper part of the drying section, and a heat exchanger receiving hot gases from the first duct in its heat receiving part and receiving in its heat imparting part gases from the drying section discharged through said third duct.

11. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, a duct receiving hot gases from the burning section, a branch duct leading from the first duct to the drying section, a heat exchanger having a lower-temperature part and a higher temperature part connected with the first duct, a second heat exchanger having a higher-temperature part and a lower-temperature part through which gases from the drying section are passed to heat them, and means for passing the gases thus heated through the lower-temperature part of the first heat exchanger to raise them to a higher-temperature and then through the higher-temperature part of the second heat exchanger.

12. The combination with a multiple-hearth furnace comprising a hearth dividing the furnace into an upper drying section and a lower burning section and means for feeding solid material from the drying section downwardly past the dividing hearth to the burning section while maintaining a gas seal, of means for supplying air to the burning section, a duct receiving hot gases from the burning section, a branch duct leading from the first duct to the drying section, a heat exchanger heated by the hot gases from the first duct, a second heat exchanger heated by the same gases as the first but at a lower temperature, a third heat exchanger heating gases from the drying section, and means for passing the gases heated by the third heat exchanger through the second and first heat exchangers in series to heat the gases to a higher temperature and then through the third heat exchangers to supply heat thereto.

13. The process of incineration which comprises passing material of high moisture content downwardly through a plurality of zones while first drying and then burning the same, temporarily retaining said material in each of a plurality of said zones, moving said material substantially horizontally through each of said zones by the application of a series of rabbling impulses thereto, preventing the direct passage of gases between two adjacent zones thereby separating the zones into a drying group and a burning group, passing air upwardly through the burning zones, withdrawing hot gases from an upper burning zone, passing part of said hot gases through said drying zones, withdrawing from the drying zones gases laden with products of the drying operation, passing the remaining hot gases from the burning zones into heat exchange relationship with the gases from the drying zones and burning combustible gases in said

gases from the drying zone as well as eliminating noxious odors.

14. The process of incineration which comprises passing material of high moisture content downwardly through a plurality of zones while first drying and then burning the same, temporarily retaining said material in each of a plurality of said zones, moving said material substantially horizontally through each of said zones by the application of a series of rabbling impulses thereto, preventing the direct passage of gases between two adjacent zones thereby separating the zones into a drying group and a burning group, passing air through the burning zones in series, withdrawing hot gases from a burning zone, passing part of said hot gases through drying zones in series, withdrawing from the drying zones gases laden with products of the drying operation, mixing the gases from the drying zones with the remaining hot gases from the burning zones and burning combustible gases in the mixture as well as eliminating noxious odors.

15. The process of incineration which comprises passing material of high moisture content downwardly through a plurality of zones while first drying and then burning the same, temporarily retaining said material in each of a plurality of said zones, moving said material substantially horizontally through each of said zones by the application of a series of rabbling impulses thereto, preventing the direct passage of gases between two adjacent zones thereby separating the zones into a drying group and a burning group, passing air through the burning zones in series, withdrawing hot gases from one of the burning zones, passing part of said hot gases through drying zones in series, withdrawing from the drying zones gases laden with products of the drying operation, mixing the gases from the drying zones with the remaining hot gases from the burning zones, burning combustible gases in the mixture as well as eliminating noxious odors, and passing the hot combustion gases resulting from burning the mixture into heat exchange relationship with the gases from the drying zones before they are mixed with said remaining hot gases from the burning zones.

16. The process of incineration which comprises passing material of high moisture content downwardly through a plurality of zones while first drying and then burning the same, temporarily retaining said material in each of a plurality of said zones, moving said material substantially horizontally through each of said zones by the application of a series of rabbling impulses thereto, preventing the direct passage of gases between two adjacent zones thereby separating the zones into a drying group and a burning group, passing air through the zones of said burning group in series, withdrawing hot gases from a burning zone, passing a portion of said hot gases downwardly the zones of the drying group in series, withdrawing from a zone of the drying group hot gases laden with products of the drying action, heating the gases from the drying group and mixing them with the remaining gases from the burning group, and burning the combustible gases in said mixture as well as eliminating noxious odors.

17. The process of incineration which comprises passing material of high moisture content

downwardly through a plurality of zones while first drying and then burning the same, temporarily retaining said material in each of a plurality of said zones, moving said material substantially horizontally through each of said zones by the application of a series of rabbling impulses thereto, preventing the direct passage of gases between two adjacent zones thereby separating the zones into a drying group and a burning group, passing air upwardly through the zones of the burning group in series, withdrawing hot gases from the upper zone of the burning group, passing part of said hot gases in series through the zones of the drying group, withdrawing from the drying group gases laden with products of the drying action, heating the gases from the drying group by heat interchange with the remaining hot gases from the burning group and burning the combustible components as well as eliminating noxious odors.

18. The process of incineration which comprises passing material of high moisture content downwardly through a plurality of zones while first drying and then burning the same, temporarily retaining said material in each of a plurality of said zones, moving said material substantially horizontally through each of said zones by the application of a series of rabbling impulses thereto, preventing the direct passage of gases between two adjacent zones thereby separating the zones into a drying group and a burning group, passing air upwardly through the zones of the burning group in series, withdrawing hot gases from an upper zone of the burning group, passing a part of said hot gases through the zones of the drying group in series, withdrawing from a zone of the drying group gases laden with products of the drying operation, and burning combustible components in the gases from the drying zone as well as eliminating odors by passing the remaining hot gases from the burning group into heat exchange relationship with the gases from the drying group.

19. The process of incineration which comprises passing material of high moisture content downwardly through a plurality of zones while first drying and then burning the same, temporarily retaining said material in each of a plurality of said zones, moving said material substantially horizontally through each of said zones by the application of a series of rabbling impulses thereto, preventing the direct passage of gases between two adjacent zones thereby separating the zones into a drying group and a burning group, passing air through the zones of the burning group in series, withdrawing hot gases from the burning group, passing a part of said hot gases through the zones of the drying group in series, withdrawing from the drying group gases laden with products of the drying operation, and burning combustible components in the gases from the drying zones as well as eliminating odors by heating the gases from the drying by heat interchange with the flow of remaining gases from the burning group, a second heat interchange with said flow before the previously mentioned heat exchange and a third heat interchange between the gases thus heated and the drying-group gases before the first heating thereof by the gases from the burning group.

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