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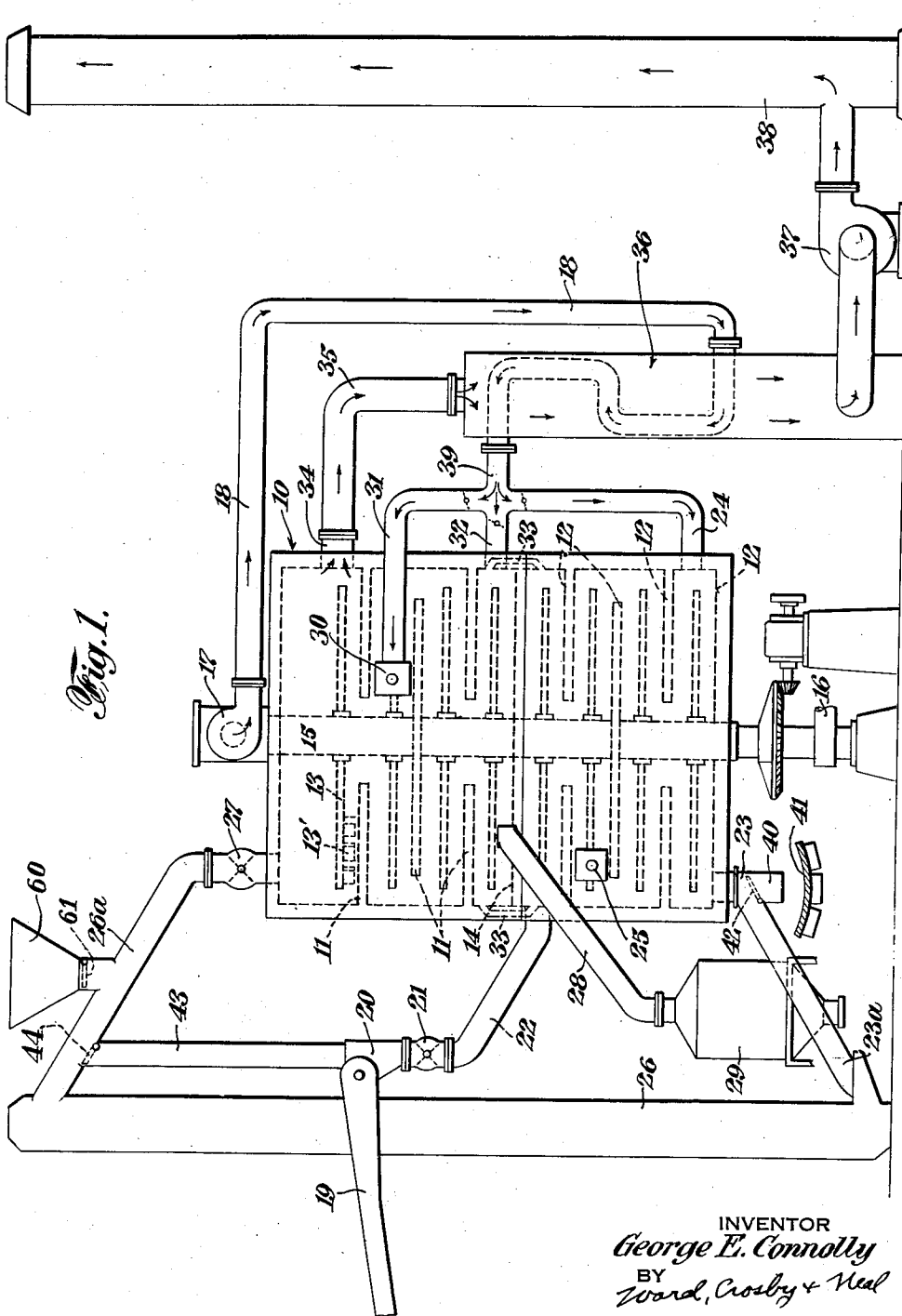
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2,147,151

DRYING AND INCINERATION OF MOIST MATERIALS

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2 Sheets-Sheet 1



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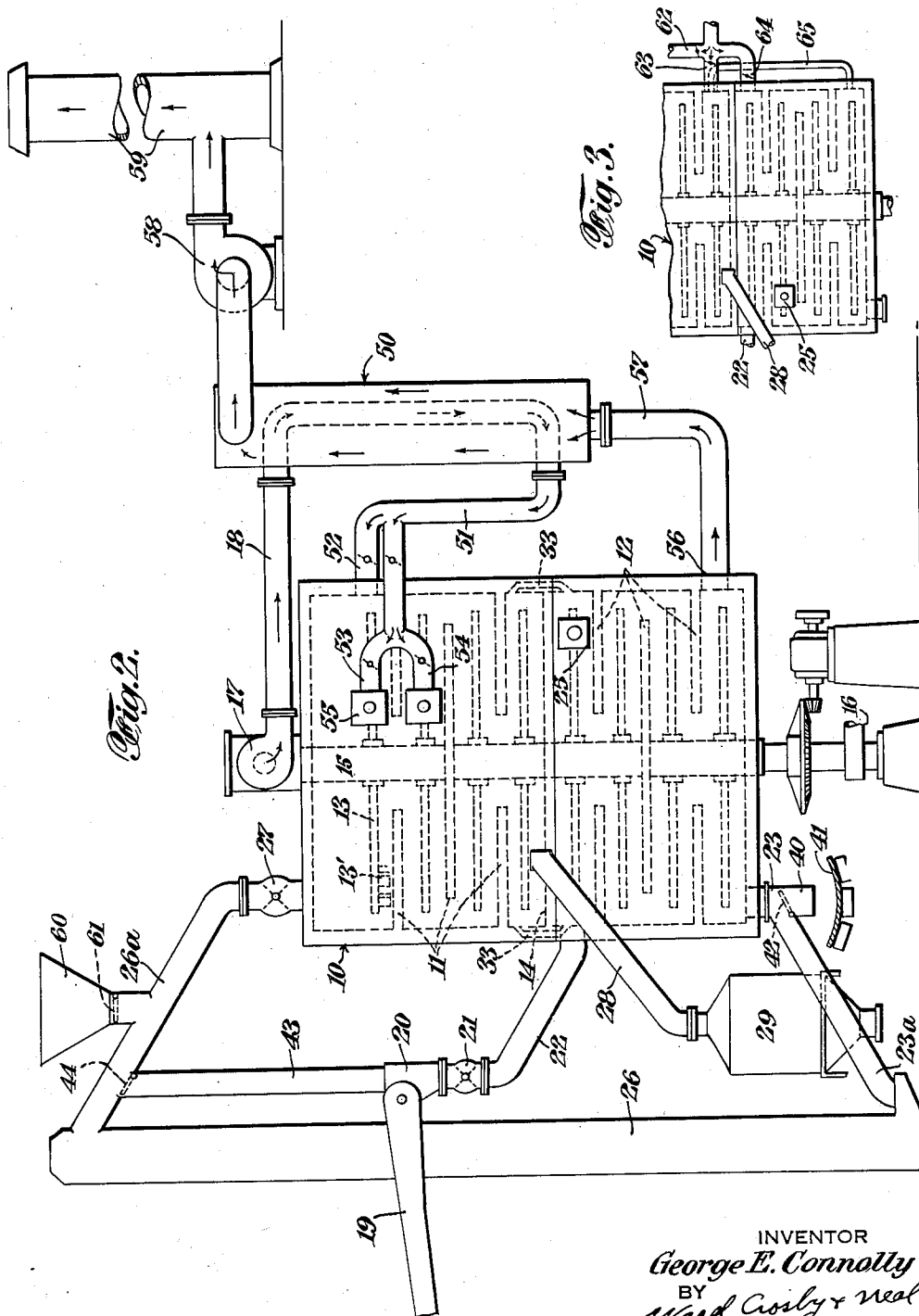
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2 Sheets-Sheet 2



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DRYING AND INCINERATION OF MOIST MATERIALS

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12 Claims. (Cl. 110—12)

This invention relates to the drying and burning of moist material and is more particularly adapted for the drying and incineration of waste material such as sewage sludge. The invention
5 embodies various improvements and modifications of the method and apparatus of the patent to Dudley Baird and Robert W. Rowen, No. 2,015,050, granted September 17, 1935.

Important features of this invention involve
10 methods and apparatus whereby waste material may be thoroughly incinerated and the evolved gases and vapor efficiently and thoroughly treated to eliminate noxious odor. The invention also if desired may embody arrangements
15 whereby desired quantities of the waste material may be efficiently dried without burning the same, such quantities of the material then being withdrawn from the apparatus for use as fertilizer, while any remaining or excess portions
20 of the material may be incinerated and the heat resulting from such incineration may be utilized to effect the drying operation, or to aid in effecting the same.

Various further and more specific objects, features and advantages will clearly appear from the detailed description given below taken in connection with the accompanying drawings which form a part of this specification and illustrate
25 merely by way of example preferred forms of the apparatus of the invention.

The invention consists in such novel features, arrangements and combinations of parts as may be shown and described in connection with the apparatus herein disclosed.

In the drawings,

Fig. 1 illustrates somewhat diagrammatically a preferred embodiment of the invention;

Fig. 2 similarly illustrates another desirable embodiment of the invention; and

40 Fig. 3 illustrates a portion of apparatus such as shown in Fig. 1, but modified in several respects.

Referring to Fig. 1, the apparatus there shown may comprise a furnace 10 having a plurality
45 of superposed hearths as at 11, mounted within the upper portion of the furnace wherein the operation of burning or incinerating the material is preferably conducted, and also a plurality of superposed hearths as at 12 mounted within
50 the lower portion of the furnace, wherein the operation of drying the material is carried out. Except for the features hereinafter described in further detail, the furnace may be of the same general type of construction as that disclosed in
55 the above mentioned Patent No. 2,015,050, a plu-

rality of rabble arms as at 13 being provided at each hearth, these rabble arms each being in turn provided with teeth as at 13' whereby the material will be distributed over each hearth as a relatively thin layer and will be periodically
5 rabbled and gradually advanced over each hearth and through drop holes to the hearth below. However, one of the hearths, for example hearth 14, at the mid portion of the furnace, may be formed without the usual drop holes whereby the
10 furnace will be substantially divided into an upper incinerating portion and a lower drying portion for purposes hereinafter explained.

The rabble arms may be mounted upon a rotatable central shaft as at 15 and the rabble
15 arms and shaft may be provided with internal cooling conduits as in the above mentioned Patent No. 2,015,050. In the particular construction shown, cooling air may be admitted as
20 through an opening 16 at the base of the shaft structure and withdrawn as by a blower 17 mounted at the top of the shaft structure, the blower 17 being connected to a conduit 18, which
25 will thus carry a supply of air somewhat preheated because of its passage through the conduits of the rabbling structure.

The material to be treated may comprise for example, sewage sludge filter cake or sewage
30 sludge of other form, which has preferably been so treated as to eliminate a considerable portion of the water content, as for example by any well-known mechanical dehydrating process. Or the material may comprise for example, ground garbage or garbage mixed with sewage sludge filter
35 cake or other waste material, and should preferably have a water content in the neighborhood of 75% or less, although material having a substantially higher water content may also be treated in the apparatus.

The material to be treated may be conducted
40 as by a conveyor 19 to a hopper 20, thence through a suitable furnace inlet feeding device as at 21, which will preferably substantially continuously permit the material to be fed into the furnace but without any substantial escape of
45 gases or vapor at this point. From the device 21 the material may be fed through a conduit 22 on to the upper drying hearth 12. The material is then periodically rabbled and gradually advanced over each of the drying hearths and
50 from hearth to hearth down through the drying portion of the furnace to an outlet as at 23. This drying may proceed in the presence of counter current streams of preheated air, which may be supplied from a conduit 24 as hereinafter ex- 55

plained. If necessary, the temperatures within this portion of the furnace may be increased as by the use of one or more gas or oil burners as indicated at 25. However, the temperatures in this portion of the furnace are preferably kept within a range such that there will be no burning or scorching of the material on the lower hearths, although the temperatures are made sufficient to rapidly and thoroughly dry the material being treated, while due to the rabbling action, the material may become gradually broken into finer and finer pieces as it becomes more and more dry and less adhering.

From the outlet 23 the dried material may be conducted through a chute 23a to the base of a conveyor 26, thence to the top of the conveyor and down through a chute 26a to a furnace inlet feeding device 27, which may be similar to the device 21 above referred to. From the feeding device 27 the dried material may fall on to the top incinerating hearth 11. Here the rabbling means serves to periodically agitate and gradually advance the material over each of the burning hearths and from hearth to hearth down through the upper or incinerating portion of the furnace, and to an ash chute as at 28 having its intake end at hearth 14 and its outlet connected to an ash bin as at 29. Suitable temperatures may be secured within the incineration portion of the furnace as by the use of one or more oil or gas burners as indicated at 30, provided if desired with a supply of preheated air for supporting combustion, this air supply being furnished through conduit 31 in a manner hereinafter explained. An additional supply of preheated air may also be introduced for example, at one of the lower burning hearths through conduit 32. Also vapor evolved from the drying material in the drying portion of the furnace, together with some warm air, may be conducted through gas ports as at 33 from the space above the upper drying hearth into the space above the lower burning hearth. The incineration action within the upper portion of the furnace may therefore take place in the presence of counter current streams of preheated air, together with gaseous products of combustion and vapor evolved from the drying and burning material. These counter current streams may finally be drawn off as through an exit opening 34 to conduit 35 connected to the upper portion of the furnace. Thus it will be noted that all of the gaseous products of combustion and vapor evolved from the drying and burning material, may be drawn off through substantially the hottest part of the furnace and hence may be readily subjected before their exit to temperatures in the neighborhood of 1100° to 1500° F., which are ordinarily sufficient to safely destroy the noxious odors of the gases and vapor.

From the conduit 35 the gases and vapor may be drawn down through a recuperator 36 as by a suction fan 37 and finally conducted to a stack 38 or other means for disposal thereof.

The air within conduit 18 which has been somewhat preheated by passage through the rabbling structure, may be passed through the recuperator 36 in heat exchanging relationship with the hot exit gases and vapor, so that such air thus becomes further preheated before it leaves the recuperator, as through a conduit 39. From conduit 39, desired portions of this preheated air may be conducted into the furnace through conduits 24, 31 and 32, the amount admitted through

each of these conduits being controlled as by the adjustment of dampers as indicated.

While several burning hearths and several drying hearths are indicated in the particular example shown, it will be understood that under some circumstances if desired, the drying may be conducted on a single drying hearth made of sufficient area to accommodate the quantity of material being treated, and similarly the incineration may be conducted on one or more incineration hearths. The conveyor 26 and the various chutes and conduits for conducting the material into and out of the furnace are preferably suitably enclosed so as to prevent the escape of any odoriferous gases, vapor or dust.

In cases where it may be desired to use some of the dried material as fertilizer, fuel, or for other purposes, then a portion or at times all of the dried material at the outlet 23 may be allowed to fall through a chute as at 40 on to a conveyor as at 41. The proportion of the dried material thus withdrawn from the apparatus may be adjusted by adjustment of a gate member as at 42. The material which is not withdrawn at this point may be conveyed to the incinerating portion of the furnace and burned in the manner above explained.

In case the supplies of waste material at times embody an abnormal percentage of moisture, it may be desirable to treat a substantial part of the material more than once in the drying portion of the furnace. Or in some cases it may be possible to reduce the number or area of the drying hearths considerably by recirculating part of the partially dried material through the drying hearth spaces. This may be done by conducting a part of the dried material from chute 26a through a chute 43 into hopper 20. The proportion of the partially dried material thus recirculated may be varied or regulated by adjusting a gate member as at 44 at the entrance to chute 43. Since the drying and burning operations are effectively isolated against merging with each other, this recirculation of the dried material may be efficiently carried out without danger of introducing ignited material into the wet sludge with consequent lumping and irregular drying and the discharge of obnoxious gases and steam, as would occur if such recirculation were attempted with the prior multiple hearth apparatus.

With the above described form of the apparatus it will be noted that the gaseous products of combustion and vapor evolved from the burning and drying material are substantially free to follow their natural upward direction of flow through the furnace and yet the arrangement is such as to permit all of the evolved vapor and gases to be drawn off through substantially the hottest portion of the furnace at the incineration hearths whereby noxious odors from the evolved gases may be efficiently and thoroughly eliminated.

Also since the drying portion of the furnace is substantially sealed against the admittance thereto of material from the burning portion of the furnace, the arrangement is such as to permit the withdrawal of substantial amounts of the dried material from the furnace for use as fertilizer, etc., without danger that this withdrawn material will embody any odoriferous scorched or burned material or ash.

Since the exit gases and vapor are withdrawn from the high temperature portion of the furnace, they will be of a sufficient temperature to

efficiently transfer heat to a supply of intake air for supporting efficient combustion within the burning portion of the furnace.

Where the drying hearths are within the top of the furnace, with the burning hearths below, in accordance with the practice heretofore, there is a marked tendency at times for the high temperature flame to progress upwardly from the burning hearths along the scattering stream of falling dried sludge, into the drying hearths. Thus it will be apparent that the line of division between the drying and burning hearths cannot be so sharply defined as to permit withdrawal of thoroughly dried sludge for use as fertilizer, etc., with the arrangements heretofore available, without at times also withdrawing smoldering, charred or odoriferous sludge and gases. However, with the above described arrangement having the drying hearths at the bottom and the burning hearths at the top, a definite predetermined separation is possible between the drying and burning hearths, with no substantial possibility for the flames of the burning gas or for hot coals from the burning hearths to enter and start combustion in the drying hearths. This will be apparent when it is noted that the first drying hearth carrying the wettest and least combustible material, is the one which is located nearest the cooler burning hearth carrying little but ash. Thus the particular burning hearth which is substantially free of flames and carries few if any live coals of burning material, is closest to the drying hearth which is carrying the material in a condition where it is most difficult to ignite. These facts, together with the above described arrangements of gas passages, make possible a substantial isolation of the burning hearths against passage of burning material or flames into the drying hearths. Although the arrangement permits the drying and burning operations to be thus substantially isolated against merging with each other, yet the structure is such as to permit all of the hearths to be enclosed within a single cylindrical furnace wall providing a compact structure conserving of heat and space. In fact, the required floor space is not increased over the requirements of the previously known apparatus, which cannot fulfill several of the above described functions of the present invention.

In Fig. 2 a somewhat similar embodiment of the invention is illustrated, like parts being indicated by the same reference numerals. However, in Fig. 2 the arrangement is such that the streams of gases, vapor and air within the furnace are passed along the path of travel of the drying and burning material, i. e. downwardly through the furnace. That is, air in conduit 18 preheated by passage through the rabbling structure, may be further preheated in a recuperator 50 and then conducted by conduit 51 to a furnace air intake opening 52 located at the upper part of the furnace. If desired, a part of this preheated air may be conducted as through conduits 53 and 54 to oil or gas burners as indicated at 55. The amount of air thus conveyed to each of the burners and the amount conveyed directly into the upper part of the furnace, may be regulated by adjusting the various dampers as shown.

Within the furnace the gaseous products of combustion evolved from the burning material at the upper hearths, together with any excess air not used for combustion purposes, may pass downwardly through the gas ports 33 into the drying portion of the furnace and thence down-

wardly through the drying portion so that the gases, evolved vapor and remaining air finally are passed out through an exit opening as at 56 at the bottom of the furnace. From this point the gas, vapor and air mixture may be drawn through a conduit 57 and recuperator 50 by a suction fan as at 58 and discharged to a stack as at 59.

It is apparent that the arrangement of Fig. 2 embodies many of the same advantages as the apparatus of Fig. 1. In addition, the apparatus of Fig. 2 permits the drying action in the lower part of the furnace to be largely effected by the heat of the evolved gaseous products of combustion coming from the upper part of the furnace with substantially a minimum of air. Accordingly, while the drying action will be efficiently promoted in the drying portion of the furnace, the absence of much air will prevent any danger of scorching or burning the drying material. Thus the danger of any substantial noxious odors being evolved at the drying hearths will be eliminated and any of the dried product which is withdrawn at the bottom of the furnace will be free of burned, scorched, odoriferous material or ash. The hearth 14 having no material drop holes, will prevent glowing clinkers and ash from falling into the drying material, so that danger of igniting the drying material will be eliminated, at the same time keeping the drying material free of ash in case it is desired to use the same for fertilizer without such ash. However, if the material being treated is of such a nature that the presence of a relatively small amount of ash in the dried fertilizer product is not objectionable, then the ash from the burning hearths may be conducted from chute 28 into one of the drying hearths.

While we have illustrated the apparatus with fuel burners for maintaining the desired temperatures both in the drying and burning portions of the furnace, in some cases especially where the material being treated does not have an unusually large moisture content, the process may be carried on without the use of extraneous fuel in view of the recovery of heat by the use of the recuperator. Additional heat may also be recovered to avoid the use of extraneous fuel by using recuperator arrangements following the principles of those disclosed in the copending application of Henry J. Hartley and Dudley Baird, Ser. No. 95,950, filed August 14, 1936.

In some cases instead of using oil or gas burners to heat the furnace, or instead of relying wholly on such burners to provide any extraneous fuel necessary, it may be found desirable to provide fuel in finely divided solid form. In that event a finely divided fuel such for example as powdered coal, sawdust or other fuel which may be cheaply available, may be mixed with the waste material and carried into the apparatus with the waste material on conveyor 19. However, in the event that it is desired to use a portion of the dried waste material as fertilizer, then the finely divided fuel material may be mixed with the remaining waste material after the latter has become dried. That is, for example, powdered coal or other finely divided fuel may be supplied as from a hopper 60 through an adjustable gate 61 into the chute or conduit 26a. The introduction of the finely divided fuel at this point not only has the advantage of permitting portions of the dried material to be withdrawn from the apparatus for use as fertilizer free of fuel or fuel ash, but also the fuel may thus be more uniformly and thoroughly mixed

with the waste material after the latter has become quite thoroughly dried and finely divided. The introduction of the fuel at this point also avoids any possibility of the distillation of noxious gases from the fuel in the drying section of the furnace and eliminates any danger of unintended combustion occurring in the drying section. Furthermore, the mixing of the fuel with the dried waste material just before incineration, substantially avoids any possibility that the fuel will smolder and produce objectionable smoke, as might occur where the fuel is mixed with the wet sludge.

In Fig. 3 a further modification of the apparatus of Fig. 1 is illustrated. With this arrangement, preheated air may be supplied to the upper sections of the furnace through conduits 62 and 63, corresponding to conduits 31 and 32 of Fig. 1. However, instead of introducing preheated air at the bottom of the drying section of the furnace as in Fig. 1, an arrangement is shown in Fig. 3 for introducing preheated air by a conduit 64 into the top of the drying portion of the furnace, whereby such air passes downwardly from hearth to hearth through the drying section of the furnace. The air then, together with vapor evolved from the drying material, may pass out from the bottom of the furnace through one or more conduits 65, and into the burning section of the furnace. The arrangement of Fig. 3 is particularly desirable in cases where relatively dry waste material is being treated, in that the preheated air is introduced at an upper drying hearth where the material is more moist, and hence less likely to be scorched or burned by the preheated air. By the time the air arrives at the lower drying hearths where the material is quite dry, the temperature of the air will be sufficiently decreased so that combustion is also avoided at this point, notwithstanding the dryness of the material.

While the invention has been described in detail with respect to particular preferred examples, it will be understood by those skilled in the art after understanding the invention, that various changes and further modifications may be made without departing from the spirit and scope of the invention, and it is intended therefore in the appended claims to cover all such changes and modifications.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. Apparatus for drying and incinerating waste materials, comprising a furnace having a plurality of superposed hearths all surrounded by a furnace wall and including one or more lower hearths for drying the material and one or more upper hearths for burning the material, said drying hearths being substantially isolated against passage of solid material thereto from said burning hearths, means for introducing the material onto said drying hearth or hearths and for rabbling the material thereover while the material is being dried, means for withdrawing a portion of the dried material from the apparatus, and means for conveying the remainder of the dried material to said burning hearth or hearths and for rabbling such remaining material over said burning hearth or hearths.

2. A furnace for drying and burning moist material, comprising a plurality of superposed hearths including one or more lower hearths for drying the material and one or more upper hearths for burning the material, means for introducing the material onto said drying hearth

or hearths and for rabbling the material thereover in the presence of a countercurrent stream of heated air, means for conveying the material after passage over said drying hearth or hearths to said burning hearth or hearths and for rabbling the material over the latter, means for conducting said stream together with vapor evolved from the drying material into contact with the material on said burning hearth or hearths and for then conducting said stream together with gaseous products of combustion evolved from the burning material countercurrent to the burning material over the burning hearth or hearths, said drying hearths being substantially isolated against passage of solid material thereto from said burning hearths, and an exit opening above an upper burning hearth whereby said gases and vapor may be withdrawn from the furnace through a high temperature burning zone for the destruction of noxious odor of such gases and vapor.

3. A furnace for drying and burning moist material, comprising a plurality of superposed hearths including one or more lower hearths for drying the material and one or more upper hearths for burning the material, means for introducing the material onto said drying hearth or hearths and for rabbling the material thereover, means for then conveying the material to said burning hearth or hearths and for rabbling the material thereover, means for causing a stream of air together with vapor and gases evolved from the material to pass countercurrent to the movement of the material over said drying hearth or hearths and then over said burning hearth or hearths, means including an exit opening at an upper burning hearth for withdrawing said countercurrent stream from the furnace through a high temperature burning zone thereof, and a heat exchanging device and connections whereby heat of said withdrawn stream may be transferred to a supply of intake air for the furnace.

4. A furnace for drying and burning moist material, comprising a plurality of superposed hearths including one or more lower hearths for drying the material and one or more upper hearths for burning the material, means for introducing the material onto said drying hearth or hearths and for rabbling the material thereover, means for then conveying the material to said burning hearth or hearths and for rabbling the material thereover, means for substantially isolating said burning hearths against passage of burning material therefrom to said drying hearths, and means for causing a stream of hot air to pass over the material on said burning hearth or hearths and for then causing remaining air of said stream together with hot gases evolved from the burning material, to pass over the material on said drying hearth or hearths whereby the material is dried in an atmosphere unfavorable for combustion.

5. A furnace for drying and burning moist material, comprising a plurality of superposed hearths including one or more lower hearths for drying the material and one or more upper hearths for burning the material, an ash outlet from the furnace located substantially at a point between said upper and lower hearths, means for introducing the material onto said drying hearth or hearths and for rabbling the material thereover, means for then conveying the material to said burning hearth or hearths and for rabbling the material thereover and to said ash out-

let, means for causing a stream of hot air to pass over the material of said drying hearth or hearths and for then causing said stream together with vapor evolved from the drying material, to pass over the material on said burning hearth or hearths, and means including an exit opening at a burning hearth for withdrawing said stream together with said vapor and gases evolved from the burning material, from the furnace through a high temperature burning zone.

6. A furnace for drying and burning moist material, comprising a plurality of superposed hearths including one or more lower hearths for drying the material and one or more upper hearths for burning the material, means for introducing the material onto said drying hearth or hearths and for rabbling the material thereover, means for then conveying the material to said burning hearth or hearths and for rabbling the material thereover, means for substantially isolating said burning hearths against passage of burning material therefrom to said drying hearths, and means for causing a stream of hot air to pass over the material on said burning hearth or hearths and along the path of travel of the material thereon, and for then causing remaining air of said stream together with hot gases evolved from the burning material, to pass over the material on said drying hearth or hearths, along the path of travel of the drying material.

7. A furnace for drying and burning moist material, comprising a plurality of superposed hearths including one or more lower hearths for drying the material and one or more upper hearths for burning the material, means for introducing the material onto said drying hearth or hearths and for rabbling the material thereover, means for then conveying the material to said burning hearth or hearths and for rabbling the material thereover, means for substantially isolating said burning hearths against passage of burning material therefrom to said drying hearths, means for causing a stream of hot air to pass over the material on said burning hearth or hearths and for then causing remaining air of said stream together with hot gases evolved from the burning material, to pass over the material on said drying hearth or hearths whereby the material is dried in an atmosphere unfavorable for combustion, and a heat exchanging device and connections for then conducting said gases together with vapor evolved from the drying material through said device in heat exchanging relationship with a supply of intake air for said burning hearth or hearths, whereby said intake air is preheated.

8. A furnace for drying and burning moist material, comprising a plurality of superposed burning hearths within the upper part of the furnace, a plurality of superposed drying hearths within the lower part of the furnace isolated against the passage of solid material thereto from said burning hearths, means for rabbling the material over said drying and burning hearths respectively, and means for conveying dried material from said drying hearths onto said burning hearths.

9. A furnace for drying and burning moist material, comprising a plurality of superposed burning hearths within the upper part of the furnace, a plurality of superposed drying hearths within the lower part of the furnace isolated against the passage of solid and burning material thereto from said burning hearths, means for rabbling the material over said drying and burning hearths respectively, and means for conveying dried material from said drying hearths onto said burning hearths, the furnace being provided with a gas passage or passages interconnecting said upper and lower parts, and also with hearth ports, permitting a stream of gases to communicate with spaces over both the drying and burning hearths.

10. Apparatus for drying and burning sewage material, comprising a furnace having a plurality of superposed hearths for drying the material and also a plurality of superposed hearths for burning the material located above said drying hearths and enclosed in a unitary structure therewith, means for introducing the material onto an upper drying hearth, means for then rabbling the material over the drying hearths in succession, means for returning a portion of the material from a lower drying hearth to an upper drying hearth and for depositing another portion of the material from a lower drying hearth onto an upper burning hearth, and means for then rabbling the latter portion over the burning hearths in succession.

11. Apparatus for drying and incinerating sewage sludge material, comprising a plurality of superposed hearths enclosed within a furnace wall and including one or more lower hearths for drying the material and one or more upper hearths for burning the material, means for introducing the material onto said drying hearth or hearths and for rabbling the material thereover whereby the material becomes dried and finely divided, means for then conveying the dried material to said burning hearth or hearths, means for mixing finely divided solid fuel with said finely divided dried material prior to the introduction of the latter into said burning hearth or hearths, and means for agitating and gradually advancing the mixture over said burning hearth or hearths.

12. Apparatus for drying and incinerating waste materials, comprising a furnace having a plurality of superposed hearths including one or more lower hearths for drying the material and one or more upper hearths for burning the material, said drying hearths being substantially isolated against passage of solid material thereto from said burning hearths, means for introducing the material onto said drying hearth or hearths and for rabbling the material thereover while the material is being dried, means for withdrawing a portion of the dried material from the apparatus, and means for conveying the remainder of the dried material to said burning hearth or hearths and for rabbling such remaining material over said burning hearth or hearths.

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