Feb. 13, 1940. A. HASSELBACH ET AL 2,190,234

HEAT EXCHANGE APPARATUS

Filed May 23, 1938 3 Sheets-Sheet 1

Fig. 1

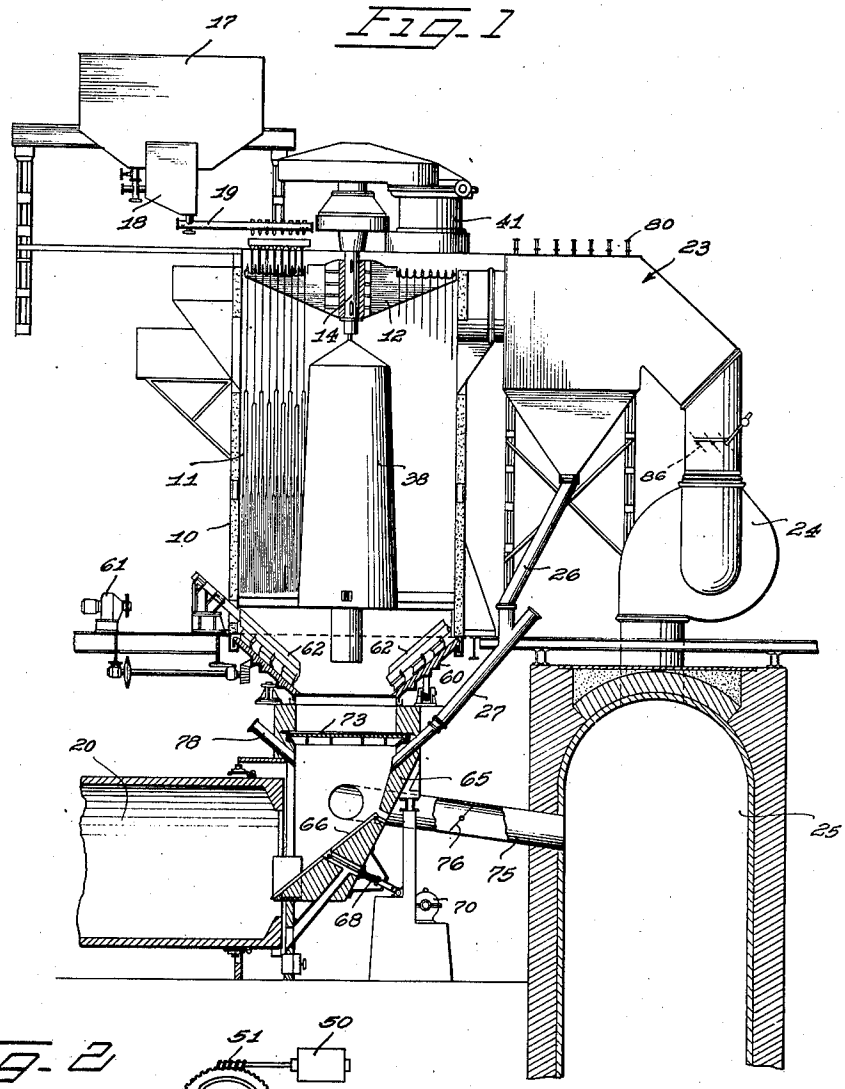
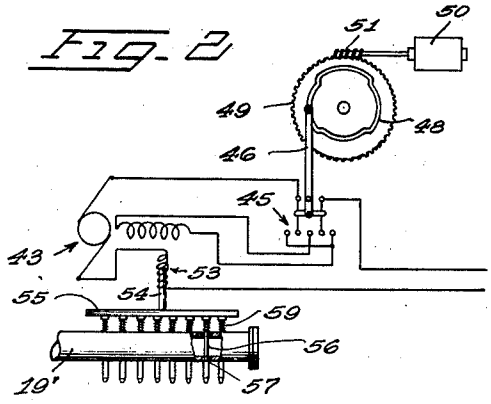


Fig. 2



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Filed May 23, 1938 3 Sheets-Sheet 2

Fig. 3

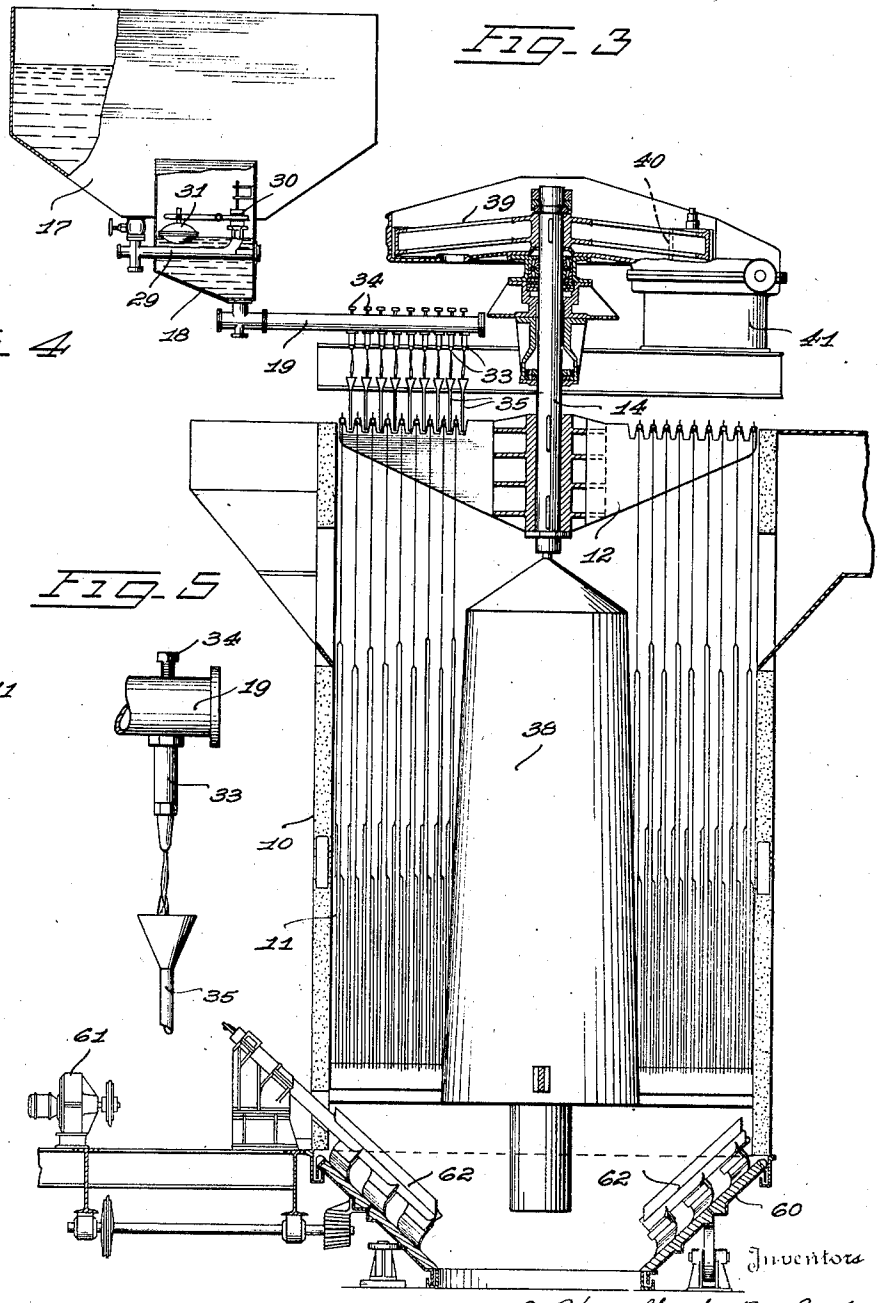


Fig. 4

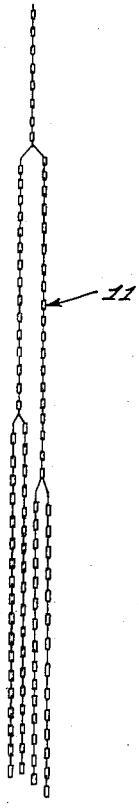


Fig. 5

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Filed May 23, 1938 3 Sheets-Sheet 3

Fig. 6

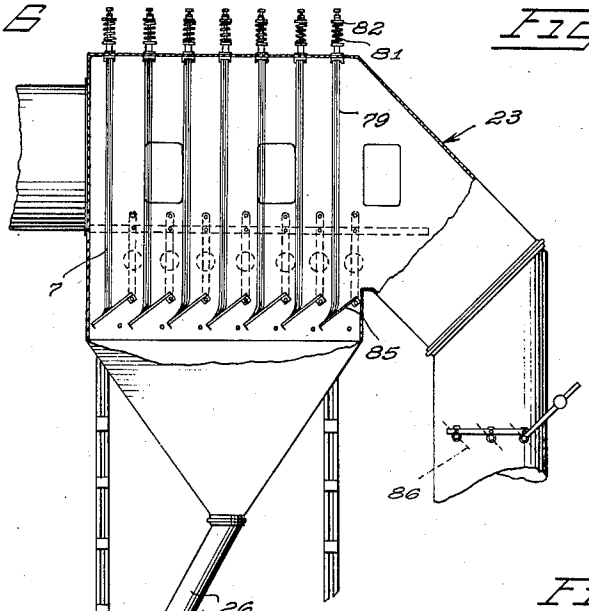


Fig. 7

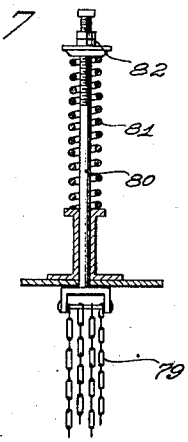
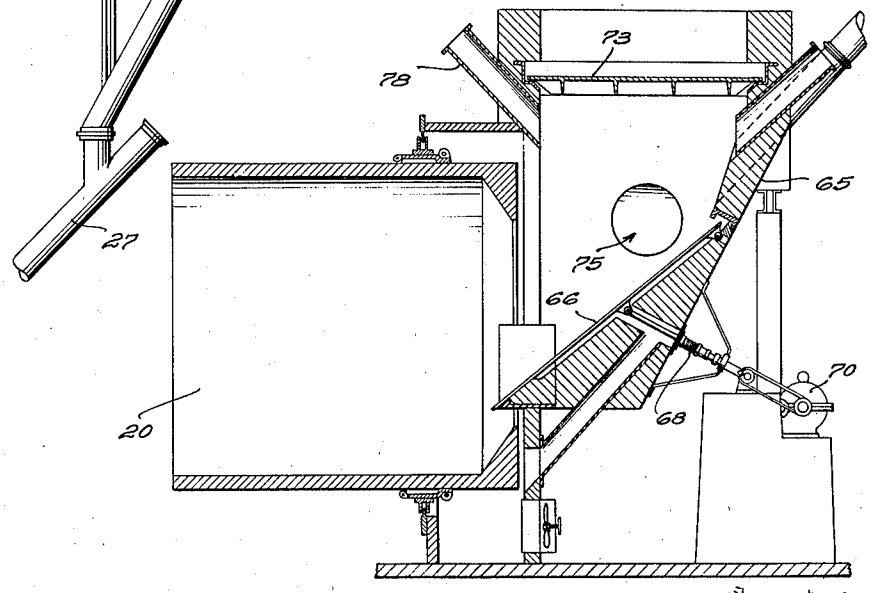


Fig. 8



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UNITED STATES PATENT OFFICE

2,190,234

HEAT EXCHANGE APPARATUS

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Application May 23, 1938, Serial No. 209,626
In Germany May 29, 1937

13 Claims. (Cl. 263—32)

This invention relates to apparatus for the heating and drying of materials of powdered or granular nature while in semi-liquid or pasty form, referred to for convenience as sludge, and is particularly applicable to the treatment of cement slurry. It is an object of the invention to provide apparatus of this character which is relatively simple and inexpensive to construct, which is largely automatic in operation, and which will treat large quantities of material rapidly and effectively. In general the apparatus is similar to that illustrated in the prior patent to Hasselbach 2,003,649, granted June 4, 1935, and employs a number of the features illustrated in that patent together with other improvements and further novel features.

It is common practice to prepare raw materials such as cement in the form of a paste or slurry prior to their introduction into the kiln for calcining or other heat treatment, and it has been heretofore proposed to dry this slurry before introduction thereof into the kiln, the material reaching the kiln in the form of small dry lumps, grains, or powder in readiness for the roasting or calcining process. When in the form of slurry, such raw material is not readily dried since it is essential that all portions of the material be adequately heated, usually by contact with hot gases, in order to effectively complete the drying. When large masses of raw material are to be dried rapidly, the pasty condition of the material retards the passage of heated gas therethrough and frequently results in the formation of large lumps which cannot be properly burned in the kiln.

It is therefore the purpose of the present invention to provide an apparatus which will thoroughly agitate the raw slurry or pasty mass during the preliminary drying operation. It is a feature of the invention that larger lumps of material formed during the drying operation are effectively broken up before discharge from the apparatus.

A further object of the invention is the provision, in apparatus for drying sludge, of means for preventing the depositing of the dried material on exposed surfaces of the apparatus and for ensuring prompt discharge of the material therefrom.

In the preferred form of the invention, the slurry or sludge is deposited upon a multiplicity of flexible elements suspended in a drying chamber through which hot gases are passed, the supporting means for the flexible elements being intermittently moved in reverse directions to agitate the elements and thus ensure the breaking up and discharge of the material as it is dried. It is proposed as part of the instant invention to interrupt the movement of such supporting means for an appreciable period of time on each reversal of movement, and to simultaneously interrupt the delivery of sludge to the flexible means for the purpose of materially improving the efficiency of the drying operation.

A further object of the invention is the provision of means for withdrawing dust from the hot gases vented from the drying apparatus and the return of such dust to the main body of the dried material.

A further object of the invention is the provision of means whereby drying apparatus of the type described, which is adapted to discharge the dried material into a kiln, may be readily rendered inoperative so that the sludge may be delivered directly to the kiln for burning without preliminary drying.

A further feature of the invention is the provision of means whereby the delivery of sludge to the apparatus may be effected in an efficient manner and the quantity of sludge thus delivered accurately controlled.

Further objects and features of the invention will be apparent from the following description taken in connection with the accompanying drawings in which:

Figure 1 is a vertical sectional view illustrating one form of apparatus constructed in accordance with the principles of the invention;

Figure 2 is a diagrammatic view of mechanism for automatically controlling the delivery of sludge to apparatus such as shown in Figure 1;

Figure 3 is an enlarged vertical sectional view of a portion of the apparatus shown in Figure 1;

Figure 4 illustrates a preferred form and arrangement of the flexible elements shown in Figures 1 and 3;

Figure 5 is an enlarged view in elevation of a detail of the slurry delivering device shown in Figures 1 and 3;

Figure 6 is an enlarged view, partly in section, of dust collecting apparatus shown in Figure 1;

Figure 7 is an enlarged detail view of one of the dust collecting elements shown in Figure 6; and

Figure 8 is an enlarged sectional view of a portion of the structure shown in Figure 1.

For convenience in describing the invention, reference is made herein to the several embodiments thereof illustrated in the drawings and

specific language is employed. It will nevertheless be understood that no limitation of the invention is thereby intended, various alterations and modifications of the illustrated structure being contemplated such as would normally occur to one skilled in the art to which the invention relates.

It will be observed from Figure 1 of the drawings that the preferred form of the apparatus includes as its principal member a drying chamber 10 within which are supported sludge-receiving flexible elements 11, the latter being carried on a support 12 which includes radiating arms and a hub portion secured to a shaft 14, the shaft being mounted in suitable bearings at the upper end of the chamber 10 for rotary or oscillatory movement in a manner hereinafter more particularly described. The sludge to be dried is received in a chamber 17 and discharged from the lower end of this chamber into a supply tank 18, such delivery being regulated by suitable control mechanism so as to maintain a constant level of sludge in the tank. From the tank 18 the sludge is introduced into the upper end of the chamber 10 by means including a supply pipe 19 disposed above the flexible elements 11 and arranged to effect uniform delivery of the material thereto. During the process of drying the material and as the result of agitation of the flexible elements 11, the material moves downwardly along these elements and when completely dried and effectively broken up, is discharged from the lower end of the chamber and delivered to the material inlet end a kiln 20 for roasting, calcining or other desired heat treatment.

The arrangement is preferably such that hot gases discharged from the material inlet end of the kiln are directed upwardly through the chamber 10 into intimate contact with the material adhering to the flexible elements 11, the gases being discharged from the upper end of the chamber into a dust separating apparatus indicated generally at 23 and thence downwardly through a blower 24 into a settling chamber 25. The dust separated out in the chamber 23 is discharged downwardly through communicating conduits 26 and 27 and thus returned for admixture with the dried material discharged from the lower end of the chamber 10.

A suitable mechanism for regulating the depth of sludge in the supply tank 18 is shown in Figure 3, this mechanism including a pipe 29 having a valve 30 associated therewith, the valve being operable by a float 31 in such manner that a substantially constant level of sludge is maintained within the tank 18. From the tank 18 the sludge flows into the supply pipe 19, the latter having a plurality of delivery nozzles 33 in the lower side thereof, the discharge of sludge through each nozzle being separately controllable by means of a threaded element 34, each of which is arranged to enter and throttle the orifice of the associated nozzle. The sludge discharged from each nozzle 33 passes through a pipe 35 disposed directly beneath the same, the lower ends of the several pipes 35 being so disposed that the sludge is delivered with substantial uniformity on the flexible elements 11 and is thus distributed radially of the chamber 10.

It will be observed that the flexible elements 11 are disposed so as to occupy and move within an annular portion of the chamber 10, the central portion of the chamber being occupied by a member 38 which is of generally cylindrical shape but preferably of somewhat larger diameter near its lower end, the member 38 constituting a closed figure functioning as a baffle to confine the flow of hot gases to the outer portion of the chamber 10. This arrangement promotes the efficiency of the drying operation by restricting the zone of contact between the hot gases and the sludge to that portion of the chamber in which adequate linear movement circumferentially of the chamber may be imparted to the flexible elements by the rotation or oscillation of the support 12.

A preferred arrangement of the flexible elements is shown more particularly in Figures 3 and 4. The flexible elements are here illustrated as metallic chains, a series of single chains being suspended at points spaced radially on each arm of the support 12. Each single chain is secured at its lower end to two further chains which depend therefrom, and each of these further chains supports two additional chains. Expressed in another way, each chain secured to the support 12 may be considered as depending the entire length of the chamber and as having secured thereto at different points in its length a plurality of additional chains, the arrangement being such that the number of individual links varies in different horizontal sections of the chamber 10, increasing toward the lower end of the chamber. Thus the flexible elements are more numerous and closer together at the lower end than at the upper end of the chamber, it having been found that such an arrangement increases the efficiency of the apparatus, the more thoroughly dried and more firmly adhering material near the lower end of the chamber being properly dislodged as the result of collision between a greater number of flexible elements. It will be observed that the increased agitation at the lower end of the kiln is further promoted by the shape of the member 38, the flexible elements being confined within a smaller annular zone at the lower end of the chamber, so that collision therebetween is more frequent.

Various types of motion may be imparted to the support 12 for the purpose of agitating the chains. Thus the support may be moved vertically, rotated or oscillated about the vertical axis of the chamber 10, or subjected to a combination of these various types of movement. I prefer, however, to impart to the support an oscillatory movement, rotating the same first in one direction and then in the other, and interrupting the movement altogether on each reversal. Thus in one form of the apparatus which has proven quite satisfactory from a practical standpoint, the support is rotated in reverse directions at a speed of 4 R. P. M. through an angle of approximately 360°, such rotary movement requiring about 15 seconds. Movement is then interrupted for a further period of 10 seconds, resulting in violent collision between the flexible elements, and the support is then rotated in the opposite direction for a period of 15 seconds, 50 seconds being required for the completion of one cycle of operation. It will be understood that these figures are given merely by way of example; the nature of the material, the moisture content and other conditions may require decided variation of this timing.

The support 12 for the flexible elements may be rotated by means of a gear 39 secured to the upper end of the shaft 14, the gear 39 being driven by a pinion 40 which is intermittently and reversely rotated by a motor and suitable gearing disposed within the casing 41. This motor, illustrated diagrammatically as a series

motor at 43 in Figure 2, is there shown as associated with suitable mechanism for correlating the operation of the motor and the control of the supply of sludge to the drying chamber. Thus a reversing switch 45 may be associated with the field winding of the motor to reverse the direction of motor rotation, this switch being actuated by a lever 46 which is in turn operated by a cam track 48 formed in one face of a worm gear 49, a small constant speed motor 50 and associated worm 51 being employed to rotate the worm gear. It will be observed that the cam track is provided with four distinct but connected portions, each portion being concentric with the axis of rotation of the worm gear 49. Thus there is provided a portion of least radius, a portion of greatest radius, and connecting portions of equal and intermediate radius. When the lever 46 is engaged by either of the cam track portions of intermediate radius, the reversing switch occupies a neutral position and the motor 43 is not energized. When the lever 46 engages the portions of the cam track of least and greatest radius the motor 43 will be supplied with current and rotated in one direction or the other. This mechanism therefore provides for the reversal of rotation of the motor 43 and for the interruption of rotation of the motor intermediate the periods of reversed movement, and it is apparent that by varying the contour of the cam groove 48 the timing of the motor may be altered as desired.

A solenoid of which the winding is indicated at 53 is in series with the motor 43. Consequently when the motor is rotated, the solenoid is energized and the armature 54 thereof is drawn upwardly. Secured to this armature is a member 55 which is positioned to extend above a series of valve elements 56 which extend through suitably packed apertures in the upper side of the supply pipe 19', each valve element 56 being arranged to cooperate with an aperture 57 in the lower side of this pipe in such manner as to interrupt the supply of sludge through the aperture when the valve is fully depressed. A coil spring 59 surrounds each valve to normally maintain the same free of the associated opening 57. It will thus be apparent that on cessation of operation of the motor 43, the solenoid 53 will be de-energized and the armature 54 and member 55 will fall, depressing the valves 56 and thereby interrupting the supply of sludge to the drying chamber. When motor operation is resumed, the member 55 will be raised and the valves will be displaced upwardly so that the sludge may be supplied to the drying chamber as hereinbefore described.

This interruption of the supply of sludge when the rotation of the chains is interrupted preliminary to reversal has been found quite important. Suspension of introduction of sludge into the drying chamber during this period ensures that the sludge will not be sprayed downwardly between, rather than on, the chains; retention of the material in the chamber for a sufficient length of time for complete drying is thus assured and the introduction into the kiln of moist or incompletely dried material, tending to form large lumps or balls which cannot be uniformly calcined or burned, is avoided.

The material is discharged downwardly from the chamber 10 through a generally conical spout 60 which is supported for rotation about the axis of the chamber, the spout being rotated by gearing from a motor 61. Stationary scraping devices 62 engage the inner face of the spout 60 to remove material therefrom and prevent caking. From the lower end of the spout 60 the material is conducted downwardly through a housing 65 which communicates with the material inlet end of the kiln 20, the housing 65 having associated with its lower inner side a plate 66 which is oscillated by a link 68 and suitable gearing, not shown, from a motor 70, this movement of the plate preventing the adherence thereto of particles and lumps of discharging materials.

Associated with the housing 65 is a gate valve 73, disposed in a generally horizontal plane. When this gate valve is closed, the downward movement of material and the upward flow of hot exhaust gases is of course interrupted, and a by-pass conduit 75, controlled by a valve 76, conveys the gases from the housing 65 to the settling chamber 25. When the drier is thus rendered inoperative, the material may be introduced directly into the kiln, for example, through conduit 78 for discharge into the housing 65 and thence to the kiln.

The hot gases moving upward through the flexible elements 11 are discharged from the upper end of the chamber 10 into the dust separating apparatus 23. This apparatus may comprise a chamber in which are suspended a plurality of flexible elements, for example chains 79, the latter being yieldably suspended from the upper portion of the chamber in the manner shown in Figure 7. Thus in the arrangement shown in this figure, a group of chains are supported on a spindle 80 which is normally urged upwardly by a coil spring 81, the degree of compression of the coil spring being regulated by means of a nut 82 threaded on the spindle. By means of this construction the chains may be readily depressed and agitated, the operation being carried out either manually or automatically, for the purpose of shaking collected dust from the same. The dust thus collected and discharged falls downwardly through the conduits 26 and 27 into the housing 65 and mixed with the dried material falling from the chamber 10. Dampers 85 are located beneath the chains 79 to control the downward movement of the gases, and discharge of the gases from the dust removing chamber is controlled by means of dampers 86 disposed intermediate the chamber and the blower 24.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In apparatus for drying sludge, the combination with a chamber, flexible carrier elements suspended in said chamber, means for depositing sludge on said elements, mechanism intermittently agitating said elements to dislodge the sludge therefrom, and means automatically operable in timed relation with said mechanism for periodically interrupting the operation of said first named means to suspend the depositing of sludge on said elements during cessation of agitation of the latter.

2. In apparatus for drying sludge, the combination with a chamber, means for causing hot gases to flow through said chamber, flexible means suspended in said chamber, means for depositing sludge on said flexible means, and mechanism for imparting to said flexible means intermittent rotation in reverse directions circumferentially of said chamber with a dwell between successive movements.

3. In apparatus for drying sludge, the combination with a chamber, means for causing hot gases to flow through said chamber, flexible means suspended in said chamber, means for depositing sludge on said flexible means, and mechanism for imparting to said flexible means intermittent rotation in reverse directions circumferentially of said chamber with a dwell between successive movements, said flexible means including a plurality of chains supported at points spaced radially and circumferentially of said chamber.

4. In apparatus for drying sludge, the combination with a chamber, means for causing hot gases to flow through said chamber, flexible means suspended in said chamber, means for depositing sludge on said flexible means, mechanism for imparting to said flexible means intermittent rotation in reverse directions circumferentially of said chamber, and means automatically operable to interrupt the delivery of sludge to said flexible means during periods intermediate the rotation of the latter.

5. In apparatus for drying sludge, the combination with a chamber, means for causing hot gases to flow through said chamber, flexible means suspended in said chamber, means for depositing sludge on said flexible means, and mechanism for imparting to said flexible means intermittent rotation in reverse directions circumferentially of said chamber with a dwell between successive movements, said last named means being operative to deliver sludge to said flexible means only when they are being rotated.

6. In apparatus for drying sludge, the combination with a chamber, flexible carrier elements suspended in said chamber, means for depositing sludge on said elements, mechanism intermittently agitating said elements to dislodge the sludge therefrom, and means associated with said chamber and affording a discharge passage for the dislodged sludge, said means including a movable wall in said passage, and means for agitating said wall to prevent adherence of sludge thereto.

7. In apparatus for drying sludge, the combination with a chamber, flexible carrier elements suspended in said chamber, means for depositing sludge on said elements, mechanism intermittently agitating said elements to dislodge the sludge therefrom, means associated with the lower end of said chamber and affording a downwardly tapered passage for discharge of dried material, and scraping means associated with said passage for preventing deposit and adherence of material therein.

8. In apparatus for drying sludge, the combination with a vertical chamber, of means for causing hot gases to flow through said chamber, means for introducing sludge into the upper portion of said chamber, a plurality of flexible elements suspended in said chamber in spaced relation, and means for agitating said elements to cause the latter to collide for discharging the dried material therefrom, the number of flexible elements in the lower portion of the chamber being greater than the number in the upper portion thereof.

9. In apparatus for drying sludge, the combination with a vertical chamber, of means for causing hot gases to flow through said chamber, means for introducing sludge into the upper portion of said chamber, a plurality of flexible elements suspended in said chamber in spaced relation, and means for agitating said elements to cause the latter to collide for discharging the dried material therefrom, said flexible elements comprising chains having additional chains secured thereto at points intermediate the ends thereof.

10. In apparatus for drying sludge, the combination with a chamber, means for causing hot gases to flow through said chamber, flexible means suspended in said chamber, means for depositing sludge on said flexible means, mechanism for imparting to said flexible means intermittent rotation in reverse directions circumferentially of said chamber with a dwell between successive movements, means for filtering dust from the gases vented from said chamber, and means for effecting admixture of dust thus filtered with dried material discharged from said chamber.

11. In apparatus for drying and burning cement slurry, the combination with a kiln, of means associated with said kiln for drying the slurry and delivering the dried material to the kiln, said means including a drying chamber, means causing hot gases from the kiln to flow through said chamber, means for delivering slurry to said chamber and retarding the flow of slurry therethrough, dried material cut-off means operable to isolate said chamber from said kiln, and separate means for supplying material to said kiln and venting hot gases therefrom when said chamber is thus isolated.

12. In apparatus for drying cement slurry prior to the introduction thereof into a kiln, the combination with a vertical chamber through which hot gases are caused to flow, of elongated flexible elements depending within said chamber adjacent the chamber walls and supported at the upper ends thereof only, the number of such elements being greater in the lower portion than in the upper portion of said chamber, means for depositing slurry upon said elements, means for agitating said elements to dislodge the slurry therefrom when dried, said last named means comprising a rotating support for said elements, and means for directing and confining the hot gases in an upward path in the direction of the chains through the whole cross-sectional area of the chamber, said last named means comprising a baffle within said chamber for deflecting the gases toward the chamber walls.

13. In apparatus for drying cement slurry prior to the introduction thereof into a kiln, the combination with a vertical chamber through which hot gases are caused to flow, of elongated flexible elements depending within said chamber adjacent the chamber walls and supported at the upper ends thereof only, means for depositing slurry upon said elements, means for agitating said elements to dislodge the slurry therefrom when dried, said last named means comprising a rotating support for said elements and means for intermittently rotating said support in opposite directions with a period of dwell between successive movements, and means for directing and confining the hot gases in an upward path in the direction of the chains through the whole cross-sectional area of the chamber, said last named means comprising a baffle within said chamber for deflecting the gases toward the chamber walls, said baffle being carried by said rotating support.

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