

Aug. 19, 1952

P. A. SHAW

2,607,537

DRYING

Filed Oct. 15, 1948

2 SHEETS—SHEET 1

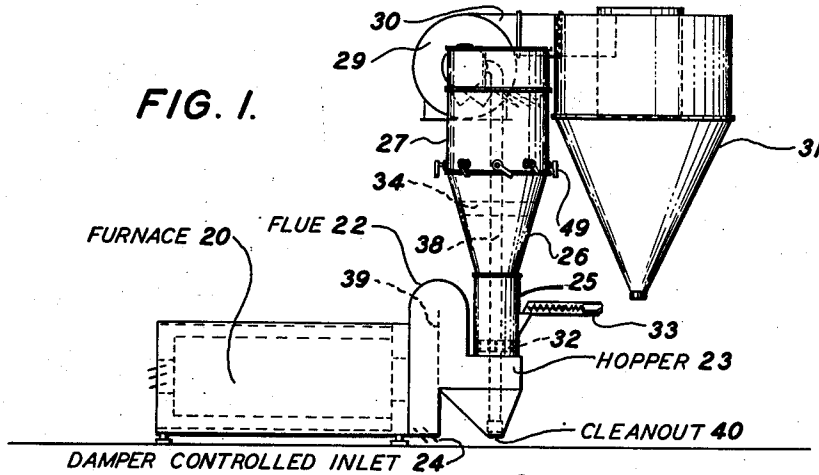
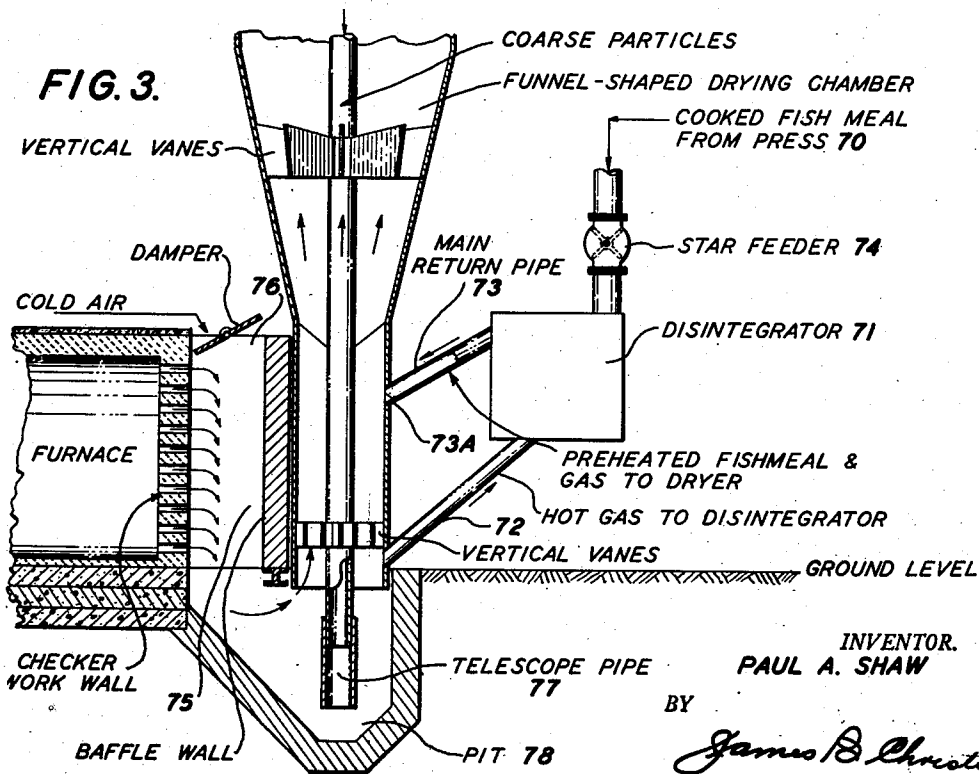
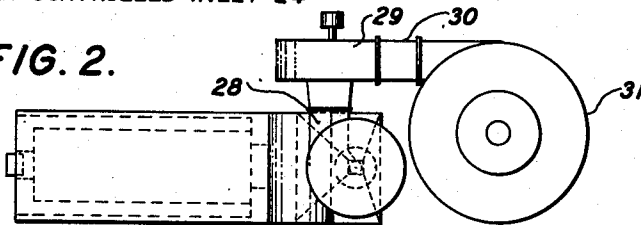


FIG. 2.



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2 SHEETS—SHEET 2

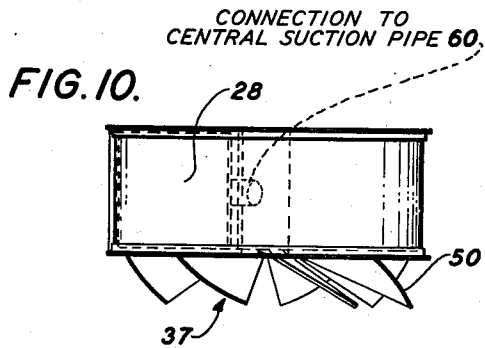


FIG. 8.

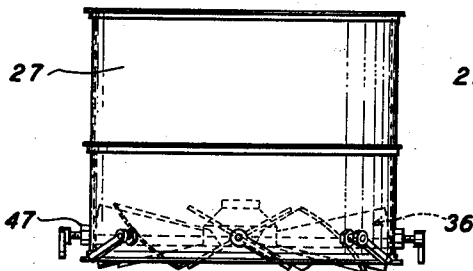


FIG. 6.

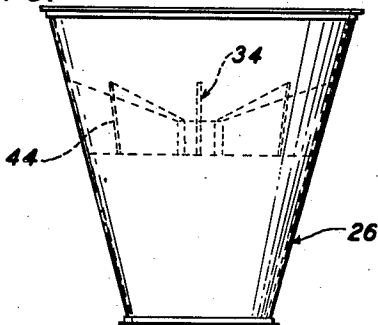


FIG. 4.

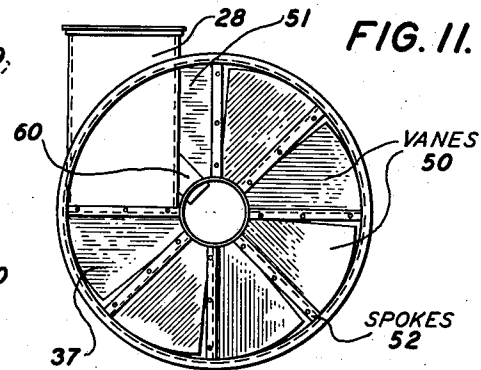
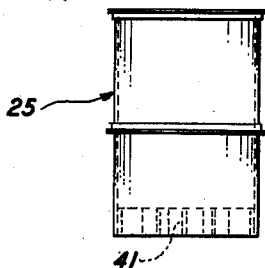


FIG. 9.

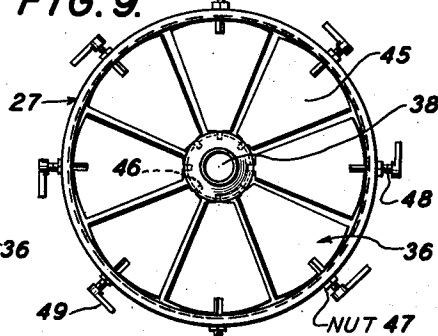


FIG. 7.

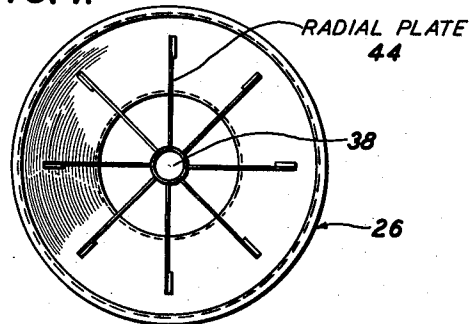
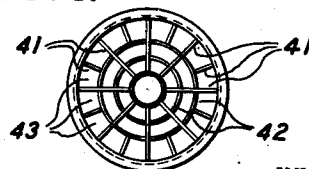


FIG. 5.



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2,607,537

DRYING

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Application October 15, 1948, Serial No. 54,616

13 Claims. (Cl. 241-47)

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This invention relates to drying, and particularly to the drying of heterogeneous finely divided material of low average bulk density and which tends to deteriorate at high temperature. However, the apparatus of the invention may be employed advantageously in the treatment of a variety of materials, including those which are homogeneous and those which can be subjected to high temperature without damage.

This application is a continuation-in-part of my co-pending application Serial No. 735,511 filed March 18, 1947, now Patent No. 2,513,370.

It is common practice to dry solids by suspending them in a current of drying gas, say hot air, and many products are dried successfully in this fashion at the present time, although thermal efficiencies are not always as high as might be desired. In other instances, such drying procedures are not satisfactory, since they result in a scorching of the material being dried or some other deterioration in quality.

Design of structures in which low density solids to be dried are carried in suspension in a current of hot air and the like frequently is based on three assumptions:

1. That wet particles are heavier than dry particles;

2. That large particles are not only heavier than small particles but also require a longer time to dry;

3. That for any properly dried product, the particles are of uniform specific gravity.

There may be cases in which these assumptions are true, but in the case of fish meal and other materials, they are incorrect and equipment designed in accordance with them does not operate properly. Wet fish meal is a heterogeneous mixture of bone, muscle, scale, skin and gut particles. Particles vary with respect to size, shape, moisture content, texture and density. There is a great difference between round, dense tuna eyes and flat, light bones, and between fluffy muscle tissue and dense leathery gut tissue. Even though the meal has been cooked, pressed and passed through a disintegrating mill, its constituents do not lose their identity and variations such as those noted above continue to exist. Both plant experience and laboratory tests show that many undried particles of fish meal are lighter and more buoyant in air than other completely dried particles. So, although each individual particle of fish meal tends to lighten on drying, the final product contains particles of widely different densities and buoyancy in a gas stream. Processes or apparatus which classify

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material particles on the basis of density either in the drying gas current, or subsequently in an operation from which the more dense particles are returned for additional drying, are not optimum for fish meal.

The apparatus of the instant invention is a practical and efficient means for low temperature drying of fish meal or the like while it is suspended in a gas current, say warm air. The scorching of protein, the odor nuisance, the smog production, the vitamin loss and the lowered feeding value which occur in the drying of fish meal in conventional dryers (including not only the air current types but also direct fired or steam tube rotary dryers) are avoided in the practice of the invention. Moreover, the apparatus of the invention is compact, and has extremely high throughput in terms of space occupied. In it the buoyancy and the carrying power of the stream of drying gas are maintained while an adequate lag between particle speed and gas speed is induced to permit proper drying in relatively small space.

The apparatus of the invention in its simplest form comprises a tower having a chamber, the cross section of which increases with height. An inverted frusto-conical chamber is preferred, but one of inverted frusto-pyramidal shape may also be employed. A conduit, preferably disposed vertically, opens into the small bottom portion of the chamber. A current of drying gas is forced up through the conduit and the chamber, either by pressure from below or suction from above. The material to be dried, say fish meal or peat moss, is introduced into the conduit and carried upward into the funnel-shaped chamber by the gas current, where it fountains outward with the increasing cross section and decreased velocity, thereby partially losing its buoyancy. The inlet section velocity and cone dimensions are so arranged that a portion of both the heavy and light solid particles will be carried to the full cone height with considerable remaining velocity. At a relatively high point, say near the top of the flared chamber, a swirling motion is imparted to the gas stream by means of a stationary baffle having radial vanes which may be made adjustable with respect to the angle which they make with the horizontal. Solid particles within the gas stream tend to resist this sudden change of gas direction, strike the baffle and are deflected downward to be again buoyed up by higher velocities in the lower cone area. Some particles, both heavy and light, will, of course, remain in the gas stream and be carried upward in a spiral motion.

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The baffle therefore acts as a partial separator but not as a classifier. A condition is thus set up where less solid matter is carried upward than is fed in. However, as the solid load in the cone builds up, an equilibrium is ultimately established and the density of solid particles in the gas stream is then high enough so that solid matter passing through the oblique baffles is equal to that being fed. Once having passed the baffle, the spiral motion will continue to carry the heavy and light, large and small, particles upward and out, say through a fan to a cyclone separator.

The angle of the baffle adjustment together with the total air volume determines the equilibrium load and therefore the drying time. Oddly enough, the holding time is reduced by moving the baffles toward a horizontal position, i. e. the holding time of material in the dryer is greater when the baffles are set at 35° from the horizontal than when they are set at 10° from the horizontal. This is due to increased gas velocity at the lower angle which permits a higher percentage of entrained solid particles to continue upward with the gas rather than being deflected downward. The total gas volume and baffle angle may therefore be adjusted so as to establish optimum conditions for the particular material being dried.

If desired, the apparatus may have a plurality of radially vaned baffles superposed one above the other, and the vanes of successive baffles may be reversed, so as to induce a reversal in the direction of swirling of the gas as it rises through the baffles. To accommodate either the single baffle or a plurality of them, a cylindrical section or the like may be disposed above the funnel section, as described in greater detail hereafter. The height of the baffle or baffles and the distance between them, if a plurality is employed, may be adjusted to suit the particular material to be dried.

It is desirable to avoid turbulence and swirling in the funnel-shaped chamber except immediately below the first or lowest baffle, since it has been determined experimentally that an abrupt change of gas direction and a sudden beginning of swirling action is desirable. With this in mind, I prefer to provide plates in the lower conduit, or in the funnel-shaped chamber or both to direct the gas upward and to prevent turbulence or swirling in the conduit and in the lower portion of the funnel-shaped chamber.

In order to facilitate the swirling induced by the radially vaned baffles in the upper portion of the dryer, I prefer to withdraw the gas from the space above the baffles through a tangential pipe. In the preferred design, the tangential pipe is connected to a suction fan, which exhausts to a cyclone collector or the like in which the bulk of the dried product is collected.

Another extremely desirable feature which may be incorporated in the dryer of the invention is a pipe which is connected to the dryer outlet, for example, in or just ahead of the suction fan and drops down through the conduit below the funnel-shaped chamber. Friction of gas against the inlet conduit walls creates a lowered velocity adjacent to the shell and some particles, principally the heaviest ones, which have been deflected downward to the cone wall will continue downward close to the shell and collect in the bottom hopper. The small diameter pipe with considerably higher gas velocities serves to re-entrain these particles, now dry, and transport them to the fan. With some products it is desirable to end

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this pipe above or below the adjustable cone baffle rather than at the fan inlet.

The foregoing and other aspects of the invention are explained in detail with reference to the accompanying drawings in which:

Fig. 1 is a diagrammatic vertical elevation, partly in section, of a drying plant designed in accordance with the invention particularly for the drying of fish meal;

Fig. 2 is a plan view of the apparatus of Fig. 1; Fig. 3 is a fragmentary vertical section of the lower portion of an alternative form of dryer of the invention;

Fig. 4 is an elevation of the vertical conduit at the bottom of the dryer of Figs. 1 and 2;

Fig. 5 is a plan view of the conduit of Fig. 4 showing the arrangement of the interior plates provided to streamline the gas and prevent turbulence;

Fig. 6 is a vertical elevation of the funnel-shaped drying chamber of the apparatus of Figs. 1 and 2;

Fig. 7 is a plan view of the drying chamber of Fig. 6 showing the arrangement of a spider of plates provided to prevent turbulence of gas in the chamber until the vaned baffle at the top of the chamber is reached;

Fig. 8 is an elevation of a cylindrical chamber in the apparatus of Figs. 1 and 2 above the funnel-shaped chamber and containing the first of two transverse baffles with radial vanes;

Fig. 9 is a plan view of the chamber of Fig. 8 showing details of the transverse baffle referred to in connection with Fig. 8;

Fig. 10 is an elevation of a cylindrical chamber in the apparatus of Figs. 1 and 2 overlying the chamber of Fig. 8 and containing a second transverse, radially vaned baffle and a tangential gas outlet which connects to a suction fan; and

Fig. 11 is a plan view of the apparatus of Fig. 10.

Attention is directed first to Figs. 1 and 2. The apparatus there illustrated is particularly adapted to the drying of fish meal following the usual steps of cooking, pressing and disintegrating, but it is also useful for drying other products of low bulk density and high moisture content, such as sewage sludge, peat moss, etc. Heat for the operation is supplied by a conventional furnace or fire box 20. The hot gases of combustion from the furnace pass into an exit flue 22 which rises vertically and then drops down to a communicating hopper 23. Cold air in controlled amount is introduced into the bottom of the flue through a damper-controlled inlet 24.

The dryer proper is disposed above the hopper. It has a lower vertical cylindrical pipe section 25 which opens into a vertical upwardly flaring frusto-conical chamber 26. The upper end of this funnel-shaped chamber opens into an upright cylindrical chamber 27 disposed directly above it and having the same diameter as the upper portion of the cone. A horizontal pipe 28 projects tangentially from the upper portion of the cylinder and serves as a connection between the cylinder and the suction side of a power-driven fan 29, the outlet 30 of which is connected to a conventional cyclone collector 31. In many instances the chamber 27 may only be of sufficient height above the cone to provide for the tangent outlet 28, since practically all drying occurs below the cone baffle.

Vertical vanes 32 in the form of a grid are disposed in the lower or inlet pipe 25 of the dryer. The material to be dried, say fish meal, is fed

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continuously into the pipe 25 by a screw feeder 33 disposed just above these vanes.

In the frusto-conical or funnel-shaped chamber of the dryer there is another set of vertical vanes 34 arranged to streamline the gas and solid flow through the lower portion of this chamber so as to present a vertically rising stream abruptly to the action of a first transverse baffle 36 (see Figs. 8 and 9) disposed at or slightly above the level where the funnel-shaped chamber joins the upper cylindrical chamber.

A second baffle 37 (see Figs. 10 and 11) having radial vanes is disposed in the upper cylindrical chamber about two-thirds of the way up, or just below the tangential outlet pipe. If the upper chamber is short the second baffle 37 may be dispensed with.

A concentric vertical pipe 38 of relatively small diameter extends from a point near the bottom of the hopper upward through the various superimposed sections of the dryer and is connected at its upper end to the suction pipe 28 which forms the inlet to the fan.

The flue and hopper construction shown in Figs. 1 and 2 is preferred for a number of reasons. The cold air entering the flue at its bottom adjacent the furnace protects the wall 39 between the two portions of the flue from the direct action of the hot gases, and the sharp bend at the top of the flue assures proper mixing of the furnace gases and the cold air which is drawn in through the dampers. Consequently, the surfaces in the hopper etc. which may come in contact with the material to be dried do not become hot enough to cause scorching of material which may come in contact with or lodge upon them. Second, the flue and hopper structure is such that it can all be built above ground level, permitting easy access to the bottom of the hopper for cleaning, etc. The bottom of the hopper is provided with a cleanout door 40 which is opened periodically to permit tramp iron and other very heavy material present in the feed to be withdrawn into a wheelbarrow, car, or the like (not shown). If desired, an opening of relatively small cross section may be provided in the hopper bottom for continuous discharge of heavy material.

The vertical vanes in the lower pipe section of the dryer of Figs. 1 and 2 are best seen in Figs. 4 and 5. The vanes comprise radial plates 41 extending from the interior suction pipe to the outside wall of the cylinder, and held together by concentric ring plates 42, the arrangement being such that a number of openings 43 of roughly equal cross section are provided. The effect of the vanes, which are located in the bottom of the pipe with their major surfaces vertical, is to reduce turbulence caused by the change of gas direction etc. in the flue and hopper.

The vertical vanes 34 in the funnel-shaped chamber of the dryer are best seen in Figs. 6 and 7. They are simply radial plates 44 which extend from the central pipe to the wall of the cone with their lower edges about half-way up the cone. They can be constructed as an integral "spider" unit and simply set into the cone. Their function is to keep the stream of gas and suspended solids rising vertically, without substantial swirling, until the first transverse baffle is reached.

This transverse baffle 36 is shown in detail in Figs. 8 and 9. It comprises eight segments 45, each of which is rotatable on a radial axis extending from a hub 46 out through the shell of the dryer. A nut 47 on the outside is threaded

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on a projecting radial shaft 48 to hold the vane at the desired angle. A handle 49 is fastened on to this shaft parallel to the major surface of the vane. It serves to rotate the vane and to indicate the angle it makes with the horizontal. When all the vanes are horizontal, they substantially close the dryer cross section, but in operation they are set as louvres at approximately equal angles. The angle with the horizontal may range from 10° to almost 90°. The average time that material is held in the dryer is adjusted by adjusting the angle of the radial baffles. As noted above, the holding time is reduced by moving the baffles toward a horizontal position, i. e. the holding time of material in the dryer is greater when the baffles are set at 35° from the horizontal than when they are set at 10° from the horizontal.

The upper transverse baffle 37 is best seen in Figs. 10 and 11. It has six radial vanes 50 occupying about three quarters of the cross section. The other quarter is closed by a floor plate 51 which underlies the tangential offtake pipe 28. Ordinarily, the vanes need not be adjustable, and are simply bent pie-shaped plates fastened at one edge to radial spokes 52 which extend from a central hub to the shell of the dryer. In some cases, the upper transverse baffle may be eliminated. In those cases in which it is employed its vanes may be so set that it tends to reverse the direction of swirling imparted by the lower transverse baffle, or vice versa. As shown in Figs. 10 and 11, the structure preferably is such that if the gas stream swirls counter-clockwise as a result of passage through the lower baffle it should be made to swirl counter-clockwise through the upper baffle.

The cone angle is not critical, but generally speaking, the heavier is the material to be dried the steeper the cone walls should be. For fish meal, the wall angle shown in Figs. 1 and 6 is about optimum.

A dryer like that just described and of relatively large size has been operated continuously to remove moisture from fish meal. It has a total height of about 25 feet and the funnel-shaped portion of the dryer is 7 feet high and 6 feet in diameter at the top. The fan is driven by a 40 H. P. motor.

The temperature of the gases entering the bottom of the dryer is low, ranging from 200° to 300° F. The fish meal is heated to a maximum temperature ranging from 100° to 125° F. At these low temperatures the meal does not scorch or give off objectionable odors or fumes.

Tuna, mackerel and sardine meal have been dried in the equipment with excellent results from the standpoint of character of product and thermal efficiency. In all cases the dried meal is light and fluffy and of much lighter color than that produced in conventional dryers. Moreover, the dried meal has a higher feeding value than that produced in conventional equipment, this being due to conservation of nutritional values by low temperature drying. A notable property of the fish meal dried in accordance with the invention is its lack of tendency to cake or harden during storage, provided that the meal is cured for a short time, say two to three hours, prior to sacking and preferably prior to grinding and sacking.

Curing preferably is accomplished by storage in a fairly well insulated bin and blowing a small volume of air upwardly through the mass of meal in the bin. This allows oxidation of fat in the meal to be substantially completed prior to pack-

aging so that the heat of oxidation is not available to injure the product during storage.

In operating the drier of the invention it is desirable to have a 2-pen temperature recorder and controller, one for recording the inlet temperature of the mixed air and furnace gas, the second pen recording and controlling the finish temperature by a bulb placed in the equipment beyond the drying cone. Suitable gauges to indicate suction, i. e. at the hopper and fan intake are recommended, together with either a variable speed drive on the fan or suitable louvers to control the total air volume.

The operation of the dryer of Figs. 1 and 2 is as follows:

The warm gas consisting of a mixture of combustion gases from the furnace and the bleed-in air meets the introduced feed and tends to carry the wet particles thereof up into the funnel or cone of the dryer. Just below the first transverse baffle the vertically rising column of gas and suspended solids suffers an abrupt change of direction. Many of the particles strike the baffle and are "bounced" downward into the lower portion of the cone where velocities are higher and they are again buoyed up.

The central pipe is connected directly to the fan by a connector 60 (see Figs. 10 and 11). A high suction exists at the lower end of the pipe sufficient to entrain the heavy particles and draw them upward through the central pipe to the fan, where they join the particles drawn up through the outer portion of the drier.

Tramp iron and other impurities which are too heavy to be lifted by even the high suction of the center pipe collect in the bottom of the hopper as waste.

Certain modifications of the apparatus of Figs. 1, 2 and 4 to 11 are shown diagrammatically in Fig. 3. As shown, fish meal 70 being passed through a disintegrator 71 preparatory to feeding into the dryer is pre-heated by gas withdrawn from a zone of relatively low suction in the drier column through a conduit 72 and returned into the column along with the preheated feed at a point 73A of higher suction. The disintegrator and the conduits are substantially gas tight (see the star feeder 74) so that the action just described can take place. It has been found that the preheating aids disintegration and yields a fluffier final product.

In the apparatus of Fig. 3 hot furnace gases pass through a checker work wall at the end of the furnace into a down draft flue 75, cold air to dilute the furnace gases being drawn in through a dampered opening 76 at the top of the flue. The lower end of the flue opens into a pit 78 into which the central pipe of the drying column projects. This pipe has a telescoped end section 77 which slides over the rest of the pipe and may be set at various levels, so as to adjust the degree of suction at the bottom of the pit.

Debris, etc., which is too heavy to be sucked up through the central pipe collects in the pit, which is cleaned out periodically, say at times of shutdown.

The rest of the apparatus of Fig. 3 is substantially the same as that of Figs. 1 and 2.

Ordinarily the fish meal from the cyclone collector is subjected to grinding prior to sacking. Increased thermal efficiency for the fish meal drying operation may be obtained by enclosing the grinder (not shown) and passing the warm exhaust gases from the cyclone exhaust through the grinder inclosure and thence to a smaller

cyclone (not shown) which collects the ground meal and feeds it to the bagging apparatus. The curing step for fish meal already discussed may be incorporated in these operations.

Numerous variations may be made in the apparatus without departing from the scope of the invention. Thus the central pipe which is employed to draw up the heaviest particles by means of higher suction, may be disposed outside the shell of the drying tower. This, however, complicates the design and is ordinarily not to be desired.

A number of the dryer units may be connected either in series or in parallel.

To summarize, the dryer of the invention is particularly useful in drying finely divided materials of low bulk density, and is particularly useful in drying heterogeneous material such as fish meal, which includes particles of widely different density. It permits drying at very low temperatures, below those at which many conventional dryers are operative. The low dryer temperature reduces fire hazards, eliminates scorching of combustible products and in the case of fish meal, etc., produces an improved product, lighter and more uniform in color, fluffier, and with a higher nutritional value. It can be operated on fish meal, etc., without causing odor nuisance or smog—serious problems in congested industrial areas. Lastly, with certain materials, i. e. peat moss, with a moisture content of 80-90% moisture may be eliminated mechanically (as mist) to a large extent, so that the evaporation efficiency in terms of thermal input may be very high—in some cases in excess of 200%.

I claim:

1. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening into the bottom of the flared chamber, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means for preventing turbulent flow of the drying gas in the tube and the lower portion of the flared chamber, and a baffle for abruptly imparting a swirling motion to the gas and the material buoyed up by it, said baffle being disposed in the drier at a level near the top of the flared chamber and transverse to the upward passage of the gas.

2. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening into the bottom of the flared chamber, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means comprising vanes disposed with their major surfaces lying in the direction of gas flow in the tube for preventing turbulent flow of the drying gas in the tube and the lower portion of the flared chamber, and a baffle for abruptly imparting a swirling motion to the gas and the material buoyed up by it, said baffle being disposed in the drier at a level near the top of the flared chamber and transverse to the upward passage of the gas.

3. In a drier, the combination which comprises an upwardly flaring drying chamber, a

tube having substantially parallel walls disposed in a substantially upright position and opening into the bottom of the flared chamber, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means comprising radial vanes with substantially upright major surfaces disposed in the flared chamber for preventing turbulent flow of the drying gas in the lower portion of the flared chamber, and a multivaned baffle for abruptly imparting a swirling motion to the gas and the material buoyed up by it, said baffle being disposed in the drier at a level near the top of the flared chamber and transverse to the upward passage of the gas.

4. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening into the flared chamber, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means for preventing turbulent flow of the drying gas in the tube, means for preventing turbulent flow of the drying gas in the lower portion of the flared chamber, and a baffle comprising radial plates disposed on a slant from the horizontal for abruptly imparting a swirling motion to the gas and the material buoyed up by it, said baffle being disposed in the path of the gas and transverse thereto at a level near the top of the flared chamber.

5. Apparatus according to claim 4 provided with means for adjusting the slant of the radial plates.

6. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening into the bottom of the flared chamber, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means for preventing turbulent flow of the drying gas in the tube comprising a plurality of plates set upright in the tube, means for preventing turbulent flow in the lower portion of the flared chamber comprising a plurality of plates set upright in the chamber, and a baffle for abruptly imparting a swirling motion to the gas and the material buoyed up by it, said baffle being disposed in the path of the gas and transverse thereto at a level near the top of the flared chamber above the upright plates.

7. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening into the bottom of the flared chamber, the horizontal cross section of the tube being substantially the same as the horizontal cross section of the flared chamber at the level at which the tube opens into it, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means for preventing turbulent flow of the drying gas in the tube and the lower portion of the flared chamber, a first baffle for abruptly imparting a swirling motion

to the gas and the material buoyed up by it disposed at a level near the top of the flared chamber and transverse to the direction of gas passage, and a second baffle to impart swirling disposed in the drier above the first and transverse to the direction of gas passage.

8. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening into the flared chamber, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means for preventing turbulent flow of the drying gas in the tube and the lower portion of the flared chamber, and two superposed transverse baffles for abruptly imparting a swirling motion to the gas and the material buoyed up by it at a level near the top of the flared chamber, the lower of the two baffles being near the top of the flared chamber and having radial plates rotatable to a slant with the horizontal, and means for adjusting the slant of the plates.

9. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening into the bottom of the flared chamber, means for feeding material to be dried into the tube, means for sucking a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means for preventing turbulent flow of the drying gas in the tube and the lower portion of the flared chamber, and a baffle for abruptly imparting a swirling motion to the gas and the material buoyed up by it disposed in the drier at a level near the top of the flared chamber and transverse to the direction of gas passage, a hopper below the tube and communicating therewith, a pipe opening into the hopper, and means for applying a higher degree of suction to the pipe than to the tube and flared chamber.

10. Apparatus according to claim 9 in which the pipe is disposed upright and passes through the tube and the drying chamber.

11. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening into the bottom of the flared chamber, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means for preventing turbulent flow of the drying gas in the tube and the lower portion of the flared chamber, a baffle for abruptly imparting a swirling motion to the gas and the material buoyed up by it disposed in the drier at a level near the top of the flared chamber and transverse to the direction of gas passage, a hopper below the tube and communicating therewith, a flue passing upward and opening into the top of the hopper, means for introducing hot gas into the side of the flue remote from the hopper, and means for introducing cooler gas into the flue below the point at which the hot gas is introduced.

12. In a drier, the combination which comprises an upwardly flaring drying chamber, a tube having substantially parallel walls disposed in a substantially upright position and opening

into the bottom of the flared chamber, means for feeding material to be dried together with warm gas into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up at least some of the material to be dried, means for preventing turbulent flow of the drying gas in the tube and the lower portion of the flared chamber, a baffle for abruptly imparting a swirling motion to the gas and the material buoyed up by it disposed in the drier at a level near the top of the flared chamber and transverse to the direction of gas passage; a disintegrator for the material to be dried connected to the feed means, and a conduit for passing warm gas into the disintegrator from the tube.

13. In a dryer the combination which comprises a tube having substantially parallel walls disposed in a substantially upright position, an upwardly flaring drying chamber disposed above the tube with its bottom in communication therewith, means for feeding material to be dried into the tube, means for passing a current of drying gas upwardly through the tube and the chamber with sufficient force to buoy up a large part of the material to be dried, means for preventing turbulent flow of the drying gas in the tube and the lower portion of the flared chamber, a transverse baffle for abruptly imparting a swirling

motion to the gas and the material buoyed up by it disposed at a level near the top of the flared chamber, a chamber disposed above the flared chamber, and an outlet conduit tangential to said upper chamber.

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