Jan. 29, 1935. A. K. DOOLITTLE 1,989,406

SPRAY DRYING APPARATUS

Filed July 30, 1931 3 Sheets-Sheet 1

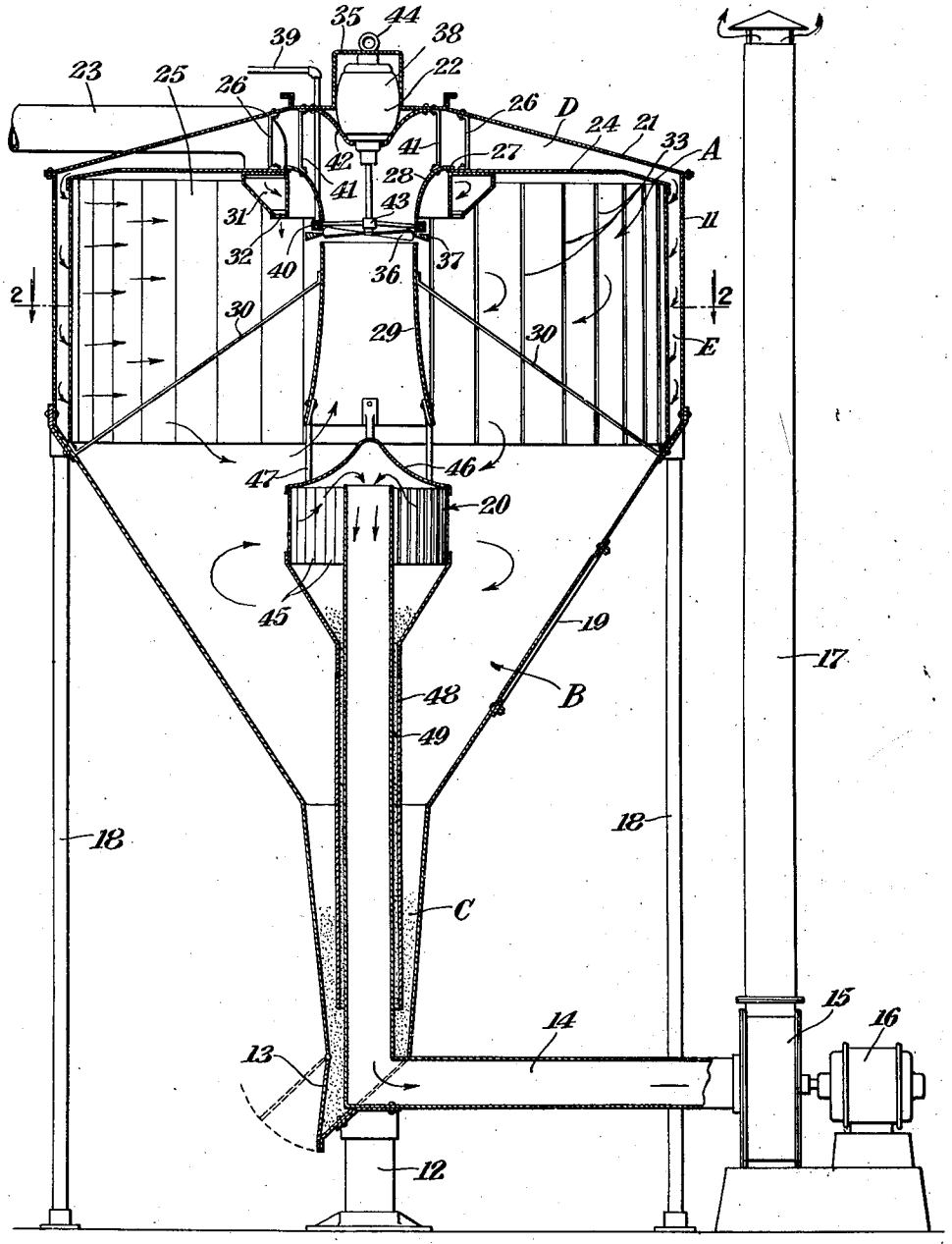


Fig. 1.

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Fig. 4.

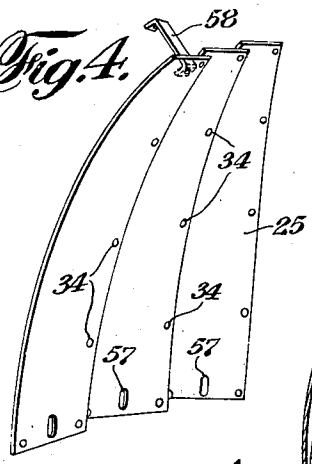


Fig. 5.



Fig. 6



Fig. 7.



Fig. 2.

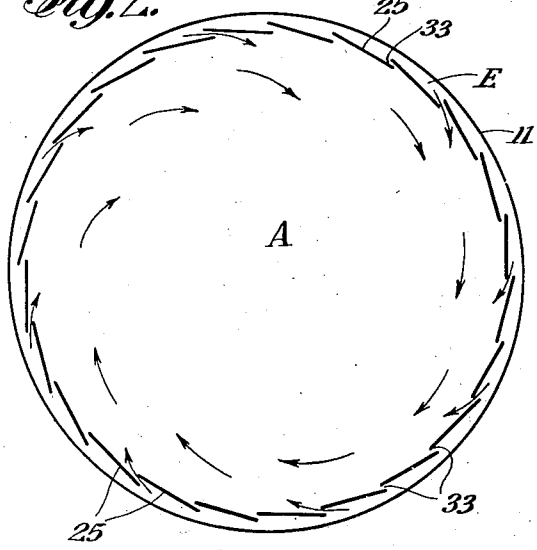
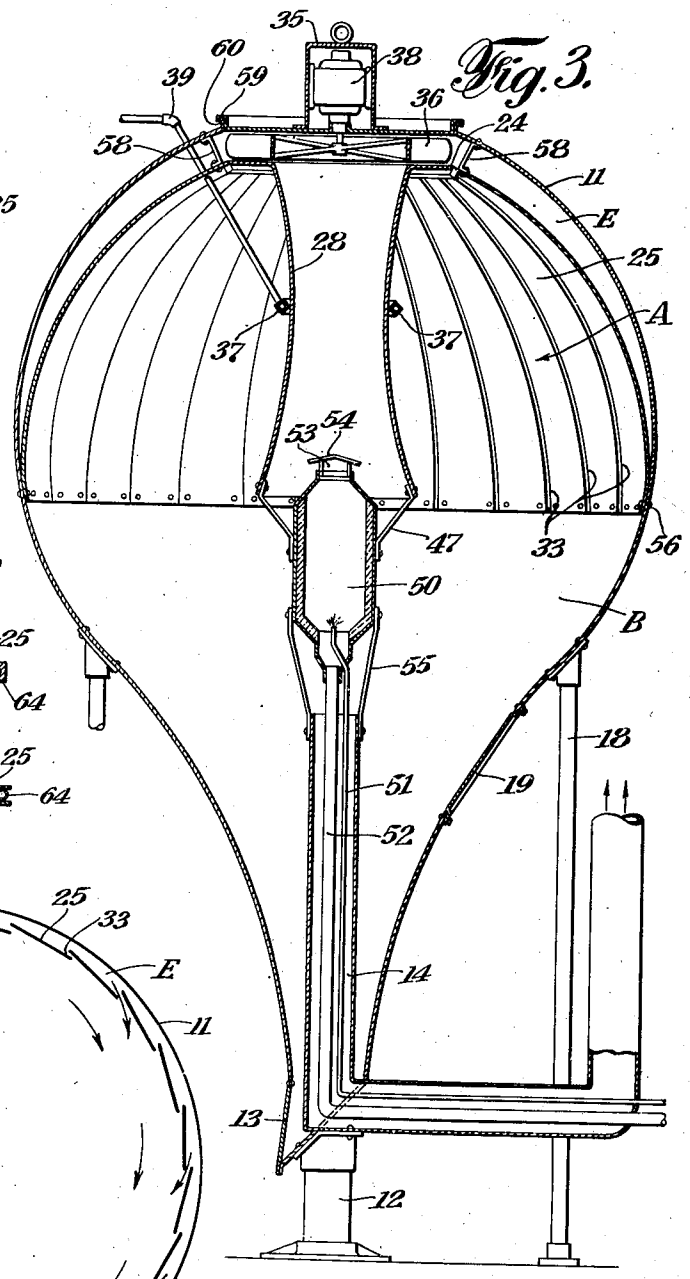


Fig. 3.



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SPRAY DRYING APPARATUS

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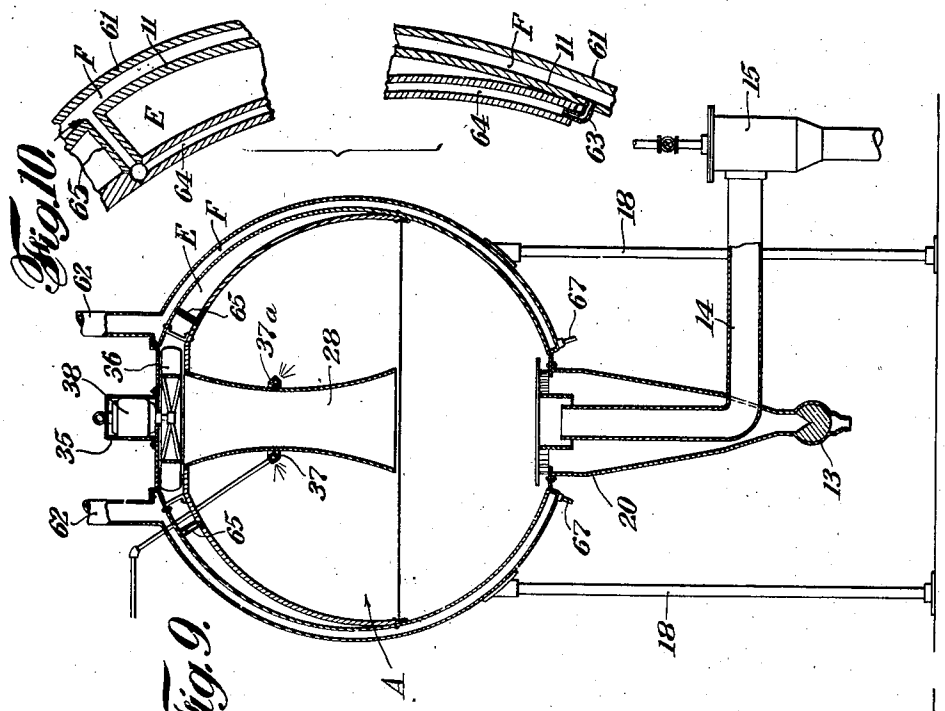


Fig. 10.

Fig. 9.

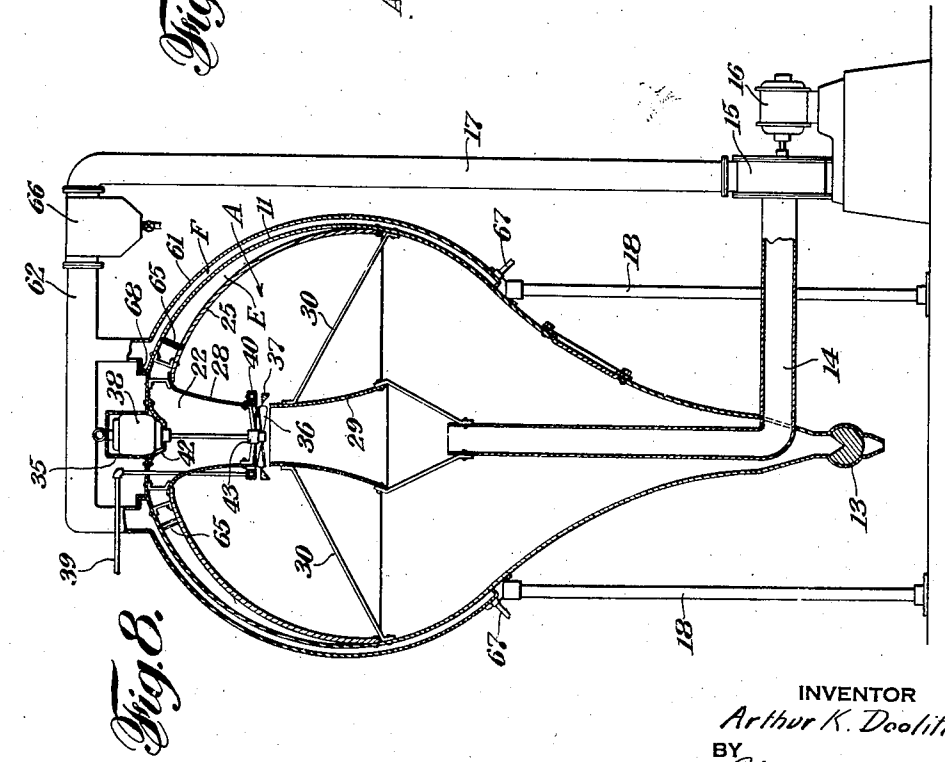


Fig. 8.

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UNITED STATES PATENT OFFICE

1,989,406

SPRAY DRYING APPARATUS

Arthur K. Doolittle, West Orange, N. J.

Application July 30, 1931, Serial No. 553,926

10 Claims. (Cl. 159—4)

My invention relates broadly to spray drying apparatus and more particularly to that type of apparatus in which the wet material to be dried is brought into contact with a heat carrying medium to remove the moisture producing a final product in the nature of a dry powder.

The object of my invention is to improve the efficiency, fuel economy and collection recovery and to decrease the power consumption of spray drying apparatus.

A further object of my invention is to provide spray drying apparatus in which the heat carrying medium is effectively recirculated within the drying chamber to conserve the heat contained therein and at the same time to build up the moisture content of the spent gases to the maximum before they are discharged to the atmosphere.

A still further object of my invention is to decrease the volume of spent gases discharged to the atmosphere for a given amount of final product by reheating the drying gases within the drying chamber.

A still further object of my invention is to provide apparatus so arranged that when the material is relatively dry but not completely dry it will not come in contact with the hotter gases and in this way the danger of charring the final product is prevented.

A still further object of my invention is to provide spray drying apparatus in which the wet material is prevented from reaching and thereby sticking to the walls of the drying chamber.

A still further object of my invention is to provide practical apparatus for the economical operation of spray drying under reduced pressure and by the principles of thermo-recompression.

The efficiency and fuel economy of my apparatus are improved over that of present apparatus by increasing its evaporating capacity which is accomplished in my apparatus by continuously circulating and recirculating the drying gases until the moisture content is so built up that the spent gases discharged to the atmosphere are a mixture of gases and vapors consisting almost entirely of water vapor instead of mostly air or other drying gases as is the result in other known forms of apparatus, and are therefore of much less quantity for a given amount of final product. The temperature of the drying gases within the drying chamber is maintained substantially the same as for apparatus now known to the art since in my apparatus heat is continuously added to the circulating gases within the drying chamber.

The collection recovery in my apparatus is improved over that in known forms of apparatus by recirculating the gases containing fine particles and building up these particles by their being picked up by additional material on reentering the drying chamber thus forming larger particles which are easily separated by the collector.

By eliminating external ducts such as are used in present forms of apparatus and by my novel method of recirculating the gases containing fine particles in suspension I am able to use a collector having a lower draft loss and thus reduce the overall static head in my apparatus and consequently reduce the power required for circulation.

The invention consists substantially of the construction combination and relative arrangement of the parts, all as will be more fully hereinafter set forth as shown in the accompanying drawings and finally pointed out in the appended claims.

Reference is to be had to the accompanying drawings forming a part of the specification in which like reference characters indicate corresponding parts throughout the several views and in which:

Fig. 1 is a cross-sectional view of one form of my apparatus;

Fig. 2 is a cross-sectional view on line 2—2 of Fig. 1;

Fig. 3 is a cross-sectional view of a modified form of my apparatus.

Fig. 4 is a detailed perspective view of the gas guide vanes such as are used in the forms shown in Figs. 3, 8 and 9.

Figs. 5, 6 and 7 are cross-sectional views on an enlarged scale of various forms of the gas guide vanes;

Fig. 8 is a cross-sectional view of a modified form of my apparatus particularly adapted for operation under reduced pressure;

Fig. 9 is a cross-sectional view of another modified form of my apparatus; and

Fig. 10 is a cross-sectional view on an enlarged scale showing a construction of the outer shell, inner shell, gas guide vanes and their connections.

In the embodiment of my invention shown in Fig. 1 the drying chamber has a portion A enclosed by walls 11, preferably lagged to minimize heat losses of substantially cylindrical form and a downwardly tapering or lower portion B which may taper more gradually at its lower end as shown at C. The lower part C rests on a pedestal 12 and is fitted with a side opening covered by a

door 13, or any other suitable device for removing solids. A duct 14 leads from the lower part of C and passes through the casing of a fan 15 driven by an electric motor 16 or other suitable driving means. The fan 15 exhausts to the atmosphere through duct 17.

The drying chamber is also supported by suitable supports 18 and the parts A and B are preferably made separable for ease in construction and installation. A manhole 19 is suitably placed in the wall of the portion B to provide access for cleaning and repair.

The duct 14 extends upwardly through the portion B of the drying chamber and is centrally located therein. Duct 14 also forms the central portion of an auxiliary collector 20.

The top 21 of the drying chamber is securely fastened to the walls 11 of the cylindrical portion A and is provided with a central opening in which the atomizing and distributing unit 22 hereinafter more fully described, rests. It is also provided with an opening through which the drying gas inlet duct 23 passes. The top 21 is shaped to provide a space or chamber D between it and a plate 24. The plate 24 is fastened to the gas guide vanes 25 and is suitably supported from the top 21 as by stays 26. The atomizing and distributing unit 22 may also be supported by the plate 24 as shown at 27.

A draft tube is centrally located in the drying chamber and is preferably of two sections, 28 and 29, one of which 28 forms part of the atomizing and distributing unit 22 and a lower portion 29 which extends downwardly below the atomizing and distributing unit 22 and is suitably supported as by stays 30.

The duct 23 extends into an annular passage 31 which is fitted under the plate 24 and around the atomizing and distributing unit 22 and is provided with vanes 32 to admit the gases substantially tangentially to the spray.

The gas guide vanes 25 consist of relatively narrow strips which are positioned on a circle of smaller diameter than that of the walls 11 of portion A, thus forming a space or chamber E between the vanes and the walls 11. The vanes 25 (as shown in Fig. 2) overlap each other in such a manner that relatively narrow openings or slots 33 between them provide a plurality of passages from the space E to the central portion of the drying chamber A. The width of the slots is kept at the desired dimensions throughout their length by spacers 34 (see Figs. 4 and 5) placed at intervals along the length of the vanes 25. The vanes 25 are held in place by being fastened at their tops to plate 24 and at their bottoms to the walls of section B.

The atomizing and distributing unit 22 consists of a top piece 35 which may also form the motor casing if a motor is used, a lower portion 28 which is of a substantially cylindrical shape and forms part of the draft tube, a fan 36, atomizing disc 37, a motor or other driving means 38 for rotating the fan and the distributing disc, feed pipe 39 for the slurry containing the material to be dried, and distributing ring 40. The top piece 35 and the lower portion 28 are fastened together by suitable stays 41. Member 42 is attached to the top piece 35 and is shaped to serve as a guide for deflecting the flow of the drying gases into chamber D. This member 42 may also serve to support the motor. The slurry feed pipe 39 passes through the top piece 35 and extends into the distributing ring 40 which has a relatively small opening around its under side. The distributing ring 40 is welded or otherwise securely attached to the member 28 at its lower portion. The disc 37 is mounted on the periphery of the fan 36 and is preferably of the novel form described and claimed by me in my copending application, Serial Number 549,643, filed July 9, 1931, but it may be of any other suitable form and the distributing ring and atomizing disc may be replaced by nozzles of any well known proper design as shown at 37 in Fig. 3. Fan 36 is mounted on the driving shaft for which a bearing is provided at 43. Top piece 35 rests by its own weight on the flanged collar at the central part of cover 21 and the member 28 rests in a similar manner on plate 24. The motor casing 35 may be provided with an eye 44 to facilitate the removal of the atomizing and distributing unit.

The distributing ring 31 for the drying gases is arranged just above and just outside of the atomizing disc 37 so that the slurry upon being thrown from the disc immediately comes into contact with freshly admitted gases.

The auxiliary collector 20 may be of any suitable form but I prefer one of the forms shown in which the side walls consist of vanes 45 similar in construction to the gas guide vanes. The duct 14 as above stated forms the central or clean gas outlet for the collector and is protected by a canopy 46. Supports 47 for the lower portion 29 of the draft tube may be fastened to canopy 46. A downwardly extending portion 48 of the collector is substantially cylindrical and of such a size that a passage 49 is provided through which the dry product may fall to the bottom of the drying chamber.

I will now describe the operation of my apparatus. The heated drying gases are introduced through duct 23 to annular passage 31 where they are given a rotary motion by vanes 32 and thence to the drying chamber A. The wet mixture or slurry is introduced through pipe 39 and passes to distributing ring 40 from which it falls on atomizing disc 37 which atomizes it and throws it off preferably in an umbrella shaped spray. This spray and the newly introduced hot drying gases meet and are carried radially outward until they enter the zone of rapidly circulating gases near the walls of the chamber. While passing from the center to the periphery, the hot gases give up a portion of their heat to accomplish evaporation, but the rest of the available heat is given up as the gases, solids, and atomized slurry are rotating at high velocity with a spiral motion inside the walls of the drying chamber. As the spiral rotation continues the dried particles gradually and continuously settle down into the lower portion B of the drying chamber where their rotational velocity is still further increased according to well understood laws. The great force produced by the spiral rotation separates the dried solids from the circulating gases and the latter, substantially free from solids return to the lower mouth of the draft tube 29 to be recirculated. The finely divided solids as they descend in B are freed from the gases and drop into C from which they may be removed through gate 13. The gases are then drawn upward through the draft tube by the action of the fan 36, are deflected by the canopy 42, and enter the chamber D and the space E between the walls 11 of the drying chamber A and the gas guide vanes 25. The gas then passes through the slots 33 between the vanes 25 and is again given a spiral motion in re-entering drying chamber A. This portion of the gas now mixes with the atomized slurry and any portion of the

gas which has not passed through the draft tube 28 and 29 and assumes a rotary, tightening spiral path. During this circulation as well as during its first contact with the slurry the gas gives up its heat to vaporize the moisture in the atomized slurry, and any solids remaining in the gases will be removed by auxiliary collector 20 before the gases are exhausted to the atmosphere and will fall therefrom to the bottom C of the drying chamber and will be likewise removable. The waste gases will be drawn through duct 14 and discharged to the atmosphere by the action of fan 15. In this operation the newly introduced and therefore relatively hot gases come into contact with the slurry only when it is at its wettest, thus preventing the danger of charring the final product by having relatively dry slurry come in contact with relatively hot gases. The introduction of the drying gases into the drying chamber at a plurality of points which extend vertically over the entire length of the section of the walls against which the slurry might strike, prevents the slurry from coming in contact with and sticking to the walls of the drying chamber which has been a source of great trouble in spray drying apparatus.

The spiral motion of the gases in my apparatus provides a path for the particles that are being dried which is equal to that of apparatus of much larger volume when such spiral motion is not employed. I therefore save by my apparatus both in initial cost of the apparatus and in surface heat losses. The period of detention may be increased by tilting the gas guide vanes 25 so that the slots 33 give the gases an upward motion in addition to their spiral motion.

In the embodiment of my invention shown in Fig. 3 the drying chamber is in two sections, A and B. The upper section A is substantially hemispherical, the walls being shown at 11, and the lower section B tapers to a narrow portion in which is located the gate or similar device 13. The lower portion B has a suitable manhole 19 for cleaning, etc. and is supported on a suitable pedestal 12 and is also supported by columns or legs 18. Duct 14 extends upwardly from near the bottom of section B and in this construction should be made of heavy material because it forms a support for a combustion chamber 50. Fuel pipe 51 and primary air inlet 52 preferably are contained in duct 14 for at least the portion of its length contained in the drying chamber.

The combustion chamber 50 may be any suitable form of fuel burning furnace or heating element, either electrical or radiating and is provided with an outlet 53 in its upper portion fitted with a pent 54 to protect the furnace and to deflect the gases.

In this construction I have shown a draft tube 28 in a single piece and atomizing nozzles 37 instead of a two sectional draft tube and an atomizing disc. The mixture to be dried is fed through pipe 39 to the nozzles 37 which are placed outside of and close to the draft tube 28 and are preferably about centrally located with respect to its length.

The draft tube is supported at its bottom by suitable stays 47 extending from the combustion chamber 50 and the combustion chamber is held in place by stays 55 extending from duct 14. The draft tube 28 at its top is fitted with a portion or plate 24 extending outwardly to the top of gas guide vanes 25.

Instead of using two fans as is necessary in the construction shown in Fig. 1, I need use but one fan in this construction. The fan 36 is of the radial blade type and is mounted in connection with a motor 38 or other driving means near the top of the drying chamber. The motor is suitably supported in a member 35 which fits into an opening centrally located in the top of portion A of the drying chamber.

The outlet of the combustion chamber 50 is shown to be located near the lower mouth of the draft tube 28 and the fan 36 is located just above the upper mouth of the draft tube but its position may be somewhat varied.

The gas guide vanes 25 are substantially spherical sections as shown in Fig. 4 and are fastened to the wall of the drying chamber at their lower parts forming a space or chamber E between the wall and the vanes. I have found the best method of fastening these gas guide vanes is by bolts 56 and slotted holes 57 in the gas guide vanes to allow for expansion and contraction. The gas guide vanes 25 are fastened at their tops to walls of the drying chamber by suitable stays 58 and rest against a plate 24 making an air tight fit. The gas guide vanes 25 overlap and are positioned as in the construction shown in Fig. 1 as shown in Fig. 5 to form passages 33 between them substantially tangential to the general surface of the gas guide vanes which is substantially spherical.

The piece 35 may or may not be bolted to the walls of the drying chamber. In my drawings I have shown it merely resting therein by means of a flange 59 on the piece 35 and flange 60 on the wall of the drying chamber.

The fuel and air for combustion are introduced into the combustion chamber 50 by means of pipes 51 and 52 respectively, and form therein hot flue gases which unite with the gases and vapors present in the draft tube 28 and are forced by means of the fan 36 into the chamber or space E between the gas guide vanes 25 and the wall of the drying chamber. The gases and vapors then enter the chamber A through the passages 33 which give them a spiral motion as they come into contact with the material to be dried which has been introduced through pipe 39 and atomized by nozzles 37. The gases continue their spiral motion separating the now completely dried product which drops into the lower part of portion B of the drying chamber.

The amount of gases mixed with vapors exhausted to the atmosphere is substantially equal to the quantity of gases and vapors introduced into the drying chamber by the combustion of the fuel and the evaporation of the moisture in the material to be dried. These gases and vapors substantially free from solid particles pass through the duct 14. If desired in order to recover the maximum amount of solid matter from these gases an auxiliary collector may be used as shown at 20 in Fig. 1.

I prefer the form of my invention described above but it is to be understood that instead of introducing the gases of combustion directly into the draft tube 28 I may pass them through suitable pipes to points located just outside of the draft tube and below the nozzles 37.

In the embodiment of my invention shown in Fig. 8 the drying chamber is in two sections and in general is of the same shape as the drying chamber shown in Fig. 3. In this embodiment I have shown a rotary valve 13 at the bottom of the lower section B of the drying chamber for removing the dry product. The construction of the atomizing and distributing unit 22 may be the same as that shown in Fig. 1, consisting of a

top piece 35, motor 38, shaft, fan 36, bearing 43, atomizing disc 37, distributing ring 40, slurry inlet 39, canopy 42 and upper portion 28 of the draft tube. The lower portion 29 of the draft tube is supported from the walls of the drying chamber by stays 30. In this figure I have not shown an auxiliary collector 20 but the same might be used in the same manner as shown in Fig. 1.

Surrounding a large portion of the surface of the drying chamber A, I fasten a jacket 61 forming space F between it and the walls 11 to which are connected two branches of the gas inlet 62.

The gas guide vanes 25 are of a shape similar to those shown in Fig. 3 and are similarly arranged to provide slots 33 and space E.

I also provide a pipe 63 at the bottom of the gas guide vanes 25 connecting the space between the wall 11 of A and the outside jacket 61 (see Fig. 10) and the longitudinal passages 64 provided in the forms of gas guide vanes 25 shown in Figs. 6 and 7 which I prefer to use in this apparatus.

The duct 14 enters the casing of a fan 15 which is driven by a motor 16 or other suitable driving means and duct 17 is connected to the exhaust side of fan 15 and goes to trap 66. The steam inlet pipe 62 is connected to the other side of trap 66.

Suitable devices 67 for removing the condensate are located at the bottom of shell 61.

The flange on which the atomizing and distributing unit 22 rests should be provided with a gasket or oil seal 68 to prevent leakage from the outside into the drying chamber.

In this form of my apparatus the slurry is fed to atomizing disc 37 from which it is atomized into the drying chamber. The vapors in the drying chamber which are exhausted continuously so that the pressure can not build up appreciably are circulated through the two sections of the draft tube 28 and 29 and are deflected into space E between the gas guide vanes 25 and the walls 11 of A. These vapors pass through the slots 33 by which they are given a spiral motion. Then these vapors mix with the atomized material to be dried and continue in a spiral direction, some of these vapors are drawn up through the mouth of the lower portion 29 of the draft tube and are recirculated. Other portions of these vapors pass through the duct 14 and enter the fan 15 where they are compressed to a pressure above that in the drying chamber. They then pass through the duct 17 and the trap 66 which removes any solids or moisture which may still be in them. The gas then enters the space F between the walls 11 of the drying chamber A and the shell 61 and circulates through pipes 65, passages 64 in the gas guide vanes 25, pipes 63 and into the space F from which any condensate is removed through 67. In this way the gas, the temperature of which has been raised by compression is used to heat the gas guide vanes 25 to assist in the process of evaporation.

The form of my apparatus shown in Fig. 9 is similar to that shown in Fig. 8 except that I have replaced the fan 36, distributing ring 40 and atomizing disc 37 by distributing nozzles 37 and have formed the draft tube 28 in one piece and placed the fan 36 at the upper mouth of the draft tube 28 in accordance with the arrangement shown in Fig. 3. Another change shown in this form of my apparatus is to make the drying chamber of substantially spherical shape with a central opening at the bottom into which a collector 20 may be fitted instead of forming the collector as an integral and the lower part of the drying chamber. This collector may be of any suitable well-known form but in which the duct 14 forms the outlet for the solid free gases.

In this form I have shown the jacket 61 carried around all the surface of the drying chamber except those portions made by the openings in which the atomizing and distributing unit 22 and the collector 20 are fitted. The operation of this apparatus is the same as that of the apparatus shown in Fig. 8 except that the inlet ducts 62 come from a source of waste heat instead of being the recompressed exhaust gases of the apparatus itself. The exhaust gases pass to a jet condenser 15 or may be exhausted to the atmosphere by a pump.

It is to be understood that the variations in detailed form that I have shown in the drawings are interchangeable and the spirit of my invention is not limited to the particular combinations of parts shown in these drawings. For example, the auxiliary collector 20 may or may not be used in the forms shown in Figs. 1, 3 and 8. The atomizing and distributing unit arrangement and two-piece draft tube shown in Figs. 1 to 8 are equally suitable for use in the apparatus shown in Figs. 3 and 9 and the one-piece draft tube and spray nozzles shown in that figure are equally suitable in the apparatus shown in Figs. 1 and 8. Likewise I may use any standard apparatus for exhausting the vapors in place of the jet condenser.

I claim:

1. In spray drying apparatus a drying chamber, an inlet for the material to be dried, means for atomizing the material to be dried, means within said drying chamber for circulating gases and vapors within said drying chamber in a substantially spiral path, an outlet for said gases and vapors, means for recompressing the same and a jacket partially surrounding said drying chamber arranged to be filled with said compressed gases and vapors.

2. In spray drying apparatus a drying chamber, an inlet for the material to be dried, means for atomizing the material to be dried, means for circulating gases and vapors, an outlet for said gases and vapors, means for recompressing the same and a jacket partially surrounding said drying chamer to be filled with said compressed gases and vapors and passages from said jacket to passages located in hollow vanes which direct the circulation of the gases and vapors in the drying chamber.

3. In spray drying apparatus a drying chamber, hollow vanes therein for guiding the circulation of the gases, means for compressing the exhaust gases and vapors and for introducing them into said vanes.

4. In spray drying apparatus a drying chamber, means for circulating gases and vapors therein, said means consisting of hollow vanes arranged substantially tangential to the walls of said drying chamber and arranged to form passages between them through which the gases and vapors circulate and containing other passages through which heating fluid is introduced.

5. In spray drying apparatus circulating and recirculating means consisting of a draft tube, a fan and a plurality of hollow vanes disposed substantially near the outer wall of the drying chamber and forming passages between them substantially tangential thereto and each of said

vanes containing a plurality of longitudinal passages.

6. In spray drying apparatus a drying chamber divided into an inner compartment and an outer compartment and means wholly contained within said drying chamber for circulating and recirculating entirely within said drying chamber the gases and vapors contained therein, said means consisting of a draft tube centrally located within said drying chamber, a fan located in said draft tube for withdrawing said gases and vapors from said inner compartment and a plurality of vanes disposed at the division of the inner compartment and outer compartment of the drying chamber and forming passages substantially tangential thereto through which passages the gases and vapors re-enter the inner compartment of the drying chamber.

7. In spray drying apparatus a drying chamber, a combustion chamber located centrally within said drying chamber, an inlet for the material to be dried, an outlet for the dried product and the spent drying gases and vapors, means for atomizing the mixture to be dried, vanes dividing said drying chamber into an inner portion and an outer portion, a draft tube centrally located in said drying chamber and extending above said combustion chamber for withdrawing the gases and vapors from the center of the inner portion of the drying chamber, the gases and vapors reentering the inner portion of said drying chamber through passages formed by said vanes which direct said drying gases into a substantially spiral path, all said means and parts being contained in said drying chamber and being arranged concentric therewith.

8. In spray drying apparatus a drying chamber having a central portion and an outer portion, means arranged concentrically and entirely within said drying chamber for circulating the drying gases, passages connecting said central portion with said outer portion, the aforesaid means arranged to withdraw said drying gases from said central portion and to introduce them into said outer portion and to force said drying gases through said passages back into said central portion, said passages disposed so that as said drying gases are reintroduced into said central portion they follow a substantially spiral path.

9. In spray drying apparatus a drying chamber, vanes dividing said drying chamber into an inner compartment and an outer compartment, means entirely within the inner compartment for circulating the drying gases including means for withdrawing the drying gases from the central portion of said inner compartment and reintroducing them therein through passages formed by said vanes so that when re-introduced into said inner compartment they follow a substantially spiral path.

10. In spray drying apparatus, a drying chamber having an inner compartment of substantially circular cross section, an outer compartment surrounding said inner compartment having therein a drying gas inlet, an inlet for the mixture to be dried, and means for atomizing the mixture to be dried, said inner compartment being arranged to separate said drying gases from the partially dried material, and a draft tube within said inner compartment through which said gases substantially free of the material to be dried, are withdrawn from said inner compartment and delivered to said outer compartment, a fan located in said draft tube for circulating, withdrawing, and delivering to said outer compartment said gases and a plurality of passages in the wall defining said inner compartment through which said drying gases reenter said inner compartment substantially tangentially to said wall.

ARTHUR K. DOOLITTLE.

CERTIFICATE OF CORRECTION.

Patent No. 1,989,406. January 29, 1935.

ARTHUR K. DOOLITTLE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 26, for "to" read and; and line 51, claim 2, for "chamer" read chamber; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of March, A. D. 1935.

Leslie Frazer
Acting Commissioner of Patents.

(Seal)