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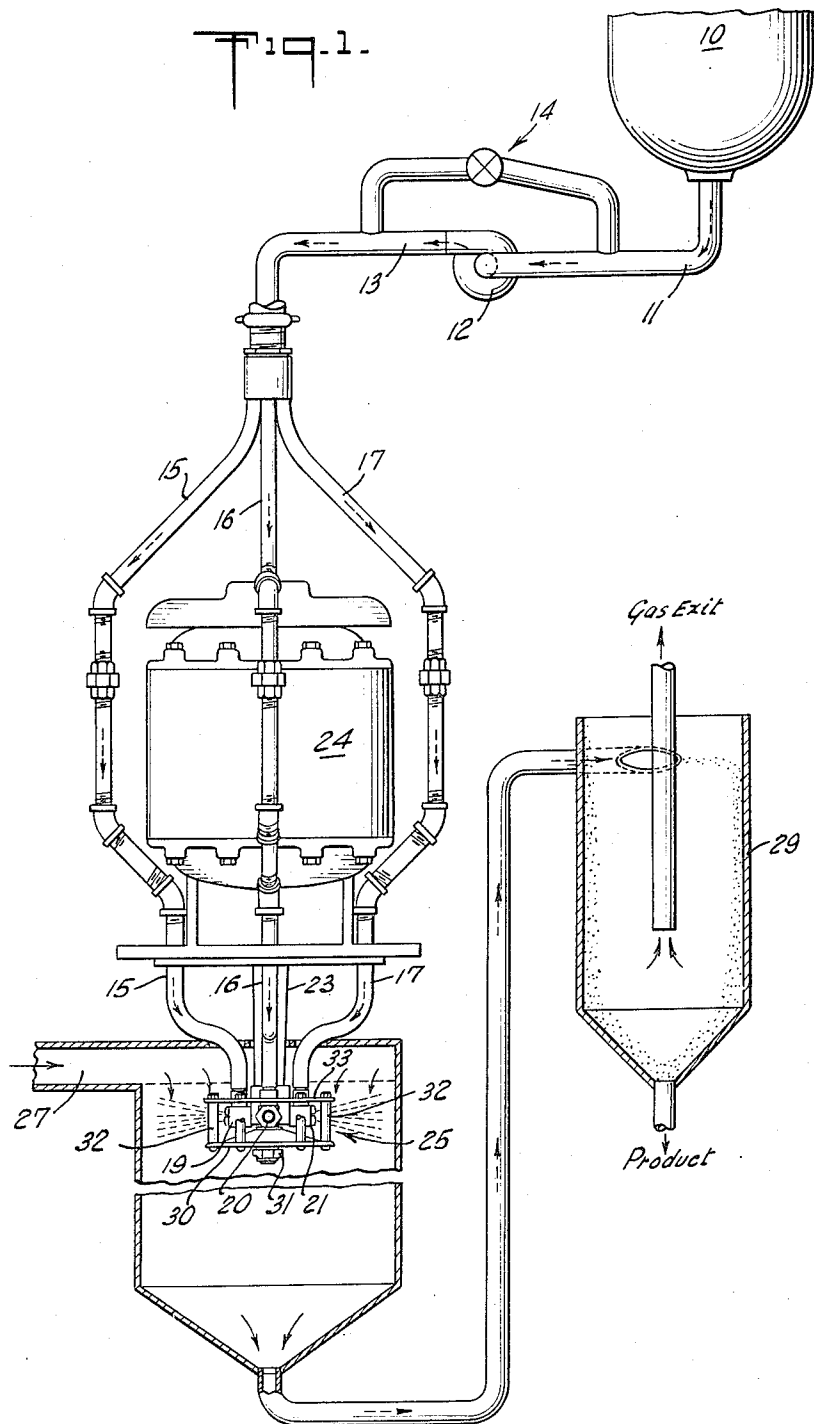
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METHOD AND APPARATUS FOR SPRAY DRYING

Filed May 7, 1956

2 Sheets-Sheet 1



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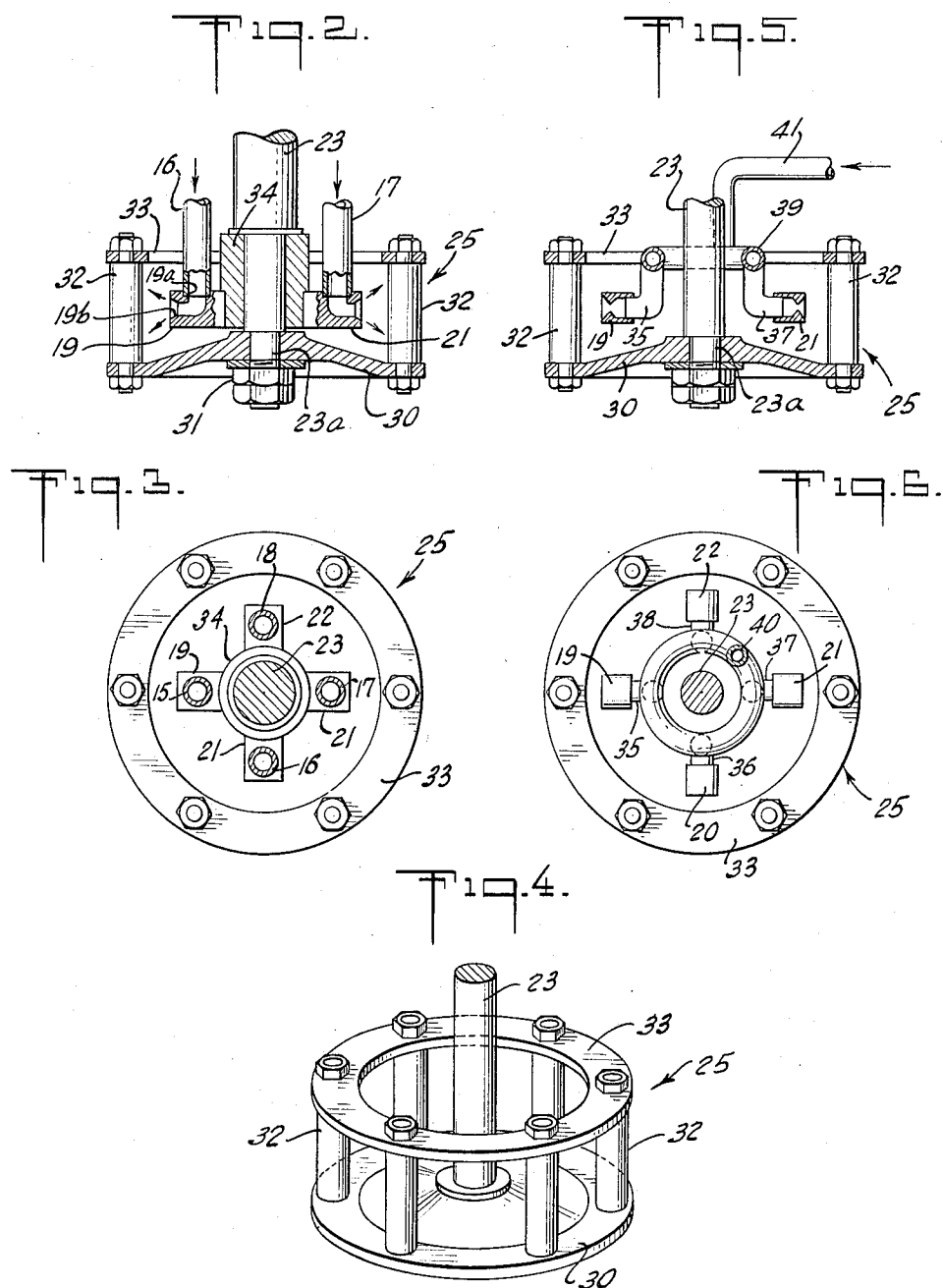
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## METHOD AND APPARATUS FOR SPRAY DRYING

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2 Claims. (Cl. 34—57)

This invention relates to an improved method and apparatus for spray drying slurries such as, for example, a kaolin slurry.

The drying of solids or liquids by spraying them into a moving column of heated gas is old in the art, various methods being employed to inject the substances into the drying chamber. It has been proposed to spray liquid slurries through one or more spray nozzles directly into the drying chamber, but this method is unsatisfactory in general because the slurries usually carry large amounts of solids which preclude the formation of a suitably fine mist. One type of apparatus sometimes used in an attempt to obtain a suitably fine mist includes a rapidly rotating disc on the surface of which the slurry is caused to fall. Another type of apparatus includes a rapidly rotating perforated basket through the holes of which the slurry is caused to be discharged. Each of these methods depends to a considerable extent on the high velocity injection of the slurry into the hot gas so that the slurry is broken up by the resistance of the gas. Here again it is difficult, if not impossible, to obtain a mist that is fine enough for satisfactory drying.

One apparatus which is used commercially consists of a cage directly connected to the lower end of the vertical shaft of an electric motor. The bottom end of the cage is a solid plate while the top consists of only a ring which leaves an open space for introduction of slurry between the ring and motor shaft. The ring and bottom plate are connected by equally spaced pins around the outer edge. The cage is rotated at high speed and the slurry is caused to flow against the lower end of the cage. The product moves spirally outward until it contacts the pins which shatter the mass as it imparts high velocity and the mass is discharged in a direction essentially tangent to the rotating cage and at high velocity. While a fairly satisfactory mist, under certain circumstances, is obtained through the use of this equipment, a kaolin slurry erodes the bottoms of the pins almost entirely away in only a few days operation, thus necessitating down time of the equipment and costly replacement of the pins. Also, the mist created is not of optimum fineness to result in maximum production.

It is accordingly among the objects of my invention to provide a method and apparatus for spray drying slurries which overcomes the aforementioned difficulties in a thoroughly efficient and practical manner, and which can be utilized to inject a very fine slurry mist into the drying chamber in such a manner as to assure efficient and economic drying of the slurry. Other objects will be in part apparent and in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the appended claims.

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In the drawing, wherein I have shown a preferred form of my spray drying apparatus,

Figure 1 is an elevation of the complete system with certain portions thereof shown schematically, others broken away, and still other parts thereof shown in section;

Figure 2 is an enlarged fragmentary sectional elevation of the mist-producing cage of impactor;

Figure 3 is a top plan view of the impactor shown in Figure 2;

Figure 4 is a perspective view of the impactor;

Figure 5 is a view similar to Figure 2, but showing a modified form of spray nozzles; and

Figure 6 is a top plan view of the impactor shown in Figure 5.

Similar reference characters refer to similar parts throughout the views of the drawing.

In general, my apparatus may include a supply tank for the slurry, from which the slurry is pumped under controlled pressure, substantially greater than atmospheric, into one or more pipes leading to the spray nozzles. These nozzles are preferably four in number and are angularly spaced at 90 degree intervals. More or less nozzles may, however, be used with satisfactory results. These nozzles are so designed and are so arranged within a pin cage or impactor as to create hollow or solid conical sprays or jets each of which will contact substantially the entire length of the impact pins. As the rapidly rotating pins impact the slurry spray, they shatter it into a fine mist that is discharged at high velocity from the cage into a drying chamber where the fine particles of the mist are subjected to the drying action of a suitably heated gas. Thus the gas flowing through the drying chamber not only dries the fine slurry particles, but also carries them out of the drying chamber into a suitable separator where the slurry particles are separated and the moisture-laden gas discharged.

This apparatus is admirably suited for the practice of my method of spray drying slurries. My method essentially includes the steps of supplying slurry at a suitable temperature and pressure, atomizing the slurry, impacting it at high velocity to create a fine mist, and thereafter drying and separating the fine slurry particles entrained in the mist.

Referring now to Figure 1 of the drawing, a preferred form of my spray drying apparatus may include a supply tank 10 of suitable size for the reception of the slurry, e.g. kaolin slurry, that is to be dried. Tank 10 is connected by a pipe 11 to the inlet side of a pressure pump 12 to the outlet side of which is connected a pipe 13. Where pump 12 is of the constant delivery type, it is preferable to provide a valved bypass generally indicated at 14 to recirculate part of the slurry, thus to control the slurry pressure in pipe 13. If desired, however, pump 12 may be of the variable speed drive type in which event bypass 14 may be dispensed with. Regardless of the type of pump used, it should have sufficient capacity to deliver slurry to pipe 13 at a pressure of the order of 30 pounds per square inch.

Pipe 13 is connected to a coupling 15 to which, in turn, are connected illustratively four leader pipes 15, 16, 17 and 18 (see also Figure 3); the lower ends of these leader pipes are connected respectively to spray nozzles 19, 20, 21 and 22. As shown in Figures 1, 2 and 3, these nozzles are angularly spaced at regular intervals around the lower end 23a of a drive shaft 23 connected to and driven by an electric motor 24. An impactor generally indicated at 25 is connected to lower end 23a of shaft 23 in such manner, as will be more particularly described hereinafter, as to disintegrate the slurry sprayed thereagainst by nozzles 19—22 and form

a fine mist of the slurry which is discharged into the upper portion of a drying chamber 26. Heat for drying chamber 26 may be provided by forcing hot combustion gas or the like through an inlet pipe 27 into the top of the drying chamber. At the bottom of chamber 26 is an outlet 26a for the dried slurry, and to this outlet is connected a pipe 28 which leads to a cyclone separator 29 or the like where the dried slurry is collected and suitably discharged and the moisture-laden gas is exhausted.

One of the more essential features of my invention lies in the disintegration of the pressurized slurry into a fine mist that can be so effectively and efficiently dehydrated as to provide an end product of dry, finely divided particles. As pointed out hereinabove, prior known methods of creating such an end product have not been satisfactorily effective, primarily because they and their implementing equipment were incapable of producing a slurry mist of a fineness that could be efficiently dried. Going back then to the more specific details of my apparatus, and with reference to Figures 2 and 3, it may be seen that impactor 25 includes a bottom plate or disc 30 which is securely fastened to shaft end 23a as by nuts and washer 31.

Disc 30 may be frustoconical in shape, as shown in Figures 2 and 4, or may be flat, but in any event it has suitably secured at angularly spaced regular intervals about its periphery the lower ends of a plurality of impact members or pins 32 whose axes are parallel to that of shaft 23 and which, upon operation of the shaft, rotate in an orbit around the shaft's axis which is defined by a cylindrical plane which, in turn, defines the area of impact.

To assure rigidity of pins 32 and the proper vertical maintenance thereof in the plane of their orbit during high speed rotation, I preferably provide a positioning and securing ring 33 (Figures 2 and 4) in which the upper ends of the pins are secured in any desirable manner. It might be added at this point that pins 32 are preferably formed of a material, metal or otherwise, that is the most resistant to the erosive action of the slurry particles which are impacted by them. Also, while I have shown pins 32 as cylindrical in shape, it will be understood that, depending on circumstances or choice, they may take other desired geometrical conformation as may best suit the characteristics of the particular slurry being treated. In other words, pins 32 are no more than illustrative of one means of providing a plurality of impacting surfaces for the disintegration of the slurry sprayed thereagainst; hence reference hereinbefore or hereinafter made to the members 32 as "pins" is to be interpreted as generic and not as a limitation to the specific devices shown in the drawing.

As noted hereinabove, nozzles 19—22 are disposed about the lower end 23a of drive shaft 23 to spray slurry radially of the shaft. Illustratively, I have shown four of these nozzles, but it will be understood that more or less of them may be used as circumstances or other factors dictate. In any event, nozzles 19—22 (Figures 2 and 3) are secured in any suitable manner to a collar 34 which is freely mounted on the lower end of shaft 23 so that the shaft end may readily rotate therein. Of course, any other suitable means of mounting the nozzles may be provided. Each of these nozzles, e.g. nozzle 19, has an outlet 19a, into which the lower end of leader pipe 16 is threaded, and an orifice 19b so shaped and oriented with respect to the upper and lower ends of pins 32 that when slurry is pressure-forced through the orifice, a spray of slurry globules or droplets in the form of a solid or hollow cone is created. Whether solid or hollow (depending on the nature of orifice 19b), the base of the conical spray at the plane of the orbit of pins or impactors 32 is of a diameter approximating the axial length of the impactors (the axis of the orifice 19b) preferably being centered with respect to the axial length

of pins or impactors 32). It will accordingly be seen that the sprayed slurry is not concentrated, as in prior apparatus at any one portion of the pins and the erosive action of the slurry is greatly minimized, if not practically obviated. Furthermore, by reason of the formation of conical sprays or jets of slurry by virtue of nozzles 19—22, the slurry is initially more finely dispersed at the time it reaches the impactors than has heretofore been the case, with the result that the impactors are much more effective in further disintegrating the slurry into the desired fine mist.

It might be further pointed out that any erosion of pins 32, by reason of their high velocity impact on the sprayed slurry, will be substantially uniform over the length thereof, rather than localized as in prior apparatus. Hence it follows that in the event of such uniform erosion, immediate replacement of the pins is unnecessary; it will suffice merely to loosen the pins and relocate them angularly, each about its own axis, a quarter of a turn or so, thus to present, for each pin, a fresh uneroded surface, without sacrificing the structural strength of the pins, and accordingly substantially prolonging the useful life of each.

In Figures 5 and 6, I have shown a modified form of nozzle structure that differs from the foregoing only in structural characteristic. Thus, as shown in Figure 6, nozzles 19—22' have their inlets secured respectively to elbow-shaped pipes 35—38, respectively, the upper or inlet ends of which are secured in any suitable manner, as by welding, for example, to a header 39, which may conveniently be in the form of an annulus encircling shaft 23. Header 36 may, of course, take any other convenient or desired shape, but in any event is provided with an inlet 40 which receives the delivery end of a pipe 41 (Figure 5) which may be connected in any suitable manner to the pressurized slurry pipe 13 (Figure 1) or may comprise a continuation thereof. Thus, pipe 41 delivers slurry under pressure to header 39 which, in turn, distributes the pressurized slurry to nozzles 19—22, which sprays it against the impactors 32, as hereinabove described.

It is to be understood that the nozzle arrangement shown in Figures 2, 3, 5 and 6 is merely illustrative and should not be interpreted in a limiting sense, as obviously other specific types and arrangements of the nozzles could be equally as effective as the type and arrangement shown. What is of importance, however, is that the nozzles be so designed and arranged with respect to the impacting surfaces of impactor 25 that a broad based slurry spray or jet be introduced at the impact area so as to attain maximum dispersion of the sprayed slurry, thus to provide the desired fine mist and to minimize or entirely avoid damaging erosion of the impactor surfaces.

By way of illustrating the efficiency of my above-described method and apparatus in comparison with at least one prior method and apparatus with which I am familiar, and which I have used commercially, I had prepared a slurry of degritted kaolin in the proportions of 60.5 pounds of kaolin suspended in 39.4 pounds of water containing 0.1 pound of sodium hexametaphosphate to maintain the slurry in a fluid condition. This slurry was fed into apparatus similar to that shown in Figure 1, but lacking the pressure system (pump 12, pipes 13, 15—18, and nozzles 19—22) and having a funnel interposed between the motor and impactor for gravity feeding the slurry into the impactor, on the bottom plate (e.g. disc 30) of which the slurry dropped. The drying chamber was generally similar to chamber 26 with the impactor similarly located. The impactor was six inches in diameter and was mounted on a shaft driven by a 15 H.P. motor operating at 9200 r.p.m. Drying gases were supplied to the drying chamber at a temperature of about 900° F. This is the apparatus referred to in the third paragraph of this specification. In operation with this apparatus, slurry at 26° C. was dropped through the fun-

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nel onto the bottom plate of the impactor at the maximum rate which would provide drying the kaolin to a moisture content of 0.3%. Under these conditions a production of 6.50 tons per hour of dry kaolin was obtained with noticeable erosion of the lower ends of the impactors. When the experiment was repeated with the unpresurized slurry at 90° C., the funnel soon became clogged and the experiment could not be continued.

The apparatus was then modified to the form shown in Figure 1. So modified, kaolin slurry at 26° C. was fed to nozzles 19—22 by pump 13 at a pressure of about 30 pounds per square inch. The production of kaolin dried to a moisture content of 0.3%, employing the same volume of drying gas, was increased to 7.30 tons per hour, a production increase of more than 12%, and damaging abrasive action of the slip on impactors 32 was substantially eliminated. Such erosion as was discernible was uniform over the length of the impactors. When this experiment was repeated with the slip at 90° C., there was no clogging anywhere in the system, and the production was increased to 7.9 tons per hour, or more than 21%.

Thus it may be seen that I have provided an improved method and apparatus of spray drying slurry, particularly kaolin slurry, which attain the several objects set forth hereinabove in a thoroughly practical and efficient manner.

As many possible embodiments may be made of the mechanical features of the above invention, and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In an apparatus for spray-drying abrasive solid-

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liquid mixtures the combination comprising a rotatable shaft, elongated rod-like impactor members carried by said shaft within a drying chamber and arranged annularly about said shaft in radial spaced relation thereto and extending generally in the direction of shaft axis to describe an orbit of rotation, and a stationary nozzle mounted within said chamber inside the orbit of said impactor members for delivering laterally against said rotating impactor members a conical spray the base diameter of which at the place of contact with said members is substantially the longitudinal dimension of said members, whereby the erosion of said members by the abrasive action of the slurry is substantially uniform along the entire length of said impactor members, and means to conduct slurry under pressure to said nozzle.

2. In an apparatus for spray-drying abrasive solid-liquid mixture the combination which comprises a rotatable pin cage comprising pins of substantially cylindrical cross-section having their longitudinal axes disposed generally parallel to the axis of rotation and in radial spaced relation to said axis of rotation to describe an orbit of rotation thereabout, a plurality of stationary nozzles mounted within said orbit each for delivering a conical spray laterally against substantially the entire length of said pins, whereby the erosive effect of the abrasive slurry is substantially uniform along the length of said pins, and means to conduct slurry under pressure to said nozzles.

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