

Filed Nov. 2, 1945

SPRAY DEVICE

3 Sheets-Sheet 1



June 14, 1949.

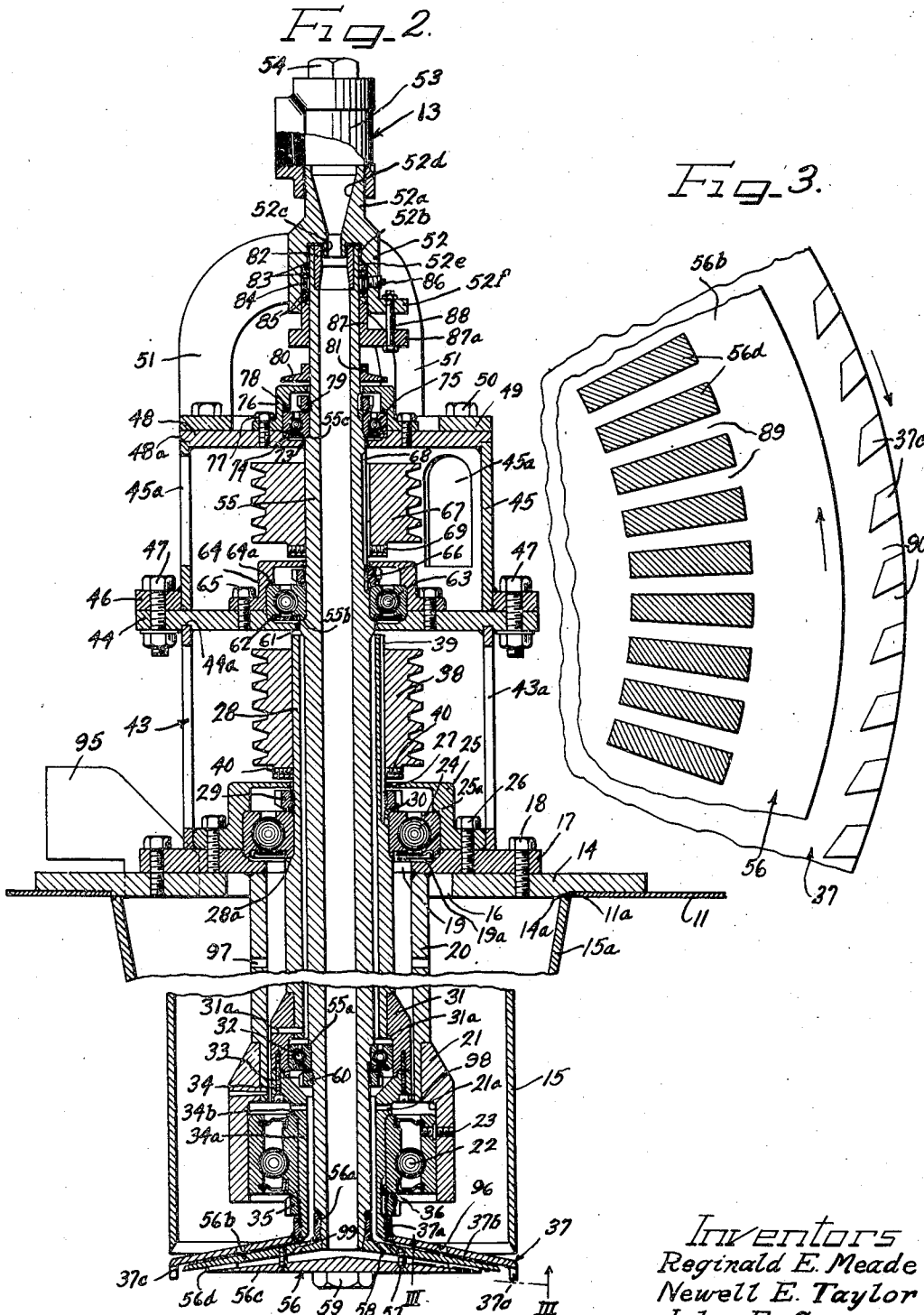
R. E. MEADE ET AL

2,473,035

SPRAY DEVICE

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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

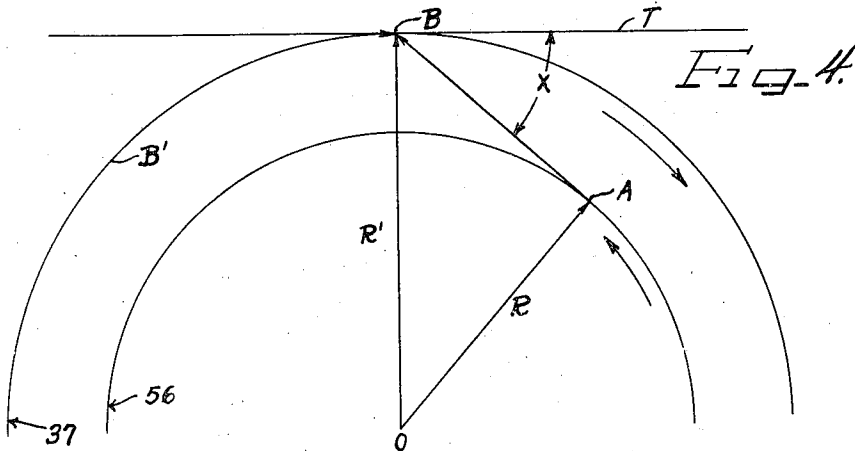


Fig. 5.

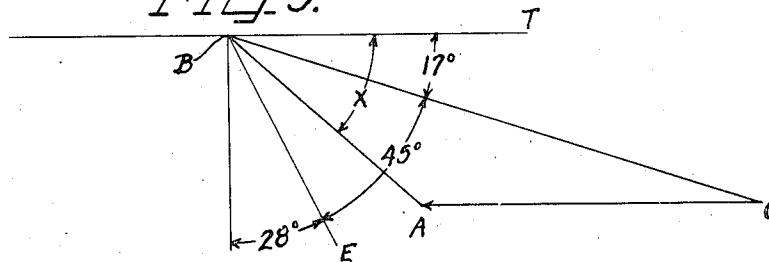
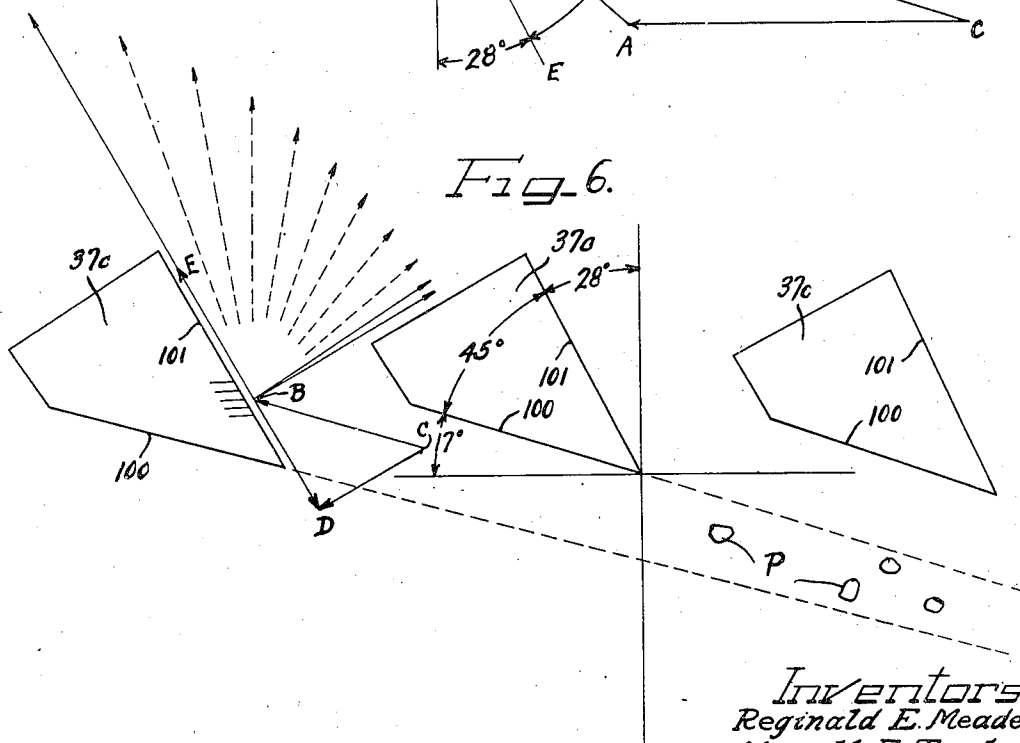


Fig. 6.



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UNITED STATES PATENT OFFICE

2,473,035

SPRAY DEVICE

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Application November 2, 1945, Serial No. 626,219

6 Claims. (Cl. 299—63)

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This invention relates to a centrifugal force type atomizer or spray device and specifically deals with a centrifugal atomizer having counter-rotatable heads or runners equipped with teeth arranged to develop maximum impact forces on material being atomized while providing efficient purge paths for the material.

A feature of the spray device of this invention is its atomizing purge paths, which are so arranged as to develop maximum delivery capacity coupled with highly efficient impact effect for efficiently atomizing particles even at a high delivery rate.

The device of this invention preferably has a first rotating head or runner, and a second counter-rotating head or runner. The first head, in some instances, need not be rotated, and can merely serve as a distributor or feeder to the second head. The first runner receives material to be sprayed on the central portion thereof, and flings this material outward through a plurality of paths around the periphery thereof. The second head has teeth enveloping the material flung out from the paths of the first head. These teeth define impact faces against which the material is impinged to be further broken up or atomized. These teeth on the second head have purge paths therebetween so arranged that an efficient outward flow of atomized particles is insured. The device of this invention is thus balanced to create highly effective differential impact velocities and purge velocities.

The counter-rotating first and second heads or runners of the device of this invention eliminate the necessity for extremely high rotating speeds such as have been used in centrifugal type atomizers, and thereby avoids heretofore encountered vibrations and dangers of extremely high speed operation. For example, heretofore known single rotating centrifugal atomizers have been driven at speeds around 15,000 R. P. M. to develop centrifugal force for atomizing material. The counter-rotating device of this invention, on the other hand, develops even more atomizing effect by counter-rotating the first and second runners at half the speed used for uni-directional rotating devices.

The teeth of the second head or runner of the device of this invention which receive the particles flung from the first rotating head or runner have inner edges so designed that they will not impede the outward flow of the particles. Thus these inner edges of the teeth have a minimum relief angle which is determined by the relation of the velocity of particles flung from the

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inner runner and the velocity of the teeth on the outer runner.

These teeth on the outer runner also have a predetermined angle of attack so that they will define self-scavenging purge paths for the atomized particles. Thus the impact faces of the teeth on the outer runner slope backward just enough to provide an efficient purge path without appreciable loss of impact force effect on the particles received thereagainst. These particles are further broken up or splattered against the backward sloping impact faces of the teeth and the teeth are relatively short in length so that their rear faces will not dam off outward flow of the splattered particles issuing from the succeeding teeth.

Another feature of this invention therefore resides in the provision of a spray device or atomizer having counter-rotating heads or runners which develop highly effective differential impact velocities to break down materials into finely atomized form and which also purge the atomized particles out of the device.

Another important feature of this invention is to provide a highly effective tooth design for centrifugal atomizers to obtain a well balanced combination of atomizing forces and purge velocities.

An object of the invention is to provide a centrifugal force type atomizer with counter-rotating atomizing parts arranged to successively act on material for efficiently breaking up the material into a spray.

A further object of the invention is to provide an atomizer having a distributor for delivering liquid to a rotating atomizer having teeth arranged at such an angle as to effectively impact against the liquid to atomize it and to define purge paths between the teeth for efficiently purging the atomized particles.

Another object of the invention is to provide a centrifugal type atomizer with counter-rotating runners to effectively atomize material at lower rotational speeds than were heretofore necessary in centrifugal type atomizers.

A still further object of this invention is to so design the teeth of a centrifugal type atomizer as to maintain a highly effective impact velocity on the material plus an efficient purge velocity.

A still further object of this invention is to spray material by flinging it outward from one runner rotating in one direction into another runner rotating in the opposite direction so that the other runner will have a very high impact effect on the material.

A still further object of the invention is to provide a high capacity centrifugal type atomizer that is efficiently operated at lower speeds than were heretofore necessary in the operation of centrifugal atomizers.

A still further object of this invention is to so design the teeth of a centrifugal atomizer that they will have maximum impact effect on material being sprayed without damming off the purging of the material.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of a preferred example only, illustrate one embodiment of the invention.

On the drawings:

Figure 1 is a vertical cross-sectional view, with parts in elevation, of a centrifugal atomizer of this invention mounted on a desiccating apparatus.

Figure 2 is an enlarged broken vertical cross-sectional view, with parts in elevation, of the atomizer shown in Figure 1.

Figure 3 is a fragmentary sectional view of the inner and outer runners of the atomizer taken along the line III—III of Figure 2.

Figure 4 is a schematic drawing of the inner and outer runners illustrating the path of a tangentially discharged article from the inner runner and its point of impacting against the outer runner as compared with the diameters of the inner and outer runners.

Figure 5 is a vector diagram illustrating the manner in which the angles for the teeth on the outer runner are determined to provide the most efficient purge paths and impact faces.

Figure 6 is a diagrammatic view illustrating the manner in which particles flung from the inner runner are broken up by the impact faces of the teeth on the outer runner and also showing the manner in which the inner edges of these teeth are relieved so as to provide no interference against outward flow of the particles.

As shown on the drawings:

In Figure 1 the reference numeral 10 designates generally a desiccating apparatus or tank having a head or dome 11 with an inlet 12 for heated air or other drying gas. The counter-rotating spray device 13 of this invention is mounted on the head or dome 11 and projects through the head into the main body of the apparatus or tank 10. As best shown in Figure 2, the top of the head 11 has an aperture 11a therein and a mounting ring 14 which overlies the top of the head has a pilot portion 14a extending into the aperture 11a to position the ring on the head 11. A tubular sheath 15 is secured to the under face of the ring 14 and projects through the head 11 to terminate in spaced relation above the outer runner of the spray device as will hereinafter be more fully described. This sheath has a tapered upper end portion 15a secured to the under face of the ring 14 as by welding or the like. The ring 14 has a central aperture 16 therethrough.

A second ring 17 is mounted on top of the ring 14 and is secured thereto as by means of screws such as 18. This second ring 17 has a central aperture 19 therethrough with a recess 19a in the top face surrounding the aperture. A tube 20 surrounds the aperture 19 and depends from the ring 17 in the sheath 15. This tube 20 is secured to the ring 17 as by welding or the like. A head 21 is secured on the lower end of the tube 20 and provides an open-bottomed recess 21a receiving an

anti-friction bearing 22 therein. The outer race of the bearing 22 is locked in the recess 21a by means of a pin 23 or the like.

A second anti-friction bearing 24 has the outer race thereof seated in the recess 19a of the ring 17 while the inner race thereof projects radially inward of the aperture 19.

A retainer cap 25 is disposed over the outer race of the bearing 24 and has an internal shoulder 25a opposing the recess 19a so as to cooperate therewith in clamping the outer race of the bearing fixedly to the ring 17. The cap 25 is secured to the ring 17 as by means of bolts 26 or the like. The cap has an aperture 27 in the top wall thereof.

A tube 28 projects through the aperture 27 of the cap 25 and through the aperture 19 of the ring 17 into the tube 20. This tube 28 is rotatably supported by the bearings 22 and 24. Thus as shown the tube has a reduced-diameter upper end portion providing a shoulder 28a bottoming the inner race of the bearing 24. A locking nut 29 is threaded on the tube 28 to thrust against the upper end of the inner race of the bearing 24. A locking washer 30 is interposed between the nut 29 and the top face of the inner race of the bearing and has a tang locked in a castellated portion of the periphery of the nut. This nut 29 is inside of the cap 25 and cooperates with the shoulder 28a to clamp the inner race of the bearing against longitudinal movement on the tube 28. Since the outer race of the bearing is similarly clamped, the bearing will support axial loads as well as radial loads.

The lower end of the tube 28 has a head 31 secured thereon. This head 31 defines an open-bottomed recess 31a receiving a third anti-friction bearing 32 for a purpose to be more fully hereinafter described. An opposing head member 33 is secured to the bottom end of the head 31 as by means of screws 34. This head 33 has a tubular extension 34a projecting through the recess 21a of the head 21 and through the inner race of the bearing 22. A shoulder 34b is provided on the tubular extension 34a in the recess 21a to bottom the top face of the inner race of the bearing 22. A lock nut 35 is threaded on the tubular extension 34a to cooperate with a lock washer 36 to oppose the shoulder 34b for clamping the inner race of the bearing 22 to the extension 34a to prevent axial movement of the extension member in the bearing. Since the outer race of the bearing 22 is held against axial movement in the head 21 by the pin 23, the bearing 22 will support thrust loads as well as radial loads.

An outer runner or head 37 for the spray device 13 is carried by the tubular extension 34a of the head 34. As shown in Figure 2 this outer runner 37 has an upstanding internally threaded collar portion 37a threaded on the lower end of the extension 34a at a level beneath the head 21. The runner 37 then has a downwardly sloping top wall 37b projecting under the sheath 15. Peripheral teeth 37c depend from the outer end of the top wall 37b.

A multi-grooved pulley 38 is keyed on the upper end of the tube 28 by means of a key 39. Set screws 40 position the pulley 38 at the desired level on the upper end of the tube 28. As shown in Figure 1 the pulley 38 is driven through a plurality of V-belts 41 by an electric motor 42 above the dome 11 of the desiccating apparatus 10.

A tubular casing 43 surrounds the cap 25 and is welded thereto. The casing 43 projects upwardly from the ring 17 to surround the pulley 38 in spaced relation. An opening 43a is provided

in the casing to receive the belts 41 therethrough. A plate 44 is mounted on top of the casing 43 and has a circular groove 44a in its under face receiving the upper end of the casing. The casing 43 is welded to the plate 44 along its inner and outer faces as shown in Figure 2.

A top tubular casing 45, preferably of the same diameter as the casing 43, is mounted on top of the plate 44. A ring 46 is welded around the lower end of the casing 45 to overlie the plate 44 and nut and bolt assemblies 47 are passed through the ring 46 and plate 44 for securing the casing 45 on top of the casing 43.

A plate 48 is mounted on top of the casing 45 and has an undercut peripheral portion 48a on the under face thereof receiving the upper end of the casing 45. The casing 45 is welded to the plate 48 as shown.

A ring 49 is mounted on top of the plate 48 and is secured thereto by means of screws 50 or the like. Legs 51 (preferably three) integral with the ring 49 extend upwardly therefrom to provide an arbor with a head 52 spaced above the central portion of the ring 49.

The head 52 has an externally threaded cylindrical upper end portion 52a projecting above the legs 51 and receiving a T fitting 53 thereon. One port of the T 53, such as the top port, is closed by a plug 54 while the remaining port receives a feed pipe (Figure 1) for supplying material to be desiccated to the device 13.

The head 52 has a recess 52b in the bottom thereof with an integral nipple portion 52c depending from the top of the recess into the central portion thereof. A tapered bore 52d extends from the top end of the head 52 in full communication with the T 53 to a cylindrical bore through the nipple portion 52c.

A rotatable feed pipe 55 projects into the recess 52b of the head 52 and extends freely through central apertures in the plates 48 and 44, into and through the tube 28, and projects through the lower end of the extension 34a on the head piece 34. The lower end of the rotating feed pipe 55 has an externally threaded reduced diameter portion receiving therearound in threaded relation the hub or upstanding collar 56a of the inner runner or first spray head 56. This inner runner 56 is preferably made in two pieces including wall member 56b secured to the hub 56a and extending outwardly and downwardly therefrom in close-running clearance relation under the top wall 37b of the outer runner 37, and a bottom wall member or disk 56c secured to the top member 56b by means of screws 57 or the like. The bottom disk 56c has upstanding peripheral teeth 56d therearound engaging the under face of the wall 56b and spacing the disk from the wall. The top face of the disk 56c is tapered downwardly from the center thereof to be in spaced parallel relation from the under face of the wall 56b to thereby cooperate therewith in defining a continuous passageway 58 extending outwardly from the feed pipe 55 in full communication with the interior of the feed pipe as best shown in Figure 2. A sheet of material to be sprayed flows through this passageway 58 to be broken up into jets in passing through the purge paths between the teeth 56d as will be hereinafter more fully described. The inner runner 56 preferably has a head 59 depending from the bottom thereof to be engaged by a wrench so that the hub 56a can be tightened on the feed pipe 55.

The feed pipe 55 projects through the inner

race ring of the bearing 32 in the head 31 carried by the tube 28 and has a shoulder 55a cooperating with a nut 60 threaded on the pipe to clamp the inner race of the bearing against axial movement on the pipe. The outer race of the bearing 32 can be affixed to the head 31 if desired in the same manner as the bearing 22.

The pipe 55 is spaced inwardly from the tube 28 and projects freely through a central aperture 61 in the plate 44. The top face of the plate 44 is recessed as at 62 around the aperture 61 to receive a bearing 63. The outer race ring of the bearing 63 is bottomed in the recess 62 and projects above the plate 44 to receive a cap 64 therearound. The cap 64 is secured to the plate 44 as by means of screws 65 or the like and has an inner shoulder engaging and overlying the outer race ring of the bearing to cooperate with the recess 62 in clamping the outer race ring to the plate 44. A nut 66 threaded on the pipe 55 cooperates with a shoulder 55b on the pipe to clamp the inner race of the bearing 63 against axial movement relative to the pipe. The bearing 63 thereby supports thrust and radial loads to rotatably hold the pipe 55 against axial movement relative to the plate 44.

A multi-grooved pulley 67 surrounds the pipe 55 in the casing 45 and is keyed to the pipe by means of a key 68. The pulley 67 is held at a fixed level on the pipe 55 by means of set screws 69. The casing has an opening 45a therethrough accommodating passage of a plurality of V-belts 70 trained around the pulley 67 in the grooves thereof and driven by an electric motor 72 which is mounted above the dome or head 11 of the desiccator 10 (Fig. 1).

As shown in Figure 2, the pipe 55 projects freely through a central aperture 73 in the plate 48. This plate 48 has a recess 74 in its top face surrounding the aperture 73 and receiving the outer race ring of an anti-friction bearing 75. This upper race ring of the bearing 75 projects above the plate 48 and is surrounded by a cap 76 secured to the top of the plate 48 by means of screws 77 or the like. The cap has an inner shoulder bottoming shims or spacers 78 to thrust against the top face of the outer race ring of the bearing 75 and cooperate with the recess 74 for clamping the outer race ring against axial movement relative to the plate 48. The inner race ring of the bearing 75 is bottomed on a shoulder 55c provided on the pipe 55 while the top of this inner race of the bearing is acted on by a clamping nut 79 threaded on the pipe 55 to cooperate with the shoulder 55c for clamping the inner race ring of the bearing 75 against axial movement on the pipe. The bearing 75 therefore also rotatably supports the pipe 55 and holds the same against axial movement relative to the plate 48.

A flinger 80 surrounds the pipe 55 above the cap 76 and is secured to the pipe by means of set screws 81 or the like. The purpose of the flinger will be hereinafter more fully described.

The upper end of the pipe 55 projects freely into the recess 52b of the head 52 and is counter-bored to receive a ring 82 surrounding the nipple 52c of the head in spaced relation. Packing rings 83 surround the pipe 55 in the head 52 and are bottomed on a shoulder 52e in the recess 52b of the head. A metal seal ring 84 thrusts against the bottom packing ring 83 and has annular grooves around the inner and outer faces thereof to supply lubricant to the packing rings 83 and to additional packing rings 85 underlying the ring 84. A plug 86 is threaded into the head 52

to provide access to the grooves in the sealing ring 84 for greasing the assembly. A packing head 87 is slidably seated in the recess 52b of the head 52 to thrust against the lower packing ring 85. The head 87 has ears 87a at spaced intervals therearound underlying ears such as 52f on the head 52. Nut and bolt assemblies such as 88 are passed through the ears 87a and 52f to tighten the head 87 for thrusting against the packing ring. It should be understood, of course, that the pipe 55 is rotatable in the head 52 and the packing arrangement is such as to permit relative rotation without permitting leakage out of the head and pipe. If any leakage does occur, the flinger 80 will prevent the leaked-out material from entering the bearing 75, since it will throw the material outward by centrifugal force away from the cap 76 for the bearing.

Material to be atomized is pumped or fed by gravity through the T 53 into the rotating feed pipe 55. This feed pipe is driven in one direction by the motor 72 at a desirable constant speed. The material flows through the rotating feed pipe 55 into the passage 58 where it is flung outward through radial purge paths 89 between the teeth 56d on the runner plate 56c as shown in Figure 3. The motor 42 drives the tube 28 in the direction opposite to the direction of rotation of the pipe 55 at a predetermined speed preferably equal to the speed of rotation of the pipe 55. The material flung out from the purge paths 89 of the inner runner 56 leaves the outer ends of the purge paths in a substantially tangential direction to fly ahead of the runner in the same manner as water is thrown from a rotating wheel. The purge paths 89 are of a width to accommodate free passage of material but are sufficiently small so that the material is initially broken up or atomized. The atomized tangential streams flung out by the inner runner 56 are impacted against the teeth 37c of the outer runner or counter-rotating spray head to develop impact forces of high magnitude because of the opposite rotation of the outer runner. These teeth 37c, as will be more fully hereinafter described, have backwardly sloping impact faces to define therebetween non-radial purge paths 90 shown in Figure 3 for efficient outward purging of the atomized material. As shown in Figure 2, the teeth 37c surround the runner 56 and are in the path of the tangential streams thrown off by the runner 56.

In order to prevent possible seepage of atomized material into the head 11 of the desiccating apparatus 10, a baffle 91 is provided at the bottom of the head 11 to surround the sheath 15 in spaced relation therefrom. The drying gases from the inlet 12 circulate in the chamber defined by the dome 11 around the sheath 15 and thence through the opening in the baffle 91 to flow downwardly around the outer runner 37 and thence outwardly and circumferentially into the main desiccating tank in admixed relation with the sprayed particles issuing from the spray device. The main tank of the desiccator 10 preferably receives the main portion of the drying atmosphere from a tangential inlet 92 at a level beneath the dome 11. The exhausted drying gases leave the desiccator through an outlet 93 while the desiccated material is removed from the bottom of the apparatus as at 94.

The interior of the sheath 15 preferably receives cool gases from an inlet 95 extending through the plate 14 of the apparatus 13 and these gases can be the same as the gases from

the inlet 12, but are unheated. The gases from the inlet 95 flow downward through the sheath 15 to flow out of the sheath over the top wall 37b of the runner 37. As shown in Figure 2, this top wall 37b has apertures 96 therein to receive some of the gas for preventing back flow of material being atomized between the wall 37b of the outer runner and the wall 56b of the inner runner.

The bearing carrying tube 20 also has apertures 97 therein to receive some of the gas from the sheath 15 and these gases circulate through the tube 20 to cool the bearings. As shown in Figure 2, the head 31 has a passage 31a therethrough and is spaced from the tube 20. Gas in this tube 20 can then flow into and around the head 31 and into the recess 21a of the head 21. The extension 34a on the head member 34 has apertures 98 therethrough to receive gases from the recess 21a and to flow these gases around the lower end of the pipe 55 into apertures 99 in the top wall 56b of the inner runner. The gases are admixed with the material to be sprayed and flow outward therewith through the purge path between the teeth 56d. The venting of gases through the apertures 99 will break up any pump effect of the centrifugal runner 56 in attempting to centrifugally pump material to be sprayed out of the pipe 55. The gas passage through the apertures 97, 98 and 99 provides an efficient vent for the inner runner 56 that will eliminate any pumping action of this runner. When operating at high speed it is desirable to feed cooling gases through the inlet 95 into the sheath 15 so that these cooling gases will pass through the apertures 96 and 97 to cool the bearings and the spray heads.

According to this invention, a maximum transfer of energy into the particles being atomized is obtained while insuring efficient purging of the particles. An optimum balance of energy transfer and purge velocity as effected by the design and arrangement of the teeth of the outer runner. Since these teeth of the outer runner are to provide impact faces for breaking up the tangentially flung particle streams from the inner runner, these teeth must have inner faces that will expose the impact faces of the teeth to the particles and, at the same time, will be out of the way of the particle streams. For this reason these inner faces are relieved to slope outwardly and rearwardly from the leading edges of the teeth. The maximum relief angle for the inner faces of the teeth is determined by the relation of the velocity of the tangential particle streams and the outer tooth velocity for any given size of runner. The resultant velocity is obtained by a velocity diagram showing addition of velocities and angular relationship of particles leaving the inner runner.

The impact faces of the outer runner teeth are so arranged as to have an angle of attack that will insure self outward scavenging of the impacted particles and still have maximum impact effect on the particles. To arrive at the optimum impact face angle for any given set of conditions, the resultant velocity of the particles attacked by the teeth is broken down into a force component parallel to the impact face of the tooth and a right angle component. The right angle component should be less than the angle of the impact face to insure outward purging.

As shown in Figure 4, with the runner 56 having a 9 inch diameter or $4\frac{1}{2}$ inch radius R rotating counter-clockwise at 3500 R. P. M., and

the runner 37 having a 12 inch diameter or 6 inch radius R' rotating clockwise at 3500 R. P. M., a particle tangentially discharged from the inner runner at A would intersect a tooth on the outer runner at B, which tooth would be at about B' when the particle left the inner runner. The particle thus has a path A-B, and travels along this path at about 137 feet per second under the above indicated speed and radius for the inner runner. The teeth of the outer runner of the above-indicated size at the above indicated speed travel at 183 feet per second. The instantaneous direction of a tooth on the outer runner at point B is tangential to the point or perpendicular to the radius line O-B. The tangent T makes an angle X of 41° with the line A-B.

In the velocity diagram of Figure 5, the line A-B is drawn to velocity component scale representing 137 feet per second. This line is at an angle X of 41° below the horizontal. In Figure 5 the reference points have been transferred from point B of Figure 4 to any one of the teeth approaching point B so that point B approaches the reference teeth at 183 feet per second and the particle approaches point B at 137 feet per second 41° below the axis or tangent line T. The line A-C is drawn on the same scale as the line A-B, but representing 183 feet per second to provide a velocity component line. The line A-C is parallel to the tangent line T and completion of the velocity diagram by drawing the hypotenuse between points B and C, shows that the resultant velocity is 300 ft. per second, represented by the line B-C at 17° below the horizontal axis or tangent line T. The inner faces of the teeth on the outer runner should therefore have a minimum relief angle of 17° from a horizontal axis as illustrated in Figure 6. Thus the teeth 37c of the outer runner have inner edges or faces 100 sloping outwardly and rearwardly at an angle of 17° from a horizontal axis passed through their apex point.

As shown in Figure 6, when particles P attack the impact faces 101 of the teeth 37c, they impinge on these faces at any point in the band between the preceding tooth and the inner edge of the tooth that they are impinging on. This band is represented in Figure 6 by two dotted lines. When a droplet first strikes the impact face of the tooth, hydraulic forces are set up in the particle. These forces are equal in magnitude in all directions, causing the individual molecules in the particles to tend to rebound from the face in an infinite number of directions. This internal force is due to the velocity of impact of the particles on the tooth face normal to the tooth face, and is represented by a line C-D which is the component of the total velocity C-B from the velocity diagram of Figure 5 in the direction normal to the tooth face. If the efficiency of the impact were 100%, the internal force set up in the individual small particles of the droplet would rebound in all directions with a velocity equal to C-D, but each of these particles already has imparted to it a momentum parallel to the impact face 101 which is represented by the line B-E. The total mass velocity of all particles remains equal and some of the particles will leave the surface parallel to the tooth face. If the velocity normal to the tooth, which is represented by the line C-D, exceeds the magnitude of the velocity represented by the line B-E, then the total velocity after impact would tend to return the impacted particles

into the path of the incoming particles and reduce the effectiveness of the atomization. For efficient purging of the atomized particles, therefore, the impact face 101 must slope backward at an angle which produces a component line B-E longer than the inward component line B-D, or not more than 45° from the inner edge of the tooth. A line B-E is therefore drawn 45° below the velocity component line B-C in the diagram of Figure 5, which line is 28° from the vertical axis of the diagram.

In addition, as shown in Figure 6, the teeth 37c must be short enough so that the rebounding atomized particles from the droplets striking the inlet face will clear the preceding tooth as shown by the dotted arrow-headed lines of Figure 6.

From the above descriptions it will therefore be understood that this invention provides an atomizer with a spray head having teeth so arranged as to produce effective atomizing impact forces on material being sprayed while insuring outward purging of the atomized particles. The preferred embodiment of the invention includes counter-rotating spray heads with a rotating inner head flinging liquid streams or particles to a counter-rotating outer head having the above-described arrangement of teeth. A maximum transfer of energy into the atomized particles is thus obtained.

It will, of course, be understood that various details of construction may be varied through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

We claim as our invention:

1. In an atomizing device, a rotatable atomizer member having an axis of rotation, a plurality of circumferentially spaced teeth on said member disposed in an annular zone about said axis, means for rotating said member in one direction of rotation, said teeth having forward faces with respect to said direction of rotation of substantial area extending from the inner and forward edges of said teeth outwardly and inclined backwardly from the radius of said axis of rotation with respect to said direction of rotation, a distributor for liquid material disposed radially inwardly of said teeth for directing substantially all of said liquid material into the path of said forward surfaces during said rotation, whereby said liquid material is struck by said forward surfaces to atomize said liquid material and direct the atomized material outwardly from said atomizing device.

2. In an atomizing device, a rotatable atomizer member having an axis of rotation, a plurality of circumferentially spaced teeth on said member disposed in an annular zone about said axis, means for rotating said member in one direction of rotation, said teeth having forward faces with respect to said direction of rotation extending from the inner and forward edges of said teeth outwardly and inclined backwardly from the radius of said axis of rotation with respect to said direction of rotation, a distributor for liquid material disposed radially inwardly of said teeth for directing said liquid material into the path of said forward surfaces during said rotation, said teeth having inner faces also extending from the inner and forward edges of said teeth outwardly and inclined backwardly from the radius of said axis of rotation with respect to said direction of rotation to provide clearance for the paths of

said liquid material from said distributor to said forward surfaces, said teeth being positioned sufficiently close together and said forward surfaces being of sufficient radial extent to cause substantially all of said liquid material to be struck by said forward surfaces to atomize said liquid material and direct the atomized material outward-up from said atomizing device.

3. In an atomizing device, a rotatable atomizer member having an axis of rotation, a plurality of circumferentially spaced teeth on said member disposed in an annular zone about said axis, means for rotating said member in one direction of rotation, said teeth having forward faces with respect to said direction of rotation of substantial area extending from the inner and forward edges of said teeth outwardly and inclined backwardly from the radius of said axis of rotation with respect to said direction of rotation, a distributor for liquid material disposed radially inwardly of said teeth and having means for directing substantially all of said liquid material in a direction having a component opposite to the direction of movement of said teeth into the path of said forward surfaces during said rotation, whereby said liquid material is struck by said impact surfaces to atomize said liquid material and direct the atomized material outwardly from said atomizing device.

4. In an atomizing device, a rotatable atomizer member having an axis of rotation, a plurality of circumferentially spaced teeth on said member disposed in an annular zone about said axis, means for rotating said member in one direction of rotation, said teeth having forward faces with respect to said direction of rotation of substantial area extending from the inner and forward edges of said teeth outwardly and inclined backwardly from the radius of said axis of rotation with respect to said direction of rotation, a distributor for liquid material disposed radially inwardly of said teeth and rotatable about said axis, means to rotate said distributor member in a direction opposite to the rotation of said atomizing member to direct substantially all of said liquid material in a direction substantially tangentially of said distributor member into the path of said forward surfaces, whereby said liquid material is struck by said forward surfaces to atomize said liquid material and direct the atomized liquid material outwardly from said atomizing device.

5. In an atomizing device, a rotatable atomizer member having an axis of rotation, a plurality of circumferentially spaced teeth on said member disposed in an annular zone about said axis, means for rotating said member in one direction of rotation, said teeth having forward faces with respect to said direction of rotation of substantial area extending from the inner and forward edges of said teeth outwardly and inclined back-

wardly from the radius of said axis of rotation with respect to said direction of rotation, a distributor for liquid material disposed radially inwardly of said teeth and rotatable about said axis, means to rotate said distributor member in a direction opposite to the rotation of said atomizing member to direct said liquid material substantially tangentially of said distributor member into the path of said forward surfaces, said teeth having inner faces also extending from the inner and forward edges of said teeth outwardly and inclined backwardly from the radius of the axis of rotation with respect to said direction of rotation to provide clearance for the paths of said liquid material from said distributor to said forward surfaces, said teeth being positioned sufficiently close together and said forward surfaces being of sufficient radial extent to cause substantially all of said liquid material to be struck by said forward surfaces to atomize said liquid material and direct the atomized material outwardly from said atomizing device.

6. In an atomizing device, a rotatable atomizer member having an axis of rotation, a plurality of circumferentially spaced teeth on said member disposed in an annular zone about said axis, means for rotating said member in one direction of rotation, said teeth having forward faces with respect to said direction of rotation of substantial area extending from the inner and forward edges of said teeth outwardly and inclined backwardly from the radius of said axis of rotation with respect to said direction of rotation, a rotatable distributor spray device disposed radially inwardly of said teeth, means for rotating said spray device in a direction opposite to the direction of rotation of said atomizer member for producing a liquid spray and directing substantially all of said spray against said forward surfaces during said rotation, said atomizer teeth having inner faces also extending from the inner and forward edges of said teeth outwardly and inclined backwardly from the radius of said axis of rotation with respect to said direction of rotation to provide clearance for the paths of said spray from said spray device to said forward surfaces, whereby said spray is struck by said forward surfaces to atomize said spray and direct the atomized spray outwardly from said atomizing device.

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