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Vliet et al.

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[54] **METHOD AND APPARATUS FOR GRINDING THERMOPLASTIC MATERIAL**

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[52] **U.S. Cl.** **241/5,** 241/15, 241/39, 241/46.17

[51] **Int. Cl.** **B02c 19/06**

[58] **Field of Search** 241/5, 15, 39, 46.17

[56] **References Cited**

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[57] **ABSTRACT**

A method and apparatus for grinding thermoplastic material utilizing a jet and anvil type mill where the particular material to be ground is injected into a chamber against a rotating anvil means while also injecting a liquid into the chamber, the liquid evaporating to cool and embrittle the particles, and then accelerating and re-injecting the particles into the chamber while the liquid continues to be injected for evaporation.

7 Claims, 4 Drawing Figures

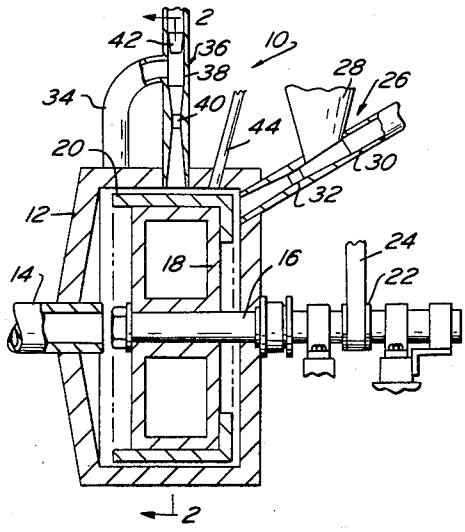


FIG. 1

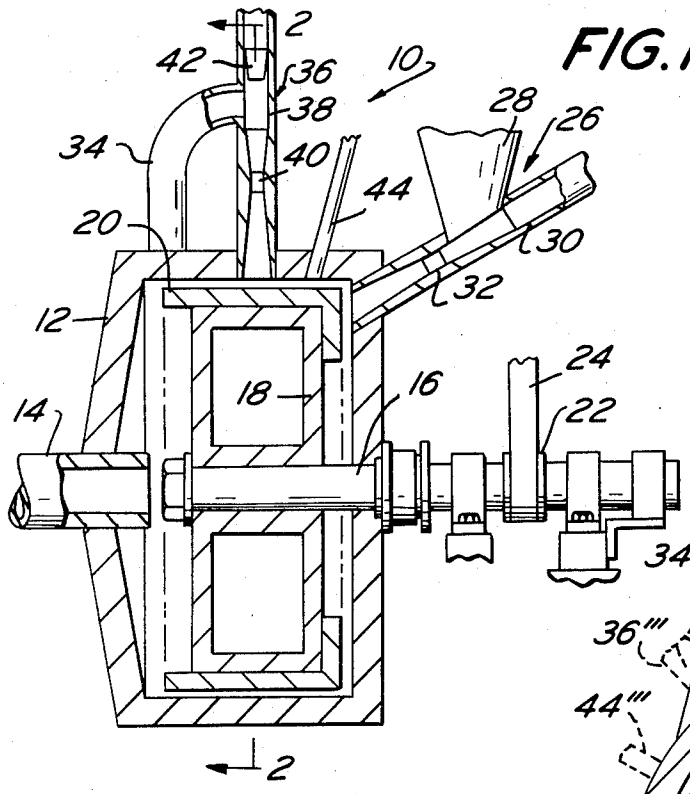
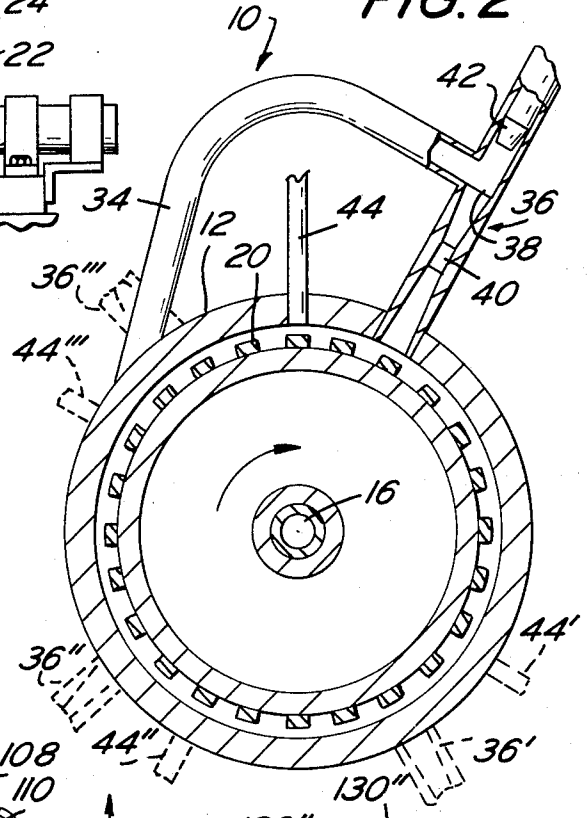


FIG. 2



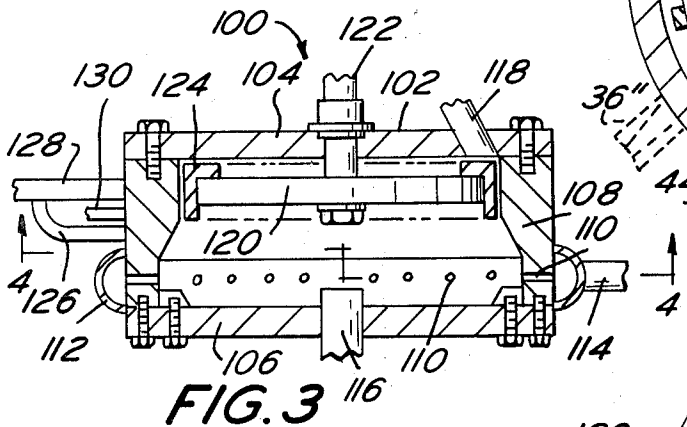


FIG. 3

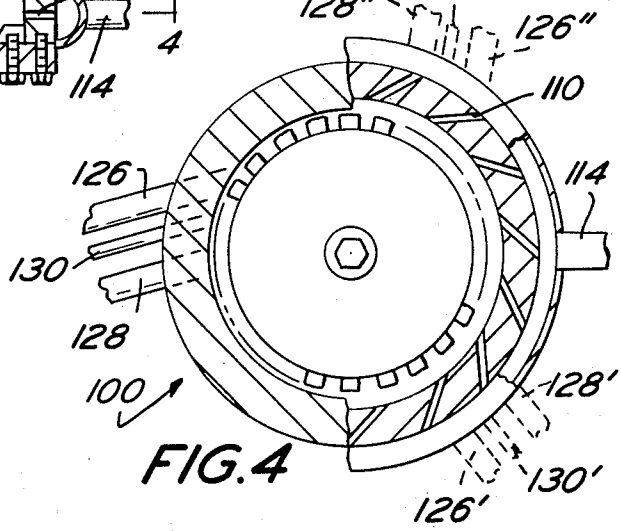


FIG. 4

METHOD AND APPARATUS FOR GRINDING THERMOPLASTIC MATERIAL

This invention relates to a method and apparatus for grinding thermoplastic material, and it particularly relates to a method and apparatus of the aforesaid type which provides a high degree of grinding without danger of deterioration of the material.

Thermoplastic materials, particularly such materials as polyethylene, polypropylene, polytetrafluoroethylene, and the like, generally have relatively low melting and plasticity points. They also tend to deteriorate or decompose at relatively low temperatures. Even tough materials such as polytetrafluoroethylene tend to decompose at temperatures as low as about 400°F, while polyethylene melts at about 230°F.

Generally, a most satisfactory grinding effect, coupled with efficiency and low cost, is obtained by the use of the so-called "fluid energy mills" which utilize no mechanical grinding parts but only the high velocity vortex action of a gas such as air or steam, whereby the particles are impacted against each other. During the vortex action, the ground particles, which include both smaller and larger particles are separated from each other by centrifugal action, and the smaller particles are centrifugally exhausted from the mill while the larger particles are centrifugally recycled for further impacts with fresh material. For the most effective grinding, such mills generally use steam. However, this would not be practicable for thermoplastic materials of low melting points. Even where air at ambient temperature is used, the grinding action has an exothermic effect, building up heat in the mass. Furthermore, static electricity is produced and this static electricity has a deleterious effect because it causes agglomeration of the particles. Such agglomerated particles are most difficult to either separate or grind, and even those particles which have been reduced in size tend to rapidly reagglomerate.

It is, therefore, one object of the present invention to utilize a modified fluid energy type mill, more specifically a "jet and anvil" type mill to effectively grind thermoplastic materials without heat degeneration or static electricity-caused agglomeration.

Another object of the present invention is to effect the aforesaid method in a simple and inexpensive manner, but with a high degree of efficiency.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following description when read in conjunction with the accompanying drawings wherein:

FIG. **1** is a view, partly in section and partly in elevation, of a "jet and anvil" type mill utilized in this invention.

FIG. **2** is a view, partly in section and partly in elevation, taken on line **2—2** of FIG. **1.**

FIG. **3** is a view, partly in section and partly in elevation, of a modified form of the mill used in this invention.

FIG. **4** is a sectional view taken on line **4—4** of FIG. **3.**

Referring now in greater detail to the figures of the drawings, there is shown in FIGS. **1** and **2** a "jet and anvil" type mill, generally designated **10,** which is similar to that disclosed in U.S. Pat. No. 3,688,991, dated Sep. 5, 1972, and more particularly in FIGS. **1** and **2**

thereof. The mill shown in FIGS. **1** and **2** of the present applications are similar to those disclosed in the aforesaid patent in that it includes an endless cylindrical chamber **12** provided with a product or "exhaust" outlet **14** toward which the centrifugal vortex action carries the finer or smaller particles.

A shaft **16** extends into the chamber **12** and mounted thereon within the chamber is a frame **18** which is provided on its outer periphery with a plurality of annually-spaced anvils **20.** The frame **18** and anvils **20** are rotatably driven by the shaft **16** which is rotated by a pulley **22** driven by a drive belt **24** operatively connected to a motor (not shown).

Raw material to be ground is injected into the chamber **12** by a feed assembly, generally designated **26,** which is of a standard type and need not further be described, except to state that the material is fed through funnel **28** and a stream of high pressure gas passing through the tube **30** carries the raw material from the funnel into a venturi **32** where it is accelerated into impact with radially extending anvils **20** located within the interior of the chamber **12.** The material in chamber **12** also impacts against the radially extending anvils **20,** which further partially comminute it. The partially comminuted or ground material is thereafter carried by a gaseous stream along the inner wall surface of the chamber **12** until discharged through conduit **34.**

The conduit **34** is directly connected to a re-injection and acceleration means **36** which includes a nozzle **38** and a venturi **40.** An inner nozzle **42** is connected to a source of high pressure gas such as air at ambient temperature. The stream of gas from inner nozzle **42** is accelerated through the venturi **40** and passed by the nozzle **38** into the interior of the chamber **12,** against the surfaces of the rotating anvils **20.** The anvils, as shown in FIG. **2,** rotate in a clockwise direction while the stream from nozzle **38** is directed against the faces of the anvils. In this manner, additional grinding takes place. The most finely ground or smaller particles are exhausted through duct **14.** The above-described apparatus is generally the same as disclosed in the aforesaid U.S. Pat. No. 3,688,991. However, in addition, there is here provided a conduit **44** leading from a source of water not shown into the interior of chamber **12.** A regulating valve of a standard type (not shown) is interposed in the conduit **44** for the purpose of regulating the rate of feed of the water into the chamber **12.** It is, of course, obvious that the water could be introduced in a variety of places, including introducing it with the feed material through funnel **28.**

In operation, the thermoplastic material is fed through the feed assembly **26** into impact with the rotating anvils located within the chamber **12** and subsequently whirled around by the feed gas (air at ambient temperature) where it is further partially comminuted by the anvils **20** and passed through the acceleration means **36** from which it passes, at high velocity, back into the chamber **12** where it again not only is ground by impacts of the particles with each other but also by impacts against the anvils **20.** During this process, water or a similar cooling liquid is fed through the conduit **44** at a rate which is so predetermined that the air will evaporate all the water. The evaporation is an endothermic process and results in cooling of the material. This cooling reduces the plasticity of the material, making the particles the more brittle and, therefore, easier to break or grind. The water also creates a rela-

tively high humidity in the chamber and this humidity bleeds off the static electricity charges. Since the static electricity causes agglomeration of the particles, the reduction of such static electricity reduces the tendency of the particles to agglomerate and, therefore, increases the speed and efficiency of grinding.

The metering of just the right amount of water relative to the air is important since the outlet air from the exhausts must be below the dew point. It is most preferable to maintain a saturation of about 80 to 95 percent at the exhaust. If the saturation falls below about 80 percent, there is a tendency to overheat the particles. If it rises above about 95 percent, condensation results and this leads to agglomeration of the particles.

It is also a feature of this invention that there may be multiple points of acceleration and/or multiple points of water feed. FIG. **2** shows, in dotted outline, the optionally provided acceleration means **36'**, **36''** and **36'''**, each being provided with a separate conduit such as shown at **34**, and it also shows the optionally provided water conduits **44'**, **44''** and **44'''**. Although four of each are shown, there may be as many of each as desired or considered necessary spaced around the periphery of the chamber **12**. By having multiple acceleration means, there is obtained a greatly increased velocity which increases the amount and degree of comminution or grinding. By utilizing multiple water injection points, the water may selectively be injected at the areas of greatest heat generation or accumulation.

FIGS. **3** and **4** show a modified form of the apparatus used in this invention. This embodiment is generally similar to that disclosed in FIGS. **7** and **8** of the aforesaid U.S. Pat. No. 3,688,991. This embodiment, generally designated **100**, comprises a grinding and classifying housing **102** of substantially circular cross-section formed by plates **104** and **106** and peripheral wall **108**.

A plurality of angularly-directed apertures **110**, constituting nozzles, are spaced around the lower portion of the peripheral wall **108**. These nozzles **110** communicate with an annular header **112** which is connected by a conduit **114** to a source of gas, under pressure, such as air at ambient temperature. An outlet duct **116** is provided in the center of plate **106**. A raw material feed means **118**, which may be similar to feed means **26**, leads through the plate **102**.

A rotatable frame **120** is mounted on a shaft **122**, and spaced anvils **124** are mounted around the periphery of the frame **120**.

A discharge duct **126** is tangentially connected to the wall **108** in the manner of duct **34** of FIGS. **1** and **2**, and this duct **126** communicates with a re-injection and acceleration assembly **128** similar to that shown at **36** in FIGS. **1** and **2**. There is also provided a water inlet conduit **130** similar to that shown at **44** in FIGS. **1** and **2**.

The device shown in FIGS. **3** and **4** operates in a generally similar manner to that shown in FIGS. **1** and **2**, except that an additional grinding effect is obtained by the high velocity fluid entering through nozzles **110**, the tangential arrangement of which provides additional and increased vortex action.

The smaller particles are exhausted through duct **116**. This is due to the fact that the larger, heavier particles are carried to the outer periphery of the vortex by centrifugal force while the smaller, lighter particles tend toward the center of the vortex because of a lesser centrifugal force. The larger particles, on the periphery, therefore, pass through the conduit. **126** and then through the acceleration means **128**.

As in the case of the embodiment in FIGS. **1** and **2**, there are, optionally, provided a plurality of conduits **126**, acceleration means **128** and water inlet conduits **130**. There are indicated, in dotted outline, in FIG. **4**, at **126'**, **128'** and **130'** and at **126''**, **128''** and **130''**, respectively. Here again as many such means as are desired may be used, although only three of each are shown.

By means of the above-described methods, a very effective comminution of thermoplastic materials is obtained, without any melting or deterioration and without any agglomeration.

Although the term "rotating anvils" has been used to describe the projections **20**, it is to be understood that, under certain conditions, with some materials, a substantially smooth rotor may be used with great effectiveness.

The invention claimed is:

1. A method of grinding granular thermoplastic material which comprises injecting said material, while entrained in a low temperature gas, into a generally annular chamber and against a rotating anvil means in said chamber, injecting cooling liquid into said chamber during the passage therethrough of said material at a rate sufficient to evaporate said liquid under the temperature conditions in said chamber, discharging partially ground particles of said material and entraining gas from said chamber, accelerating said particles and gas, reinjecting said particles and gas into said chamber for further impact against said rotating anvil means, and exhausting the more finely ground particles from said chamber while the temperature of the gas is maintained below the dew point.

2. The method of claim **1** wherein the reinjection takes place at a plurality of positions around the periphery of said chamber.

3. The method of claim **1** wherein the cooling liquid is injected at a plurality of positions.

4. The method of claim **1** wherein additional gas under pressure is tangentially injected into said chamber to increase the rotational velocity of said particles in said chamber.

5. Apparatus for grinding granular thermoplastic material comprising an anvil frame rotatably mounted within a curvilinear housing, said anvil frame having an outer curvilinear surface and a plurality of anvils extending radially from said curvilinear surface, feed means for the introduction of material to be ground into said housing above the curvilinear surface of said anvil frame and into impact with said anvils during rotation of said anvil frame, liquid-injection means for injecting a coolant liquid into said housing above the curvilinear surface of said anvil frame, discharge means on the outer surface of said housing for the discharge of partially ground material circulating in said housing above the curvilinear surface of said anvil frame, gaseous fluid injector means for accelerating said partially ground material and injecting it into high velocity impact with said anvils during rotation of said anvil frame, and outlet means for discharging fully ground material, said outlet means being positioned radially inward of said discharge means for partially ground material.

6. The apparatus of claim **5** wherein there are a plurality of gaseous fluid injector means.

7. The apparatus of claim **5** wherein there are a plurality of liquid injection means.

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