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[54] **METHOD AND ARRANGEMENT FOR PERFORMING LOW-TEMPERATURE GRINDING OPERATIONS IN A VIBRATING MILL**

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[51] **Int. Cl.**.....**B02c 17/06,** B02c 23/00, B02c 25/00

[58] **Field of Search**.....241/15, 17, 18, 30, 241/38, 41–44, 65, 153, DIG. 13

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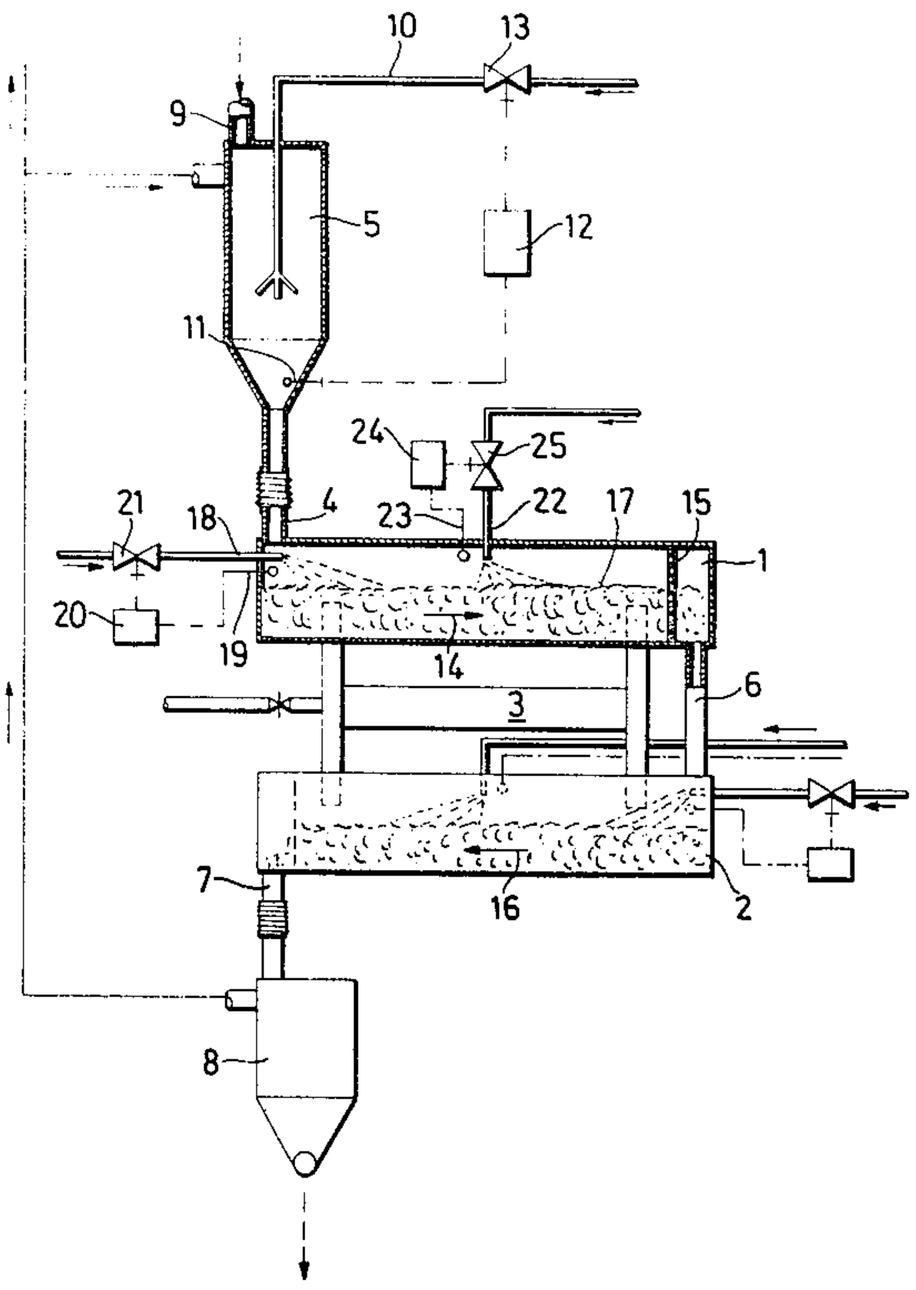
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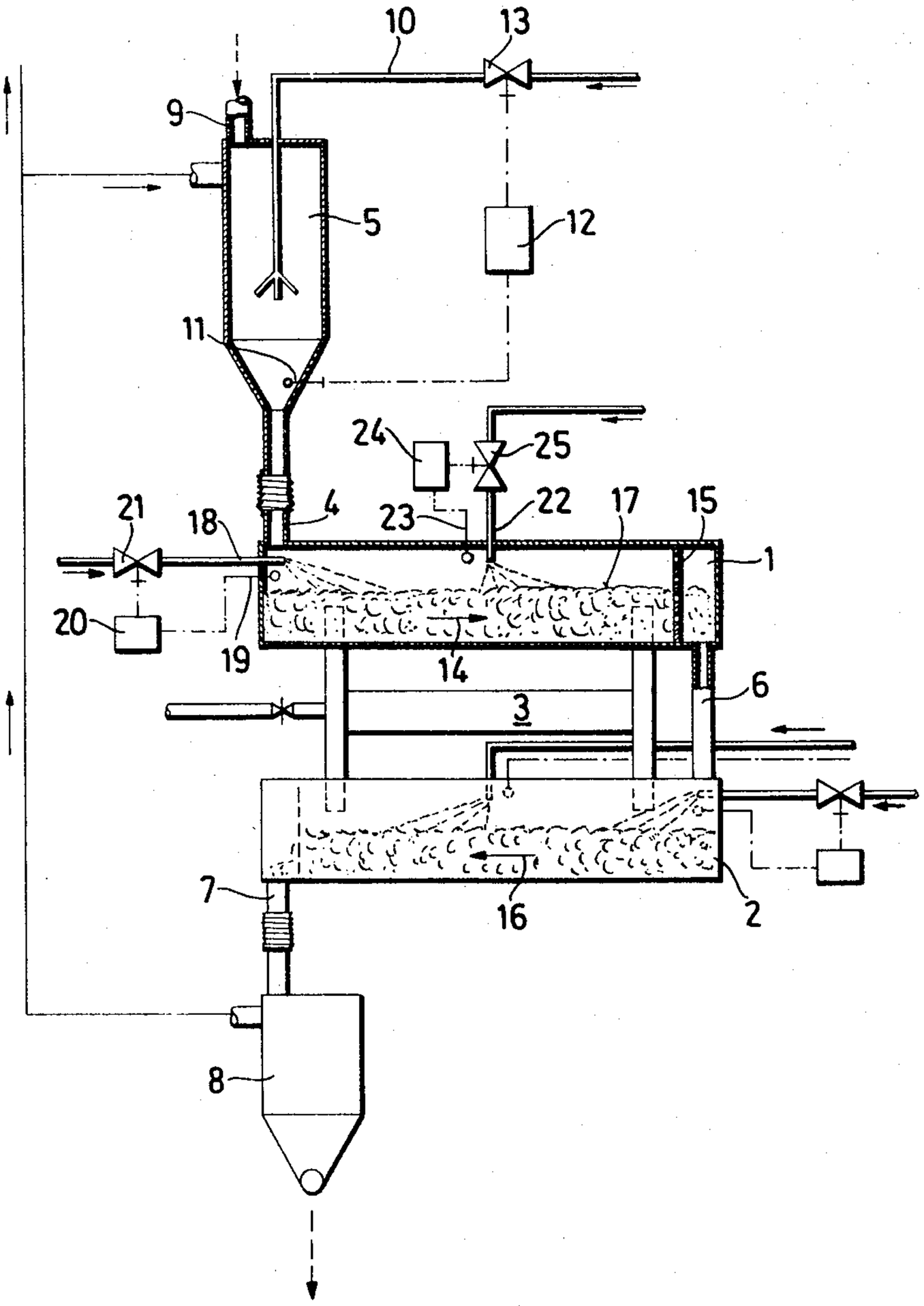
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[57] **ABSTRACT**

Low-temperature grinding operations are performed in the horizontal and longitudinal tubular grinding chambers of a vibrating mill by introducing the material to be ground at one end of the grinding chambers introducing at least at one point of the grinding chambers adjustable amounts of a refrigerant—for example liquid nitrogen—above the surface of the material to be ground in the grinding chambers, and arranging a thermometer probe at each point of introduction at a point spaced ahead of the points of refrigerant introduction when considering the direction of travel of the material to be ground lengthwise in said grinding chamber, said thermometer probe being used for adjusting the amount of refrigerant introduced into said grinding chamber to maintain the temperature in the latter at a predetermined level.

6 Claims, 1 Drawing Figure




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METHOD AND ARRANGEMENT FOR PERFORMING LOW-TEMPERATURE GRINDING OPERATIONS IN A VIBRATING MILL

The invention relates to a method for performing low-temperature grinding operations in a vibrating mill by the addition of refrigerants into the grinding space.

The German Auslegeschrift DAS 1 004 460 discloses a device for cold-grinding of solid, viscous materials in which the materials to be ground—for instance, thermoplastic resins—prior to the introduction in the grinding device are conveyed through a cooling tub filled with liquid nitrogen. In this nitrogen-filled tab the materials to be ground are made brittle and are then conducted into the grinding device. For the cooling of the feed lines and of the grinding space are employed the vapors which are produced in the liquid bath of the cooling tub.

It has now been discovered that this known method for cooling the grinding device is not sufficient and that in particular in a fine-grinding operation taking place in a vibrating mill, certain amounts of heat are released which require another form of cooling of the material to be ground in the grinding chamber. This is particularly true for materials whose point of embrittlement lies only about 10° to 30° C. above the temperature of the refrigerant.

It is an object of the invention to overcome these disadvantages of this known method in that the refrigerant is introduced above the surface of the material to be ground in the grinding chamber by employing at least one injection nozzle provided with a regulating valve, whereby the amount of refrigerant to be injected by each injection nozzle is determined by a thermometer probe which, when viewed in axial direction of the tubular grinding chamber and from the point of introduction of the material to be ground, is arranged in spaced relation ahead or in front of the associated injection nozzle. This procedure on one hand permits the maintenance of the required grinding temperature within the grinding chamber in spite of the amounts of heat which are produced by the grinding operation. On the other hand, however, the low temperature of the material to be ground when it enters the grinding space as a rule requires only small amounts of refrigerants for the maintenance of the grinding temperature, but during a continuous injection the consumption of refrigerants would be comparatively high, and the regulation of the amount of refrigerant is only possible by measuring the temperature in the grinding chamber. By making use of the fact that during continuously operating vibrating mills the material to be ground travels from the point of introduction along the grinding chamber in the direction toward the discharge point, and that also in view of the movement of the grinding bodies and the movement of the material to be ground within the grinding tube causes the injected refrigerant to move in the same direction, the regulation of the amount of injected refrigerant requires a temperature measurement by means of a temperature probe, which latter—viewed in the axial direction of the grinding chamber and from the point of introduction of the material to be ground—is arranged in front of the associated injection point. In this manner it is possible in a simple manner to determine the temperature rise along the length of the grinding chamber by the released heat as a result of the grinding operation, whereby then in each case

within the range in rear of the point where the temperature is measured in relation to the temperature measured at this point, additional amounts of refrigerant may be introduced into the material to be ground in the subsequent part of the grinding chamber without that the newly introduced amounts of refrigerants influence the temperature measurements.

In accordance with the invention, the method provides that each temperature probe in each instance by means of a regulator cooperates with the adjusting device of the regulating valve of the associated injection nozzle. In view of this procedure, it is possible to obtain the advantage of a continuous operation.

According to a preferred embodiment of the invention, the regulator is so constructed that the opening and closing, respectively, of the associated regulating valve takes place in each instance when the upper or lower temperature limit, respectively, has been reached. It is of advantage when the regulator is provided with a so-called time element which preferably closes the regulating valve already before reaching the lower temperature limit.

According to another object of the invention, the refrigerant is sprayed in liquid condition from above onto the exposed top surface of the material to be ground in the grinding chamber. This procedure has the advantage that on one hand very simple spray nozzles may be employed which assure a good distribution of the refrigerant in the grinding chamber within the range of the injection location, while on the other hand, the advantage is obtained that the helical movement of the material to be ground owing to the influence of the vibratory movement of the grinding chamber causes the refrigerant sprayed onto the upper surface of the material to reach also the lower ranges of the filling of the material to be ground in the grinding chamber.

In the following will be described the method of the invention by way of example with reference to flow diagram of an embodiment illustrated in the accompanying drawing.

Referring to the drawing, the two horizontally arranged grinding tubes **1** and **2** are disposed in spaced relation vertically one above the other and are secured in a supporting frame **3** which is mounted to be vibrated and is also provided with means for vibrating it. The left-hand end of the upper grinding tube **1** is connected with a vertically extending feed pipe **4** whose upper end is connected to a cooling device **5** in which the material to be ground is cooled. The two grinding tubes **1** and **2** are connected with their right-hand ends with each other by a vertically disposed connecting pipe **6** and the left-hand lower end of the grinding tube **2** is provided with a material discharge pipe **7** which conducts the ground material into a collecting container **8.**

The material to be ground is introduced by a sluiceway **9** into the upper end of the cooling device **5.** Into this cooling device also extends a downwardly directed portion of a pipeline **10** which extends from above into the filling of the material in the cooling device **5** and has at its lowermost end a system of nozzles which introduce a refrigerant—for instance, fluid nitrogen—into the mass of material in the cooling device. The amount of nitrogen is determined by a thermometer probe **11** connected with a regulator **12** which in turn cooperates with a regulating valve **13** arranged in the pipeline **10.**

The cooled material to be ground is discharged from the cooling device 5 into the pipe 4 which conveys the material into the grinding container comprising a horizontally disposed longitudinal tube 1 closed at both its ends.

Under the influence of the vibratory movement and the continuously introduced material through the pipe 4, the individual particles of the material travel in the direction of the arrow 14 through the grinding container 1 which is filled with grinding bodies. The ground material passes at the right-hand end of the grinding container 1 through the small apertures provided in a partition 15 which permits solely the passage of ground material, while the grinding bodies remain in the grinding chamber of the tube 1. The ground material is then conducted through the connecting pipe 6 into the grinding tube 2 which likewise is filled with grinding bodies. In this grinding tube 2 the material to be ground travels under the influence of the vibratory movement and the constantly supplied ground material from the discharge end of the connecting pipe 6 in the direction of the arrow 16 toward the discharge pipe 7 of the grinding tube 2 and from there into the collecting container 8.

In order to compensate for the "cold losses" which occur during the grinding operation which latter produces heat in spite of the arrangement of the insulating jackets on the grinding tubes, a nozzle 18 introduces into the grinding chamber of the grinding tube 1 at a place above the surface 17 of the material to be ground additional refrigerant. At the place where this nozzle 18 enters the grinding chamber a thermometer probe 19 is arranged which by means of a regulator 20 cooperates with a regulating valve 21 which is arranged ahead of the injection nozzle 18 to the left thereof. The arrangement of the injection nozzle 18 and of the thermometer probe 19 with respect to each other is such that the injection nozzle 18 extends farther into the grinding chamber than the thermometer probe 19 so that the measurement of the temperature is not influenced by the injected refrigerant.

The refrigerant which in the meantime has evaporated is withdrawn from the collecting container 8 and depending upon its temperature and amount is returned entirely or partly to the cooling device 5 for the purpose of primary cooling of the material in the cooling device 5.

Preferably the injection nozzle 18 is so constructed that the refrigerant is sprayed onto the surface 17 of the material to be ground and can enter this material while it performs a substantially helical movement which takes place in the direction of the arrow 14 and which is caused by a circular oscillating movement directed at right angles to the plane of the drawing.

Since depending upon the length of the grinding chamber and the period of the time the material remains in the grinding chamber, the amount of refrigerant introduced at the point of introduction of the material is not sufficient to keep the temperature in the grinding container constant, the invention provides that at a distance of about one half of the length of the grinding tube a second injection nozzle 22 is arranged which sprays additional refrigerant onto the surface 17 of the material to be ground in the grinding tube. For the purpose of regulating the amount of refrigerant with reference to the direction of movement indicated by the arrow 14, a thermometer probe 23 is arranged

spaced in front of the second injection nozzle 22 and this thermometer probe 23 is connected by its own regulator 24 with a corresponding regulating valve 25 arranged in the supply pipe leading to the nozzle 22. In view of the fact that the thermometer probe 23 is arranged with reference to the axial direction of movement of the material in front of the injection nozzle 22, the rise in temperature in the first half of the grinding chamber, namely from the point of introduction in the range of the introduction of the material up to about the center of the grinding chamber, may be regulated without being influenced by the amount of refrigerant sprayed by the nozzle 22 into the second half of the grinding chamber.

The regulators 20 and 23, respectively, are preferably constructed as so-called two-point regulators in which an upper and a lower temperature value are adjusted, so that when the upper value of the temperature is reached the regulating valve 21 or 25 is opened, while upon reaching the lower limit value of the temperature the regulating valve 21 or 25 is closed.

Each regulating circuit comprising a thermometer probe, a regulator, and adjusting valve, an injection nozzle and the grinding chamber may advantageously be modified in such a manner that by means of so-called timing elements arranged within the regulators when the upper limit value of the temperature is reached, the injection valve is only opened for a limited period of time so as to avoid that the regulating valve closes only then when the lower limit value has been reached. Preferably, these timing elements are so constructed that during the closure operation the injected amount is continuously reduced. In this manner the temperature variations can be kept within the adjusted limit values. It is not required to drop the temperature below the lower limit value of the temperature because this would only cause an additional amount of refrigerant. The so-called timing elements of the device which is to be regulated is suitably adjustable concerning the opening times of the valve.

The grinding tube 2 in which the final grinding operation takes place as the grinding tube 1 is provided in similar manner with injection nozzles, thermometer probes, regulators and regulating valves which operate in the same manner as these elements operate in the grinding tube 1.

In place of an automatic regulation, the thermometer probe may only be equipped with an indicating instrument. The operation of the regulating valves then takes place manually and if desired by remote control means. This last-named arrangement may then find application when in view of the size of the mill, the amount of the material to be ground, the quality of the insulation, etc., it is necessary to continuously introduce a refrigerant into the grinding chamber so that only excessive variations have to be controlled.

What we claim is:

1. Method for performing low-temperature grinding operations in a horizontal and longitudinal grinding chamber of a vibrating mill, comprising introducing the material to be ground at one end of said grinding chamber and causing it to travel toward the other end, introducing at least at one point of said grinding chamber adjustable amounts of a refrigerant into said grinding chamber above the surface of the material to be ground therein, and arranging a thermometer probe at each said point of refrigerant introduction at a point spaced

ahead of the points of introduction of said refrigerant when considering the travel direction of the material to be ground lengthwise in said grinding chamber, said thermometer probe being effective to adjust the amount of refrigerant introduced into said grinding chamber, so as to maintain in said grinding chamber a predetermined temperature.

2. Method according to claim 1, in which each of said thermometer probes is connected by its own regulator with the adjusting means of an individual regulating valve cooperating with means introducing a spray of refrigerant into said grinding chamber at a particular point.

3. Method according to claim 1, in which each of said thermometer probes is connected by its own regulator with the adjusting means of an individual regulating valve cooperating with means introducing a spray of refrigerant into said grinding chamber at a particular point, said regulator causing an opening and closing, respectively, of said regulating valve upon reaching a predetermined upper or lower temperature in said grinding chamber.

4. Method according to claim 1, in which each of said thermometer probes is connected by its own regulator with the adjusting means of an individual regulating valve cooperating with means introducing a spray of refrigerant into said grinding chamber at a particular

point, said regulator being provided with a timing element which is effective to close said regulating valve and continuously reduces the injection of refrigerant just prior to the reaching of the predetermined lower temperature.

5. Method according to claim 1, in which said refrigerant is sprayed in liquid form onto the surface of the material to be ground in said grinding chamber.

6. An arrangement for performing low-temperature grinding operations, comprising a vibrating mill provided with a horizontally disposed grinding tube, vibratory frame supporting said grinding tube, means for introducing the material to be ground at one end of said grinding tube, nozzle means for spraying at least at one point of said grinding tube adjustable amounts of a refrigerant onto the top surface of the material to be ground in said grinding tube, a thermometer probe for each said nozzle means arranged at a point spaced ahead of said nozzle means when considering the direction of travel of the material to be ground due to the vibrations of said grinding tube caused by said vibratory frame, and means connecting said thermometer probe with nozzle adjusting means to cause said nozzle means to spray said adjustable amounts of refrigerant into said grinding tube so as to maintain within the latter a predetermined temperature.

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