

[54] **PROCESS AND APPARATUS FOR  
GRINDING GRANULAR MATERIALS AT  
LOW TEMPERATURES**

[75] Inventor: **Anton Ledergerber**, Domatems,  
Switzerland

[73] Assignee: **Inventa AG fur Forschung und  
Patentverwertung**, Zurich,  
Switzerland

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[56] **References Cited**

**UNITED STATES PATENTS**

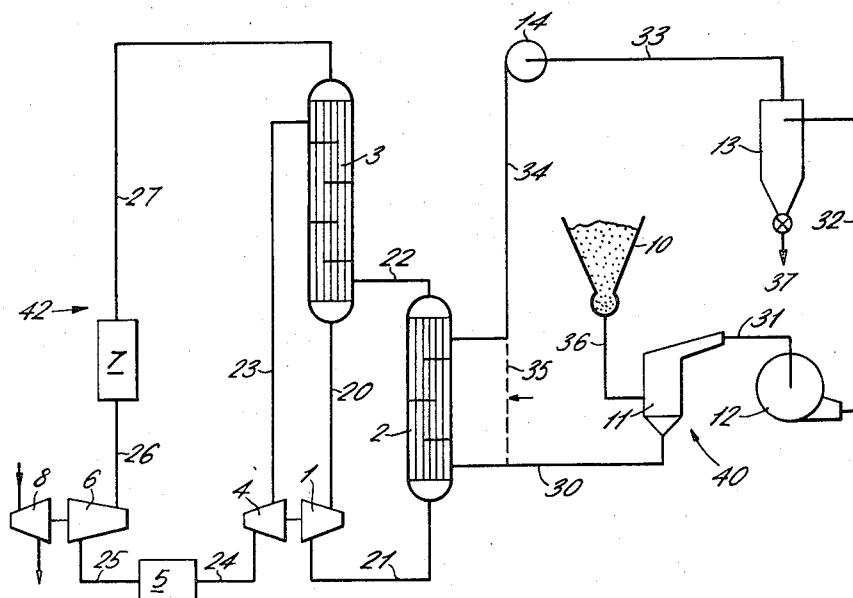
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Primary Examiner—Charles Sukalo  
Attorney, Agent, or Firm—Bierman & Bierman

[57] **ABSTRACT**

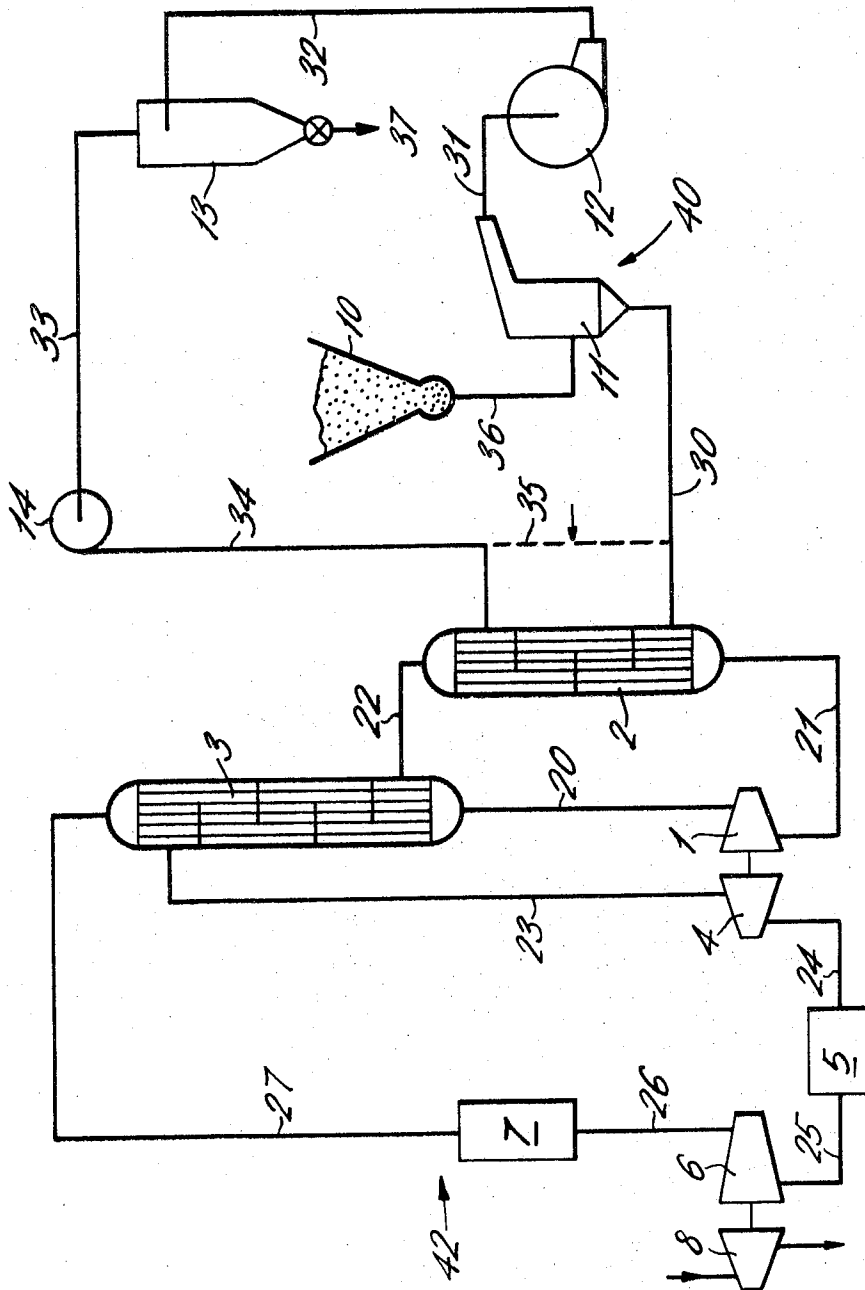
Method and apparatus for the grinding of granular materials is provided in which the granular material is kept cool during the grinding operation. A stream of cool gas is mixed with the granular material in the grinding mill and recycled to a heat exchanger in which its heat is given up to a cool gas being continuously recycled through the heat exchanger. Compression and isentropic expansion means are provided in conjunction with the cooling gas to control the temperature of the cooling gas and thereby the temperature of the gas which is mixed with the granular material.

**5 Claims, 1 Drawing Figure**



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ANTON LEDERGERBER  
INVENTOR

BY

Marmorick & Bitlerman, ATTORNEYS

# PROCESS AND APPARATUS FOR GRINDING GRANULAR MATERIALS AT LOW TEMPERATURES

In the grinding of granular materials into powder, the properties of the material require, in many cases, that the grinding operation be carried out at low temperatures. This applies in the grinding of granular plastics of rather great toughness and relatively low melting points. An example of such plastics is a copolymer formed out of the polyamides 6, 6,6 and 12, which must be ground substantially below 0° C so that a satisfactory powder capable of flowing and of uniform grain structure may be obtained.

If the heat generated during the grinding is not removed in a sufficiently effective manner, too high temperatures occur. Such heat generation may bring the material to a temperature above its melting point, so that the grinding effect is reduced and the output of the mill is considerably decreased.

There are various art-known methods for removing the heat of grinding. For instance, pre-ground solid carbon dioxide may be admixed with a pre-cooled charging product before it enters the grinding mill. The heat of grinding is then removed by a cooling medium, both partly from the pre-cooled charging product and from the vaporizing residual dry ice (solid CO<sub>2</sub>). Although good grinding results are obtained by this method, it nevertheless has the disadvantage that uniform metering of the carbon dioxide presents difficulties, as a result of which the maintenance of an exact temperature is not readily realizable. Moreover, the handling of the cooling medium is troublesome and operation is uneconomical.

Another possibility consists in the use of liquid nitrogen as a cooling medium. If there is direct contact between the liquid nitrogen and the charging product, the extremely low temperature may produce an impairment of the comminution properties of the charging product.

Both methods are not very flexible as regards temperature control and require either an installation for producing liquid gas connected directly to the grinding apparatus or troublesome transport of these refrigerating agents over rather large distances. These methods are therefore economically unattractive.

It has been found that these disadvantages can be reliably avoided by a process for grinding granular materials at low temperatures. In accordance with the present invention, the heat generated during grinding is removed from the mill by a cooled gas circuit which for its part gives up the absorbed heat via a first heat exchanger to a cold-gas circuit, the necessary refrigerating capacity being produced by an approximately isentropic expansion of a compressed gas in one or more expansion machines. The expanded gas, after absorbing the heat in the first heat exchanger, is heated in a second heat exchanger to approximately ambient temperature by transfer of heat to the same gas compressed in an interposed compressor, which is cooled to the intake temperature of the expansion machines in counter-current to the heat-absorbing gas stream.

With a sufficiently large refrigerating capacity, cold gas turbines as customarily used in gas liquefying plants may be employed as expansion machines. The braking of the turbines may either be effected electrically with the interposition of a conventional gearing mechanism,

useful energy being obtained, or a braking blower may be coupled directly to the turbine to pre-compress the gas. Both turbocompressors and reciprocating compressors may be employed for gas compression, depending upon the size of the required refrigerating capacity and on the pressure ratio employed.

Air is preferably employed as recycle gas, since in this way the cost of topping up the system in the event of leakage losses is low. Of course, other gases which are not liquefied in the working range may also be employed.

The process according to the invention allows the temperature during the grinding operation to be adjusted simply and within wide limits to any desired level and to be kept exactly constant thereat. Regulation may be effected by varying the pressure gradient in the refrigerating circuit, by varying the amount of gas in circulation or by varying the effective heat-exchanger area. The cost of cold production by the new process is substantially smaller than in the case of the other processes that are known and operation is extremely simple in comparison to known processes.

The process will be explained in the following Example with reference to the accompanying drawing.

5,000 kg of air at 10 atmospheres absolute are expanded in the expansion turbine 1 to 1.5 atmospheres absolute, the air being cooled from -60° to -130° C. The cooled air is then conveyed through the pipe 21 to the first heat exchanger 2, being heated to -90° C by absorption of heat from the grinding circuit. In the heat exchanger 3, the air is heated further to +10° C, the heat being extracted from a stream of air carried in counter-current, as is explained hereinafter. The air leaving the heat exchanger 3 is conveyed through the pipe 23 to the braking blower 4, where it is compressed from 1.2 to 1.8 atmospheres absolute. After intermediate cooling in the cooler 5, the air passes to the compressor 6 and is compressed thereby to 10 atmospheres absolute. Shown coupled to compressor 6 is a steamturbine 8 which can be replaced by any other suitable prime mover to drive the compressor 6.

In the final cooler 7, the heat of compression is given off and the air finally passes through the pipe 27 back to the heat exchanger 3, in which the re-cycled air is cooled to the turbine intake temperature of -60° C.

The stream of air contained in pipe 34 is cooled to -100° C in the heat exchanger 2 and recycled to pipe 30 to a fluidized bed cooler 11, in which the plastics granules fed from the supply vessel 10 are pre-cooled. The mixture of air and granules passes through the pipe 31 to the mill 12, in which the granules are crushed into powder. The heat of grinding that is generated is removed from the stream of charging product, as a result of which the air temperature increases to -60° C. The powder is separated from the recycled air in the separator 13 and is conveyed to a screening arrangement through valve 37, while the air is carried back to the heat exchanger 2 by the fan 14.

Conduit 35 (dotted lines) may be used in an alternative embodiment to recycle a portion of the heated air to pipe 30 to somewhat raise and regulate the temperature of air in conduit 30. Appropriate conventional valves may be used to achieve this.

In effect, two separate gas flow circuits are shown. The first is indicated generally by numeral 40 and carries the gas used to cool the granular material as it is ground in grinding mill 12. The second circuit is a

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closed gas circuit indicated generally by numeral 42 and is the circuit used to control the temperature of the gas flowing in the first circuit 40. The only element common to both circuits is heat exchanger 2, although the gases contained in the two circuits are not intermixed with each other by heat exchanger 2.

While only a limited number of embodiments have been shown and described, it is to be understood that many other modifications will occur to those skilled in the art. It is intended to cover all such modifications which fall within the spirit and scope of the appended claims.

What is claimed is:

1. In a process for controlling the temperature of granular material during grinding in a grinding mill of the type in which the granular material is mixed with a cold gas prior to grinding, separated from the ground material after grinding, recooled in a heat exchanger and then reused to cool additional granular material during grinding, the improvement comprising the steps of feeding a gas which is cooler than the separated gas to the first heat exchanger such that the separated gas gives up at least a portion of its heat to said cooler gas, then heating said gas to approximately ambient temperature in a second heat exchanger, expanding said heated gas substantially isentropically to a predetermined cooler temperature in an expansion machine and recycling said cooler gas to said first heat exchanger.

2. The process specified in claim 1 wherein the step of heating the gas in the second heat exchanger com-

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prises the steps of feeding gas having a temperature greater than that of the gas to be heated into the second heat exchanger, the warmer gas being fed into said second heat exchanger in counter-current to the direction of flow of the gas to be warmed.

3. The process specified in claim 2 wherein the warmer gas is obtained by removing the heated gas from the second heat exchanger after it has been heated, compressing the removed gas, and recycling back to the second heat exchanger.

4. The process specified in claim 3 further comprising the steps of removing the gas fed in counter-current in said second heat exchanger and feeding it to said expansion machine.

5. Process for grinding granular materials, in particular granular plastics, at low temperatures, characterized in that the heat generated during grinding is removed from the mill by a cooled gas circuit which for its part gives up the absorbed heat via a first heat exchanger to a cold-gas circuit, the necessary refrigerating capacity being produced by an approximately isentropic expansion of a compressed gas in one or more expansion machines, and the expanded gas, after the heat absorption effected in the first heat exchanger, being heated in a second heat exchanger to approximately ambient temperature by transfer of heat to the same gas compressed in an interposed compressor, which is cooled to the intake temperature of the expansion machines in counter-current to the heat-absorbing gas stream.

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