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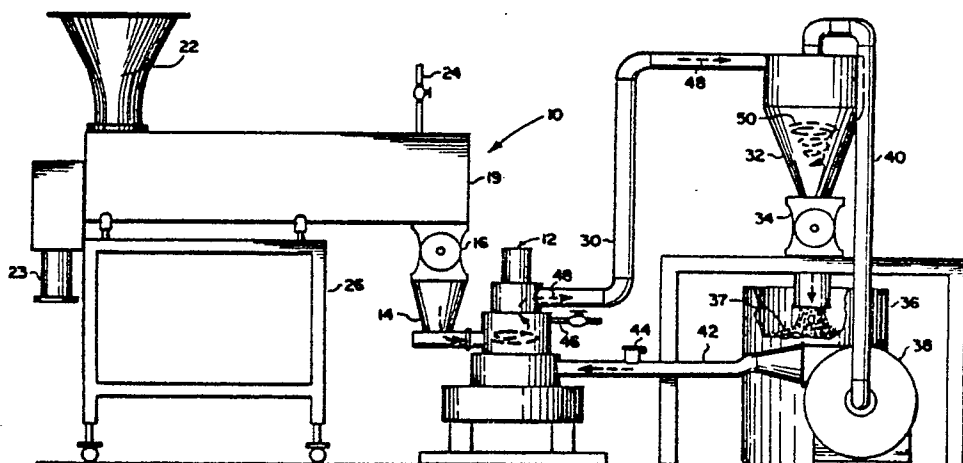
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(54) Method and apparatus for fine grinding.

(57) A method and apparatus for fine grinding materials normally difficult to grind at ambient temperature, e.g. plastic and elastomeric materials and foodstuffs in a fluid classification type impact mill utilizing liquid cryogen to pre-cool the material to be ground, to cool the material and the mill during grinding and to recycle vaporized cryogen from the mill back into the mill as the medium for conveying material to be ground into the mill.

FIG. 1



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METHOD AND APPARATUS FOR FINE GRINDING

TECHNICAL FIELD

5 The present invention pertains to fine grinding and especially to fine grinding of plastic and elastomeric materials and foodstuffs.

BACKGROUND OF THE PRIOR ART

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Fine grinding, pulverizing or size reduction all terms used to denote comminution of relatively soft or resilient materials such as rubbers and plastics has been the subject of a great deal of interest and research for many years. In particular the rubber and plastics industry has been interested in fine grinding scrap or
15 reject material in order to recycle the material for reuse. However, in order to make effective use of recycle material the recycle material must be ground to a particle size finer than 80 mesh in order to be mixed with virgin material for reuse.

An effective and economically cost justifiable fine grinding system would be an asset to the rubber and plastics industry because of the various states and the federal government making it more and more
20 difficult to dispose of scrap rubber and plastic material. Currently there is no economical process for producing powdered rubber or plastic or a particle size finer than 80 mesh. Thus large amounts of scrap and reject material are being stockpiled for recycle or disposition in accordance with current environmental laws.

In the past several attempts have been made to solve the problem of fine grinding by utilizing different
25 types of grinding (pulverizing, size reducing or comminution) mills which incorporate a liquid cryogen such as liquid nitrogen either before or inside the mill.

For example conventional hammer mills have utilized liquid nitrogen both inside the mill and before the mill in a pre-cooler. However over the past decade within which these devices have been used it has been
30 found that the hammer mill cannot grind the tough rubber and plastics economically because of the excessive amount of liquid nitrogen required.

Attrition mills have also been modified to use liquid nitrogen both inside and before the mill in a pre-cooler. This also has been done for about 10 years and it is known that the attrition mill cannot grind the tough rubber and plastics economically due to excessive plate wear inside the mill.

Lastly air-swept impact mills (fluid classification mills) have been utilized with nitrogen to pre-cool the
35 material to be ground. Although a fine ground material was obtained the economics of the process were unfavorable due to the excessive amounts of liquid nitrogen required.

The art is replete with various types of schemes to utilize liquid nitrogen in combination with a grinding mill to effect the grinding of normally resilient or soft materials. U.S. Patents 2,609,150, 2,735,624, 2,919,862, 3,614,001, 3,771,729 and 3,273,294 illustrate the use of a liquid cryogen (liquid nitrogen) to pre-cool and/or cool the grinding mill to achieve a ground product.
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U.S. Patent 3,771,729 shows a particularly effective pre-cooling apparatus for conditioning the material for grinding.

Other techniques for grinding materials that are normally soft, viscous, plastic or elastomeric in nature at room temperature are illustrated in U.S. Patents 441,951, 637,465, 2,467,318, 3,314,802, 2,347,464,
45 2,435,503, 2,583,697, 3,647,149, 3,658,259, 2,665,850, 3,734,412, 2,836,368, 2,893,216, 2,974,883, 3,319,895.

SUMMARY OF THE INVENTION

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The present invention pertains to a method and apparatus for fine grinding (e.g. to a -40 mesh particle size) of plastic and elastomeric materials utilizing a fluid classification impact grinding mill combined with a liquid cryogen system to pre-cool the material to be ground, utilizing liquid cryogen inside the mill to cool the material during grinding which also cools the mill and recycle vaporized liquid cryogen for use as the

classifying fluid or the sweep fluid for the mill.

BRIEF DESCRIPTION OF THE DRAWING

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FIG. 1 is a schematic elevational view of the system and method according to the present invention.

FIG. 2 is a front elevational view, partially in section, of a fluid classification mill modified in accordance with the present invention.

10 FIG. 3 is a view taken along line 3-3 of FIG. 2.

FIG. 4 is a bottom plan view of the manifold according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

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Referring to FIG. 1 the overall system according to the invention is designated generally by the numeral 10. System 10 includes as the central apparatus a fluid classification impact mill 12 such as offered for sale by Mikropul Division of Hosakawa Micron International Inc., Summit, New Jersey, 07910, under the product designation ACM Micro Pulverizer.

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Material is conveyed to the mill 12 for grinding by means of a transition chute 14 which is connected to an air lock 16 which in turn is connected to a cooling conveyor 18. Cooling conveyor 18 is preferably of the type shown and described in U.S. Patent 3,771,729 and offered for sale by Air Products and Chemicals, Inc., Trexlertown, Pennsylvania under the Cryo-Grind trademark. Cooling conveyor 18 has a feed hopper 22 as well as a conduit 24 for admitting liquid cryogen to the conveyor as shown in the '729 patent. Conveyor, 25 18 can be of any type that will provide means for pre-cooling the material to be ground to its embrittlement temperature. Cooling conveyor 18 can be conveniently disposed on a portable carriage or table 26 and includes drive mechanism 23. Downstream of mill 12 and connected to mill 12 via suitable piping 30 is a separator 32 such as a cyclone separator. Cyclone separator 32 has disposed at its discharge opening an 30 air lock 34 to permit discharge of the product into a receptacle or drum 36 without opening the system to ambient atmosphere.

A recycle blower 38 receives the vaporized cryogen exiting mill 12, after separation of the product 37 through suitable fluid tight connections and piping 40. Recycle blower 38 conveys the separated vaporized cryogen back to the mill 12 by means of conduit assembly 42 which includes a pressure relief valve 44.

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A suitable conduit 46 conveys liquid cryogen to the mill 12 in a manner as will hereinafter be more fully disclosed.

The process according to the invention as practiced in the apparatus or system of FIG. 1 takes place by introducing material to be ground to the cooling conveyor 18 by means of the hopper 22 and air lock 20. As the material is conveyed through the cooling conveyor 18 it is pre-cooled by liquid nitrogen introduced to 40 the cooling conveyor through conduit 24 to cool the material to its embrittling temperature. The material after cooling in cooling conveyor 18 is conveyed through a suitable air lock 16 and transition chute 14 to the fluid classification impact mill 12. As is well known in the art mill 12 can be adjusted to provide product of a given fineness. In the case of the present invention the mill is set to grind the starting material to a size that will pass through an 80 mesh (U.S. Standard) screen. The fine ground material entrained in vaporized 45 cryogen exits the mill 12 in the direction shown by arrow 48 and enters the classifier or cyclone 32 where the particles shown by arrow 50 are separated from the vaporized cryogen and collected as product 37 in product drum 36. The vaporized cryogen exiting the cyclone 32 is conveyed by circuit 40 to the inlet or suction side of blower 38 whereby it is recycled to the fluid classification mill 12 to be used as the classification fluid as will hereinafter be more fully explained. Thus material processed according to the 50 invention can be finely ground very effectively. The process is economical because the vaporized cryogen is recycled to be used as a classification fluid but more importantly the low temperature of the vaporized cryogen is utilized as an aid in cooling of the incoming product and the mill.

The process according to the present invention can be operated effectively with the following process conditions:

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Table 1

Piece of Equipment	Process Variable	Operating Limits
Cooling Conveyor	Temperature	0 ° F to -320 ° F
Cooling Conveyor	Speed	0 to 100 volts
Fluid Classification Mill	Temperature	+ 70 ° F to -320 ° F
Fluid Classification Mill	Classifier Speed	0 to 5000 rpm
Blower	Speed	100 to 3500 rpm

Most common materials can be ground to size utilizing the parameters set out above. Experimentation has shown if the process is operated significantly outside the above limits the particle size required cannot be produced economically.

Scrap or recycle tire tread has been ground successfully utilizing the process of the present invention which material has been incorporated into virgin material for remolding.

FIG. 2 shows a fluid classification grinding mill such as the ACM Mikro pulverizer identified above which has been modified in accord with the present invention. Mill 12 includes an inlet chamber 60 containing an inlet conduit 64 which in turn is connected to the transition chute 14 of FIG. 1 by suitable fittings (not shown). Chamber 60 contains means for supporting a central rotor 64 which in turn is connected to the pin rotor 66 which supports a plurality of hammers 68. Chamber 60 has mounted thereon a housing 70 which in turn supports a second housing 72 which contains an outlet conduit 74 which in turn is connected to the piping 30 as shown in FIG. 1. Disposed within housings 70 and 72 is a separator shaft and bearing housing 4 which in turn supports the rotatable classifier 76. Disposed within housing 70 and surrounding a portion of the rotating classifier 76 is a shroud and baffle ring 78. Material to be ground is introduced to the mill 12 via a feed hopper and auger device 14 as is well known in the art. This basically is the conventional fluid classification impact grinding mill. In normal operation the material to be ground enters the mill and is contacted by hammers 68. A classification fluid (e.g. nitrogen) enters the mill through inlet conduit 64 as shown by arrows 80 and flows through the mill to drive the particles in the direction shown by the arrows. The ground particles pass through the classifier 76 in accordance with the speed of rotation of the classifier and the selected particles are removed with the nitrogen via the arrows as shown. According to the present invention a spray header or manifold 82 is disposed inside of the shroud and baffle ring 78. Spray header 82 is adapted to direct liquid cryogen, e.g. liquid nitrogen in the direction shown by the hollow arrows 84. Spray header 82 is in turn connected through a suitable fitting 86 to a source of liquid cryogen (not shown). Spray header 82 can be disposed at the top of the shroud and baffle ring, at the bottom thereof as shown by the ghost lines or at any position intermediate thereof depending upon the mill and the degree of cooling and liquid cryogen consumption required. Tests have shown most economical use of liquid cryogen is effected when spray header 82 is disposed at the bottom of shroud and baffle ring 78. Liquid cryogen injected into the mill cools not only the mill, but the product as it is being ground. As the cryogen contacts the particles to be ground, it warms up and it vaporizes the vapors forming part of the product arrows 85 which leave the mill 12 and are conducted towards the cycle 32 for separation and recycled to the mill as hereinafter described.

Figure 3 shows the shroud and baffle 78 and the housing 70 as well as the spray header 82. Spray header 82 as shown in figure 4 is basically a circular tube containing a plurality of orifices or holes 90 for directing the liquid nitrogen towards the product being ground. Spray header 82 is constructed with a suitable manifold 94 so that the liquid cryogen entering the inlet conduit 96 passes to the orifices 90 without diminution.

Utilizing the method and apparatus according to the present invention of the total volume of liquid cryogen (e.g. liquid nitrogen) used, 10-20% is used in the pre-cooler with the balance being used for direct injection into the mill.

Having thus described our invention, what is desired to be secured by Letters Patent of the United States is set forth in the appended claims.

Claims

1. A method for utilizing a fluid classification impact grinding mill for fine grinding comprising the steps of:
pre-cooling the material to be ground to a temperature below its embrittlement temperature;

injecting said pre-cooled material into said mill while simultaneously injecting a liquid cryogen into said mill;
 recovering said ground material and cryogen vaporized in said mill;
 separating said vaporized cryogen from said ground material and recycling said vaporized cryogen to said mill as a classifying medium.

- 5 2. A method according to Claim 1 wherein said liquid cryogen is nitrogen.
3. A method according to Claim 1 wherein said pre-cooling is accomplished by utilizing liquid cryogen.
4. A method according to Claim 1 wherein said ground material is recovered as a product.
5. A method according to Claim 1 wherein the ground material has a particle size that will pass a 40 mesh screen.
- 10 6. A closed system for fine grinding rubber and plastic material comprising in combination means for collecting and conveying said material to a fluid classification grinding mill said means including means to pre-cool said material to below its embrittlement temperature;
 a fluid classification grinding mill connected in fluid tight relation to said collecting and conveying means said mill including means to inject a liquid cryogen onto said material during grinding;
 15 removal means to conduct ground material and cryogen vaporized in said mill to separator means;
 separator means to separate such ground material from said vaporized cryogen;
 recirculation means to convey such vaporized cryogen from said separator means to said mill; and
 collection means to recover said ground material as a product.
7. A system according to Claim 6 wherein said collecting and conveying means includes a feed hopper
 20 and a cooling conveyor with an air lock therebetween.
8. A system according to Claim 6 wherein an air lock is disposed between said collecting and conveying means and said fluid classification grinding mill.
9. A system according to Claim 6 wherein said separator means includes a cyclone type separator.
10. A system according to Claim 6 wherein said recirculation means includes a blower the suction side
 25 connected to said mill through said cyclone and said output connected to said fluid classification mill.
11. In a fluid classification type grinding mill of the type wherein a normal gaseous fluid is used to convey particles to be ground into the mill and ground particles out of such mill, the improvement comprising:
 means to inject a liquid cryogen into the particles during grinding to cool said particles and said mill.
- 30 12. An apparatus according to Claim 11 wherein said means includes a spray header disposed in said mill above active grinding devices with means to direct said cryogen toward said active grinding devices.

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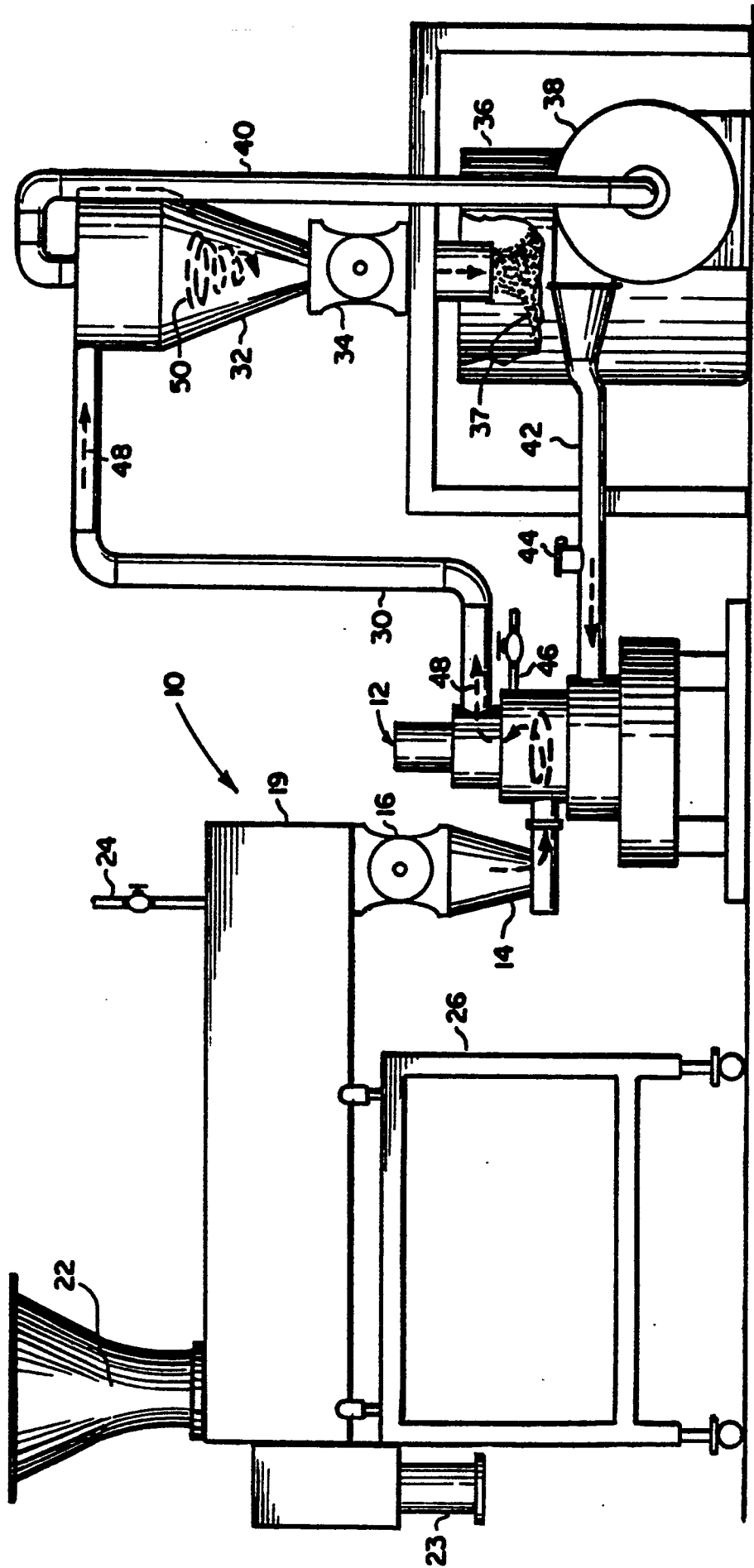
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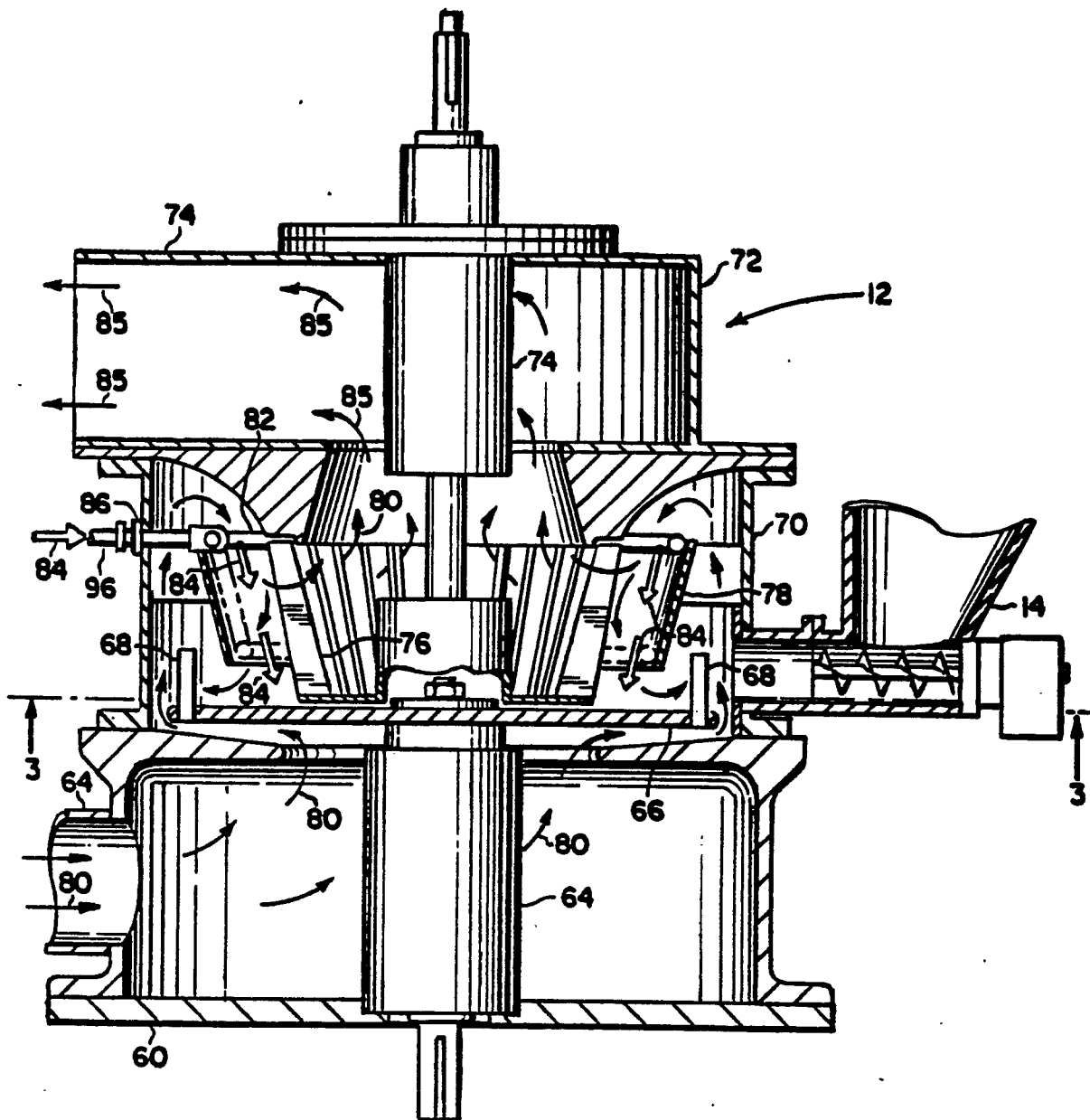
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FIG. 1



**FIG. 2**

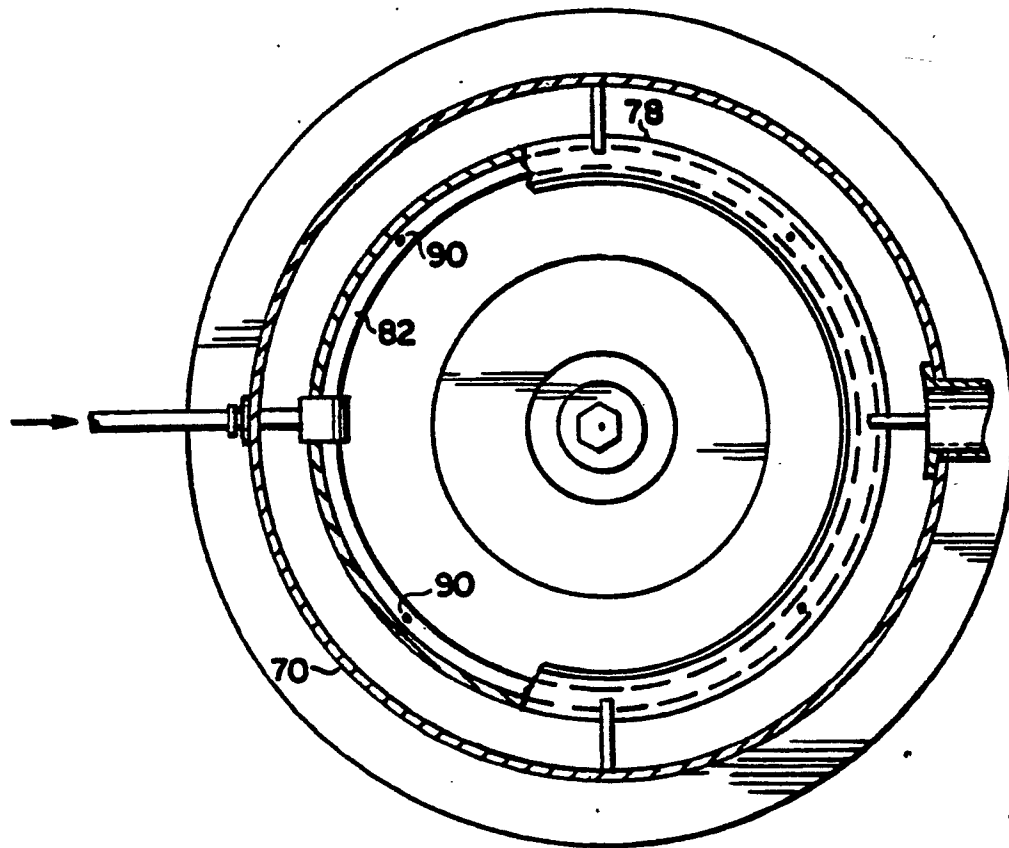


FIG. 3

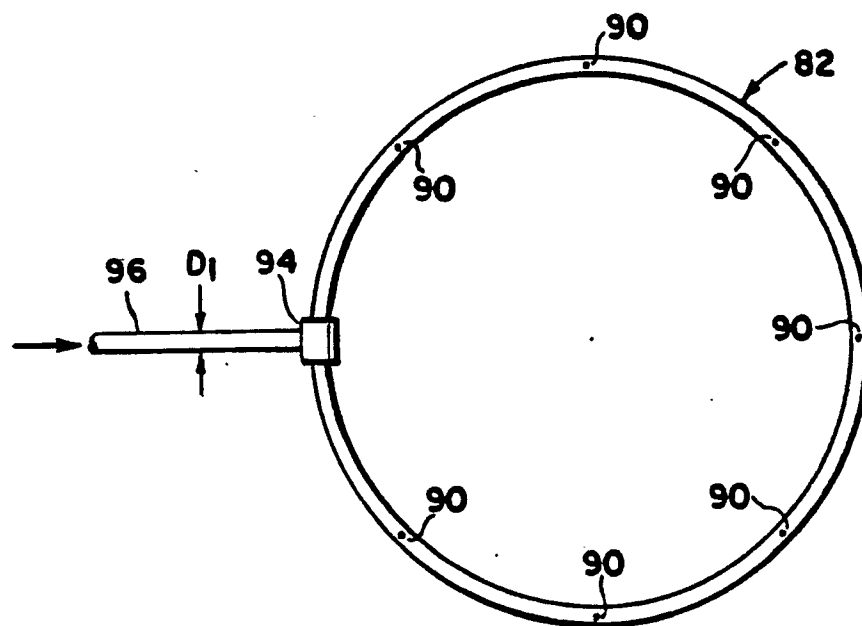


FIG. 4