United States Patent

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[54] TWO-STAGE HAMMER MILL

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[52] **U.S. Cl.** **241/55**, 241/154

[51] **Int. Cl.** **B02c 13/04**

[58] **Field of Search** 241/55, 56, 50, 51, 45, 154, 241/43, 73, 188, 185

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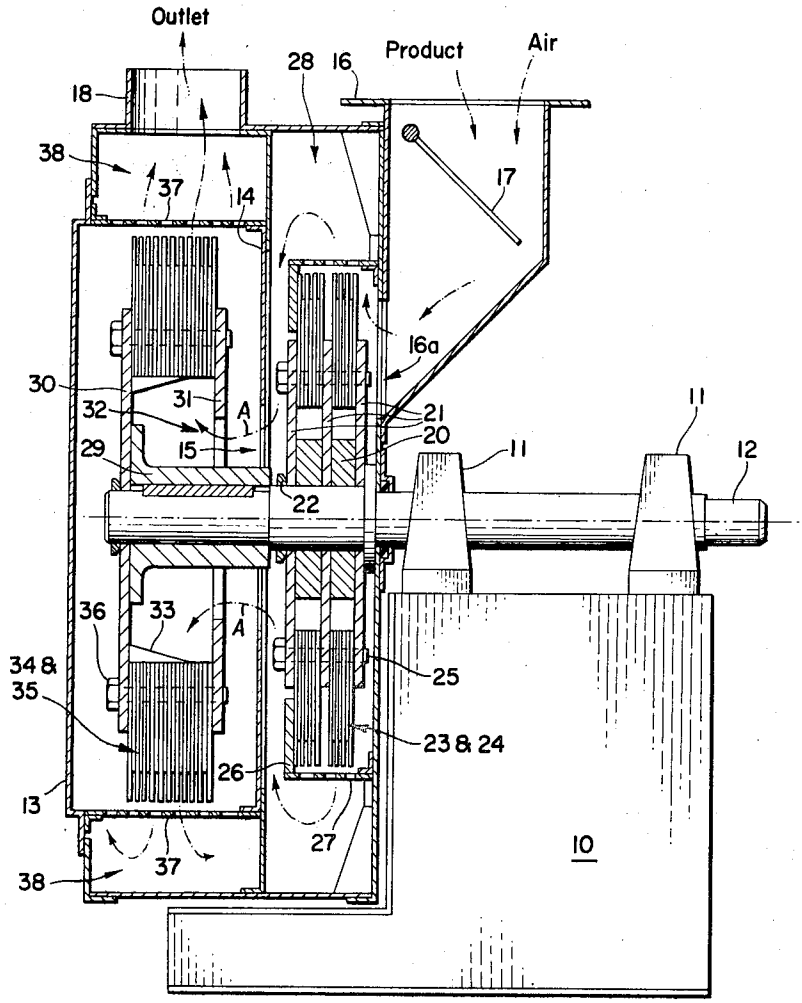
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[57] **ABSTRACT**

A two-stage rotary hammer mill having first and second rotary hammer mill stages mounted on a common drive shaft and driven together in unison, the first stage producing a semiground product, and the second stage receiving the semiground product and producing a finely ground product, in which the second stage incorporates blower means drawing air through the system and thereby ensuring free flow of product therethrough, the two stages being arranged in a common housing, and product released from the screen of the first stage being collected in a generally annular space and directed into a conduit and delivered to the second stage around the central axis thereof.

10 Claims, 6 Drawing Figures



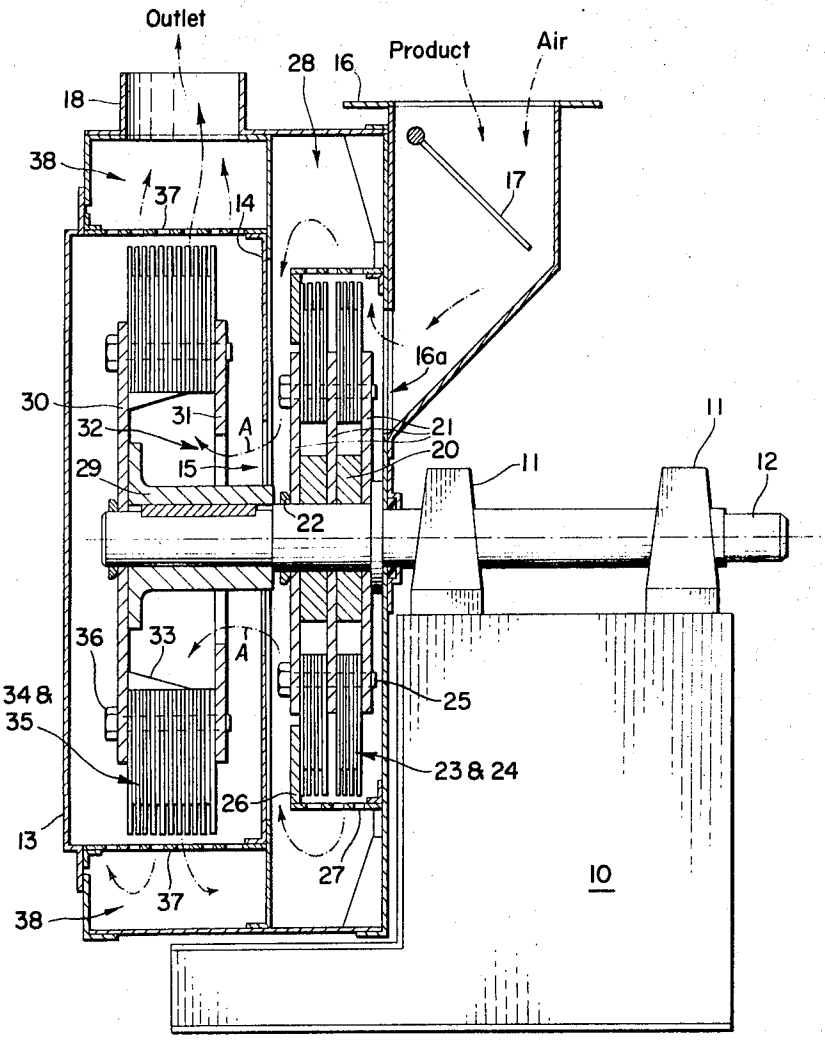


FIG. 1

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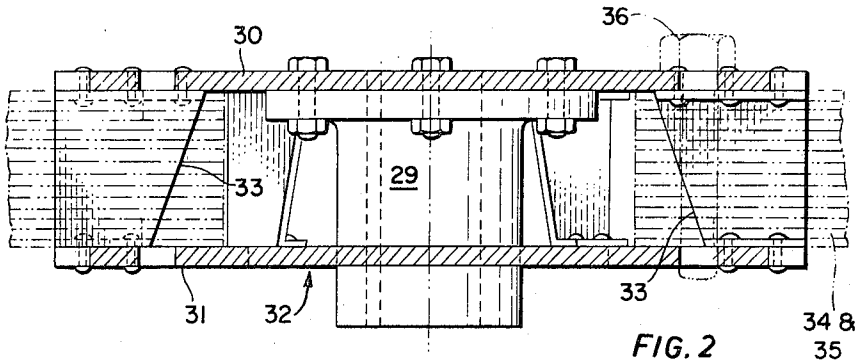


FIG. 2

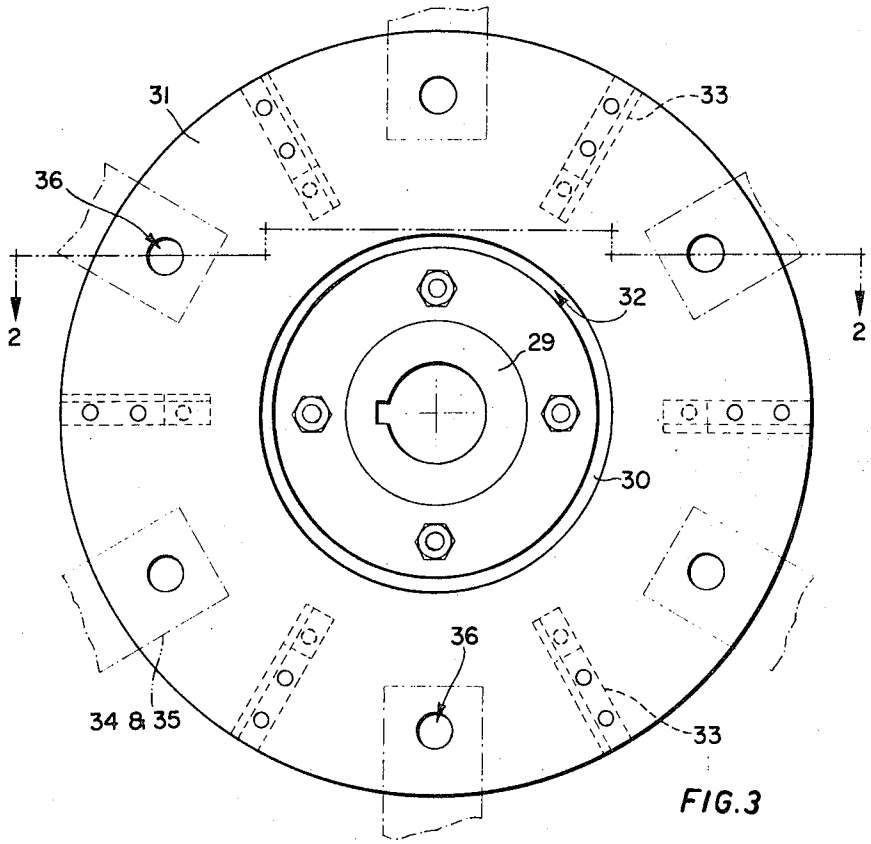


FIG. 3

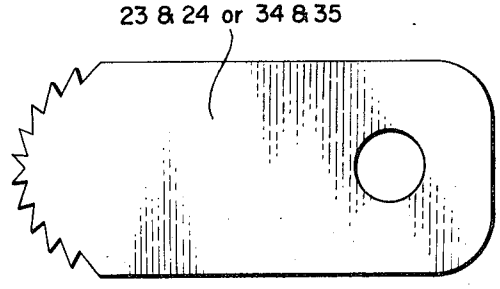


FIG. 4

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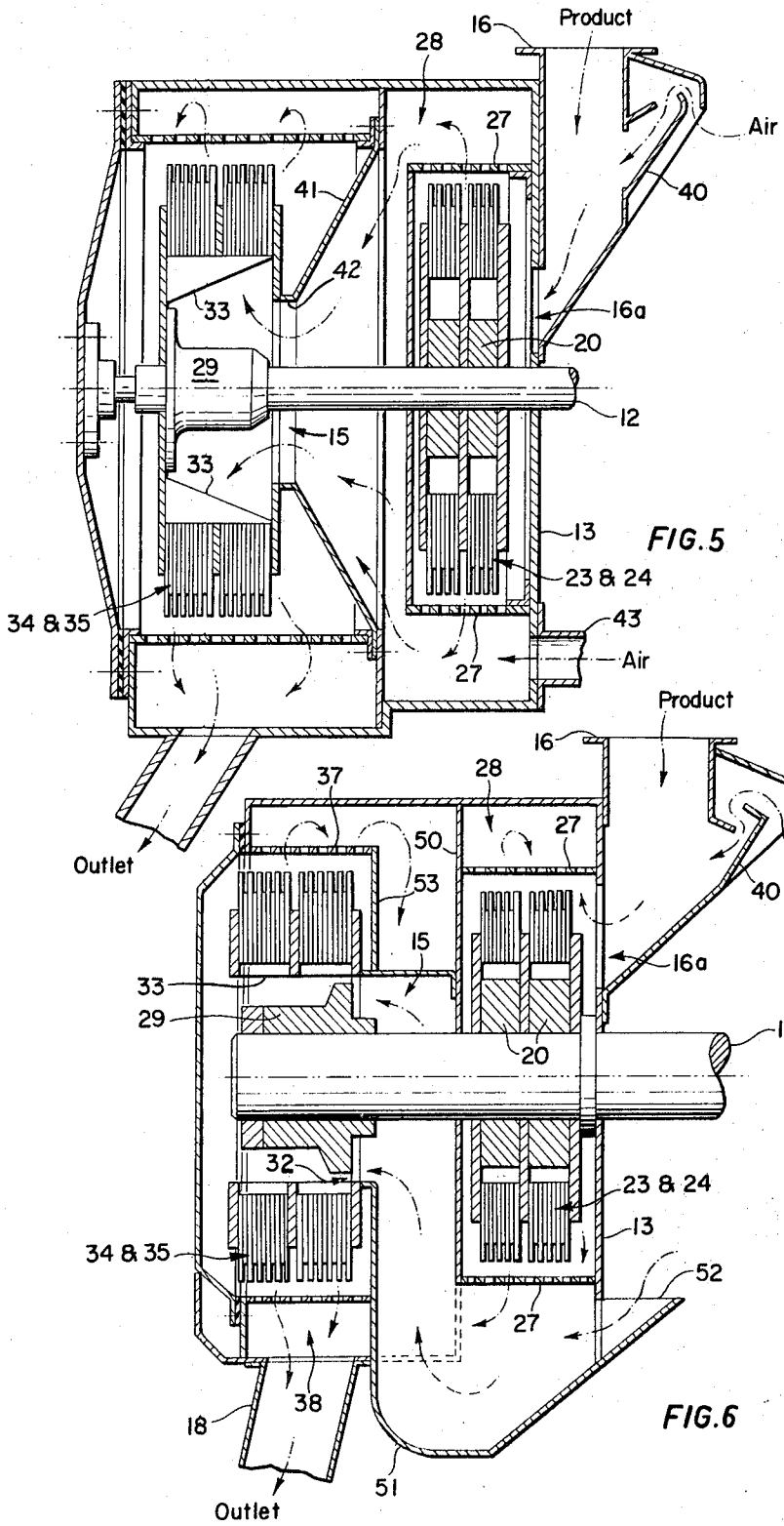


FIG. 5

FIG. 6

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TWO-STAGE HAMMER MILL

This invention relates to a hammer mill provided with two separate grinding stages operating simultaneously on a common drive shaft.

Single stage hammer mills are well known, in which the product to be ground is subjected to a flailing motion from a large number of so-called hammers or bladelike members carried on a central rotor. In such mills, it is common to experience a relatively high rate of wear, and the degree of grinding is not always consistent, especially when a substantial reduction in particle size is required in a single stage.

Furthermore, in such single stage hammer mills, if it is desired to obtain a consistent finely ground product, it is necessary that a fine screen should be employed, which obviously slows down the rate of flow of material therethrough. As a result, the speed with which a relatively coarse material can be ground is substantially restricted, and in fact, the rate of output, when using such a fine screen is quite inefficient and uneconomical. If it is attempted to speed up the input of coarse material, then the usual result has been to completely clog the screen.

In addition, the design of the hammers or flail like members within the hammer mill which are suitable for grinding coarse material may not always be suitable for grinding fine material, and vice versa. As a result, the maximum efficiency is seldom obtained.

One of the factors effecting the rate of flow of the fine material through a fine screen is the amount of airflow that can be achieved through the mill. Such finely divided material will seldom move under the influence of gravity, or even by the centrifugal forces applied within the mill. In fact, in order to move substantial masses of finely divided powdered material in the circumstances, it is found to be essential to provide for a substantial airflow so as to entrain the powdered material and clear the screen more rapidly.

With a view overcoming these various disadvantages the invention seeks to provide a hammer mill having two stages consisting of a coarse grind followed by a fine grind. The two rotor portions of the hammer mill are arranged spaced apart from one another on a common drive shaft, mounted within a common housing, and separated by a partition, the first stage providing a relatively coarse reduction of the material through a relatively coarse screen, after which the coarsely ground material flows around the partition into the second stage in which it is finely ground passes through a fine screen. Substantial quantities of air are entrained in the process, and the use of a two-stage rotor system is found to procure increased airflow therethrough by centrifugal action. Where extra heavy material is to be ground, additional air is admitted between the first and second stages, and the spacing between the first and second stage rotors on the drive shaft is increased, and an enlarged passageway is provided for flow of the coarsely ground material to the second stage rotor.

Accordingly it is an objective of the invention to provide two hammer mills on a common operating shaft, together with means for continuously and automatically conveying the semiground product from the first stage to the second stage, thereby substantially reducing the rate of wear and ensuring a more uniform end product and providing a greater reduction in particle size.

A further objective of applicant's invention is to provide a two-stage hammer mill, the semiground product being moved from the first stage to the second stage by pneumatic means.

A further objective of the invention is to provide a two-stage hammer mill in which the second stage is provided with fan means whereby air is continually drawn through the first stage thereby entraining the semiground product, and is blown directly out of the outlet end of the mill, entraining such ground end product with the mass of air being moved by such fan means for delivery in any desired manner.

More particularly, it is an objective of the present invention to provide a two-stage hammer mill having the foregoing advantages in which product is introduced to the rotor means in the first stage from one side thereof, and in which the semiground product exiting from the first stage is introduced to the second stage more or less around the axis of the common drive shaft and into a central region of the second stage rotor, and passes outwardly through such second stage rotor under centrifugal force and substantial airflow, induced by such second stage rotor.

More particularly, it is an objective of the present invention to provide a two-stage hammer mill having the foregoing advantages which is particularly adapted for heavy duty grinding in which air is introduced to the first stage, and in which conduit means are provided between the output side of the first stage, and the axial input side of the second stage, and in which additional air is introduced into such product conduit.

More particularly, it is an objective of the present invention to provide a two stage hammer mill having the foregoing advantages in which the second stage rotor is of greater diameter than the first stage rotor thereby providing increased peripheral speeds of the grinding members in the second stage.

The foregoing and other objectives will become apparent from the following description of a preferred embodiment of the invention which is given here by way of example only with reference to the following drawings in which like reference devices refer to like parts thereof throughout the various views and diagrams and in which;

FIG. 1 is a side elevational view of a two-stage hammer mill according to the invention, with the principal features thereof sectioned and designed for high volume use with lighter more easily ground feed;

FIG. 2 is a greatly enlarged side elevational view of the second stage rotor of the mill shown in FIG. 1;

FIG. 3 is an end elevational view of the rotor member shown in FIG. 2;

FIG. 4 is an enlarged end elevational view of a hammer blade member.

FIG. 5 is a sectional side elevational view of an alternative embodiment of the invention particularly designed and adapted for medium duty operation, and,

FIG. 6 is a sectional side elevational view of a still further embodiment of the invention particularly designed and adapted for heavy duty use.

Referring now to FIG. 1 the invention will be seen to comprise a base **10** having bearings **11** carrying a shaft **12** driven by any suitable means (not shown). A stationary rotor housing **13** is supported by any suitable means (not shown), and is divided by partition **14** into first and second rotor chambers, communicating through a central circular port formed in partition **14** and indicated as **15**. A product inlet opening indicated as **16** in housing **13** and is provided with an airflow regulating vane **17** adjustably mounted therein. A product outlet port **18** communicates with the second rotor chamber for delivery of finely ground product therefrom.

The first rotor stage consists of a rotor member **20** preferably being provided with three separate disc portions **21** member **20** being attached to shaft **12** by any suitable means such as a retaining member. Long and short hammer blade members **23** and **24** (which are seen edge on in FIG. **1**, and are shown in more detail in FIG. **4**), are mounted side by side with one another on mounting bolts **25**. It will be understood that blades **23** and **24** are of different lengths although being substantially of the shape shown in FIG. **4** and are mounted alternately along respective bolts **25** in spaced apart locations around rotor member **20**, there being in all approximately six such bolts **25** carrying respective groups of blades **23** and **24** in this preferred embodiment. The annular retaining wall **26** is fastened within housing **10** closely adjacent the path of the rotor blades **23** and **24** as shown, and an annular screen **27** is supported between member **26** and housing **13** for screening the semiground product from the first rotor stage and permitting the same to escape radially outwardly therefrom as soon as the same passes the mesh of such screen **27**. Housing **13** defines a substantial annular space indicated generally as

28 around screen 27 for the purpose of permitting free passage of ground product therefrom, and space 28 in turn communicates with the disc shaped passageway, lying between member 26 and partition member 14, thereby providing free communication of air and entrained semiground product, along the pathway indicated by the arrow A through the port 15 and into the second stage.

The second stage of the present invention consists essentially of a second hammer mill assembly generally similar to the hammer mill assembly in the first stage although somewhat larger, together with a centrifugal fan for drawing air through the first stage and then entraining the product and blowing the same out of the outlet 18. Both the hammer mill assembly and the centrifugal fan of the second stage are supported on the same rotor member 29 which is preferably provided with two separate disc portions 30 and 31 respectively, disc member 31 being provided with a central annular opening 32 through which semi or partially ground product from the first stage may enter from port 14. In this preferred embodiment, six separate fan blades 33 are mounted between disc members 30 and 31 arranged therearound in a radial manner as shown in FIGS. 2 and 3. In addition to such fan blades 33 there are provided, in this preferred embodiment, six groups of hammer blade members 34 and 35, blade 34 and 35 being of different lengths, although being substantially of the shape shown in FIG. 4. Blade members 34 and 35 are mounted side by side alternately on mounting bolts 36. An annular screen member 37 is supported within housing 13, closely adjacent to the circumferential path of blades 34, to permit the escape of ground product therefrom, and housing 13 further defines a substantial annular space indicated generally as 38 extending around the exterior of screen member 37, for permitting free flow of ground product entrained with air from screen 37 therearound and out of outlet 18.

In operation, product is introduced through the inlet 16, and enters the housing 13 to one side of the primary rotor 20, which is rotating at high speed, thereby causing such product by centrifugal force to flow outwardly between the hammer blade members 23 and 24, and is ground by such hammer blade members 23 and 24 against the mesh screen 27. As stated, screen 27 is relatively speaking coarse in relation to the produce being ground, whereby only a semigrinding or coarse reduction takes place after which the semiground product is free to pass through the screen 27 into the annular passageway 28. Since both rotors 20 and 29 are mounted on a common shaft, rotor 29 will be rotating at the same speed at rotor 20, and the fan blade means 33 on the rotor 29 will cause a relatively massive air flow therethrough and outwardly through product outlet 18. Air expelled by this means can of course enter through the product inlet 16, and as a result there is a continual relatively massive air flow through inlet 16, and around the rotor 20, through the mesh screen 27 into the annular space 28 and thence through the opening 15 in partition 14 and out of outlet 18. Such airflow will entrain with it the semiground material exiting from the screen 27 into the space 28 and such material will be carried by such air in the direction of the arrow A passing through the disc-shaped passageway between the rotor 20 and the partition 14 until it passes through the central axial opening 15 into the second stage. At this point, due to the impeller action of the fan blades 33, the air and entrained semiground product passes through the axial opening 32 in the rotor disc member 31 and is then expelled outwardly by centrifugal force and combined airflow between fan blades 33 and hammer blade means 34 and 35. At this stage, such semiground product is then subjected to further fine grinding between the blades 34 and 35 and the fine screen 37, after which, as soon as the same passes through such fine screen 37 it enters the annular space 38 and exits from the housing 13 through outlet 18, being entrained with the mass airflow exiting therefrom.

According to a further embodiment illustrated in FIG. 5, where a medium weight of product is to be ground, the design of the housing 13 and partition 14 may be modified to ensure a somewhat freer product flow from the first stage to the second stage, and in addition, additional air inlet means are provided in the housing to permit the introduction of additional air between the first and second stage.

Thus as shown in FIG. 5, the housing 13 is provided with a product inlet 16, and a primary air inlet means 40 permits the introduction of air somewhat closer to the first stage, than in the embodiment of FIG. 1, thereby ensuring that the incoming unground product is fully aerated and flows freely. The design of the first and second stage rotors 20 and 29 is essentially the same as in the embodiment of FIG. 1, with the exception that they are spaced somewhat further apart on the drive shaft 12 in order to permit freer flow of air and entrained semiground product from the first to the second stage. In addition, the partition member 41 is provided, corresponding to the partition member 14 of FIG. 1, partition 41 being of generally frustoconical saucer-shaped construction and provided with lips 42 defining the opening 15 therethrough, the lips 42 opening directly into the central axial spacing around rotor 29 whereby to ensure that the air and entrained semiground product passes directly into such central axial region and is completely ground thereafter. The annular spacing 28 is provided around the screen 27, and, since the product being ground in this embodiment will be somewhat heavier, the majority of such semiground products will fall under the influence of gravity to the lower region of such annular space 28. In order to ensure free and continuous flow of air and entrained semiground product from such annular space 28, a secondary air inlet 43 is provided adjacent the lowermost position of the annular spacing 28 whereby additional air is introduced into the system, such additional air being inducted by the fan blades 33 and the rotor member 29. As in the case of the embodiment of FIG. 1, the screen 37 of the second stage is of somewhat greater diameter and width than the screen 27 of the first stage, whereby to provide a greater screen area for the passage of the finely divided material without plugging of the screen at any particular location. A product outlet 18 is provided in a somewhat different location for delivery of the finely ground product therefrom.

As is apparent, by means of the embodiment of FIG. 5, the somewhat heavier product and semiground product from the first stage is provided with a somewhat larger passageway for freer flow of air and entrained semiground product, thereby ensuring maximum throughput at all times.

A still further embodiment of the invention is shown in FIG. 6 for heavy-duty use where an even heavier product is to be ground. In this case, the housing 13 is separated essentially into two separate compartments by means of the partition 50, and the primary and secondary rotors 20 and 29 are spaced still further apart on the drive shaft 12, although again, being of essentially the same design as in the embodiment of FIGS. 1 and 5. In the embodiment of FIG. 6, the screen 27 of the primary stage extends between the wall of the housing 13 and the partition member 50 thereby completely enclosing the primary rotor 20, the annular passageway 28 extending around the exterior of screen 27, and communicating at its power end with the product delivery duct 51. Duct 51 is located at the lower end of the housing 13 since substantially all of the heavy semiground product will quickly pass under the influence of gravity to the lower portion thereof. As in the case of the embodiment of FIG. 5, a primary air inlet 40 is provided adjacent to the product inlet 16, thereby ensuring free flow of unground product into the housing 13, to one side of the rotor 20 as shown.

A secondary air inlet indicated as 52 is provided communicating with the semiground conduit 51, permitting the intake of additional air to entrain and carry the semiground product upwardly through the opening 32 and into the central region of the secondary stage rotor 29. It will be noted that an additional partition 53 is provided in this embodiment substantially enclosing the secondary stage rotor 29, and the secondary stage screen 37 extends between the sidewall of the housing 13 and the partition 53. A product outlet 18 commu-

nicates with the annular space **38** for delivery of finely ground product therefrom.

In the operation of the embodiment of FIG. **6**, the unground product is introduced into the product inlet **16** and flows under the influence of gravity in through the opening **16***a* in housing **13**, and into the central region of the rotor **20** where it is thrown by centrifugal force outwardly between the hammer blades **23** and **24** and is ground to a semiground condition against the screen **27**. As soon as the semiground material passes through the screen **27**, it is drawn downwardly to the lower region thereof into the product conduit **51** by means of air inducted through the primary air inlet **40** and product inlet **16** under the influence of the fan blades **33** of the secondary stage motor. At this point, additional air is continually drawn in by the fan blades **33** through the secondary air inlet **52** and ensures that all such semiground product is completely entrained and drawn upwardly through the conduit **51**, and through the opening **15** of the partition **53** and through the opening **32** in the disc member **31** of the rotor **29** and into the central region of the rotor**2 9** where it is thrown outwardly by centrifugal force and is ground against the screen **37** by means of the blades **34**, **35**. The product then passes around the annular space **38** out of the product outlet **18**.

By this means, it is found that the power requirements of the system for reducing even relatively course material to a fine grind are greatly reduced, for a given product output in comparison with the power requirement of known systems, and, in addition, the rate of wear on the moving parts is greatly reduced, and the possibility of causing undesirable overheating of the product during grinding is also reduced.

The foregoing is a description of the preferred embodiment of the invention which is given here by way of example only.

What I claimed is:

1. A two-stage rotary hammer mill, for continuous grinding of a product in two steps, the first grinding stage reducing said product to a predetermined semiground condition, and the second stage reducing said semiground product to a more finely ground end product, said apparatus comprising:

housing means enclosing first and second grinding stages and having an inlet opening in said first stage and an outlet opening in said second stage;

partition means within said housing means separating said first and second stages;

a first rotary hammer mill means and mill screen means therearound, located in said housing means and spaced therefrom, and adapted to reduce said product to said semiground condition, and deliver same between said mill screen means and said housing means;

a second rotary hammer mill means in said second stage coaxial with said first hammer mill means and adapted to receive said semiground product, and further reduce the same to said finely ground end product;

drive means for said first and second stage hammer mill means;

an annular product outlet space around said first hammer mill means;

axial opening means in said partition means for conducting semiground product from said first stage to said second stage along the central axis of the second rotary hammer mill means;

product passageway means communicating only between said annular space and said opening in said partition; and,

fan blade means mounted on said second rotary hammer mill means for rotation therewith to draw air through said first stage and through said axial opening into said second stage and impel air out of said outlet thereby ensuring free flow of product through both said stages.

2. The apparatus as claimed in claim **1**, including a common housing for said first and second stages; and

a drive shaft extending into said housing, and said first and second stage hammer mill means mounted in spaced-apart relation on said drive shaft.

3. The apparatus as claimed in claim **1**, including an annular product outlet space around said second hammer mill means.

4. The apparatus as claimed in claim **1**, wherein said second stage includes at least two spaced-apart disc portions mounted on a central hub;

hammer members swingably mounted between said disc portions, and,

fan blade means mounted between said disc portions.

5. The apparatus as claimed in claim **4**, including an annular product inlet opening in one of said disc portions at least, arranged to admit semiground product around said hub member, said product thereafter passing between said disc members for grinding.

6. The apparatus as claimed in claim **1**, including primary air inlet means associated with said product inlet opening in said housing.

7. The apparatus as claimed in claim **1**, including secondary air inlet means communicating with said housing means for communicating additional air between said first and second stages.

8. The apparatus as claimed in claim **1**, wherein each said stage comprises at least two disc members mounted spaced apart from one another on a hub member, hammer members swingably mounted between said disc members for rotation in unison therewith, and annular screen means extending around and spaced from said hammer members.

9. The apparatus as claimed in claim **1**, wherein said partition means is shaped in the form of a shallow cone with the apex thereof directed towards said second stage, and a circular product opening formed in said partition around the apex of said cone.

10. The apparatus as claimed in claim **1**, including air inlet means communicating with said annular space around said first stage to permit entry of additional air.

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