March 3, 1964 L. PALYI 3,123,312

HAMMER MILL HAVING COAXIAL IMPELLER

Filed July 28, 1961 4 Sheets-Sheet 1

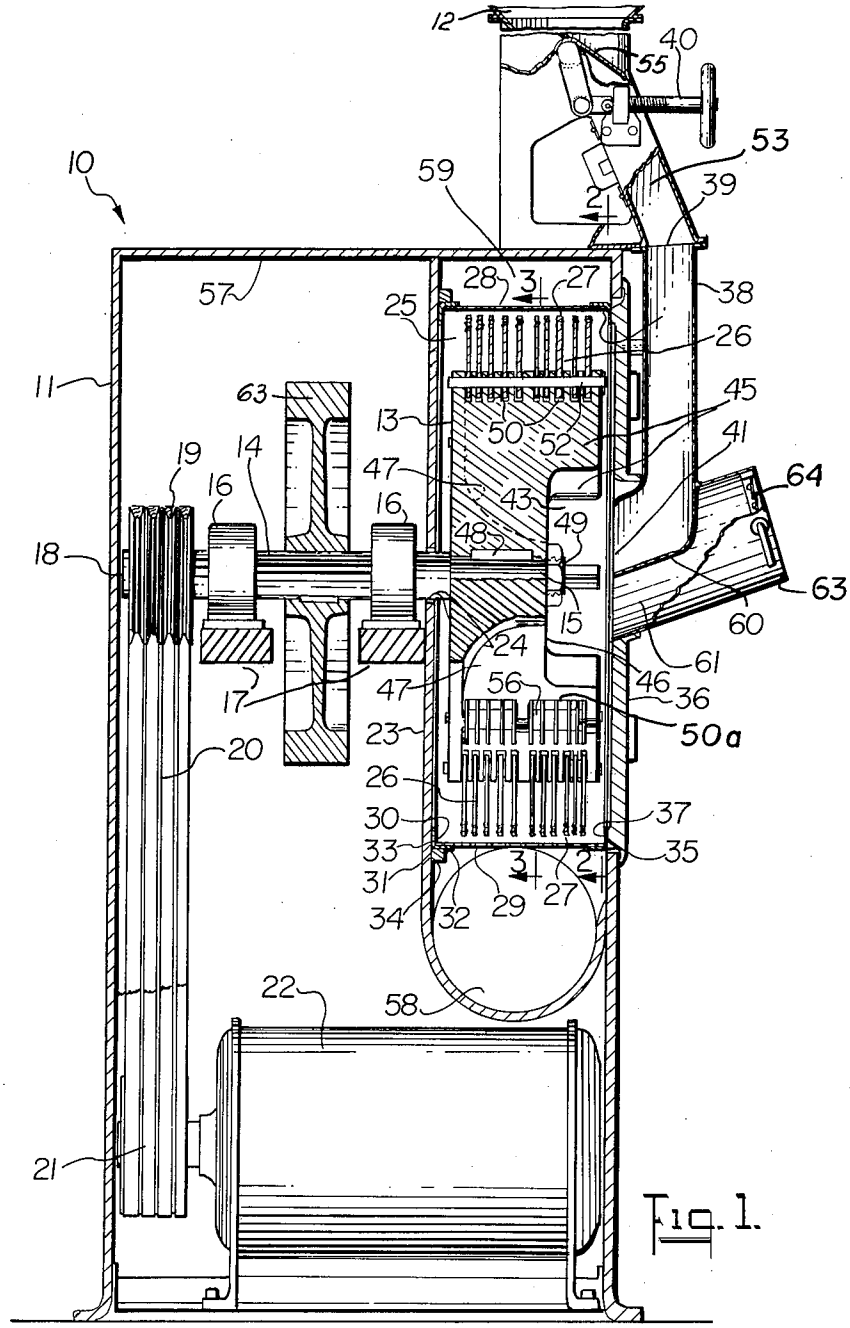


FIG. 1.

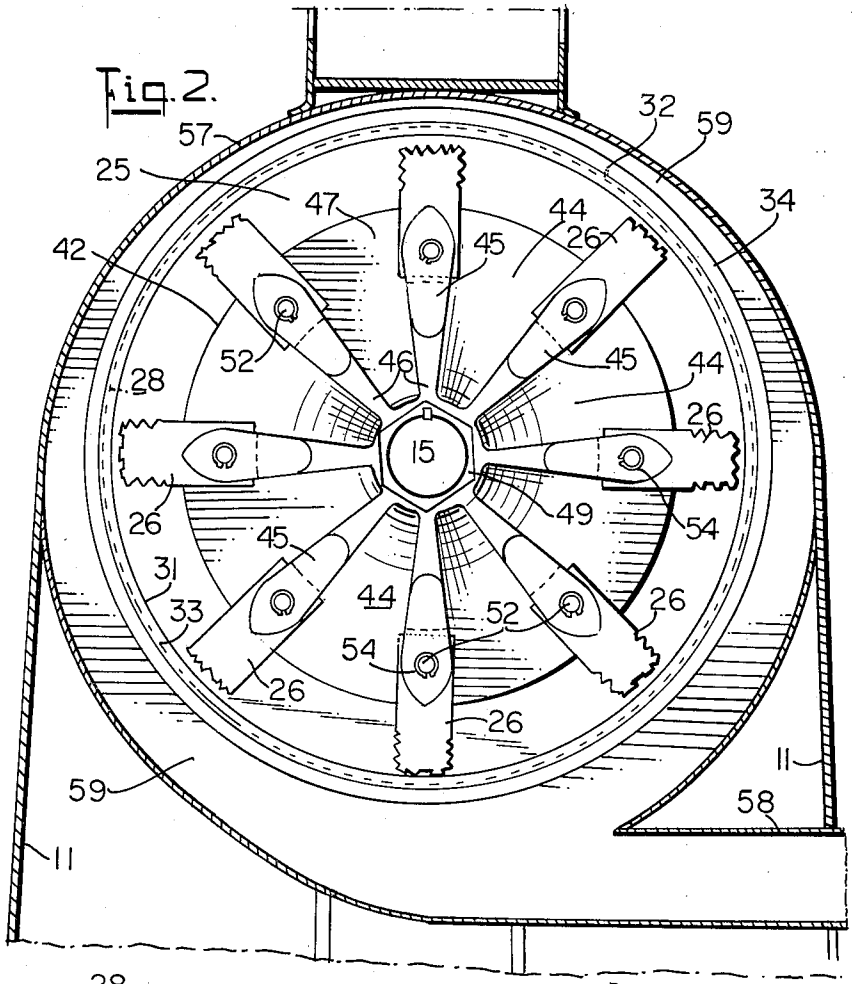
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Fig. 2.



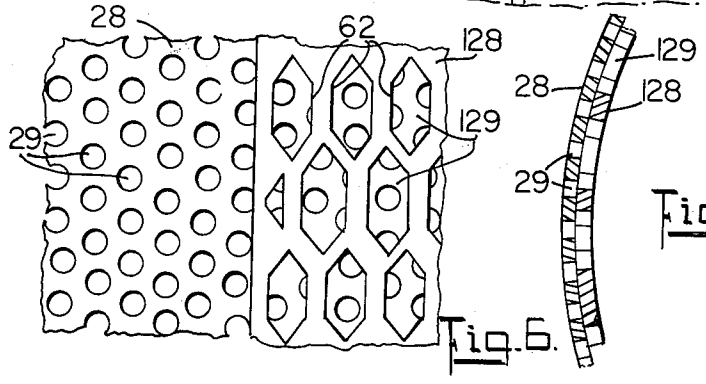


Fig. 5.

Fig. 6.

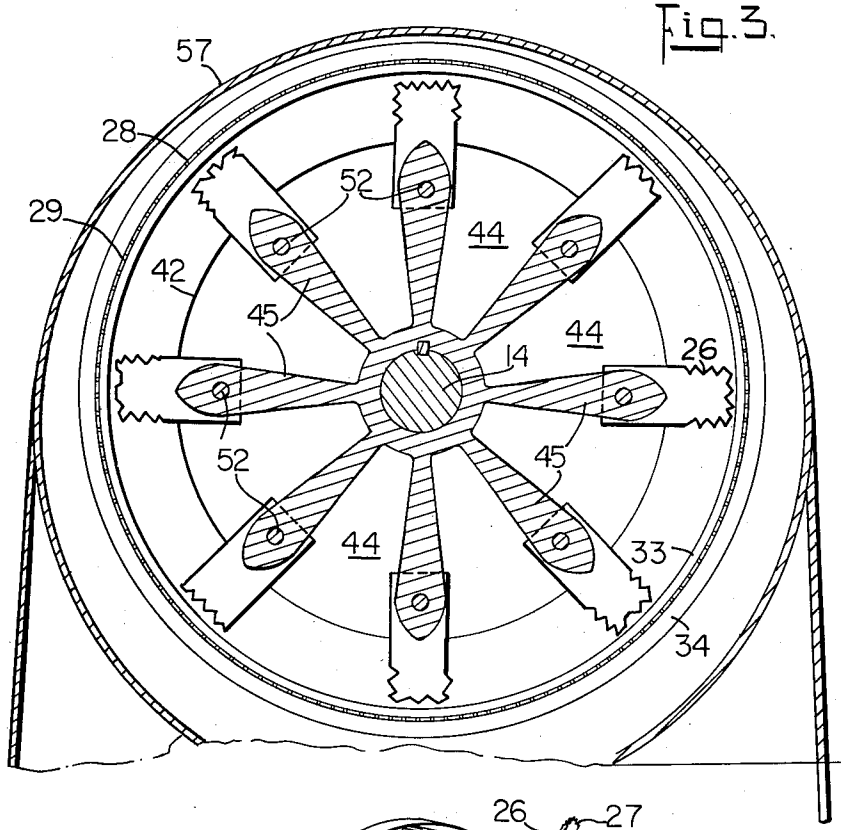
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Fig. 3.



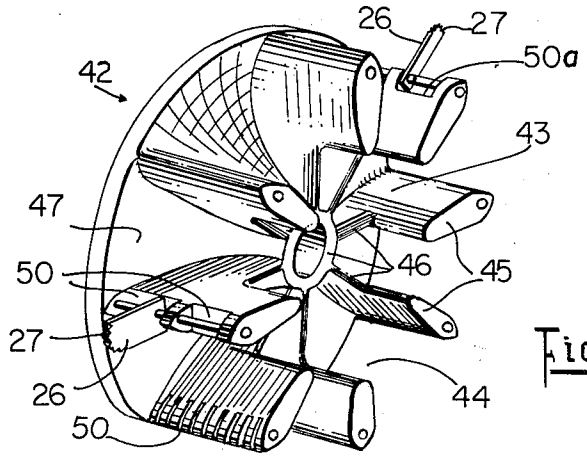


Fig. 4.

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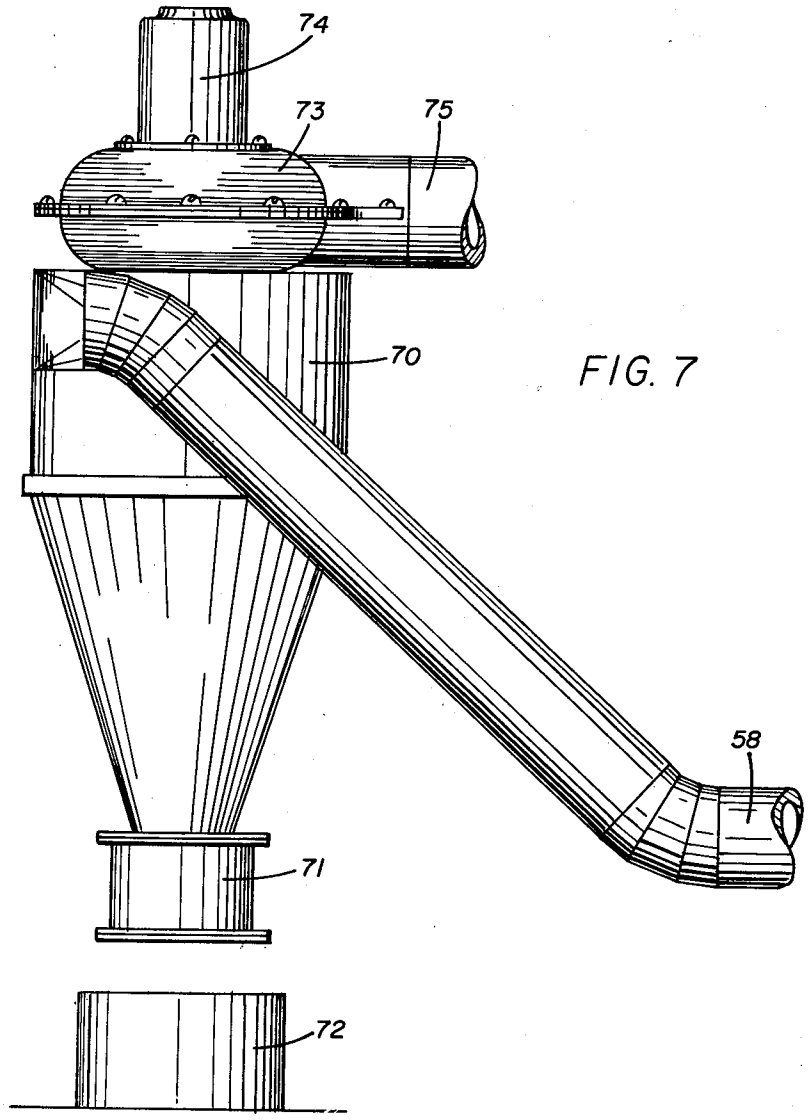


FIG. 7

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HAMMER MILL HAVING COAXIAL IMPELLER

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1 Claim. (Cl. 241—55)

This invention is in the art of comminuting materials and more particularly is embodied in apparatus for impact milling having a plurality of striking hammers carried by a rotor formed as a radial impeller moving in an annular comminuting zone bounded by a cylindrical shell screen.

Heretofore the milling of a wide variety of materials by known forms of impact disintegrator machines has proved relatively inefficient, as evidenced by low output in terms of pounds of ground product milled per horsepower hour of work expended. A serious disadvantage has been excessive temperature rise of product undergoing fine milling, condensation of moisture on the surfaces of the grinding chamber and bridging of screen apertures causing clogging.

Applicant has discovered that improved milling efficiency by impact milling apparatus may be realized when there is provided a relatively high radial pressure gradient of gaseous fluid transversely of the thickness of a sizing screen, i.e. outwardly of an annular comminuting zone bounded by a cylindrical perforated shell-walled screen structure. Such pressure gradient assists in the removal of fragments whose dimensions permit their passage through screen openings and inhibits stagnation of particles, thereby permitting a greater mass of particles to occupy the comminuting zone without inducing clogging and plugging. When a high velocity circulatory gas flow within the comminuting zone is maintained in conjunction with the high pressure gradient, high efficiency of grinding action with low temperature rise of milled product is achieved.

In applicant's copending United States application Serial No. 72,893 filed December 1, 1960, there is described apparatus and method for fine milling of various materials, employing blower means for injecting a high velocity flow of gaseous fluid under pressure into the comminuting zone of a hammer mill in the direction of circulatory flow along the inner wall of a cylindrical sizing and abrading screen surrounding the zone; such apparatus preferably employs a group of toothed striking blades moving closely adjacent the inner wall of the cylindrical screen, which is formed with radial recesses, whereby coarse fragments moving therealong in the direction of circulatory flow are repeatedly struck and caused to rebound from the screen so that a rapid disintegrating action is produced and sized fragments are removed as quickly as reduced. Such milling apparatus and method produces a high yield of product per unit of work expended, without causing excessive temperature rise of product.

The present invention is embodied in apparatus similar to but of simpler construction than the apparatus of the copending application, and does not necessitate the provision of a separate high pressure blower for injecting gaseous fluid into the comminuting zone. Instead, according to the present invention a radial pressure gradient across the screen wall and a high tangential velocity of circulatory gas flow is produced by virtue of the inherent impelling characteristics of a specially formed combined rotor and impeller assembly. Apparatus according to the invention comprises a hammer mill having a rotor-impeller supporting groups of toothed striking blades rotatable in a housing within an annular comminuting chamber which is circumferentially bounded by a cylindriform

apertured wall, the wall comprising a combined disintegrating and sizing screen axially bounded by housing end walls, the housing having one end wall apertured coaxially for admitting gaseous fluid, and having also an external chamber between the housing and the exterior of the screen wherein a reduced gas pressure is maintained for augmenting the radial pressure gradient in the screen apertures, a rotor shaft extending through an aperture in the other housing end wall into the chamber and supporting an impeller having a hub and a disc portion, the impeller having a plurality of angularly spaced sectoral lobes or vanes integrally joined with the disc portion and extending axially therefrom, the striking blades being pivotally supported from the outer ends of each lobe or vane.

In carrying the invention into effect a hammer mill according to the invention is constructed with a housing having a pair of spaced apart end walls enclosing and supporting between them a cylindrical apertured screen wall bounding a comminuting chamber, wherein a system of striking blades supported on an impeller formed as a right cylinder coaxial with the screen wall is arranged to be rotated in the housing to produce a high tangential velocity of the blades for impacting and tearing fragments of material introduced through an infeeding aperture provided in an end wall, part of the inner surface of the screen wall being recessed to assist in the disintegration of fragments moving along the inner surface, the impeller having sectoral vane form and each vane supporting a group of blades, the impeller having a coaxial recess in registration with an inlet aperture in the housing for directing inflowing gaseous fluid which is impelled by the vanes to provide a high pressure gradient radially of the screen.

In grinding mills constructed according to the invention, the rotation of the rotor assembly effects a vigorous radial flow through the passages between the vanes and produces a high velocity tangential flow within the comminuting zone along the inner surface of the screen. The end walls of the comminuting chamber lie close to the impeller end faces, to provide minimum pressure loss from the grinding zone.

Preferably the screen wall has a substantial percentage of its total area formed as apertures, and supports on its inner face an auxiliary disintegrating screen layer formed as an apertured metal strip secured to the screen wall and having a pattern of apertures whose dimensions are a small multiple of the dimension of an aperture in the screen wall and which exceed considerably the thickness of the metal strip. The disintegrating screen is arranged to overlie the inner surface of the screen wall along an arc which may subtend any suitable angle, generally from 120 to about 300 degrees. Such disintegrating screen provides, by virtue of its apertures, a recessed surface whereof the recesses expose the sizing screen apertures over their bottom areas, and whose marginal edges serve a cutting function for fragments impacting thereagainst, and an agitating function for producing a vigorous fine pattern turbulence in the gaseous fluid layers adjacent the screen wall.

Material to be comminuted may be fed either directly into the annular comminuting zone or axially into the impeller for radial delivery by the impelling action of the vanes. A close spacing is preferably provided between the screen and the outer tips of the striking blades, whereby the material is caused to be struck forcibly and thrown along the inner surface of the screen, whose recesses effect inward rebound or ricochet of partly disintegrated fragments. At each rebound the tangential component of the fragment's velocity is reduced, whereby a fragment moving in the zone is struck again and again in a very short interval of time by blades moving at rela-

tively high velocity with respect to the fragment. The major part of the disintegrating effect is believed to be attributable to impacts with the blades and a lesser part to the result of impacts against the screen recess edges; whatever the exact mechanism of grinding may be, it is believed that the agitation of fragments and finer particles is to an important extent assisted by the vigorous fine-pattern turbulence of rapidly moving gaseous fluid, which assumes irregular flow pattern as it passes over the recess edges.

The vigorous scouring action of fluid flow apparently dislodges and entrains fragments which would otherwise stagnate at the screen apertures and cause bridging and induce clogging, while fragments whose cross-sections are sufficiently reduced to permit them to pass through the screen openings are discharged at high velocity by the high pressure gradient across the screen wall.

The pressure of the gaseous fluid within the comminuting chamber immediately adjacent the inner wall of the screen approaches the pressure head corresponding to the tangential velocity of the blade system, such velocity preferably being of the order of several hundreds of feet per second. When a reduced pressure is maintained in the region surrounding the screen exterior equivalent to a few ounces of water suction head a substantial pressure difference is produced across the screen, which preferably is of the order of 2 to 3 pounds per square inch or higher.

Relatively open screens, for example having 30% or more net aperture area, pass large flows of gaseous fluid per unit time at substantial pressure gradients, hence the supply of fluid must be adequate if the gradient is to be maintained. The rotor assembly therefore requires to be so constructed that the cross-sectional area of the impeller passages between the vanes is related to the aperture area of the screen, and that the passages between the vanes are aerodynamically smooth and relatively unobstructed to promote efficient delivery of the gaseous fluid therethrough.

The invention may be the better understood in its practice by the following description of preferred embodiments, which is to be read in conjunction with the accompanying figures of drawing, wherein:

FIG. 1 is a side elevation view in partial section illustrating a comminuting apparatus constructed according to the present invention;

FIG. 2 is an enlarged section taken along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged section taken along the line 3—3 of FIG. 1;

FIG. 4 is a perspective view of the rotor-impeller of FIG. 1;

FIG. 5 is an enlarged detail in transverse section showing the assembly of a sizing screen and a disintegrating auxiliary screens;

FIG. 6 is an enlarged plan view of the detail of FIG. 4; and

FIG. 7 is a general illustration of a suction apparatus forming part of the apparatus of the present invention.

Referring to FIGURES 1 to 4 inclusive of the drawing, the preferred embodiment illustrated comprises a grinding mill generally designated 10, having a suitable supporting housing 11. A rotatable rotor assembly 13 is mounted upon a horizontal shaft 14 adjacent one end 15 thereof. The shaft is journalled in a pair of spaced bearings 16 of suitable type supported on transverse frame elements 17 secured to the housing. A flywheel 63 of conventional design is mounted on shaft 14 between the spaced bearings 16 and serves to increase the angular moment of inertia of the rotor assembly. The other end 18 of the shaft carries a pulley 19 which is coupled as by belts 20 with drive pulley 21 of an electric motor 22 of suitable size for driving the mill.

A rigid vertical wall 23 having aperture 24 coaxial with the shaft is fixed within the housing to provide an end wall of a comminuting chamber designated 25. Within the chamber, the rotor assembly is spaced closely to wall 23 on one side and closely to the front wall of the housing on the other side, and carries on its outer periphery a plurality of blades 26 having outer ends 27 toothed. A cylindrical screen wall 28 surrounds the rotor assembly coaxial with the shaft and is spaced radially a small distance from the outer ends of the blades. The screen is provided with a plurality of apertures 29, and as will presently be further described, preferably has a portion of its inner periphery recessed. The axial end margins 30 of the screen are secured in flanged rings 31 comprising cylindrical flange portion 32 and radial flange portion 33, the ring bearing against wall 23 being received in support ring 34 secured to the wall 23.

The other end of the screen is in registration with an aperture 35 in the front wall of housing 11, the aperture having a diameter such as to allow guard rings 31 to pass freely thereinto. The aperture 35 is closed by a door 36 which may be latched by any suitable means (not shown) in closed position with a screen engaging ridge 37 facing axially inwardly to bear against flange 33.

Material to be fed to the comminuting chamber is introduced at any radial distance from shaft 14 radially inward of the screen 28 where the pressure of gaseous fluid in the chamber is not so great as to cause blowback.

A preferred infeeding arrangement is illustrated in FIGURE 1 whereby material may be introduced from hopper 12 by way of sloping chute 53 and vertical chute 38 into the comminution chamber 25 through aperture 61 in door 36. Hopper 12 is supported on housing 11. An opening at the base of the hopper is closed by a movable flap 55. The feeding rate of material may be controlled through adjustment of the movable flap 55 by an associated hand wheel and shaft 40. A sloping chute 53 extends downward from beneath the hopper opening to a point adjacent the upper edge of door 36. A vertical chute 38 is formed as a part of door 36 and its upper end connects with the lower end of sloping chute 53 at 39. Chute 38 leads the feed into the chamber through aperture 61 in door 36, preferably above the axis of shaft 14.

An air duct 62 of larger diameter than the terminus 41 of chute 38 partially surrounds the lower part of chute 38 and with chute 38 bounds the aperture 61. This duct provides a convenient means of regulating air flow to the comminution chamber. The introduction of air to the air duct may be controlled by any suitable means such as a shutter or louvre system 64 with control handle 65 illustrated in FIGURE 1.

The rotor assembly consists of a thick disc 42 having a coaxial recess 43 formed in one side, and a plurality of axially and radially outwardly flaring passages 44 separated by lobes or vanes 45. The passages are recessed axially deeper than the bottom 46 of recess 43, and the lobes or vanes are integrally joined by their axially inward ends with the inside face 47 of disc 42. The passages are smoothly faired axially inwardly from recess bottom 46 and curve along the face 47 which forms the axial margins of the passages. Shaft 14 is keyed to the impeller by key 48 received in a keyway in the reduced diameter end portion 15 of the shaft, upon whose end the nut 49 is threadedly received to retain the impeller.

Each lobe or vane of the impeller has a streamlined symmetric cross-section as viewed on a projection plane transverse to the shaft axis, and has radial inward recesses 50 formed between its axial ends. Bore 51 extending parallel with shaft 14 through each lobe end receives a pin 52, on which the apertured striking blades 26 are pivotably supported for limited rotation with respect to the impeller. Each pin is secured against axial displacement by means of retainer device 54 as for example a spring ring seated in a circumferential groove.

The striking blades are generally strips of rectangular outline, having any suitable thickness, and have their outer

marginal edges toothed or hooked at **27**, the opposite edges being symmetrically formed about a longitudinal center line along the blade. Various forms of blade configuration may be employed, the exact nature of such blade outline forming per se no part of the present invention. The bales are preferably spaced axially and this may be accomplished by providing individual recesses **50** for each blade as shown clearly in FIGURES 1 and 4. Alternatively more than one blade may be grouped in a wider recess as illustrated in FIGURE 4 as **50***a* and each blade separated by spacing washers **56** of appropriate thickness. In general, it is preferred that the array of blades grouped along the outer end of each lobe or vane will be staggered with respect to the blades of an array supported by another vane of the impeller.

The housing includes a curved upper wall **57** which continues about the entire periphery of screen **28** and is spaced therefrom by a radial distance which increases progressively in both directions, to a larger clearance below the screen. An exhaust duct **58** opens into the bottom of the external chamber **59** which lies between screen **28** and the curved wall **57**.

A suction apparatus of any siutable type is connected with the duct **58** in a conventional manner. A suitable suction apparatus is illustrated in FIGURE 7. Referring to FIGURE 7, the duct **58** leads to the intake of a cyclone separator **70** which is arranged conventionally to discharge deposited solid material through a rotary air lock **71** into a collection receptacle **72**. Suction is provided by a fan **73** motivated by motor **74**, the intake of fan **73** communicating with the interior of cyclone collector **70** and discharging air from which the solids have been substantially removed through discharge duct **75**. The duct **75** may discharge to atmosphere through a conventional dust collection system (not shown). Such suction apparatus will be designed to have a capacity adequate to maintain a satisfactory value of reduced pressure of gas within chamber **59**, for example from one inch to several inches of water column.

Operation of the machine described above will be understood from the description which follows: The apparatus is put into operation with the rotor-impeller assembly revolving about the shaft axis at a suitable rate, for example 3200 r.p.m. or more. Such speed is generally satisfactory for impellers spanning about 18 inches and striking blades spanning about 24 inches. The material to be comminuted, which will be already in the form of lumps or fragments of suitable size, is fed into the comminuting zone **25** from hopper **12**, through chutes **53** and **39** and opening **41** in the door port **61**. As the material enters the comminuting zone it is struck repeatedly and forcibly, being cut or shredded at each collision with a blade, and being driven with radial and tangential components of velocity into the inner surface of screen **28**. The latter has a portion of its periphery recessed as may best be understood from FIGS. 5 and 6, wherein an auxiliary screen layer **128** is adhered in close contact with sizing screen **28**, and has its apertures **129** larger than apertures **29** or screen **28**. Preferably, the apertures **129** are non-circular, and may be of rhombic, hexagonal, rectangular or parallelogram plan form. At least some of the edges of recesses **129** are preferably aligned parallel with the shaft axis as indicated at **62**. The arcuate length of screen layer **128** may be chosen as may readily be determined by experiment, or in some applications it may be omitted entirely, as for example with readily frangible materials.

The high tangential velocity of the impeller lobes or vanes sets up a high velocity flow of gaseous fluid in zone **25**, which serves to scour the inner surfaces of screen **28** and screen **128** if the latter is provided. Moreover the effect of the rotating gaseous volume is to create a high radial pressure, which, together with the reduced pressure on the outside of the screen, develops a large pressure difference between opposite ends of screen openings.

The violent agitation of particles in the comminuting zone, together with the improved cleansing action urging reduced particles through screen openings, accomplishes a more precise degree of granulation, pulverizing, or fine milling, as will be determined by choice of screen aperture dimensions. The following table illustrates reductions obtained in one pass through a mill constructed according to the invention.

Starting material	Corn grits, 4 W. mesh size							
Screen size	½ x 5/32		4 W. mesh		8 W. mesh		16 W. mesh	
Lbs. throughput per H.P. hour	1,250		822		360		215	
Temperature rise of product, ° F.	5		5		5		9	
	Thru	Over	Thru	Over	Thru	Over	Thru	Over
Percentage by weight of product in size ranges—bolting wire mesh:								
6	97	3	97	3	x	x	x	x
10	29	68	61	36	x	x	x	x
16	21	8	43	18	94	6	x	x
24	14.5	6.5	28	15	28	66	96	4
30	x	x	15	13	21	7	39	57
36	x	x	10	5	17	4	28.5	16.5
54	x	x	x	x	x	x	14	14.5

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

A hammer mill of the type wherein a cylindrical screen defines a comminution chamber having a generally axial inlet for an airstream in which is suspended the material to be comminuted within which there is rotated a rotor having radial blades adapted for air motivation and a plurality of peripherally mounted hammer elements adapted to sweep close to said screen and create a comminuting action in the space adjacent thereto, and a casing spaced from and surrounding said screen forming a collection chamber for comminuted product, said hammer mill comprising: a rotor mounted for rotation within said comminution chamber upon a drive shaft extending thereinto coaxially of said cylindrical screen from the end thereof opposite said airstream inlet, said rotor having a hub portion which fits around and is secured to the portion of said drive shaft which extends into said comminution chamber, said hub portion flaring radially outwardly in a smooth curved surface extending to the periphery of said rotor adjacent the end thereof remote from said airstream inlet, a plurality of symmetrically disposed radially extending vanes rooted in said curved surface, each said vane having an axial extent, which at the periphery of the rotor corresponds substantially to the interior length of said comminuting chamber, and a cross section which when taken on a plane at right angles to the axis of the rotor is essentially bi-convex, and means adjacent the peripheral end thereof for mounting a plurality of hammer elements; a plurality of axially spaced apart hammer elements mounted adjacent the peripherial ends of said vanes and extending radially outwardly therefrom in close proximity to the interior surface of said screen to form a comminution zone in the space between the periphery of said rotor and said screen; the spaces bounded by said smooth curved surface of said hub portion and the sides of adjacent vanes rooted therein forming radially and axially unobstructed passageways adapted to conduct air and feed material entering said comminuation chamber through said airstream inlet to said comminuation zone; conduit means leading from said collection chamber to a product collection system; suction means associated with said conduit means adapted to maintain, during operation of said hammer mill a reduced pressure of down to about one inch of water within said collection chamber, the

total pressure drop across said screen during operation resulting from said suction means on the one hand and said rotor on the other serving to maintain a high velocity of airflow within said passageways whereby feed material passing therethrough arrives at said comminuation zone without having acquired any substantial peripheral velocity in the direction of rotation of said rotor, providing for a maximum relative velocity between said material and said striking blades on initial impact therebetween.

References Cited in the file of this patent

UNITED STATES PATENTS

2,026,426	Matejck	Dec. 31, 1935

FOREIGN PATENTS

482,706	Italy	July 8, 1953
556,400	Belgium	Oct. 4, 1957
905,442	France	Apr. 16, 1945