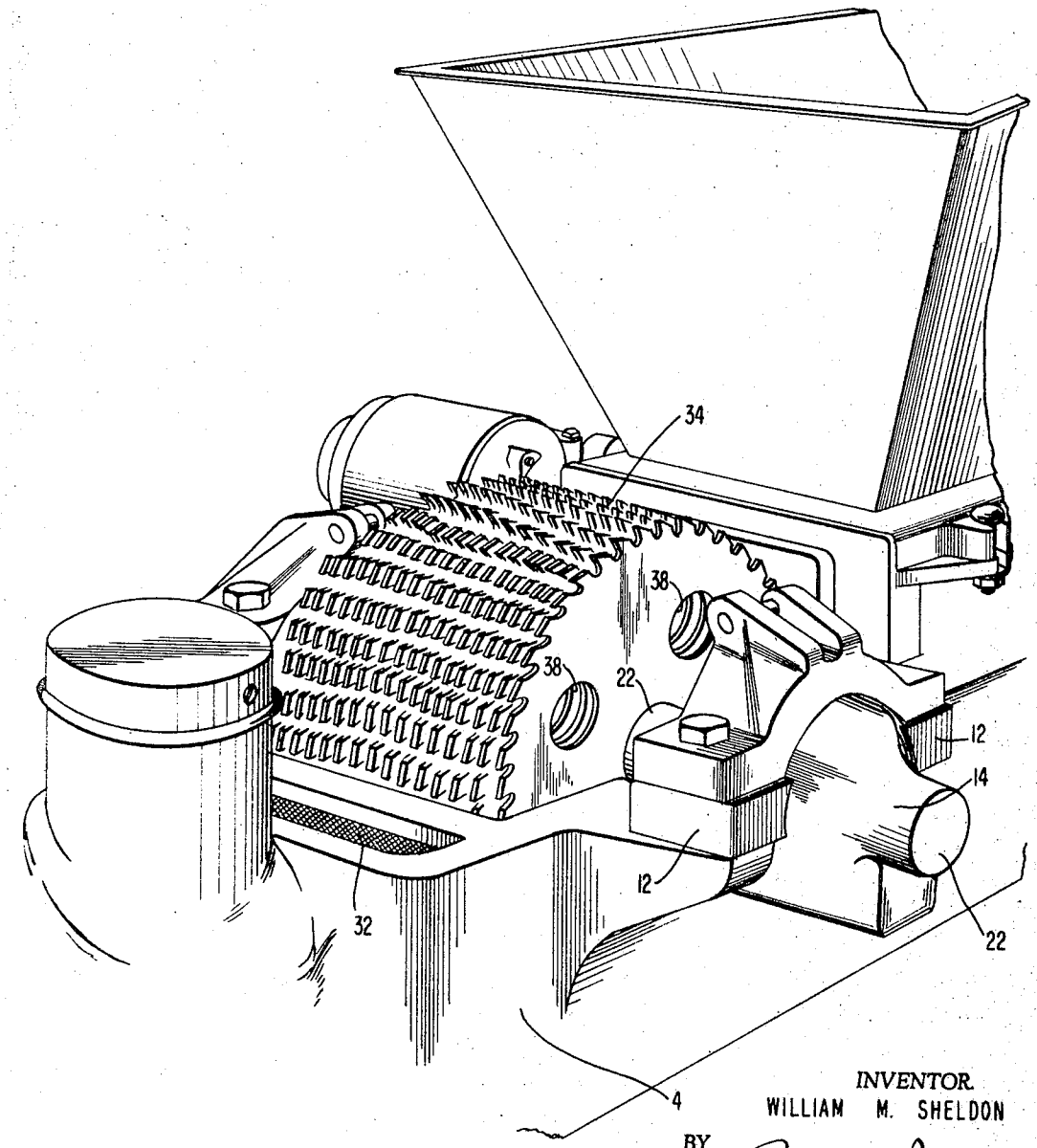
April 1, 1969 W. M. SHELDON 3,436,025

FINE GRANULATOR

Original Filed April 29, 1963 Sheet 1 of 5

Fig. 1a



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FINE GRANULATOR

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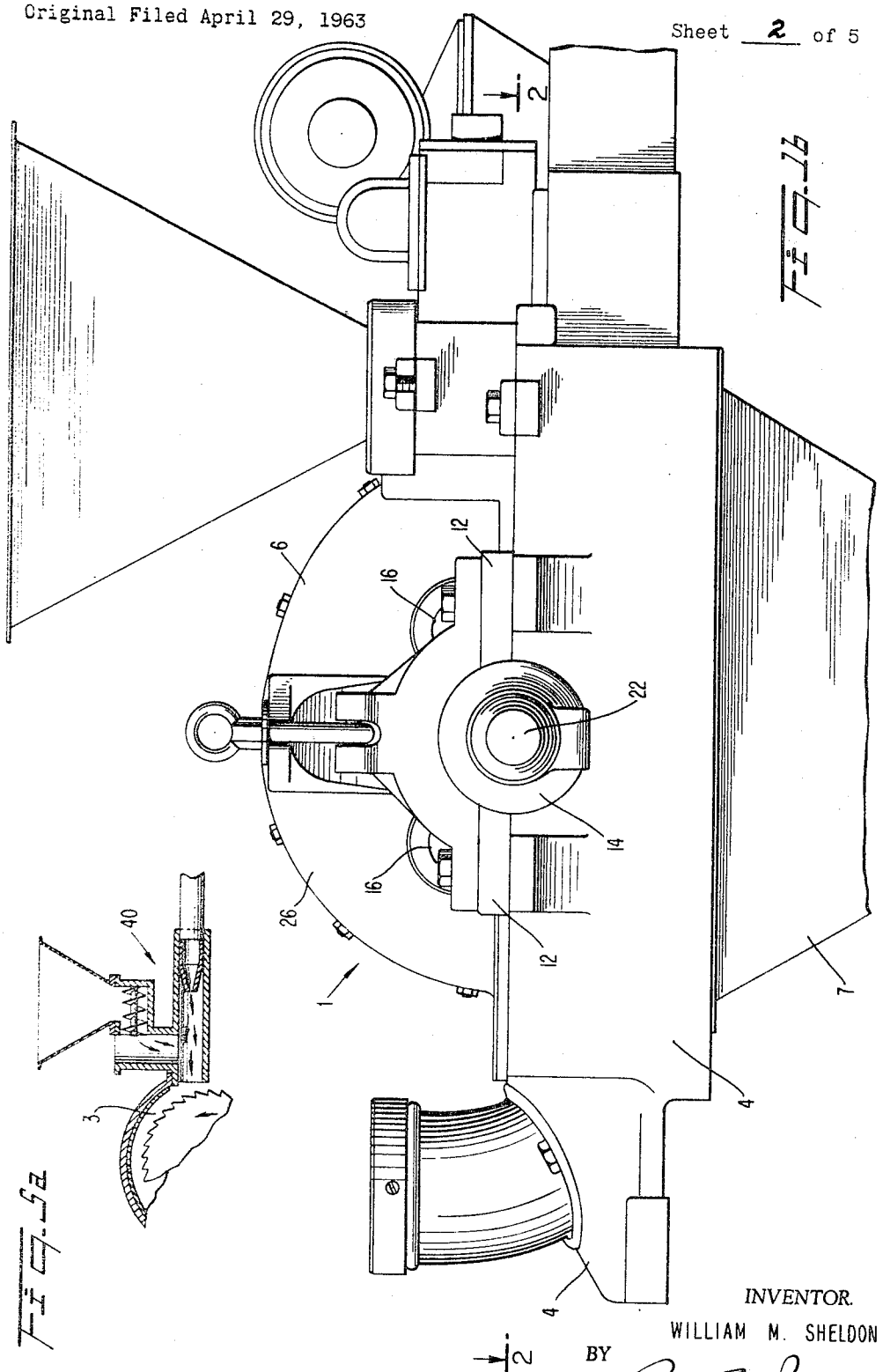


FIG. 1A

FIG. 2A

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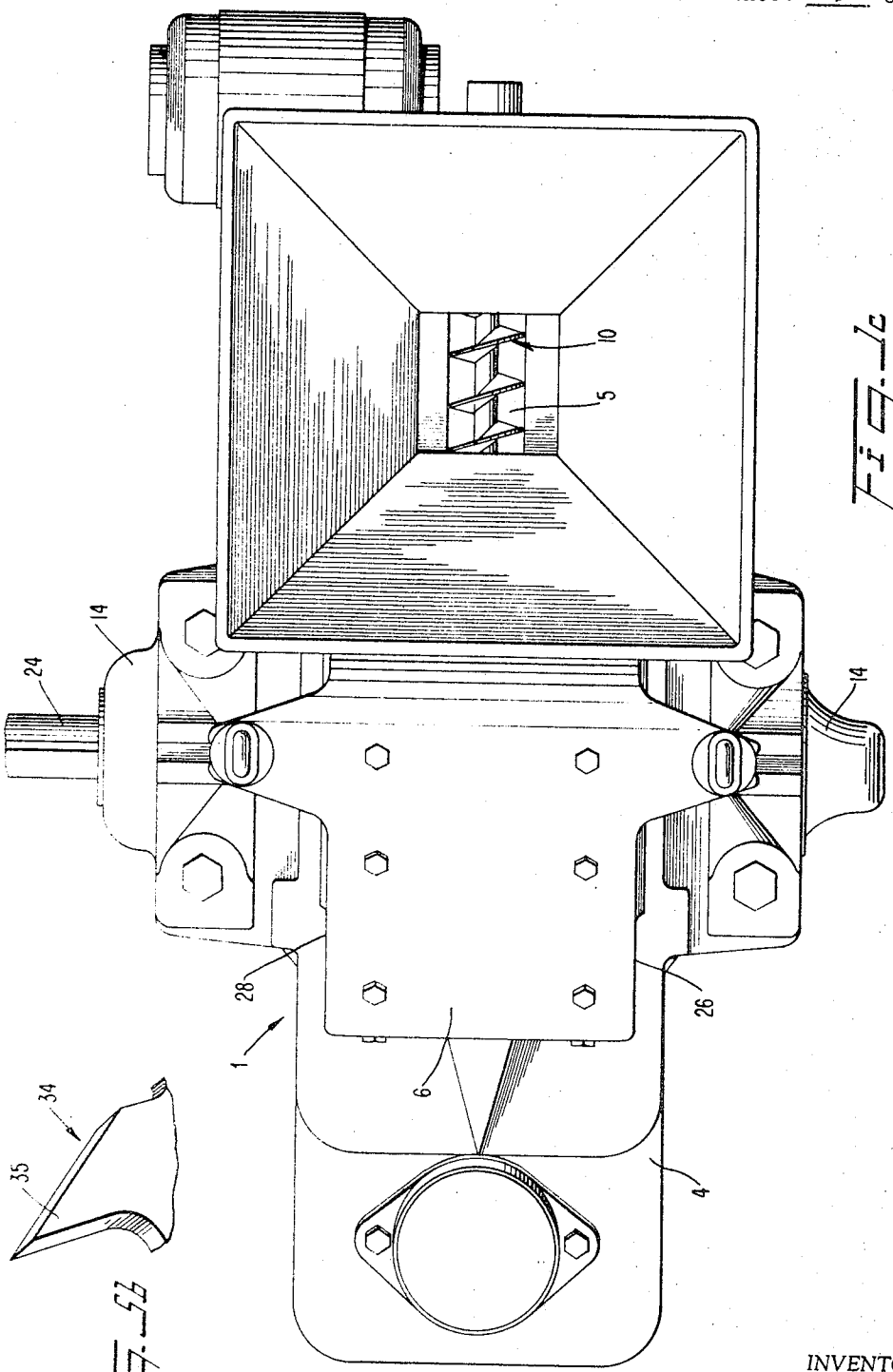


Fig. 1c

Fig. 1a

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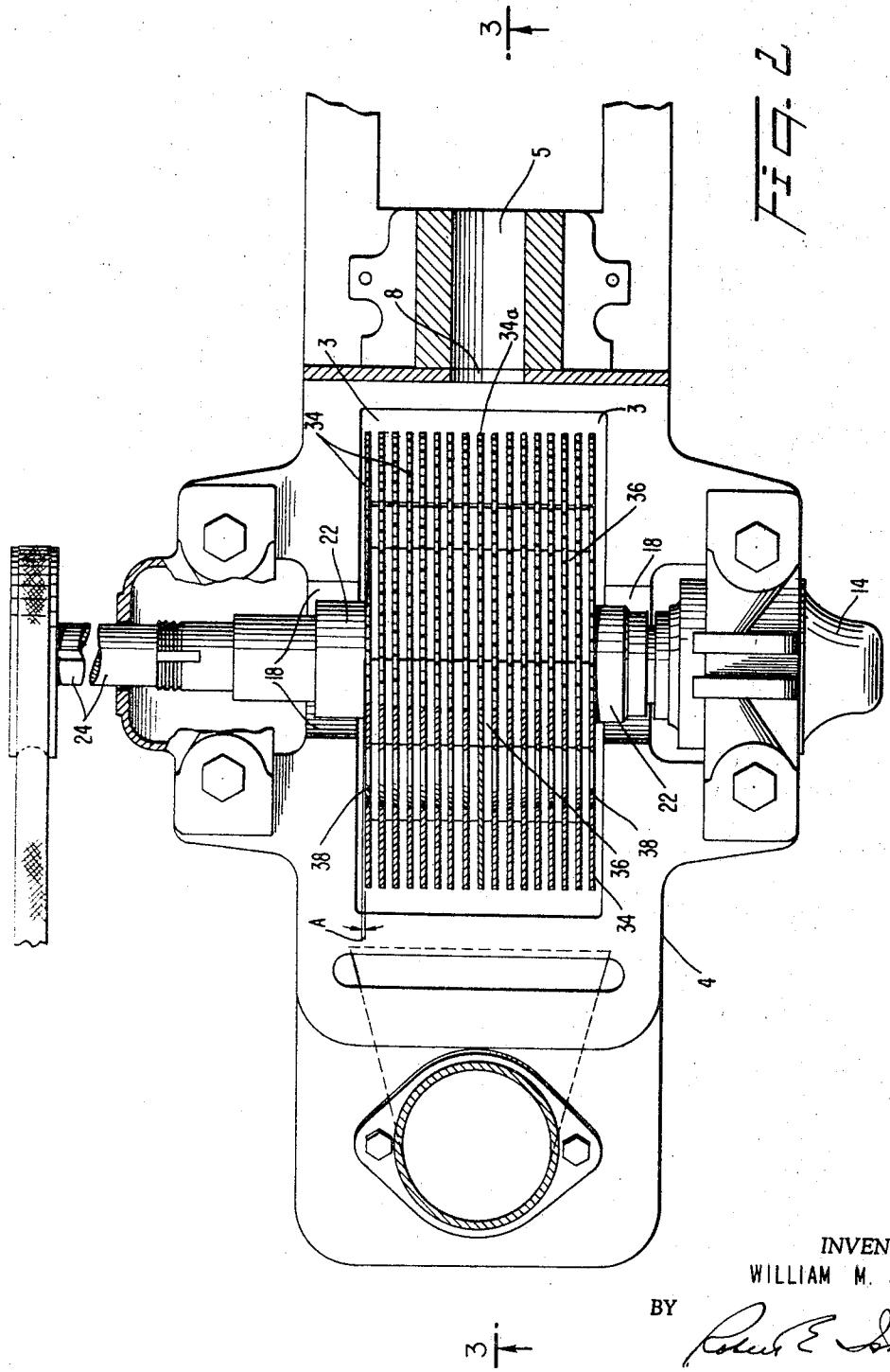


Fig. 2

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FINE GRANULATOR

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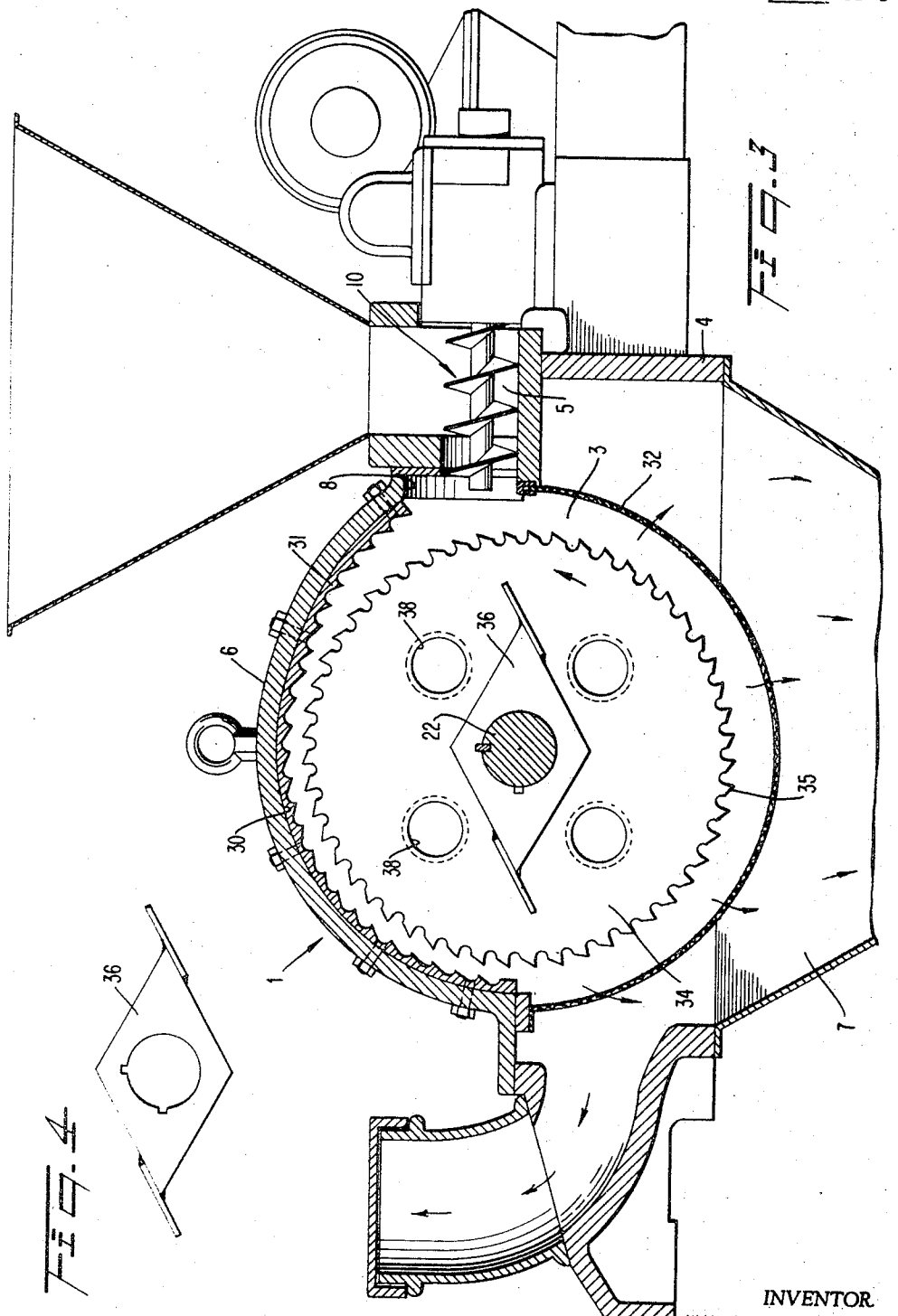


FIG. 3

FIG. 4

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United States Patent Office 3,436,025 Patented Apr. 1, 1969

3,436,025

FINE GRANULATOR

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Original application Apr. 29, 1963, Ser. No. 276,645, now Patent No. 3,241,776, dated Mar. 22, 1966. Divided and this application Feb. 15, 1966, Ser. No. 527,453

Int. Cl. B02c 7/06, 7/12

U.S. Cl. 241—15 1 Claim

ABSTRACT OF THE DISCLOSURE

Method of comminuting material by subjecting material confined in suspended condition within a generally cylindrical comminuting zone by a selectively directed flow of gaseous carrier to the cutting impact of multiplicities of discrete rapidly moving acute angle shearing edges disposed in selectively spaced relation to said comminuting zone and to each other to facilitate said selectively directed flow of gaseous carrier therepast.

This is a division of my copending application Ser. No. 276,645 filed Apr. 29, 1963, now Patent No. 3,241,776.

This invention relates to the comminution of material and particularly to an improved method for effecting comminution of suspended material by cutting impact on a shearing edge in the presence of a selectively directed gaseous carrier.

Comminution of material by impact pulverization is widely employed in the commercial arts and widely varying types of apparatus are utilized in accord with the type of material to be comminuted and the desired particle size range of the resulting comminuted product. Comminuting apparatus of the so called hammer mill types are widely used for effecting impact pulverization of materials to a particle size range of about 5000 to 40 microns. Such hammer type mills are generally characterized by a high speed rotating shaft having mounted thereon a plurality of hammerlike members. Most, if not all, mills of this type effect reduction by impact, while the material is in suspension, in conjunction with an associated breaker surface usually constituted by a part of the housing surrounding the rotating elements. Such mills, however, are usually characterized by the production of what for many end uses is an unacceptable amount of ultra fines and an undue amount of heat generation. The development of such ultra fines is usually objectionable as, for example, when the comminuted material is to be used in forming tablets or for injection molding. The development of undue amounts of heat is particularly objectionable in the handling of materials that tend to agglomerate, either by release of water of combination or hygroscopicity or by reason of sensitivity to temperature.

This latter problem has become of increasing importance with the continually expanding use of synthetic resins and so called "plastics" and other polymerization products, many of which are somewhat resilient in nature and/or have a tendency to become soft and plastic beyond certain temperatures. In the attempted handling of materials of the types above noted in conventional hammer mill type apparatus various expedients, such as the prereduction of product temperatures or of ambient air temperature by the utilization of Dry Ice or other refrigerants have been employed to limit the degree of temperature rise and to limit the maximum temperatures attained during comminution. Such expedients, however, are palliative in nature at best and, apart from the additional expense involved, have been characterized with a marked lack of commercial utility due to necessarily reduced production,

increased cost and in some instances, the necessity of removing, by a subsequent drying operation, atmospheric moisture condensation that becomes incorporated in the comminuted material.

This invention may be briefly described as an improved method for effecting comminution of suspended material by cutting impact with rapidly moving acute angle shearing edges in a rotor induced selectively directed gaseous carrier which conveys heat or other agglomeration inducing factors away from the locus of material deformation and serves to rapidly reduce the temperature of the comminuted product.

Among the advantages of the subject invention is the permitted comminution, at ambient air temperatures and with a markedly decreased temperature rise, of an extended range of materials including many, if not most, of those whose comminution is effected only with difficulty, if at all, in conventionally constructed impact pulverization apparatus even with the expedients above noted. Other advantages of the subject invention include a marked increase in induced flow of gaseous carrier into and through the locus of deformation, an improved control of particle size range of the resulting product and the avoidance of the production of undue amounts of ultrafines characteristic of impact pulverization operations. Still other advantages include the provision of greatly extended effective length of cutting edge, markedly improved yields per unit power input and a simplicity of construction that permits appreciable economies both in initial cost and maintenance of apparatus embodying the subject invention.

The primary object of this invention is the provision of an improved method for effecting comminution of suspended material by cutting impact with a rapidly moving shearing edge in a rotor induced selectively directed gaseous carrier which serves to convey heat or other agglomeration inducing factors away from the locus of material deformation and rapidly reduces the temperature of the comminuted material.

Another object of this invention is the provision of improved method for effecting comminution of agglomerative materials.

Other objects and advantages of the invention will be set forth in the following specification and claims and will be ascertainable from the appended drawings which illustrate, by way of example, the principles of the invention as the same would be practiced in a presently preferred embodiment of a comminuting apparatus.

Referring to the drawings:

FIGURE 1A is an oblique view, partially broken away, of a mill (with the housing cover removed) incorporating the principles of this invention;

FIGURES 1B and C are side elevational and plan views, respectively, of the mill illustrated in FIGURE 1A and with the housing cover in place;

FIGURE 2 is a schematic and somewhat idealized plan view of the essentials of the comminution chamber and rotor assembly contained therein as the same would be viewed with the housing cover portion thereof removed;

FIGURE 3 is a sectional view taken on the line 3—3 of FIGURE 2;

FIGURE 4 is a side elevation, in enlarged scale, of a presently preferred configuration for a fan blade type spacer element;

FIGURE 5A is a schematic representation of an air injector type of material feed which may be utilized in conjunction with the subject mill;

FIGURE 5B is an enlarged oblique view of a preferred configuration for the saw teeth on the rotor assembly.

Referring to the drawings, there is provided a housing assembly, generally designated 1 and formed of a base member 4 and a substantially semi-cylindrically shaped

upper or cover member 6 removably securable thereto. The base and cover members 4 and 6 are shaped to generally define an internally disposed comminution chamber 3, a material feed channel 5 communicating therewith and a dependent receiving chamber 7 for the comminuted material after the same passes through the semi-cylindrically shaped screen member 32 which also serves to cooperatively define the above mentioned comminution chamber 3. As best illustrated in FIGURE 1B, the cover member 4 is provided with a plurality of particularly located circular air inlet apertures 16, suitably three, in each of the side wall portions 26, 28 thereof, as well as a material entry aperture 8 in alignment with the feed channel 5 to accommodate material entry into the comminution chamber 3 by a worm type feed mechanism generally designated 10. The air inlet apertures 16 are preferably screened with a coarse screen or mesh of suitable size as to prevent egress of uncomminuted material therethrough but yet not impede air flow therethrough into the comminution chamber.

The base housing member 4 is suitably shaped to terminally support the extending arms 12 of a pair of suspended rotor supporting journals or bearing assemblies 14. A rotor shaft 22 is rotationally suported in the journals 14 and is provided with an extension end 24 extending beyond one side of the housing for facilitating a drive connection thereto. As best shown in FIGURES 2 and 3, the internally disposed comminution chamber 3 is essentially of cylindrical configuration being defined by the apertured and essentially planar wall portions 26, 28, an upper curved wall 30 of essentially semi-cylindrical configuration and a lower curved wall formed by the perforate and removable plate or screen 32 of complemental semi-cylindrical configuration. As will be apparent to those skilled in this art, the removable lower screen 32 is provided with apertures of predetermined size to determine the maximum particle size of the comminuted material that is permitted to exit from the comminution chamber.

Disposed within the comminution chamber 3 is a rotor assembly formed of a plurality of circular saw-like blades or serrated periphery disc-like members 34 fixedly mounted on said rotor shaft 22 and maintained in close parallel spaced relation by interposed spacer washers 36. As illustrated in FIGURES 1A, 2 and 3, the disc-like members 34 are peripherally saw toothed so as to present a succession of cutting edges in the direction of rotation and, for most applications are preferably collectively mounted in a slightly skewed or offset relation as indicated by the angle A (FIGURE 2) to a plane normal to the axis of rotation of the shaft 22 to minimize, if not prevent, undesired tracking of material introduced through the feed channel 5. As best illustrated in FIGURE 5B the saw teeth on the periphery of the blade members 34 are preferably shaped to provide a chisel-like, acute angle cutting edge 35 disposed substantially parallel to the axis of the rotor shaft 22. As illustrated, the trailing edge of each tooth declines so as to completely expose the cutting edge on the succeeding tooth. The provision of the above described chisel-like cutting edge disposed substantially parallel to the rotor shaft axis results, when the number of available teeth per blade and number of blades are considered, in a greatly increased effective length of cuttting edge all localized within and operatively displaceable through the locus of material deformation. Secured to the undersurface of the upper curved wall 30 and disposed remote from the material feed aperture 8 is a deflector type liner member 31 having a surface configuration disposed in facing relation with the rotor periphery and of suitable contour to deflect material in a more or less radial direction back into contact with the cutting edged periphery of the saw toothed rotor.

As will be apparent from the foregoing, the saw tooth configuration of the periphery of the disc or blade members provides a plurality of successive selectively positioned cutting edges, which, upon engagement with the material, effect comminution primarily by a cutting impact with a rapidly moving chisel-shaped shearing edge, as distinguished from the so-called pure impact principle of grinding or comminution.

Referring again to FIGURES 2 and 3, each of the saw blade members 34 is provided with a plurality of apertures 38, suitably four in number, preferably arranged in equiangular relation and disposed substantially tangent to the periphery of the interposed spacer element 36 and in substantial radial alignment with the screened air inlet apertures 16 disposed in the opposite side wall portions of the cover member 6. Although discrete circular air inlet apertures 16 are preferred, a single elongate arcuate aperture in each side wall subtending an arc of about 80 degrees would also be suitable. As illustrated, the blade members 34 are mounted on the rotor shaft 22 in such manner as to preferably dispose the blade apertures 38 in substantially axial longitudinal alignment. In the specifically illustrated embodiment wherein ambient air inlet apertures 16 to the comminution chamber are disposed on both side walls of the cover member 6, a balanced bidirectional air flow toward the center of the rotor is obtainable by preferential utilization of an unapertured or imperforate central blade member 34*a* and by beveling or tapering the apertures in the blades on either side thereof so as to be divergent in the direction of the desired air flow, as best shown in FIGURE 2. The inclusion of the beveled or tapered apertures 38 in the saw blade members 34 and the alignment thereof in the manner described thus provides a plurality of channels for selectively directed gas flow, specifically a flow of ambient air, longitudinally of the rotor 22. In addition thereto, the interposition of the spacer members 36 intermediate adjacent blade members serves to separate the same and thereby define a plurality of radially disposed channels for selectively directed gas flow, each having a plurality of common junctions with the aforedescribed longitudinal channels.

It is to be understood that while the presently preferred embodiment is constructed as above set forth, a balanced bidirectional gas flow will also be obtained by utilization of an apertured but preferably unbeveled central blade 34*a*. Also, as now will be apparent to those skilled in this art, other arrangements as to degree or selective direction of bevel, and size and location of the saw blade apertures may be made as desired to obtain optimum results with a particular machine and/or particular material to be comminuted, for example, unbeveled apertures 38 in association with interposed spacer washers 36 of the fan blade type configuration, as illustrated in FIGURE 4, will also result in the desired and selectively axially directed flow of the gaseous carrier. In addition thereto, other expedients, such as an injector type material feed, as illustrated in FIGURE 5A may be employed.

In operation of the subject unit, unidirectional high speed rotation of the rotor assembly effects a positively induced and greatly increased primary bi-directional flow of ambient air or other gaseous carrier into the comminution chamber through the ambient air inlet apertures 16 on each side of the housing, longitudinally of the rotor shaft 22 through the tapered or beveled apertures 38 therein and, intermediate each pair of blades 34, a secondary flow radially outward into and through the locus of comminution, such radial flow being accelerated and reinforced by the action of the fan type spacer members 36 when the same are employed as heretofore described.

Although the mechanics of the above described rotor induced air flow pattern are not fully understood at the present time, it is believed that it serves, in addition to maintaining the material to be comminuted in suspended and separated condition in the vicinity of the chisel-shaped blade cutting edges, to uniformly convey heat away from the locus of deformation and to markedly and rapidly reduce the temperature of the comminuted product prior to the necessary intersurface contact thereof required for agglomeration.

The effect of maintaining the material to be comminuted in suspended and separated condition and uniformly conveying heat away from the locus of deformation has resulted, as shown in tests, with a saw tooth rotor embodying this invention, in the (1) production of granular grinds with a minimum of ultra-fines, (2) marked increase in the production rate per H.P./hr., (3) comminution, at satisfactory commercial rates, of many materials heretofore reduceable only at reduced rates and/or with the expedients referred to earlier in conventional equipment, (4) reduction in grind temperatures, (5) avoidance of the need, in many cases, of the expedients referred to earlier.

By way of example, in a recent comparative test on polystyrene having Dry Ice necessarily mixed herewith, a conventional machine incorporating a standard stirrup type rotor produced 33 lbs. per hour of comminuted product at 3 and ½ H.P. A saw tooth rotor unit embodying the principles of the subject invention operating on the same material produced an equivalent comminuted product at a rate of 60 lbs. per hour at 1 H.P. Other comparative tests on varying materials have shown as much as a 4 to 1 capacity ratio in favor of the subject invention over conventional and commercially available equipment.

In another comparative test on cellulose propionate (a fibrous material similar to cellulose acetate), a conventional machine with a bar hammer rotor produced 12.5 lbs. per H.P. hour of 92.6% through 40 mesh product with a .039 Rd. Pt. screen. The production obtained by the unit embodying the subject invention and with an equivalent speed and screen, was 20 lbs. per H.P. hour and of an average analysis of 94% through a 40 mesh and with a grind temperature about 25° F. lower than that produced in the conventional machine.

In still another comparative test, pure gum nitrol rubber (Hycar) could not be satisfactorily comminuted in a conventional bar hammer rotor machine due to a rapid rise in temperature, softening of the material in the grinding chamber and smoking of the material. The same material was processed satisfactorily in a unit embodying the subject invention with 3/32" and 1/8" Rd. Pt. screens at respective capacities of 18.5 and 27 lbs. per H.P. hour.

In other tests on a polyester resin having a melting point of 235° F. and a softening point of between 110° F. and 115° F. an unsuccessful attempt was made to produce a screened product of 100%, —40 mesh and 15% maximum, —140 mesh using liquid CO_2 as a coolant, on a bar type conventional machine. Using applicant's device on the same material and without coolant there was obtained a screened product analysing 100%, —40 mesh and 20%, —140 mesh when grinding the resin with an anti-caking agent and 100%, —40 mesh and 11.1% —140 mesh when no anti-caking agent was added. The temperature of the ground material never exceeded 98° F. with a 75° F. feed material and 80° F. atmospheric temperature.

In general, and apart from the specific advantages delineated above, tests to date indicate that units incorporating the subject invention produce satisfactory results in about 80% of those cases wherein it has been tested on materials which could not be satisfactorily processed by conventional equipment. Also, tests have shown that it is generally possible to operate the subject unit at appreciably higher mill temperatures than can be tolerated with conventional pulverizing machines. For example, it has been found possible with applicant's device to process low density polyethylene at outlet temperatures as high as 200° F. without any fusing in the comminution chamber. Nitrol rubber has been successfully run without fusing at outlet temperatures of 160° F. This feature is of extreme importance in increasing capacity and reducing the size of required equipment to do a particular job. It is also indicative of the fact that something more than a simple reduction of heat rise is responsible for the unexpected beneficial and new results that have been obtained from the subject construction to date.

In addition to the above mentioned comparative test results, the subject invention has been found to be particularly advantageous in the production of high density powdered sugar (47½ lbs. per cubic foot packed density) and which after comminution has been remarkably free from lumping, even though no starch was added before grinding. Tests have been run on lots of sugars from different refiners, and comminution has been performed under a wide range of relative humidities with no apparent difference in the non-lumping storage characteristics.

Applicant is unable to explain this highly advantageous result except to suggest that it may be due to the combined features of maintaining the material to be comminuted in suspended condition and uniformly passing air through the suspended material while it is being comminuted, combined possibly with the additional fact that the material is being comminuted by a fast acting shearing action, on an acute angle cutting edge.

The following is a list of random test results on various materials which to date have been found to be particularly adapted to comminution by method incorporating the subject invention:

Material	Character	Mill temp. (° F.)	Lbs. per hr.	Grind
Cellulose propionate	Fibrous and moderately tough.	148	19.0	94%—40
Cocoanut, stripped	Brittle		120	19%+14
				18%—80
Coffee, roasted	do		125	99%—12
				23%—40
Licorice extract	Very brittle		300	2%+14
				10%—100
PVC, chlorinated type No. 1	Tough	140	7.5	0.3%+40
				53%—100
Polyester, pigmented resin	do	146	3.3	34%+50
				2.4%—100
Polyethylene, H.D. and carbon black	do	130	7.5	91%—16
Polyethylene and pigment	Fine, granular with 2½% pigment.	84	200	(1)
Polyethylene, L.D. reactor flake	Tough	200	8	51%—40
Polystyrene	do	105	90	1.3%+12
				16.6%—40
Polystyrene, pigmented, 50:50 TiO_2	Brittle	120	5.5	47%+40
				3%—80
Potatoes, dried sliced, raw	Hard		200	1%+10
				20%—40
Resin, misc. A.C.X	Moderately tough	120	22.0	2%+40
				33%—140
Rice	Hard		210	0.0%+10
				49%—10+50
				41%—50+200
Rubber, nitrol (crude) type No. 1	Tough resilient	140	4	0.0%+10
				36%—40
Rubber, nitrol (crude) type No. 2	do	160	18	4.0%+20
				51%—50

See footnote at end of table.

Material	Character	Mill temp. (° F.)	Lbs. per hr.	Grind
Rubber, silicone flashings (cured)	Tough		15	4.5%+20 82%−20+50
Sugar	Brittle	104	190	99.8%−70 88.3%−200
Teflon and fibre glass 70:30 mix	Soft fibrous lumps		60	
Vinyl scrap	Tough	194	12	1%+12 2%−100
Wheat	Hard		450	7%−8 13%−40

[1] Excellent color dispersion.

Other materials which have also been found to be particularly suited for comminution by method incorporating the subject invention include:

elastomers
leather scraps
nylon pellets
polyurethane
scrap rubber
synthetic crude rubber
vinyl resins.

Having thus described my invention, I claim:

1. In the comminution of material, the steps of confining suspended material to be comminuted within a comminuting zone of generally hollow cylindrical configuration by a selectively directed flow of gaseous carrier and subjecting said suspended material to the cutting impact of multiplicities of discrete rapidly moving forwardly directed acute angle shearing edges disposed in substantially parallel relation to the axis of said comminuting zone and in spaced relation therealong and which are rapidly moving in a circular path of travel through said comminuting zone, said selectively directed flow of gaseous carrier including a first component substantially parallel to the axis of rotation of said shearing edges and intermediate said axis of rotation and the path of travel of said shearing edges and a second component substantially perpendicular to the axis of rotation of said shearing edges and flowing intermediate the same.

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