

Jan. 26, 1960

H. HARDINGE

2,922,586

COMMINUTING AND CLASSIFYING SYSTEM AND METHOD

Filed Feb. 18, 1954

5 Sheets-Sheet 1

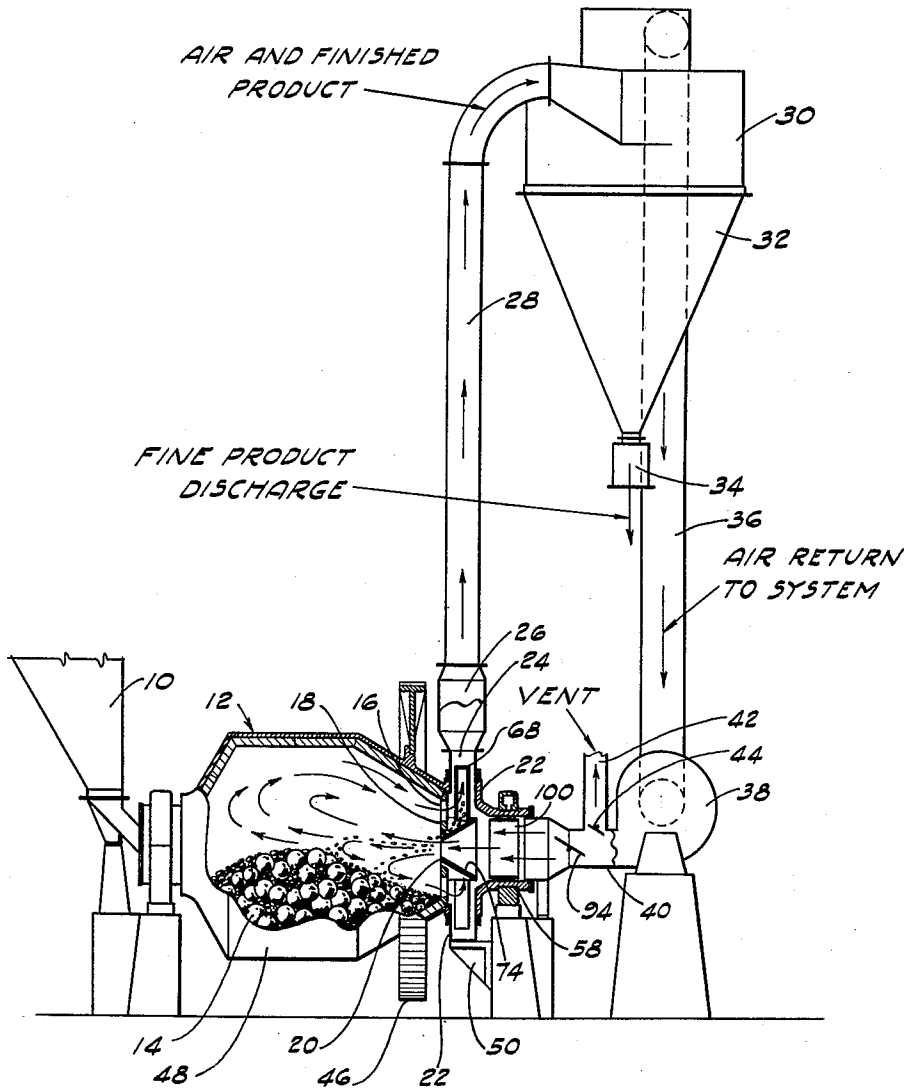


FIG. 1

INVENTOR
HARLOWE HARDINGE

BY

H. Harlowe Just

ATTORNEY

Jan. 26, 1960

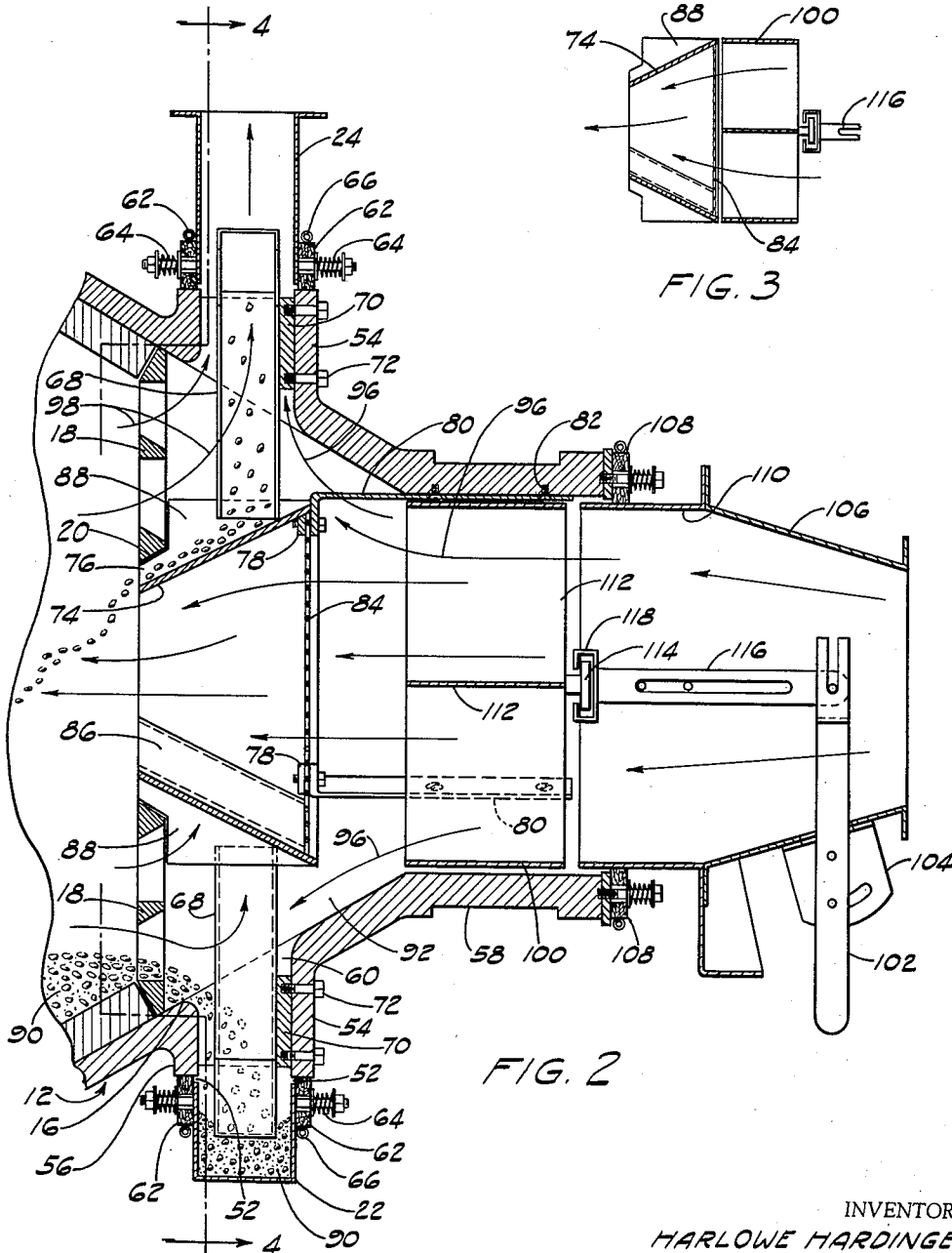
H. HARDINGE

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INVENTOR
HARLOWE HARDINGE

BY

W. Hering

ATTORNEY

Jan. 26, 1960

H. HARDINGE

2,922,586

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5 Sheets-Sheet 3

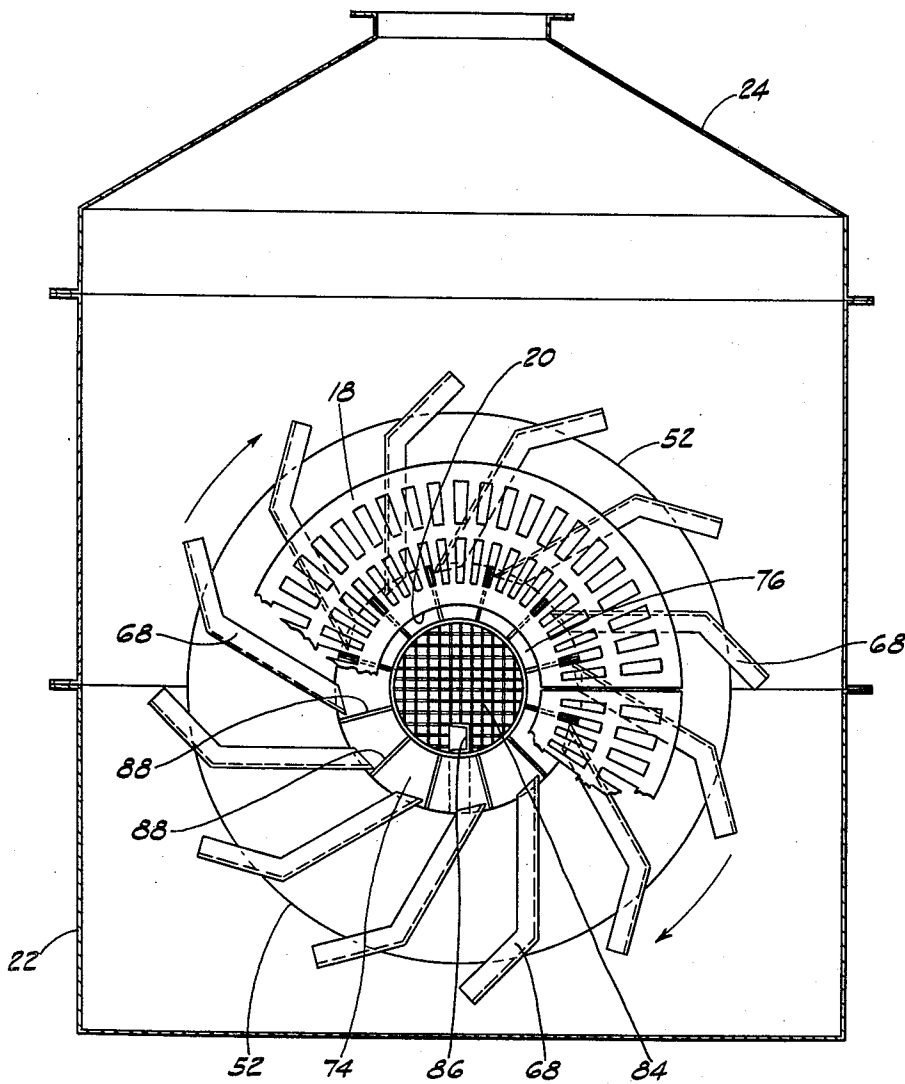


FIG. 4

INVENTOR
HARLOWE HARDINGE

BY

[Signature]

ATTORNEY

Jan. 26, 1960

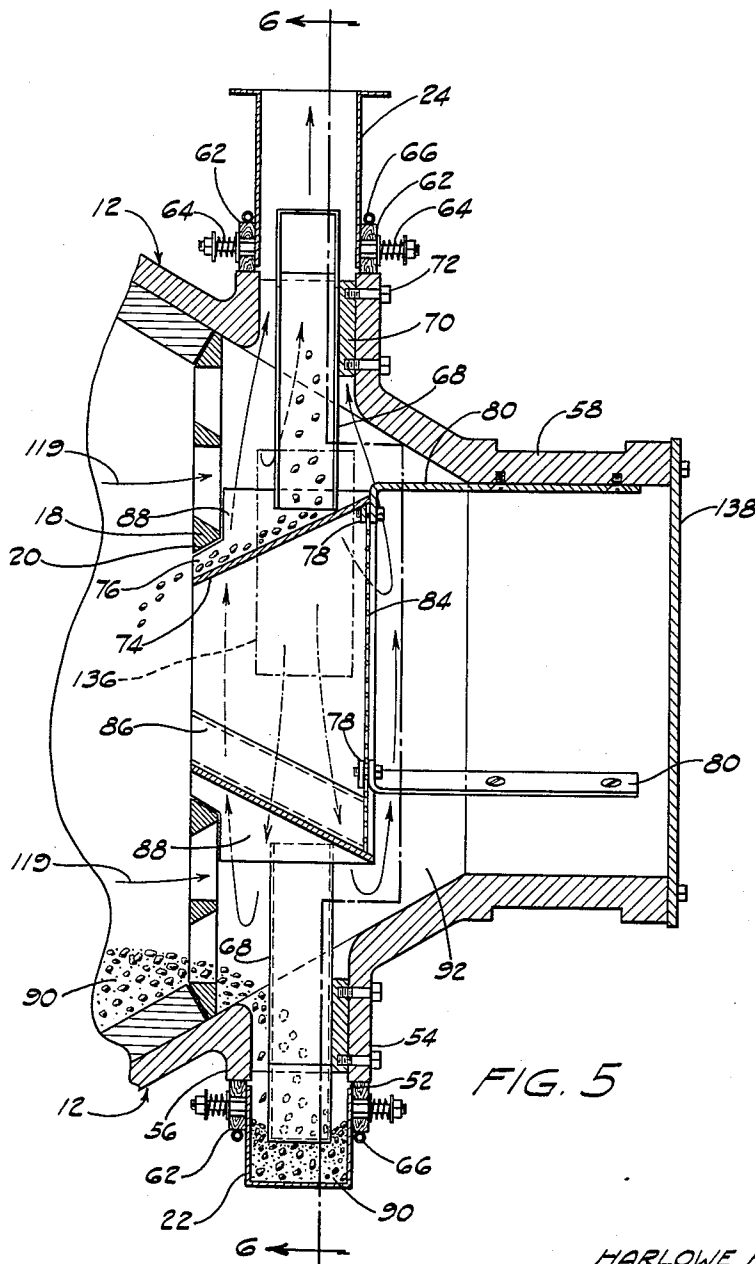
H. HARDINGE

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COMMUNTING AND CLASSIFYING SYSTEM AND METHOD

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5 Sheets-Sheet 4



INVENTOR
HARLOWE HARDINGE

BY

ATTORNEY

Jan. 26, 1960

H. HARDINGE

2,922,586

COMMUNUTING AND CLASSIFYING SYSTEM AND METHOD

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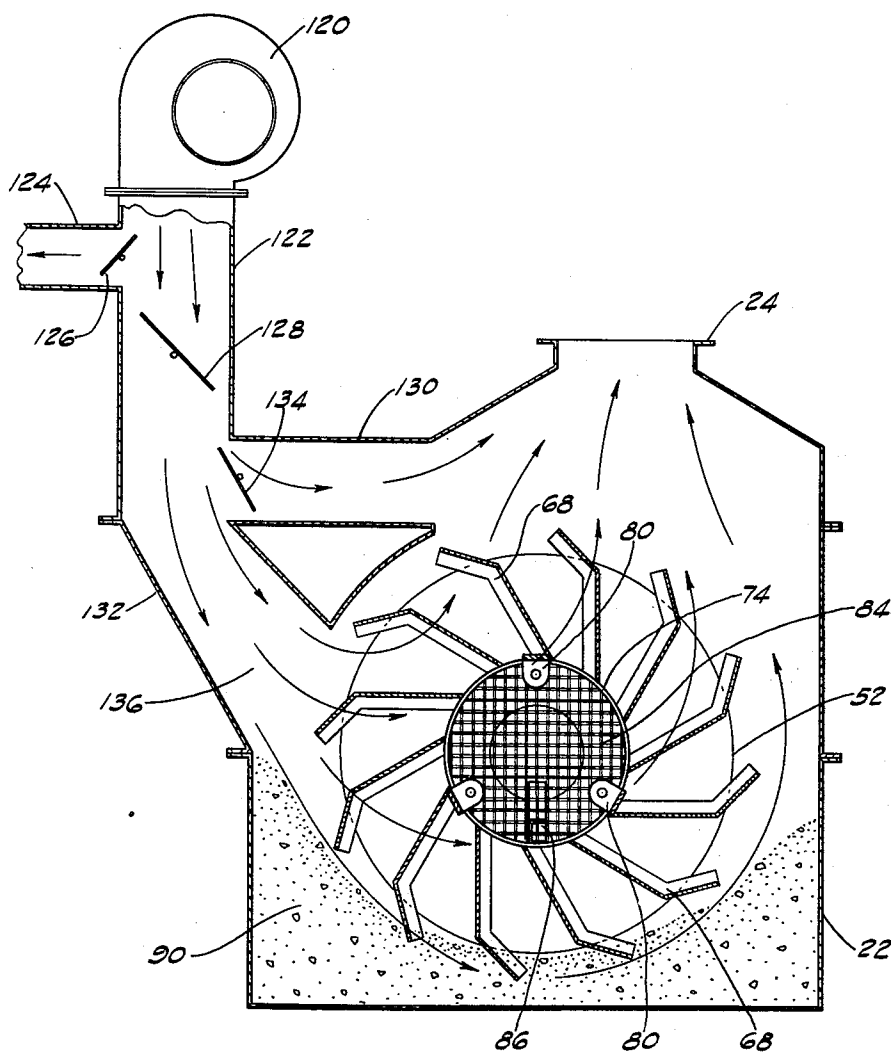


FIG. 6

INVENTOR
MARLOWE HARDINGE

BY

W. Herous Just

ATTORNEY

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2,922,586

COMMUNITING AND CLASSIFYING SYSTEM AND METHOD

Harlowe Hardinge, York, Pa.

Application February 18, 1954, Serial No. 411,117

12 Claims. (Cl. 241—19)

This invention relates to a system and method for pulverizing or comminuting mixtures of solid material consisting of various sizes of particles, the principal object of the system and method being to reduce progressively the particles of raw material to a fine product within a predetermined range of size and continuously removing said fine product from the material.

In the preferred embodiment of the invention, the raw material is comminuted or pulverized in a rotatable, drum-type mill in one end of which an exit is arranged through which the comminuted material containing desired products of a predetermined range of fine sizes, as well as coarser particles are discharged. The invention principally relates to a system and method for handling and treating the discharged product after it has been acted upon by said mill. Such system, therefore, is operable with other types of comminuting mills and is not to be restricted for use necessarily with mills of the type illustrated.

Many types of systems and methods have been devised heretofore for reducing to a predetermined degree or range of fineness a solid material. Such comminuting or pulverizing operations are common and necessary in treating many types of products such as mined ores for purposes of extracting desired elements or compounds therefrom and separating the desired products from the waste or undesired material. In other situations, a raw material of unusable large size requires comminution or pulverizing to reduce the material to a more or less uniform degree of fineness in which condition it is useful for various purposes.

So called ball or rod-mills, either conical or otherwise, long have been used for such pulverizing or comminuting operations. The disintegrated raw material is discharged from the mill, said material usually containing usable fines as well as larger particles which require further milling. Separation of the material of desired fineness from the coarser material has been accomplished in many different ways.

Frequently the material being comminuted is highly abrasive in nature and wear upon the comminuting as well as the separating apparatus has been great. Also, where separation is accomplished by fluid streams, prime movers having relatively high power consumptions are required to deliver said fluid current, such as air or gas, to the apparatus for purposes of moving the mixture discharged from the mill to auxiliary separators where those particles of certain desired degrees of fineness are separated from the coarser particles in the stream.

In certain types of previously used mechanism for accomplishing the foregoing purposes, said fluid currents are introduced into the mill to entrain mixed fine and larger particles of the pulverized material and the fluid currents containing both desired fines and oversize particles of material are directed upward or in other directions to mechanisms of various kinds for purposes of separating the larger or coarser particles from the desired fines. The upward movement usually is used to permit some

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of the larger particles to return to the mill by gravity. Considerable power also is required to move the undesired oversize products through the separating mechanism and, after separation from the desired products, the coarser particles are returned to the mill for further reduction in size. Such procedure obviously includes considerable wasted or useless effort and repetitious operation and consumption of power. Many of these separating mechanisms require very high velocities of current to effect desired separation of the fine products from the oversize material and power requirements to produce the same also are high.

Particularly where the material being acted upon for example, consists of an ore containing metals or minerals of different sizes, the largest particles of raw material tend to remain in the mill until reduced to such size that a fluid current introduced into said mill is capable of entraining the reduced particles and removing the same from the mill to a separation apparatus in which the various particles of acceptable fine size, as well as oversize particles, are separated from each other. While the larger particles are being acted upon in the mill, they tend to act as a cover or restricting agent for a considerable quantity of finer products which otherwise could be entrained in the fluid currents and removed from the mill. This condition is one of the reasons why the previous methods of grinding and classifying with the system are inefficient.

The present invention provides a mechanical system and method for comminuting and classifying mixtures of raw solid material of various sizes and overcomes most of the inefficiencies of the previously used devices by more effectively dispersing and agitating, by mechanical means as distinguished from pneumatic means, the mixtures of partially disintegrated or comminuted raw material, containing certain amounts of desired, usable fines and larger, incompletely ground particles which require further pulverizing. This mixture of material which is dispersed by mechanical means requiring comparatively low amounts of power, as compared to previously used devices, is subjected, while dispersed, to fluid streams which effectively and efficiently remove fine material of various predetermined ranges of desired size from the coarser particles of material which require further comminuting. Progressively with such separation, the oversize particles sequentially are returned to the mill by mechanism which is subjected to a minimum of wear and which is required to move said oversize material a minimum distance in order to return it to the mill for further disintegration.

The present invention also affords considerable improvement over the previously used devices for accomplishing similar results in that, by using the present invention, comparatively low velocities of fluid current can be utilized to achieve the desired results. Further, the relatively fine material which is removed from the mill after separation from the coarser particles can be so regulated in size that a minimum of further separation is required between the particles of various fine sizes within predetermined ranges of the material removed from the mill by said fluid current.

Further, classification is aided by mechanical agitation within the classifying zone which breaks up the tendency of air zoning into high velocity channels that tend to short-circuit through the system and carry with them too much unwanted coarse particles out with the fines.

Several embodiments of the invention are included for achieving the desired classification of products, as well as the separation of the desired fine particles from the coarser material which requires further disintegration, these different embodiments respectively having application to various installations, depending particularly upon plant arrangements and associated mechanism with which

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the system is to be used. Thus, these several embodiments of the invention are not full equivalents of each other although, basically, they employ similar principles and perform closely related methods.

Details of the foregoing objects and advantages of the invention and the mechanisms comprising the invention, as well as other objects thereof, are set forth in the following specification and illustrated in the accompanying drawings comprising a part thereof.

In the drawings:

Fig. 1 is a side elevation, partly in vertical section, of an exemplary mill system incorporating one embodiment of the present invention.

Fig. 2 is a vertical sectional view, on a larger scale than that used in Fig. 1, illustrating mechanism adjacent the discharge end of the mill which is operable to effect separation of desired fine products of a predetermined range of size from coarser particles which require further comminuting. This figure illustrates the same embodiment of the invention as Fig. 1.

Fig. 3 is a detail of the mechanism shown in Fig. 2, in section and on a smaller scale, and illustrating a different relationship of certain components than that shown in Fig. 2.

Fig. 4 is a vertical sectional view taken on the line 4—4 of Fig. 2.

Fig. 5 is a vertical sectional side view, similar to Fig. 2, but illustrating another embodiment of separating and classifying mechanism of the invention.

Fig. 6 is a vertical sectional view taken on the line 6—6 of Fig. 5.

Referring to the drawings, Fig. 1 illustrates an overall mill system incorporating one embodiment of the present invention which is illustrated therein on a small scale but is otherwise shown in greater detail in Fig. 2.

Considering the system in its entirety, raw material comprising a mixture of particles of solid material of various sizes is introduced into inlet hopper 10. A rotatable drum-type mill 12 is mounted, in conventional manner, for rotation about a substantially horizontal axis. The hopper 10 discharges the raw material into the inlet end of the mill 12, shown at the left-hand end in Fig. 1. The mill 12 contains conventional pulverizing media such as balls 14 of various sizes, the mill being partly filled with said media and raw material. The illustration in Fig. 1, though exemplary, illustrates a practical condition for operating the mill. The exit 16 of the mill preferably is covered by a heavy screen or grate 18 having a substantially central opening 20 therein.

Associated with the exit end of the mill 12 is a closed container 22. Communicating with the upper portion of container 22 is the inlet end of a conduit 24 through which finely divided products of a predetermined range of size are withdrawn from the container 22 by means to be described. Usually, some type of initial separator or classifier 26 is connected to outlet 24 to separate especially any medium or small oversize particles for return to container 22. The material, after passing through classifier 26 is drawn upward by suction through conduit means 28 which discharges into a finished product separator or collector 30. The latter may be any conventional type collector operable to separate the air from the fines removed from the mill. The finished product accumulates in cone 32 and is removed through the discharge mechanism 34.

The fluid medium or current which conveys the fine products through conduit 28 to collector 30 is exhausted therefrom through return conduit 36 which usually is under suction produced by fan 38. The fan 38 discharges into fluid stream conducting means comprising inlet conductor 40. The fluid medium passing into the fan through return conduit 36 is substantially clean of dust particles under usual conditions of operation. In preferred systems of this nature, inlet conductor 40 has a vent 42 rising therefrom, entrance to the vent 42 being controlled by an adjustable damper 44. The conductors and mechanism

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just described relative to the fluid medium are well known and greater description thereof is not believed necessary. For further illustration of such mechanism, attention is directed to applicant's prior Patents No. 1,721,594, dated July 23, 1929 and No. 2,174,630, dated October 3, 1939.

Mill 12, containing the grinding media 14 and raw material intermixed therewith is rotated by any conventional mechanism such as gear 46, it being understood that said gear is actuated by suitable power means such as an electric motor. If the mill is a conical type as illustrated in the figures, the pulverizing media 14 and raw material are continuously in motion in pulverizing manner within the mill. The coarsest particles of raw material usually remain within the larger zone or main body portion 48 of the mill.

The portion of the mill adjacent the outlet end 16 is of smaller diameter so as to provide a constricted outlet and the operation of the mill is such that partially pulverized material, including small oversize particles intermixed with fine particles of product size, gradually is moved through the openings in the grate 18 at the outlet end 16 of the mill, whence it is discharged progressively into the lower portion of container 22 as illustrated in detail in Fig. 2. Some of the large oversize particles of material also may be discharged into the container along with the pulverized material but the apparatus functions to handle the same as is described hereinafter.

The container 22 may be of any desired shape. In the specific illustration thereof in Figs. 2 and 4, for example, the container is substantially rectangular in vertical transverse sectional elevation and the same is stationarily supported by any suitable means such as brackets 50. The spaced end walls of the container 22 preferably are not widely separated and each wall contains a substantially circular opening 52 within which parallel, annular, connected flanges 54 and 56 on the mill adjacent the trunnion 58 are disposed rotatably. The annular flanges 54 and 56 are connected by a series of spaced webs 60 which, for example, may be cast integrally with said flanges and spaces between said webs accommodate part of the mechanism and afford passages for fluid streams and material.

Particularly in installations where substantial freedom from dust is desired, sealing mechanism in the nature of rings 62 are connected to the end walls of container 22 and slidably engage the peripheries of the annular flanges 54 and 56 as shown in detail in Fig. 2. These sealing rings may be of any suitable material and wood or felt is highly adaptable for the purpose. The sealing rings may be composed of a plurality of curved segments which respectively are held against the end walls of container 22 by springs 64 and additional means such as constricting elastic members 66, shown as springs, surround the peripheries of the segmental sections of sealing ring 62 in order to closely to hold the inner surfaces of said sealing rings in sliding relationship with the peripheries of the flanges 54 and 56.

Material engaging and lifting or elevating mechanism, which also agitates and disperses the material, is provided within container 22, said mechanism also breaking up the tendency of the fluid streams and currents to channel and convey too large, coarser particles out with the fine material. This mechanism comprises a plurality of substantially radially extending bucket or scoop members 68. These scoops extend between the webs connecting flanges 54 and 56 and are attached to the mill 12 so as to be rotatable therewith. In the exemplary illustration in Figs. 2 and 4, the scoops 68 are each welded to a block 70 and said block and scoops are fastened to annular flange 54 by suitable bolts 72. Other attaching means may be used, which preferably space the scoops 68 from flanges 54 and 56 and container 22.

Also fastened to the mill 12 so as to be rotatable therewith is a material guiding or directing member comprising a truncated cone 74 which is open at both ends and is substantially coaxial with the mill 12. The conical

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member 74 tapers toward its axis and the exit opening 20 in the grate 18. In the preferred embodiment of the invention, the smaller end of the conical member 74 extends somewhat into the grate opening 20 but is peripherally spaced therefrom so as to provide a substantially annular opening 76 for purposes to be described.

The larger end of conical member 74 is provided with a plurality of lugs 78 to which the intumed ends of brackets 80 are attached. The brackets 80 also are secured in any suitable manner to the mill 12 such as by being attached to the interior of trunnion 58 by any suitable means such as screws or welding, as clearly shown in Fig. 2. Further, the larger end of the conical member 74 is provided with a screen 84, secured to brackets 80, for example, for purposes of preventing passage through the conical member 74 of either very coarse oversize particles of material or elements of the grinding media 14. In the event any of this type of material enters conical member 74, a return scoop or chute 86 is fixed thereto for purposes of engaging such material as the conical member revolves with mill 12 and, when said chute 86 reaches the upper portions of its path of movement, said material will be returned by gravity down said chute to the mill.

Conical member 74 also is provided with a plurality of substantially radially projecting vanes 88 which extend outward from the outer surface of the member 74 as clearly shown in Figs. 2 and 4. From Fig. 4 particularly, it will be observed that the scoop members 68 terminate at their inner ends in spaced relationship to the conical member 76 but said inner ends of the scoop members extend between adjacent vanes 88 as seen from Fig. 4.

In operation, as the mill 12 rotates, the scoop members sequentially are moved into contact with accumulated, intermixed, finely divided and partially pulverized material 90 deposited by the mill in the lower portion of container 22 as clearly shown in Fig. 2 particularly. Under preferred conditions, the operation of the mill is regulated so that the material mixture 90 progressively and continuously is fed into container 22 and is removed therefrom by scoops 68 at such a rate that the upper level of said material does not extend above the openings 52 in the end members of container 22. Thus, there will be a minimum of or no tendency for material to leak between the sealing rings 62 and the annular flanges 54 and 56 unless the system becomes overloaded. However, this arrangement also comprises an indicating means in that, if the mill 12 is being fed at too fast a rate and material is accumulating within container 22 too rapidly, there will be a tendency for material, for example, being moved in container 22 to leak through said sealing means and thereby indicate to the operator that the operation of the machine requires adjustment.

As the mill 12 is rotated and the scoop members 68 progressively engage and lift or elevate portions of the accumulated material mixture 90 in container 22, said scoop member 68 will commence to discharge the elevated material as the scoops are moved toward their uppermost position, the material falling by gravity from said scoops onto material return or directing means comprising conical member 74, above the axis of said member, as clearly shown in Fig. 2. Due to the sloping nature of conical member 74, the discharged material flows by gravity through annular opening 76 and re-enters the mill in the nature of a falling stream or streams passing downward across the smaller opening of conical member 74.

Such operation upon the material 90 causes a very effective dispersion of the same, as well as an agitation thereof and disposes the material in highly suitable condition effectively to be subjected to and treated by a fluid current for purposes of entraining and removing from said material fines within a predetermined range of sizes which, under most preferred conditions of operation, largely con-

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stitute finished and desired products. Thus, the fluid current passes beneath the coarser particles and flows therein back toward the feed end of the mill by intersecting their path of fall. It is to be noted that this dispersion or agitation of the material 90 is performed by mechanism of an extremely simple nature which requires a minimum amount of additional power to operate over and above that required to rotate the mill 12, the elevating scoops 68 being carried by and movable with said mill during the rotation of the latter. Due to the fact that the scoop members 78 are not of great length, the overall diameter of the assembly of scoops is smaller than that of the largest diameter of the mill 12 and a minimum amount of elevating movement of the material 90 thus is required to achieve the desired results. The mechanism also is subjected to minimum wear and the effective dispersion of the material permits the use of low velocities of fluid currents to effect desired entrainment of fine material therein.

In the embodiment of the invention illustrated in Figs. 1 through 4, it will be seen from the foregoing that a fluid current or stream is discharged from fan 38 through inlet conductor 40 into the interior of hollow trunnion 58 of the mill. This stream or current is directed axially through the trunnion 58 and into the space 92 adjacent the fluid current inlet end of conical member 74, within which space the current expands. This space results from the conically tapered formation of the exit end of the mill 12 as shown in Fig. 2 and entrainment of fine products by the fluid current takes place therein as well as elsewhere.

For purposes of the present explanation, it is assumed that the fluid current or stream of fluid medium indicated by the arrows in Fig. 2 will be moving at relatively high velocity as is well known in systems of this nature and particularly in those illustrated in the aforementioned patents, the inlet damper 94, as well as damper 44 controlling vent 42, may be so regulated that a negative pressure can be produced in the space 92. Assuming now that the fluid current axially introduced into space 92 and conical member 74 is moving at high velocity, said fluid current will be dispersed in several different directions upon entering space 92. For example, as indicated by arrows 96, a portion of said fluid current, due to its energy and suction in outlet 24, will be directed against the scoops 68 and engage the material being elevated and dispersed thereby so as to entrain fine material of a predetermined range of sizes and remove such entrained material from container 22 through uptake outlet 24 which is under suction present in conduit 28.

Due particularly to the axial direction of the main portion of the entering fluid current, a large proportion of said current will enter the mill 12 through the smaller end of conical member 74 and circulate through the mill, in reverse current manner, as shown by the arrows in the mill illustrated in Fig. 1. Details of such reverse current operation are illustrated and described in applicant's aforementioned prior patents. The result of such reverse current action is that fines of a predetermined size or range of sizes within the mill 12 will be engaged and entrained within said fluid current and such current will exit through the openings in grate 18 and enter container 22 but due to the suction present in outlet 24, said particle laden fluid currents will rapidly be withdrawn from said container through conduit 28.

Another advantage of the embodiment of the invention illustrated in Figs. 1 through 4 is that the fluid current entering the mill 12 through conical member 74, being concentrated by the inner open end of conical member 74 is not interfered with by exiting currents containing entrained fines. Said fine laden exiting currents pass through the openings in the grate 18, as indicated by arrows 98 in Fig. 2 and from there pass into container 22 and into uptake outlet 24.

Thus, due to the foregoing arrangement for introducing

the fluid current into the mill and the fact that the counter-current return of entrained fine particles in the fluid current passes independently of said incoming current through grate 18 into container 22 for exit through outlet 24, such counter-current does not exit through the trunnion 58 as was necessary in previously used counter-current mills in which the fluid current was introduced through the trunnion. Accordingly, the trunnion 58, which incidentally is rather expensive to manufacture, may be reduced in size materially over the sizes required in other previously used arrangements referred to above, thereby not only reducing the cost of the same but also greatly improving the efficiency of the system principally due to the lack of conflict between incoming clean fluid current and exiting fluid current entrained with fines and oversize particles. Further, the passage for fluid current in the trunnion in the system comprising the invention conducts a clean fluid current only and is not scoured and abraided with product particles as in such previously used mill systems, thereby greatly reducing wear on the trunnion.

The percentage or degree of the fluid current entering the grinding zone of mill 12 may be varied by suitable control or regulating means illustrated in Figs. 1 and 2 and comprising a slidable sleeve 100 which is movable between its retracted position illustrated in Fig. 2, relative to conical member 74, and its extended or closed position shown in Fig. 3 relative to member 74.

Any suitable regulating or positioning means for sleeve 100 may be provided. In Fig. 2, for example, a lever 102 is pivotally secured to a bracket 104 fixed to connecting conduit 106 which extends between inlet conductor 40 and the outer end of hollow trunnion 58. Connecting conduit 106 is stationary and, in the preferred embodiment of the invention, an additional sealing ring 108 similar to sealing ring 62, is attached to trunnion 58 by means clearly illustrated in Fig. 2 and resembling those by which rings 62 are secured and held in close sliding engagement with extension conduit 110 which is fixed to connecting conduit 106.

The slidable sleeve 100 is provided with a plurality of transverse webs 112 which are connected substantially at the axis of said sleeve and an annularly flanged member 114 is connected to said webs substantially coaxially with the sleeve. A connecting rod or strip 116 is guided for longitudinally slidable movement within conduits 106 and 110, the rod 116 being coaxial with member 114. The inner end of member 116 has a reversely bent member 118 which engages opposite surfaces of the flange on member 114 for purposes of moving the sleeve axially of the trunnion 58 when connecting rod 116 is moved longitudinally. The opposite end of connecting rod 116 is connected to a slotted end of lever 102 so that, as lever 102 is moved about its pivot, the sleeve 100 will be moved toward or away from the larger end of conical members 74.

When sleeve 100 is moved to the position illustrated in Fig. 3, substantially the entire fluid current entering the trunnion 58 will be directed through conical member 74 and into the mill 12 to produce the reverse current effect described above for purposes of entraining as much of the finely divided material of predetermined desired size as possible within the mill and from there said entrained material exhausts through grate 18 and outlet 24 as described. However, when it is desired to have a portion of said fluid current enter the space 92 so as to be circulated to a greater degree within container 22 and reduce the reverse current action in the mill which alters the location of the oversize material blown back into the grinding zone, the sleeve 100 is moved toward its retracted position any amount desired in order to achieve the optimum desired operating condition in the mechanism.

In view of the above described operations and details of the mechanism, resistance to the passage of the fluid current into and through the mill, as well as in engaging the material elevating and returning mechanism compris-

ing scoop members 68 and conical member 74, is greatly reduced over the resistance encountered in conventional mills operating on a reverse current basis. Thus, for a given volume of air, the power required to exhaust the entrained fluid current is minimized. Further, highly efficient engagement of the fluid currents takes place with the dispersed incompletely comminuted or pulverized material 90 in container 22 as handled by scoop members 68 to elevate and disperse the same against conical member 74 in order to facilitate entrainment of the desired fines in said material within said fluid current.

Effective return of said material is achieved by the provision of vanes 88 which prevent lateral movement of said material relative to conical member 74 as said material flows by gravity down the cone and in front of the smaller open end of member 74. Thus, as the incoming fluid current passes through and intercepts said falling stream of material, as clearly shown in Fig. 2, the fine material of desired size or range of sizes contained in the falling stream of material therein is entrained efficiently by said fluid current. Still further, the concentrated inlet of said fluid current caused by the constricted inner end of conical member 74 is directed fully against said downward falling stream of material and the coarser or oversize particles of material in said falling streams are blown more or less axially back into the mill toward the larger zone 48 thereof to a far greater and more efficient degree than if the stream merely fell by gravity into said mill. Due to this, the coarser particles of material are placed or returned to the zone in said mill wherein the larger pulverizing media usually is located and pulverizing takes place more rapidly.

The width of the scoop members 68 is selected to be such that adequate space is provided between the sides of said scoop members and the end walls of container 22 to permit effective fluid circulation, and no binding or damaging engagement is encountered between larger particles of partially pulverized material with said scoop means and side walls takes place. This results in minimizing wear and also maintaining power requirements at a minimum.

Particularly in plant conditions where space is at a premium, the beneficial results of the present invention may be achieved by utilizing the embodiment of the invention illustrated in Figs. 5 and 6. In these figures, all of the elements of the invention which are common to the embodiment shown in Figs. 1 through 4 are similar. The principal difference between said embodiments is that in the latter embodiments shown in Figs. 5 and 6, different means are utilized for introducing the fluid current to the container 22 and, in addition, fluid current represented by arrows 119, is introduced into mill 12 through the inlet end adjacent hopper 10 by suitable conventional means, not shown.

In Fig. 6 particularly, it will be seen that the fan 120 discharges into a conduit 122, it being assumed that the fan 120 obtains the fluid medium, for example, from a suitable source such as the return conduit 36 illustrated in Fig. 1. A vent 124 communicates with and extends away from conduit 122. Entrance of the fluid medium into vent 124 is controlled by damper 126 which functions similarly to damper 44. Conduit 122 also contains a regulating damper 128, for purposes similar to those described above relative to damper 94. The conduit 122 preferably terminates in a pair of branched inlet conduits 130 and 132, conduit 130 also having a control damper 134 therein. The inlet conduits 130 and 132 communicate with container 22 in a direction substantially transversely or radial to the axis of the mill 12 and conical member 74.

The fluid current thus is introduced, under pressure, into container 22 through conduits 130 and 132 in the exemplary description given herein. Due to the transverse direction of the fluid current entering container 22

in this embodiment of the invention, as distinguished from the axial entry of said fluid medium in the embodiment of the invention shown in Figs. 1 through 4, the overall length of the comminuting and classifying system may be reduced materially as clearly shown from Fig. 5. Regulation of the damper 134 will determine how much of the fluid medium initially will be directed to the outlet 24 and the amount which will be directed into the container through radially extending inlet opening 136.

Fig. 5 is a vertical longitudinal sectional view of the trunnion and exit end of the mill 12 and Fig. 6 is taken on the line 6—6 of Fig. 5 as viewed in the direction of the arrows. Thus, in Fig. 5, the half of the container 22 which has inlet opening 136 therein is not present in Fig. 5. Accordingly, the opening 136 in Fig. 5 is illustrated in phantom fashion for purposes of understanding operation of this embodiment of the invention.

As the fluid current enters casing 122 through opening 136 it will encounter material 90 which is being operated upon by the scoop members 68 for purposes of dispersing and agitating said material and effecting entrainment of fines of a desired range of sizes therein with said fluid current. Said currents also will pass into space 92 and engage and entrain any fine material of desired range of size therein for purposes of separating the same from the coarser particles of material 90 in the atmosphere therein and remove said entrained fine material through outlet 24. It will be noted in Fig. 5 particularly that the outer end of trunnion 58 is closed by a cap plate 138 but the inner surface of said trunnion has fixed thereto the brackets 80 which support the conical member 74 in fixed relationship to the mill 12 for rotation therewith.

Otherwise, the operation of the embodiment illustrated in Figs. 5 and 6 is similar to the embodiment shown in Figs. 1 through 4 except that the fluid current is not passed actively or forcefully through the conical member 74 for purposes of carrying the coarser particles deposited upon conical member 74 back into the mill toward the main portion 48 thereof. However, such coarser particles move by gravity into the mill by sliding down conical member 74.

From the foregoing, it will be seen that in both embodiments of the invention, great reduction in resistance to the passage of the fluid medium through the mill and material returning mechanism is achieved. Coarse particles or so-called tramp oversize material are returned inside of the mill system mechanically and not necessarily by the use of a fluid medium or current. However, in the embodiment of the invention illustrated in Figs. 1 through 4, fluid current is utilized when introduced into the mill to assist in moving the oversize particles returned to the grinding zone of mill beyond the grate and farther back therinto than otherwise and no duct means which would be subject to wear are required as in previously used mills of this nature to accomplish this purpose. Thus, a saving in wear and power occurs.

In both embodiments of the invention, the coarse oversize particles of material discharged initially from the mill are trapped in a stationary container adjacent the exit end of the mill and are not allowed to pass up the uptake or discharge conduit through which the desired product fines of a predetermined range of sizes are removed from the mill. By such an arrangement, material saving in wear upon such outlet duct is achieved, as well as eliminating or minimizing resistance to the free flow of the fluid current.

Velocities of fluid currents used generally are materially lower than those previously required to move the fine material from the mill up to a conventional classifier since, rather than the exhaust and particle entrained fluid current being required to carry at least some small oversize particles, the latter now are not contained in the exhaust fluid current, which current contains only fine material of a predetermined range of sizes. The

oversize particles drop down into the container used in both embodiments of the invention and are conveyed from there mechanically back into the mill by mechanism which is subjected to a minimum of wear and which requires far less power to operate than the fan and blower mechanisms previously required to move such exhaust fluid streams.

Further, where an auxiliary classifier is used in conjunction with the comminuting and classifying systems incorporated in the several embodiments of the present invention, since substantially all coarse oversize particles are not entrained in said exhaust streams of fluid current, the auxiliary classifier does not have to act upon such coarser particles of oversize and only handles and operates upon fine materials of a predetermined range of sizes. Therefore, the loading of the auxiliary classifier is less and the efficiency of operation is increased which, in turn, reduces the amount of finished product being returned with the oversize to the mill and further increases the overall efficiency of the system. In addition, the greater and more efficient ability to control the entry of fluid currents into the mill and the action of said currents upon the oversize material particularly in the embodiment shown in Figs. 1 through 4, now make it possible to control the grinding operations with the mill to a far higher degree of efficiency and advantage and under a wider range of operating conditions than previously was possible.

The several embodiments of the invention described and illustrated herein handle and treat the material in novel ways comprising new methods of treatment which comprise part of the present invention. The essence of these methods is the unique dispersion of mixtures of incompletely ground and fine material by mechanical means, as distinguished from pneumatic, while subjecting the dispersed material to fluid currents to entrain from the incompletely ground and comminuted coarser particles fines of a predetermined range of sizes which may either constitute or include the desired finished product.

While the invention has been shown and illustrated in its several preferred embodiments, and has included certain details, it should be understood that the invention is not to be limited to the precise details herein illustrated and described since the same may be carried out in other ways falling within the scope of the invention as claimed.

I claim:

1. A disintegrating and classifying system operable to treat solid material and comprising in combination, a rotatable drum-type mill having a discharge exit, a stationary enclosing container adjacent said exit arranged to receive from said mill disintegrated material of various sizes including fines of desired product size, material lifting means mounted within said container for movement relative thereto and operable progressively to raise from said container and discharge quantities of said material in a falling stream, and means operable to subject said stream of material to a fluid current to remove the finer products therein.

2. A mill and classifying system operable to receive material to be reduced to a predetermined size and comprising in combination, a comminuting mill mounted for rotation about an axis and having a discharge exit, a stationary enclosing container positioned adjacent said exit to receive therefrom comminuted material of various sizes including fines of desired product size and coarser particles, material dispersing means within said container, means operable to move said material dispersing means relative to said container to form falling streams of said material and disperse it, means operable to direct a fluid current through said material while dispersed, and means positioned to intersect the path of falling coarser particles of material and operable to reintroduce said coarser particles of material into said mill.

3. A system operable to receive and treat a mixture of

particles of solid material of various sizes and comprising in combination, a drum-type mill mounted for rotation about a substantially horizontal axis and having a discharge exit adjacent one end, a stationary closed container adjacent said exit arranged to receive from said mill disintegrated material of various sizes including fines of desired product size, scoop means attached to said mill adjacent the exit thereof and rotatable therewith about the axis of the mill, said scoop means being operable to scoop and elevate from said container quantities of said material and disperse the same adjacent said exit, and means operable to produce a fluid stream and direct the same from said exit against said dispersed material, thereby to entrain and remove from said dispersed material the finer products therein.

4. A mill operable to receive and treat a mixture of solid material including particles of various sizes and comprising in combination, a drum-type mill mounted for rotation about a substantially horizontal axis and having a peripheral discharge exit adjacent one end, grate means in said mill adjacent said exit having a central opening therein, an enclosed container positioned stationarily adjacent said exit and arranged to receive therefrom comminuted material of various sizes including fines of desired product size, conical material directing means open at both ends and coaxial with said mill, said conical directing means sloping downward and inward toward the exit of said mill, the smaller end of said conical means terminating adjacent said opening in said grate and being peripherally spaced therefrom, lifting means movable within said container and operable to elevate material from said container and discharge the same onto the upper surface of said conical means for discharge by gravity past the smaller open end of said means for return to said mill through the opening in said grate, and means operable to introduce a fluid stream into said container in a direction axially of said conical means to entrain therein fines of a predetermined range of desired product sizes and remove the same from the coarser particles of material within said container, whereby the material discharged onto said conical means is unburdened of fines of desired product size, said fluid stream also being directed by said conical means through the smaller open end thereof and against the coarser particles falling therepast to project the latter back into said mill away from said grate.

5. A mill operable to receive and treat a mixture of solid material including particles of various sizes and comprising in combination, a drum-type mill mounted for rotation about a substantially horizontal axis and having a peripheral discharge exit adjacent one end, grate means in said mill adjacent said entrance having a substantially central opening therein, an enclosed container positioned stationarily adjacent said exit and arranged to receive therefrom comminuted material of various sizes including fines of desired product size, conical directing means open at both ends and coaxial with said mill, said conical means sloping downward and inward toward the exit of said mill, the smaller end of said conical means terminating adjacent said opening in said grate and being peripherally spaced therefrom, lifting means movable within said container and operable to elevate material from said container and discharge the same onto the upper surface of said conical means for return to said mill through the opening in said grate, a conduit communicating with said container oppositely to said mill exit and substantially coaxial with said conical means and spaced from the larger end thereof, means operable to introduce a fluid stream into said conduit for discharge into said container to entrain therein product fines of a predetermined range of sizes and remove the same from the coarser particles of material within said container, and a sleeve slidable within said conduit and axially movable thereto toward and from said conical

means to vary the amount of fluid current discharged axially into said conical means.

6. A mill and classifying system operable to receive material to be reduced to a predetermined size and comprising in combination, a comminuting mill mounted for rotation about an axis and having a discharge exit, a stationary closed container positioned adjacent said exit to receive therefrom comminuted material of various sizes including fines of desired product size and coarser particles, material engaging means within said container, means operable to move said material engaging means relative to said container to form falling streams of coarser particles of said material and disperse it, means positioned and operable to direct a fluid current from said mill through said dispersed material within said container to entrain and remove therefrom the finer products therein, means positioned to intersect said falling streams of coarser particles and direct the same into said mill through said exit, and means operable to direct a fluid current toward and through said exit of said mill to engage said falling coarser particles directed into said mill to facilitate the return thereof into said mill through said exit by said last mentioned means.

7. A system operable to receive and treat a mixture of particles of solid material of various sizes and comprising in combination, a drum-type mill mounted for rotation about its axis and having trunnions at opposite ends supported by bearings, one of said trunnions being hollow and the mill having a discharge exit adjacent said hollow trunnion, a stationary container positioned between said trunnions adjacent said exit and arranged to receive from said exit disintegrated material of various sizes including fines of desired product size, material lifting mechanism carried by said mill adjacent the exit thereof and operable within said container to elevate relative to said stationary container quantities of said disintegrated material and discharge the same in a falling stream to disperse it adjacent said exit, and means operable to direct a fluid stream from said exit against said stream of dispersed falling material, thereby to entrain and remove from said stream of material the finer products therein.

8. A system operable to receive and treat a mixture of particles of solid material of various sizes and comprising in combination, a drum-type mill mounted for rotation about a substantially horizontal axis and having trunnions at opposite ends supported by bearings, one of said trunnions being hollow and the mill having a discharge exit adjacent said hollow trunnion, a stationary closed container positioned between said trunnions adjacent said exit and arranged to receive from the exit of said mill disintegrated material of various sizes including fines of desired product size, a plurality of scoops attached to said mill adjacent the exit thereof and extending substantially radially to the axis of said mill into said container, said scoops being operable with said mill successively to engage material in said container and elevate quantities thereof relative to said container and discharge the same from an elevated position to disperse it, a truncated cone open at both ends mounted adjacent said exit with the smaller end extending therethrough and positioned to intersect the streams of dispersed material discharged from said scoops and direct the coarser particles thereof downward and into said mill through said exit, means operable to direct a fluid stream from said exit and against the material while being dispersed by said scoops, thereby to entrain and remove from said material the finer products therein, and additional means operable to direct a fluid current through said hollow trunnion and cone to blow the falling streams of coarser material back into said mill.

9. A mill and classifying system operable to comminute a mixture of solid raw material including particles of various sizes to a predetermined range of fine product sizes and comprising in combination, an enclosed sta-

tionary container, conduit means having an entrance communicating with said container, means to produce suction in said conduit means, a drum-type mill mounted for rotation about a substantially horizontal axis and having trunnions at opposite ends supported by bearings, one of said trunnions being hollow axially and said mill having an exit adjacent one end and said hollow trunnion and communicating with one side of said container, said exit being operable to discharge into said container comminuted material of various sizes including product fines of desired ranges in size, fluid stream conducting means communicating with the opposite side of said container and substantially axial with said mill exit, said conducting means being operable to direct a fluid stream into said container through said hollow trunnion and into contact with material therein to entrain therefrom said product fines and the suction in said conduit means being operable to withdraw said fluid stream with entrained fines therein from said container, a cylindrical valve member movable axially relative to said hollow trunnion and opposite end of said container and operable to control the discharge of said fluid stream through said conducting means into said container and mill, and material dispersing means mounted within and movable relative to said container and operable to engage material within said container and positively move the same therein to disperse it for engagement by said fluid current to entrain the fine particles thereof and move the coarser particles thereof for return to said mill.

10. A method of comminuting solid material of various sizes to a predetermined range of fine sizes and comprising the steps of disintegrating and comminuting said particles of material in a mill, discharging the products from one end of said mill into a stationary container whereby a portion of said material is permitted momentarily to come substantially to rest therein, mechanically and positively agitating and elevating said material within said container by means moving relative to said container to disperse it, and while said material is dispersed in falling streams subjecting the same to a fluid stream directed toward the interior of said mill and falling material to entrain therein a desired range of fine products, removing the same from said container, and utilizing part of said fluid stream to blow the coarser particles of falling material back into the mill to subject the same to further disintegration and comminution.

11. A method of comminuting solid material of various sizes to a predetermined range of fine sizes and comprising the steps of subjecting said material to progressive comminution and disintegration with a mill and collecting the disintegrated material as discharged progressively from said mill into a container, scooping said collected comminuted material from said container by mechanical means moving relative to said container to disperse said material positively in a falling stream, subjecting said falling stream of material to a stream moving transversely to said falling streams to entrain and remove therefrom the finer products of desired range of size, and progressively resubjecting the coarser particles of said material to comminution and disintegration.

12. A mill and classifying system operable to receive material to be comminuted and comprising in combination, a comminuting mill mounted for rotation upon hollow trunnions at opposite ends of said mill about an axis and having a discharge exit between said trunnions, one trunnion being an inlet for material to be fed to the mill and the opposite trunnion being adjacent said discharge exit, a closed container positioned stationarily adjacent said discharge exit and arranged to receive from the exit of said mill comminuted material of various sizes to be classified including fines of desired product size discharged from said mill, material engaging means movable relative to said container, means operable to establish relative movement between said stationary container and material engaging means to effect positive dispersing movement of said material relative to said container, and means operable to subject said dispersed material to a fluid current introduced through one of said trunnions to entrain therein and remove from the dispersed material in said container the finer products by means of said fluid current.

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