Aug. 11, 1959 H. HARDINGE 2,899,139

METHOD AND APPARATUS FOR CONCENTRATING AND CLASSIFYING MATERIAL

Filed June 14, 1954 4 Sheets-Sheet 1

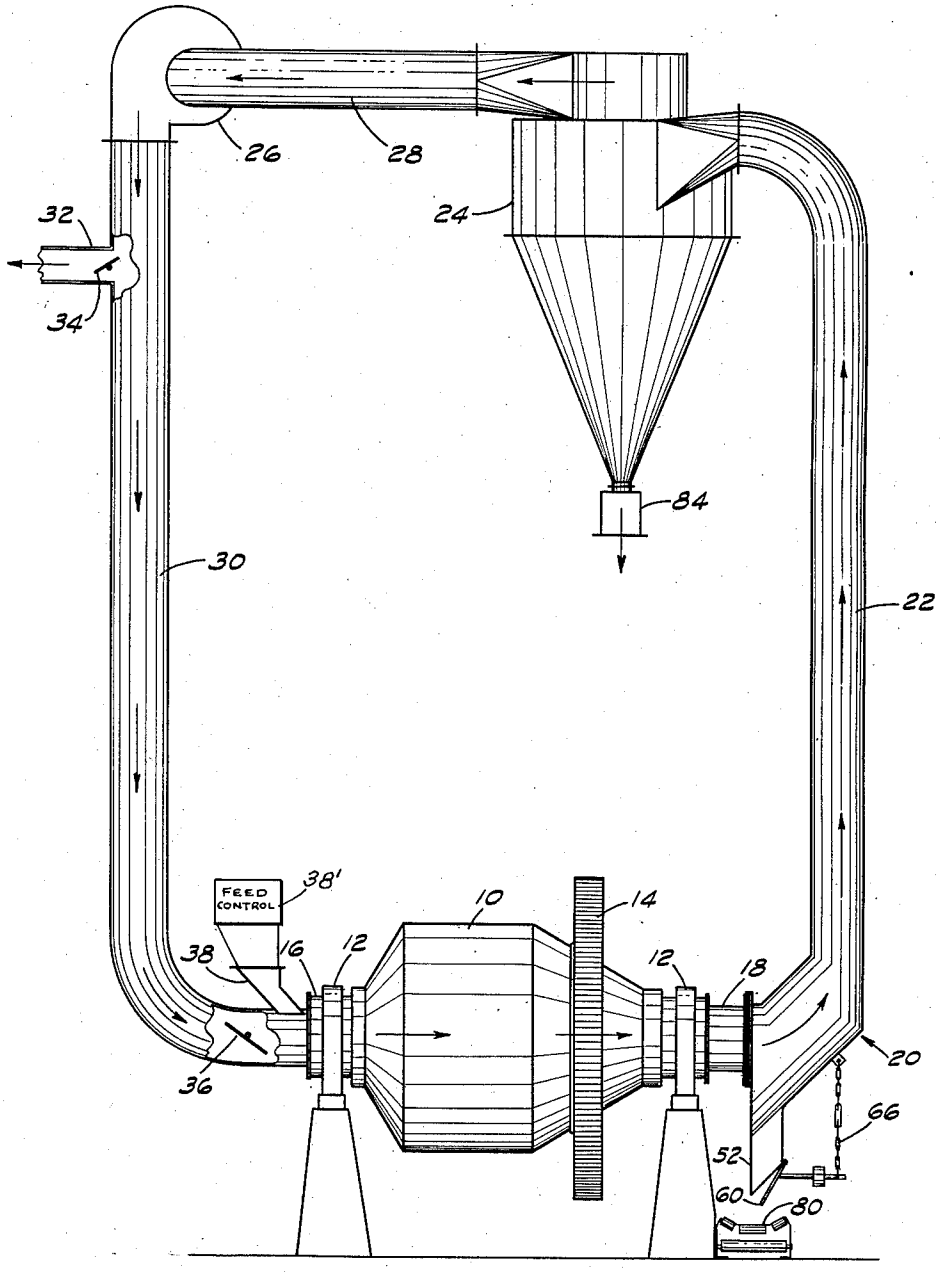


FIG. 1

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METHOD AND APPARATUS FOR CONCENTRATING AND CLASSIFYING MATERIAL

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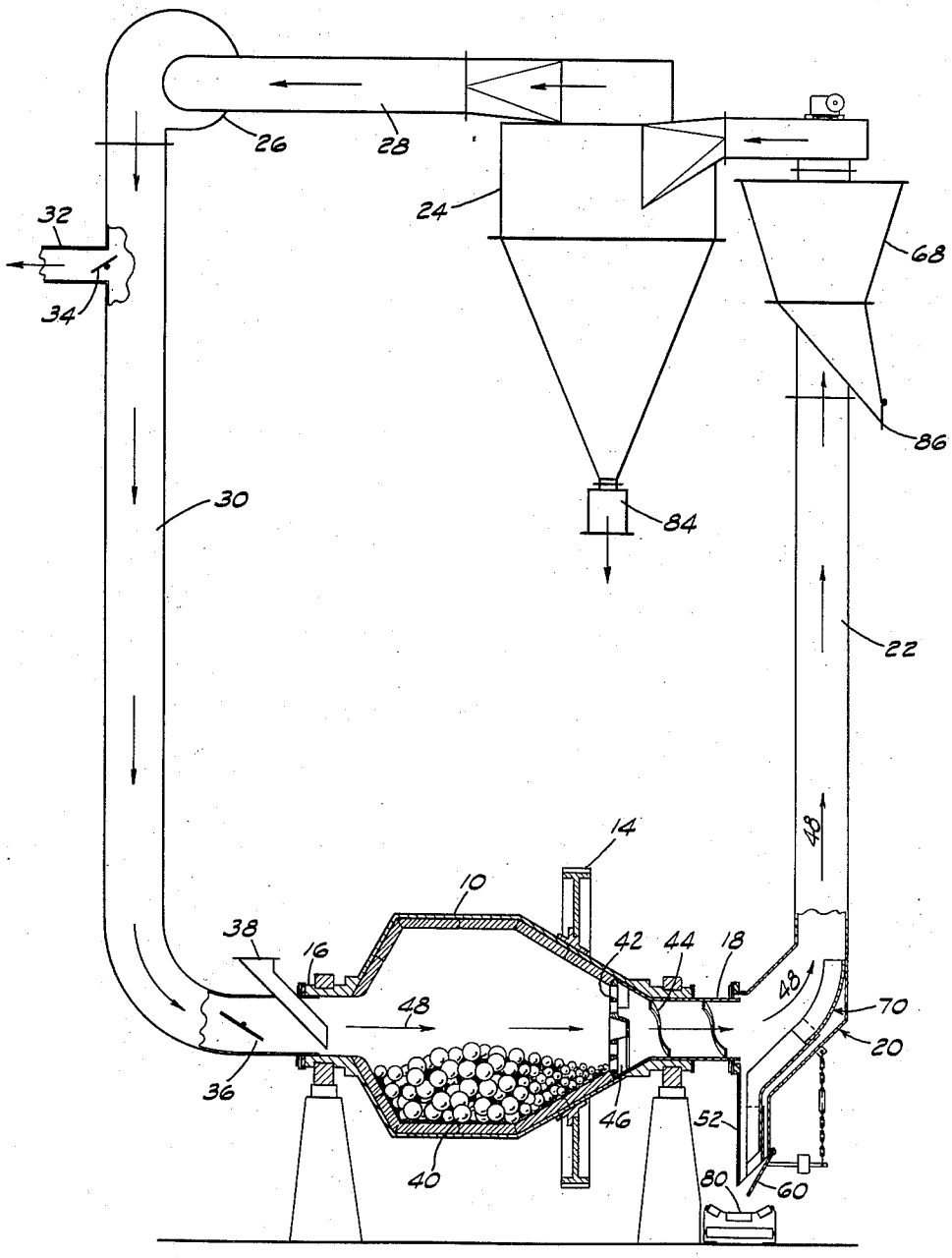


FIG. 2

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METHOD AND APPARATUS FOR CONCENTRATING AND CLASSIFYING MATERIAL

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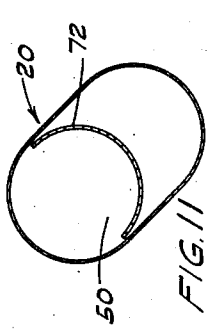


FIG. 11

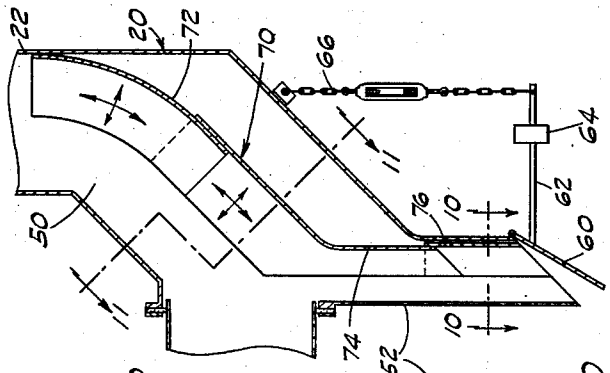


FIG. 9

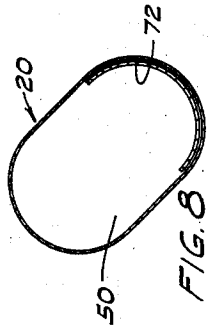


FIG. 8

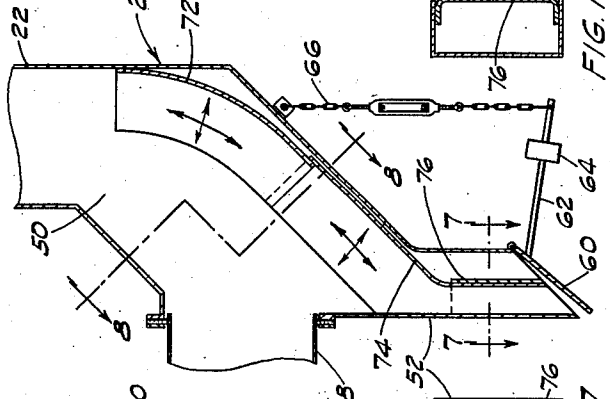


FIG. 6

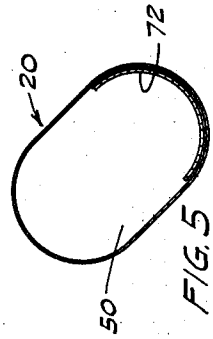


FIG. 5

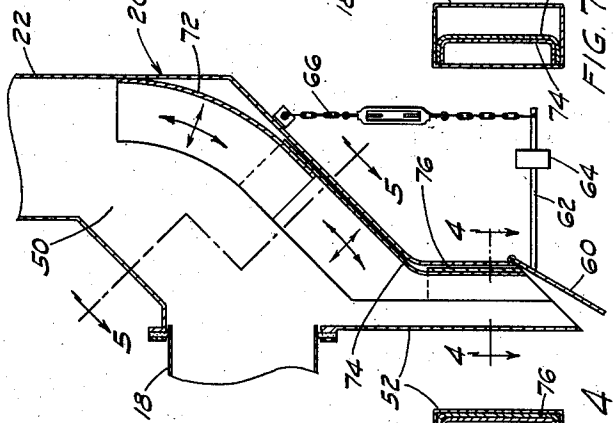


FIG. 3

FIG. 10

FIG. 7

FIG. 4

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METHOD AND APPARATUS FOR CONCENTRATING AND CLASSIFYING MATERIAL

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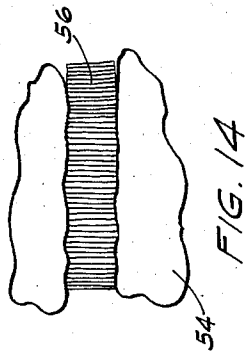


FIG. 14

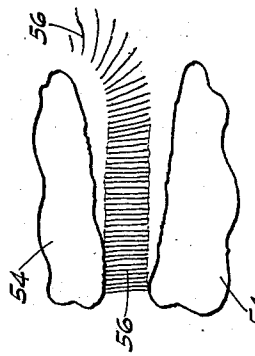


FIG. 15

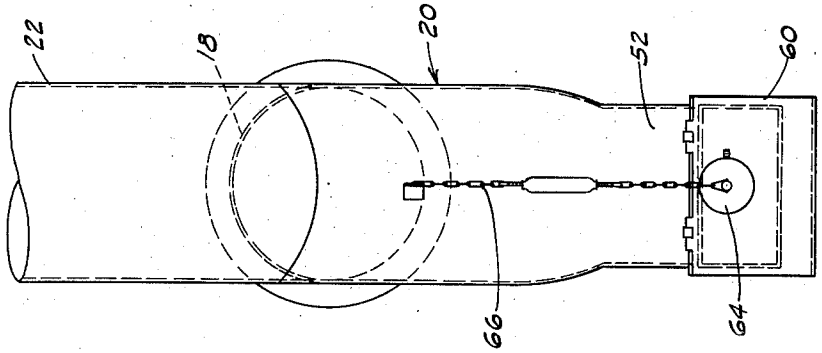


FIG. 13

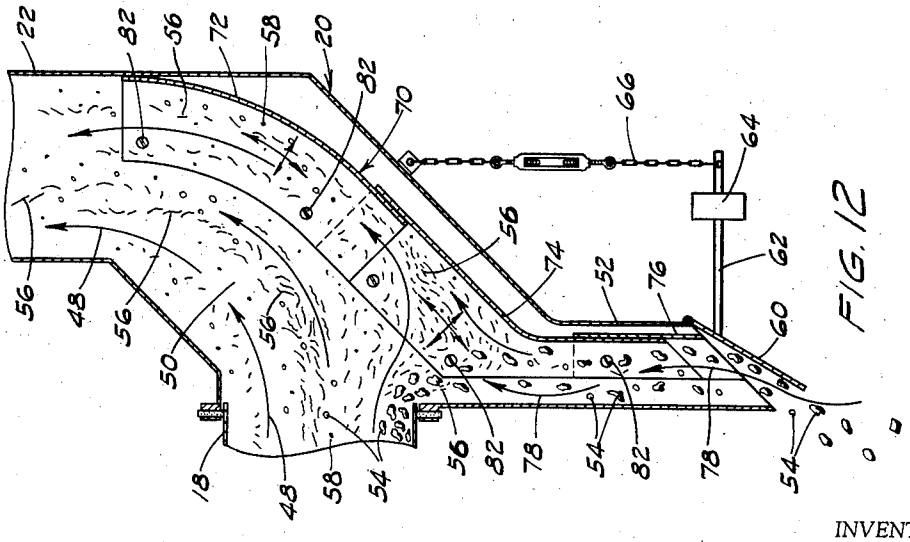


FIG. 12

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United States Patent Office 2,899,139 Patented Aug. 11, 1959

2,899,139

METHOD AND APPARATUS FOR CONCENTRATING AND CLASSIFYING MATERIAL

Harlowe Hardinge, York, Pa.

Application June 14, 1954, Serial No. 436,338

11 Claims. (Cl. 241—19)

The present invention relates to a method for concentrating and classifying material and also to an exemplary apparatus capable of performing the method in a desirable manner. Without restriction thereto, the method and apparatus primarily are useful to treat material comprising usable product particles distributed or interspersed throughout waste material and preferably capable of being separated from the waste material by crushing and comminuting said material in a mill, such crushing and comminuting not only reducing both the desired and waste material to various sizes of particles but also parting the usable or desired material effectively from the waste material.

One type of material which the present method and apparatus is particularly applicable for treating is asbestos rock wherein clusters, layers or laminations of asbestos fiber are interspersed throughout waste rock material. The asbestos fibers are quite readily parted from the waste rock material simply by crushing and comminuting lumps of the raw asbestos rock. This rock contains fracture points and cleavage planes which render the same readily disintegrated and this characteristic renders this type of raw material readily applicable to the apparatus and method comprising the present invention. However, it is to be understood that the apparatus and method of the present invention are not to be restricted for use with this specific type of material since the same may be used for purposes of concentrating, and separating for instance slate from coal, ores of different physical properties, and other mineral materials of various kinds where the character of the same adapts itself for treatment by the method and apparatus constituting the invention.

At present and heretofore, various types of tumbling mills, such as ball or rod mills have been used for treating various kinds of mineral ores and the like for purposes of pulverizing and comminuting the same either to reduce it to a required fineness wherein it may be used in a desired process, or to reduce the raw material for purposes of exposing and disintegrating or comminuting particles of a desired component of or compound in the raw material so that the desired material might be suitably treated in additional refining operations.

It now has been discovered that certain raw material, of which asbestos rock is one specific example, may be treated for example, in a tumbling mill, such as a rod or a ball mill, for purposes of fracturing the lumps of raw material to sever or part the desired useful particles of material from the waste material and then separating the desired usable particles of material from the waste material. The present invention comprises a method and apparatus for accomplishing this and it has been found that by suitably regulating the rate of feed of the raw material to the mill; the operation of the mill; the passage of a gaseous current through the mill; controlling the rate of discharge of the mixture of crushed and comminuted material from the exit of the mill; and integrating said rates of operations and controls, substantially all of the desired useful particles of material may be entrained within a

gaseous current and separated from a substantial portion of the waste material which is discharged finally from the mill itself substantially free or barren of useful particles of material, thereby considerably increasing the capacity of the mill over methods and procedures heretofore used. Thus, as the material passes through the mill, the action is sufficient not only to part or sever the useful product particles from the waste material but also reduce the size thereof and separate the same from each other into desired proportions, determined principally by relative buoyance, and respectively discharge the desired usable material and a substantial portion of the waste material in different pathways leading from the exit of the mill and into different collecting means.

In accordance with the preferred embodiment of the invention, the mill and gaseous system are so operated and the feed of the material thereto and therethrough is so controlled that the mill will discharge a quantity of crushed and comminuted material too large for the gaseous current to entrain with the useful products. The operation is such as to break away the coarser waste material from the desired or useful material which in the process of reduction becomes more readily fluid borne than at least the coarser waste pieces or particles, with the result that a substantial portion of the waste material, and especially that which is coarser, heavier or less buoyant, or harder to reduce than the desired material, is permitted simply to drop out of the exiting stream of material from the mill through a passage arranged therefor onto a suitable conveyor for removal from the system in some conventional manner. Said particles of waste material are substantially barren of desired usable product particles and such waste material thus is discarded quickly, thereby increasing the capacity of the mill, and need not be returned to or retained in the mill for final reduction which is a waste of energy and if they were passed out of the system with the useful material would further increase concentration or refining expense.

The invention also contemplates further improvements over existing methods and apparatus by providing a waste product air or gas column adjacent the exit of the mill and so controlling the current of air moving upward therethrough that said current not only insures removal of any remaining particles of desired useful product from the coarser or heavier particles of waste material as discharged from the mill, but said air column may be controlled to regulate the degree, quantity and/or fineness of waste particles which are to be discharged at this point. The fine particles of waste material allowed to pass out with the useful product subsequently are removed by other means from the desired particles of useful product. Apparatus for accomplishing such regulation of said waste product air column also comprises part of the invention consisting of the entire system for producing the aforementioned overall process or method.

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

In the drawings:

Fig. 1 is a vertical elevation illustrating an exemplary system embodying the principles of the invention and capable of performing the method comprising a part of said invention.

Fig. 2 is a view similar to Fig. 1 but illustrating in cross-section certain elements of the system so as better to illustrate details thereof and the system shown in Fig. 2 also including a fine material separating unit.

Fig. 3 is a fragmentary vertical sectional view of the product discharge unit of the system shown in Figs. 1 and 2, this unit containing adjustable members which are disposed in one position of adjustment wherein the several

discharge throats of the unit are in fully opened position.

Fig. 4 is a sectional plan view of the unit shown in Fig. 3 and taken on the line 4—4 of said figure.

Fig. 5 is a sectional view of another throat portion of the unit shown in Fig. 3, said view being taken on the line 5—5 of said figure.

Fig. 6 is a view similar to Fig. 3 but showing the adjustable member in one throat of the unit in a different position of adjustment from that shown in Fig. 3.

Fig. 7 is a sectional plan view of said throat of the unit taken on the line 7—7 of Fig. 6.

Fig. 8 is a sectional view taken on the line 8—8 of Fig. 6.

Fig. 9 is a view similar to Figs. 3 and 6 showing the adjustable member in one throat of the discharge unit adjusted to a different position from that shown in Figs. 3 and 6 and the adjustable member in the other throat being positioned as illustrated in Fig. 3.

Fig. 10 is a sectional plan view of one throat taken on the line 10—10 of Fig. 9.

Fig. 11 is a sectional view taken on the line 11—11 of Fig. 9 and showing the adjustable member in the other throat of the unit adjusted to a different position from that shown in Figs. 3 and 6.

Fig. 12 is a view similar to Figs. 3, 6 and 9 but illustrating details of the mechanism for holding the various throat adjustment members in desired positions of adjustment.

Fig. 13 is an end elevation of the unit shown in Fig. 12 as viewed from the right-hand side of Fig. 12.

Fig. 14 is an exemplary side elevation of a lump of raw asbestos rock as obtained from the mine and prior to being subjected to the method and apparatus comprising the present invention.

Fig. 15 is an exemplary view illustrating the lump of asbestos rock shown in Fig. 14 in the process of being crushed and disintegrated to separate the desired useful particles of asbestos fiber from each other and from the waste material.

For purposes of facilitating the explanation of the method and apparatus comprising the present invention, it will be assumed that the apparatus is treating asbestos ore progressively fed to the system but, as stated above, the present invention is not to be restricted for use with this specific type of ore. However, it is convenient to understand the operation of the invention with reference to this type of ore in that the asbestos fibers are the desired useful product particles and, being flocculent, are most capable of being entrained in a gaseous current especially to separate the same from less buoyant waste material comprising rock which is crushed into various sizes during the milling operations but nevertheless readily is parted or severed from the asbestos fibers simply by crushing and comminuting the rock in a suitable pulverizing mill such as the exemplary ball or rod mill **10** comprising part of the system illustrated in Figs. 1 and 2 of the drawings. Such specific mill is for illustrative purposes only, it being understood that other types of pulverizing mills may be used such as hammer or roller mills, as well as those in which the large aggregates of raw material act as the grinding medium.

Referring now particularly to Figs. 1 and 2 of the drawings, the exemplary mill **10** has hollow trunnions at either end which are supported in bearings **12**. Mills of this nature usually are driven by any conventional means such as a gear **14** which is energized at desired speed by a suitable prime mover. One trunnion constitutes an inlet **16** and the other an outlet or exit **18**. A discharge and product separating unit **20** communicates with the exit **18** and also with the lower end of an exhaust conduit **22**. The upper end of exhaust conduit **22** communicates with a collector **24** for example.

Mechanism to produce a fluid stream is illustrated in an exemplary manner in Figs. 1 and 2 as constituting a fan or blower **26**. The inlet end of the blower **26** is connected by a conduit **28** to the collector **24**. The exhaust or pressure end of the blower **26** communicates with conduit **30**, the other end of said conduit **30** communicating with the inlet **16** of the mill **10**. Intermediately of its ends, the conduit **30** is provided with a pressure exhaust vent **32** having an adjustable valve or damper **34** therein. Further, the outlet end of conduit **30**, adjacent the inlet **16** of the mill, also is provided with a fluid stream control valve or damper **36**, the valves **34** and **36** being adjustable to any desired setting to regulate the volume and force of the fluid current discharged through conduit **30** into the interior of mill **10**.

Raw material is introduced to the mill through an inlet chute **38**. The raw material preferably is introduced through said chute at a continuous, controlled rate by any conventional means generally indicated **38'** in Fig. 1. This rate is adjusted in accordance with the operation of the mill **10** so that, as the raw material is crushed, comminuted, and pulverized within the mill **10** by balls **40**, shown in Fig. 2 for example, as well as the lumps and particles of the raw material itself while being processed within said mill, the desired degree of crushing and comminution takes place so as to insure substantially complete severeance and parting of the desired useful particles from the particles of waste material of various sizes, as well as desired grinding of the useful particles to render them more capable of being entrained in a gaseous current.

The shape of the mill and operation thereof, in accordance with customary conditions, is such that the comminuted and crushed material gradually moves from the entrance or inlet **16** to and through the exit **18**. The mill **10** preferably contains a grate **42** adjacent the exit end thereof, particularly for purposes of preventing balls or large sized particles of raw material from passing into the exit **18**. The exit **18** also may be provided with a fixed helical blade **44**, for example, which, as the mill is rotated, serves to return to the mill the coarser particles of material which may require further disintegration and which happen to enter the inlet **18**. These particles are returned to the interior of the mill by any suitable scoop or other means **46**, thereby insuring further disintegration and comminution of said particles of material.

The crushed and comminuted material which is discharged from the mill through the exit **18** constitutes a mixture of particles of desired product material and waste material of various degrees or ranges of sizes and weights of particles. The useful and waste particles are severed or parted from each other but nevertheless are intermixed.

Separation of the desired useful particles of product material from the waste material is at least partially accomplished by passing a stream of air, or other appropriate gaseous current, indicated by arrows **48**, through the mill **10** from the inlet to the exit thereof. Said gaseous current passes through the mill at a controlled rate which is regulated partly by damper **36** in the outlet end of pressure conduit **30**, and partly by the valve or damper **34** in the pressure exhaust vent **32**. Thus, a gaseous fluid current **48** moves through the mill and exit **18** at a rate which is efficient to entrain the comminuted desired or useful product particles as well as fine particles of waste material that are unavoidably reduced at the same time. The intermediate sizes of waste material may also be carried out by the air stream or flow out over the helical blades **44**, the coarser fractions being returned to the mill by the blades **44**.

The discharge and separating unit **20**, which communicates with the outer end of exit **18** and extends between the same and the entrance end of exhaust conduit **22**, is illustrated best, and in detail, in Figs. 3 through 13. In effect, the unit **20** actually can be considered part of the exhaust conduit **22** and comprises an intermediate throat portion **50**. Said throat portion extends outward and upward from the exit **18** as is clearly

shown in Figs. 3, 6, 9 and 12. Depending from the unit **20** is a waste product conductor **52**, which preferably is immediately adjacent the outer end of exit **18** and conductor **52** receives particularly the coarser particles of waste material which fall therethrough by gravity upon leaving the outer end of exit **18**. A range of sizes of these coarser particles are indicated **54** in Fig. 12, wherein the action of the separating gaseous currents, the path of the current borne usable particles, and the path of travel of the fine waste material also are indicated in suitable manner. The disintegrated fibers of asbestos are indicated **56** in Fig. 12 and the fine particles of waste material generally are indicated **58** in said figure.

The lower end of waste product conductor **52** is provided with a pivoted valve or closure **60**, the same having an arm **62** upon which a counter-weight **64** is mounted adjustably. Under most preferred conditions of operation, the valve **60** should remain open a predetermined amount at all times to allow a predetermined amount of air to pass upwardly through conductor **52** and, to insure this, any suitable mechanism may be employed such as a chain **66** of adjustable length. Thus, as the stream of waste particles, particularly the coarser waste particles, is discharged through the conductor **52**, the valve **60** will automatically be opened a greater amount momentarily than that for which it is set if the volume of discharge material is great enough to force it to a more fully opened position. However, as soon as the discharging stream of waste material permits, the counterweight **64** will restore the valve to its desired position of operation.

It will be understood that, under normal conditions of operation, the conduit **22**, as well as the unit **20**, will have a fluid current of negative pressure therein with respect to the atmosphere. That is, said conduit and unit will be under suction produced by the fan or blower **26**. Such negative pressure will induce the stream or fluid current **48** within which the useful particles of product material are entrained to pass through the intermediate throat portion of the unit **20** and up the conduit **22**, and then either to the classifier **68**, shown in Fig. 2, or directly to the collector **24** shown in Figs. 1 and 2.

Depending upon the operating conditions of the mill and the characteristics of the fluid current **48** passing therethrough, the fluid current exhausting or exiting through mill exit **18** and moving into unit **20** and conduit **22** will contain a substantial percentage of the desired useful products and various percentages of fine particles of waste material comprising a proportion of the total waste material. The quantity of waste material, as well as the range of sizes thereof, will be determined partly by the setting of the valve **60** for a given operating condition of the fluid current **48** and grinding characteristic of the mill **10** as well as the rate of discharge of the material from the mill. The amount and size of the waste particles contained in the stream of desired product particles being removed from the mill and carried up to the product collector also will depend upon the setting of constricting mechanism mounted in the intermediate throat **50** and lower throat comprising conductor **52**, described below in detail. Further, although the present illustration shows a substantially closed circuit system, it is to be understood that the invention is not to be restricted to such closed system.

Figs. 3 through 12 illustrate one composite exemplary type of throat and conductor constricting means which may be used to vary the cross-sectional area of the throat portion **50** and the conductor **52**. Said constricting mechanism is generally indicated **70** and comprises a plurality of adjustably articulated members. The uppermost member **72** is curved from end to end as shown in Figs. 3, 6, 9 and 12 and, it is also semi-circular in cross-section as shown in Figs. 5, 8 and 11. This member overlaps an intermediate member **74** and is slidably adjustable therewith at its upper end. The lower end of intermediate member **74** telescopically and slidably receives the lowermost constricting member **76** which, preferably, is U-shaped in cross-section as shown in Figs. 4, 7 and 10. The lower end of intermediate constricting member **74** is complementary to lowermost member **76**.

By suitably sliding the various constricting members longitudinally relative to each other as well as transversely respectively of the throat portion **50** and the conductor **52**, as indicated by the direction arrows in Figs. 3, 6, 9 and 12, it will be seen that the intermediate throat **50** may be constricted to various degrees irrespectively of the constriction in the lower throat or conductor **52**, or in conjunction with the latter also being constricted to any desired degree of its possible limits of adjustment. Similarly, the lower throat or conductor **52** may be constricted to any desired degree irrespectively of the intermediate throat **50**, as indicated in Fig. 6 for example.

The constricting of the throat **50** of unit **20** and also of the conductor **52**, which conducts the discharged coarser particles of waste material from the system, is desirable to provide a further control or adjustment means by which the size and amount of the fine waste particles particularly are included in the desired useful product particles which are entrained in the exhausting fluid current **48** moving through unit **20** and up conduit **22**, the path thereof also being relatively clear and unobstructed. This minimizes the possibility of the current dropping particles therefrom, especially while passing over conductor **52**. Said fluid current **48**, as stated above, is induced to move through the unit **20** and up conduit **22** by the suction normally existing within the latter. Such movement of the particle entrained fluid current will cause air or any other gaseous medium surrounding the unit to be drawn into conductor **52** through the opening between valve **60** and the lower end of said conductor.

The degree of opening of the valve **60**, in conjunction with the suction head within the throat **50**, will control the amount of air drawn upward into conductor **52**, as an upwardly moving column, which engages the falling stream of waste material consisting mainly of coarser particles thereof and insures the substantially complete separation of any desired useful particles of material from said waste material as it is discharged. Further, the velocity and volume of the upwardly moving air column through conductor **52** will cause said column to remove from the falling stream of coarser waste particles fine particles of waste material of a predetermined range of size, said size depending upon the force and volume of said upwardly moving column of air.

Conductor **52** is in all the adjustments preferably of substantially constant cross-sectional area construction from bottom to top so as to form a column of constant velocity, thereby permitting the particles within the column to fall or rise an appreciable distance within the same condition of buoyancy, thus insuring close sorting and minimizing the tendency of over or under concentration at any point which would then cause surging and reduce the overall efficiency of classification here.

The particle entraining effect of the upwardly moving column of air, indicated by arrows **78** in Fig. 12, will depend upon the adjustment of the constricting members **74** and **76**. The interior of the conductor **52** may conveniently be referred to as the lower throat portion. If, for example, either substantially no fine particles of waste material or only a range of very fine sizes thereof are desired to be entrained in the fluid current **48** along with the particles of desired useful product, the constricting members **74** and **76** are disposed in the position shown in Figs. 3 and 9. That is, the lower throat portion is fully open. However, if a larger percentage of the material tending to drop out of the conductor **52** is desired to be kept in the fluid stream **48** or, in other

words a coarser size range of particles 54 is wanted in the waste discharge, then the constricting members 74 and 76 are moved either to the position shown in Fig. 6, wherein the greatest velocity of incoming air 78 will be effected, or to an intermediate position such as that shown in Fig. 12.

Adjustment of the cross-sectional area of the throat portion 50 will control the amount of the entrained load permitted to drop out of the fluid current 48 as it passes through unit 20 and up conduit 22. That is, as the fluid current 48 passes through exit 18 and enters unit 20, the degree of constriction provided in throat portion 20 by the adjustment of constricting members 72 and 74 will regulate the degree of dropping out of the air stream 48 of particles 54 that are too heavy or whose buoyancy characteristics are such that they will fall from the fluid current 48 into conductor 52. Likewise, under certain conditions in the fluid current, some of the desired product particles may also tend to fall from the said fluid current, depending upon the amount of constriction within the throat portion 50 but, in the event some of said desired useful particles should fall from the current 48, the upwardly moving air stream in conductor 52 will re-entrain said useful particles within the exhausting fluid current 48 and thereby insure substantially complete removal of all desired particles of useful product from the waste material discharged through the conductor 52, as illustrated best in Fig. 12.

This will insure that at least the coarser waste particles 54 are all that are discharged through the exit end of conductor 52, these being substantially barren of any desired useful product particles. Such an operation also reduces the percentage of waste material later to be separated or eliminated from the desired product. This invention also permits the system to operate at higher capacity as compared with operations in which the discharged coarser material must be returned to the mill for further disintegration and comminution or the feed rate reduced so that the coarser particles are all reduced to a size suitable for being air borne.

Another important feature covered by this means of operation is that within limits, the grinding and separating conditions within the mill may be maintained at their optimum condition of operation while the subsequent separating and discharging operation of the product may be independently controlled.

As shown in Figs. 1 and 2, an exemplary conveyor 80 may be provided beneath the lower end of conductor 52 for purposes of receiving and conveying to a waste dump the waste material discharged through the conductor 52.

Any suitable means may be used to hold the constricting members 72, 74 and 76 in any desired position of adjustment relative to the unit 20 and conductor 52. In Fig. 12, for example, it will be seen that exemplary adjusting screws 82 are shown passing through the various constricting members and the walls of the unit 20 and conductor 52. It will be understood that once a desired setting of these constricting members is achieved for a given operation of a mill when acting upon a material of a more or less consistent nature and relative composition of desired and waste material, the setting of the constricting members may remain substantially constant. This is true also of the settings of the valves or dampers 34 and 36, as well as the valve 60 at the lower end of the conductor 52.

When the mill initially is set in operation, the products discharged from the mill are constantly inspected and the necesasry adjustments are made to the mill circuit including dampers 34 and 36 as is well known in the art. Valve 60 and constricting members in unit 20 and conductor 52 are thus adjusted until a desired setting of all of these components is achieved. These settings of course are also made in relation to the grade, size and rate of feed of the raw materials to the mill, the operation of the mill, and if a classifier 68 is included in the system, such adjustments are also made in relation to the desired fineness adjustment of such classifier.

Under situations where a certain pecentage of predetermined ranges of sizes of fine waste particles are included in the fluid stream which conducts the desired useful particles of product from the mill, these may be subjected to any suitable classifier such as the exemplary unit 68 illustrated in Fig. 2. No details of this classifier are shown inasmuch as it may be one of a number of different types of suitable commercial classifiers operable to separate useful and desired particles from waste particles. In this instance however the thus separated desired useful product particles are collected and discharged at 86. The waste in this case is the fine dust which is separated from the circuit by collector 24, the same being removable therefrom through a conventional outlet 84.

While the inventon 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 process of treating raw mineral material comprising the steps of progressively crushing and comminuting said raw material in a mill to produce fines of various sizes mixed with coarser particles, progressively removing said mixture from the exit of said mill and permitting the same to fall by gravity down a passage having a throat of adjustable size but afford a substantially constant cross-sectional area in any adjusted size of throat, and subjecting the falling material to a fluid current of controlled volume and adjusted cross-sectional area to produce a force moving upwardly in said passage and regulated to entrain and separate relatively fine particles of material of a predetermined range of sizes from said falling material while permitting the coarser particles of material to fall through said passage, the size of said throat being variable to adjust the force of said fluid current, thereby to determine the range of sizes of fine particles separated from said coarser particles.

2. A process for comminuting and classifying mineral material comprising the steps of feeding raw lump-like material to a mill system at a controlled rate to reduce the size thereof and produce coarse and fine particles of material, passing a current of gaseous fluid through said mill to entrain fine particles of said material within a predetermined range of sizes therein and carrying the same with said current through the exit of the mill in a substantially horizontal path, discharging coarser material with some finer particles mixed therein progressively through said exit and removing the same along a predetermined path extending substantially vertically from said path of fluid current discharging through said exit, subjecting said coarser material while moving along said predetermined path to another gaseous fluid current moving counter to the falling material and varying the cross-sectional area of the current at least at the inlet end thereof, thereby causing a countercurrent sweeping and separation of a desired range of sizes of the finer particles from the discharging coarser particles, and joining said other gaseous current with said first mentioned gaseous current to carry the finer particles entrained therein from the mill discharge.

3. The process according to claim 2 further characterized by regulating the size of the cross-sectional area of a major portion of the countercurrent sweeping of said other fluid current to cause the same to entrain finer particles therein of a predetermined desired range of sizes.

4. The process according to claim 2 further characterized by said coarser particles with finer material entrained therein falling within a confined path of prede-

termined cross-sectional area extending downward from the exit of the mill, whereby the upper end thereof is traversed by said substantially horizontal fluid current exiting from said mill to cause said other fluid current to move upward through said confined path by suction and merge with said fluid current exiting from said mill prior to common vertical removal from the mill discharge.

5. Material classifying mechanism operable with a mill and positionable adjacent the exit thereof to receive from said mill a mixture of particles of waste and usable material discharged from said mill at a controlled rate, said mechanism comprising a conduit arranged to be positioned adjacent said mill exit and having a discharge port, a discharge conductor depending from said port and positioned to receive and permit particles of waste material to drop by gravity therethrough from said discharge port, said conductor having a substantially constant cross-sectional area, means operable to produce a fluid current in said conduit moving in a direction away from the exit of said mill and over said discharge port, said current being operable to separate particles of useful material from said waste material and carry said useful material through said conduit, means positioned within said discharge conductor and adjustable transversely thereof to vary the cross-sectional area thereof, a valve movably connected to the lower end of said conductor and operable automatically toward open position upon contact by falling waste material, and valve positioning means adjustable and operable to maintain said valve at a desired minimum open position at all times to permit said fluid current in said conduit to effect an upward draft through said discharge port, the velocity and volume of said fluid current being controlled by regulation of the cross-sectional area of said discharge conductor in conjunction with said valve to insure separation of substantially all useful material from the particles of waste material as the latter falls by gravity through said discharge conductor.

6. Material classifying mechanism positionable adjacent and operable relative to the discharge end of a mill to receive from said exit at a controlled rate a mixture of particles of material of various sizes and comprising in combination, a conduit positionable adjacent the exit of said mill and in substantially axial alignment therewith, said conduit having a discharge opening in the lower portion thereof, a discharge conduit communicating with and depending from said opening and arranged to receive a material mixture falling by gravity therethrough from the exit of said mill, said conduit being of substantially constant cross-sectional area, means operable to produce a gaseous current upwardly through said discharge conduit and falling material, thereby to entrain in said current the finer particles of the falling mixture while the larger particles fall through said conduit, and adjustably positionable means extending longitudinally of said discharge conduit and movable transversely therein in parallelism with the axis thereof to produce a longitudinal discharge opening through said conduit of transversely adjustable but substantially constant area throughout the length thereof for any desired adjusted position of said last mentioned means.

7. Material pulverizing and classifying mechanism comprising in combination, a mill having an inlet at one end for raw mineral material and an outlet at the other end, means to operate said mill at a controlled rate to crush and communicate the raw material and form a mixture of relative coarse and fine particles thereof, said mill having a substantially unobstructed horizontal passage therein for gaseous currents exiting through the outlet end of the mill, an exhaust conduit communicating with the outlet of said mill and having an substantially horizontal portion extending outwardly therefrom to conduct said mixture from the mill, said exhaust conduit having a throat portion inclined upwardly at the outer end of said horizontal portion of the conduit, constricting means extending longitudinally within said throat portion and movable transversely to the axis of said throat to vary the cross-sectional area thereof, another conduit communicating with the outlet end of said throat portion, means to introduce a fluid current into said mill controlled to entrain fine particles therein within a predetermined range of sizes and discharge the same through said exit and discharge conduit and throat portion and into said other conduit, said constricting means being adjustable to vary the entraining effect of said fluid current and thereby vary the range sizes of fine material separated from said mixture discharged from said mill, whereby the coarser particles drop from said current in the vicinity of said throat and are separated from the finer particles entrained in said discharging fluid current, and means communicating with said throat portion to discharge said coarser particles from said exit conduit.

8. Material classifying mechanism comprising in combination, a mill having an inlet for raw mineral material, means to operate said mill at a controlled rate to crush and communite the raw material and form relatively coarse and fine material, said mill having a substantially unobstructed horizontal passage therethrough for gaseous currents, an exhaust conduit communicating with the exit of said mill and including a throat portion, a discharge conductor depending from said exhaust conduit and communicating therewith adjacent the exit of said mill, said conductor having a substantially constant cross-sectional area and arranged to receive material falling therethrough by gravity as progressively discharged through the exit of said mill, an adjustable draft inlet valve operably positioned relative to said conductor to control the inlet of air therethrough, elongated passage constricting means adjustably positionable within said throat portion and conductor in directions transverse thereto respectively and operable to change the particle entraining effect of gaseous currents passing therethrough, a blower, a conduit connecting the inlet of said blower to said exhaust conduit, another conduit connecting the outlet port of said blower with the inlet of said mill, whereby gaseous currents are discharged into and through said mill, and an adjustable valve in said another conduit operable to control the gaseous current entering said mill, said valves being adjustable relative to each other and the operation of said mill to control the fluid current moving through said mill and exhaust conduit and effect a desired intake of air by suction upwardly through said discharge conduit and into said exhaust conduit, whereby said air and gaseous currents moving from said mill and through said exhaust conduit and discharge conductor entrain fine products therein and separate the same from coarse material discharged through said discharge conductor.

9. Material classifying mechanism operable with a mill and positionable adjacent the exit thereof to receive from said mill a mixture of particles of relatively coarse and fine material discharged from said mill progressively at a controlled rate, said mechanism comprising a conduit extending outward from said exit of said mill to transmit said mixture therefrom and including a throat portion extending inclinedly upwardly, means extending longitudinally within said throat portion and movable transversely to the axis of said throat to vary the cross-sectional area of said throat through a desired range of cross-sectional areas, said conduit also having a substantially vertically extending discharge port opening downward in operation and positioned adjacent the entrance of said throat to permit particles of coarse material to drop by gravity therethrough as progressively discharged from said exit of said mill, means operable to produce a fluid current in said conduit moving in a direction away from the exit of said mill and over said discharge port, said current being operable to entrain and separate fine particles from said coarse material

and carry said entrained particles of fine material through said conduit, and a valve positioned at the lower end of said discharge port for coarse material and adjustable to permit said fluid current in said conduit to effect an upward draft through said discharge port to entrain therein any remaining particles of fine material from the coarse material as the latter falls by gravity through said discharge port, the adjustability of said cross-sectional area of said throat portion permitting variation in the entraining effect to said fluid current.

10. Material classifying mechanism operable with a mill and positionable adjacent the exit thereof to receive from said mill a mixture of particles of relatively coarse and fine mineral material discharged from said mill progressively, said mechanism comprising a conduit extending outward from said exit of said mill to transmit said mixture therefrom and including a throat portion extending inclinedly upwardly, means extending longitudinally within said throat portion and movable transversely to the axis of said throat to vary the cross-sectional area of said throat through a desired range of cross-sectional areas, said conduit also having a discharge conductor opening into said conduit adjacent the entrance of said throat portion and extending vertically downward to permit particles of coarse material to drop by gravity therethrough as progressively discharged from the exit of said mill, means positioned within said discharge conductor and extending longitudinally thereof, said means being adjustable transversely to the axis of said conductor to vary the cross-sectional area thereof, means operable to produce a fluid current in said conduit moving in a direction away from the exit of said mill and over the upper end of said discharge conductor, said current being operable to entrain and carry fine particles

of material from said mill through said conduit and also induce an upward draft through said conductor operable to entrain and separate additional fine material from the coarse material as the latter falls through said conductor, and a valve positioned at the lower end of said conductor and adjustable to vary said induced draft therein, the adjustability of said means within said discharge conductor and the valve at the lower end thereof permitting variations in the entraining effect of said induced draft.

11. The material classifying mechanism set forth in claim 10 further including intermediate means within said throat portion of said conduit and said discharge conductor, said intermediate means extending between and bridging said transversely movable means extending longitudinally respectively of said throat poriton and said discharge conductor and adjustable longitudinally thereof when they are selectively or both adjusted, thereby to effect a smooth surface for the passage of a fluid current and entrained material through said throat portion of said conduit and said discharge conductor.

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