Oct. 6, 1970 D. A. DUNN 3,532,276

DRUM SCREEN FOR FERTILIZER

Filed April 23, 1968 2 Sheets-Sheet 1

FIG. 1

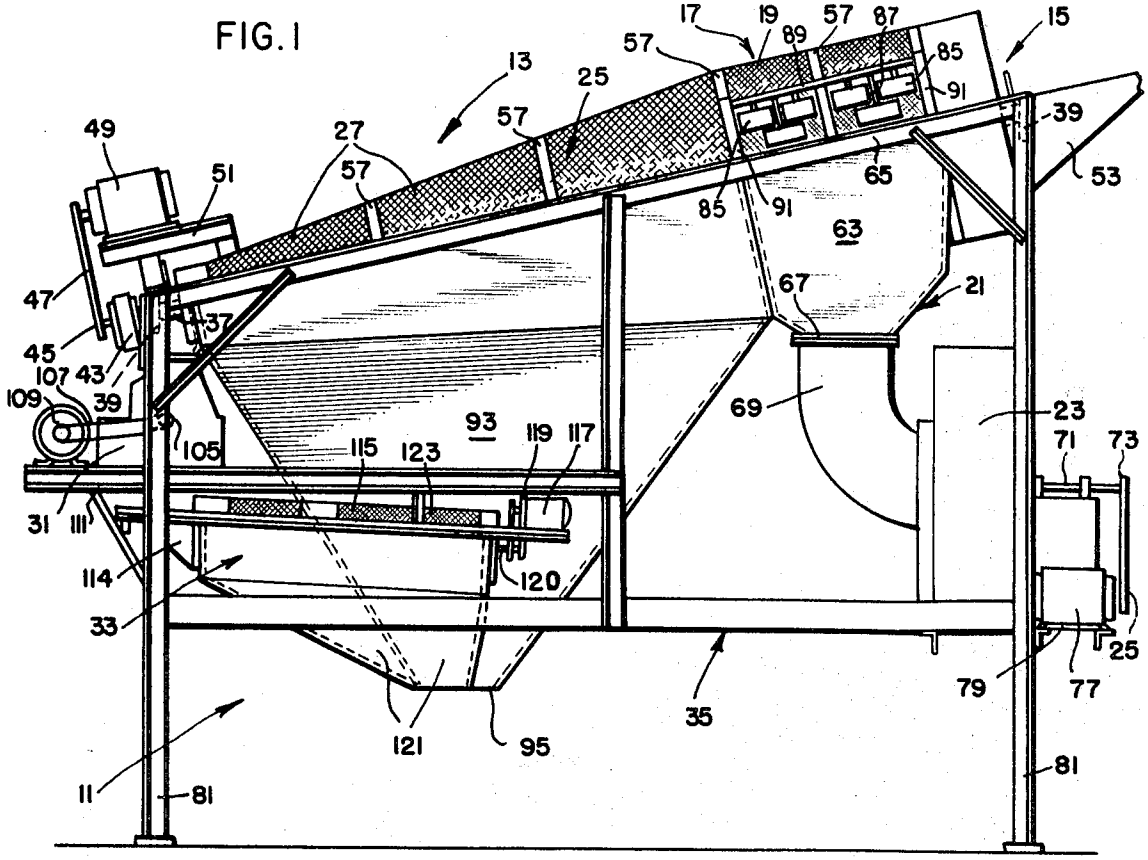
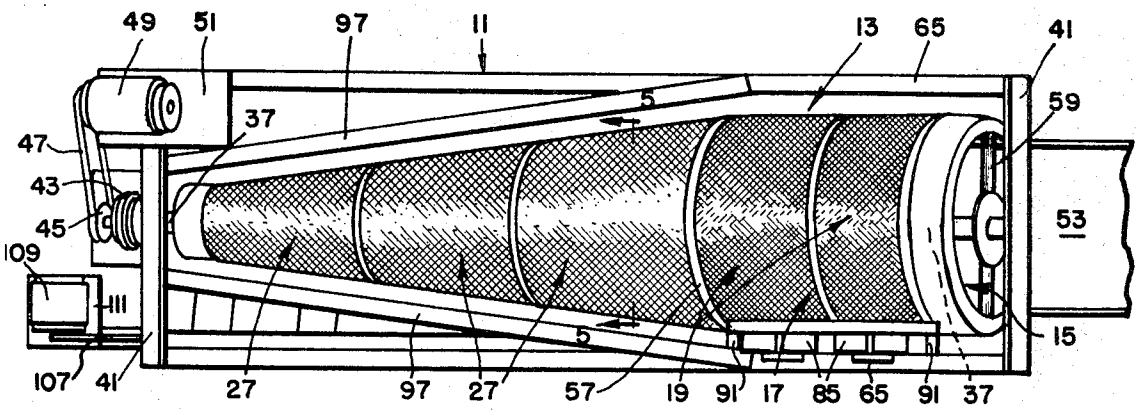


FIG. 2



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FIG.3

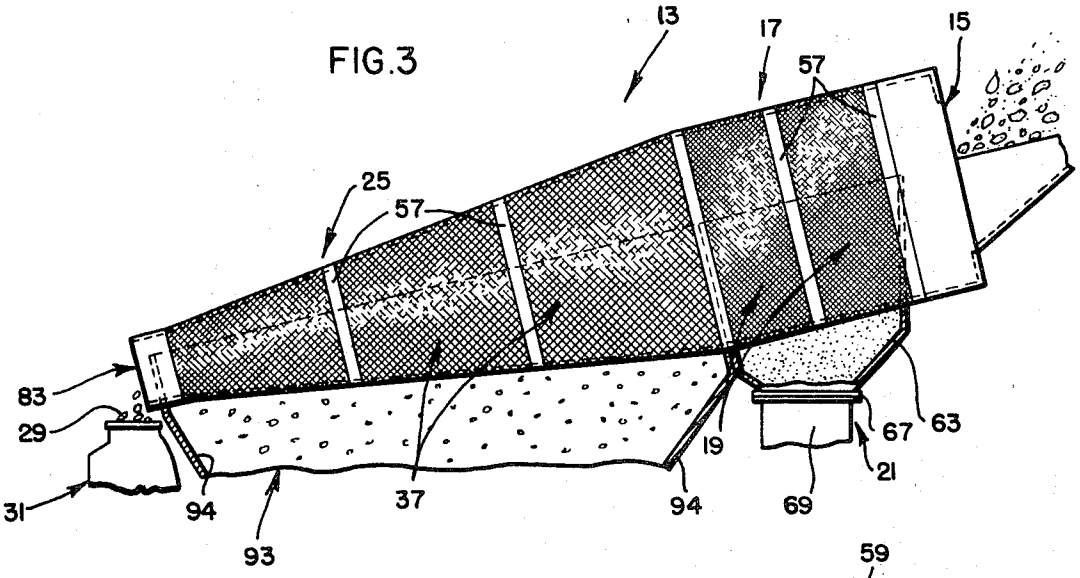


FIG.4

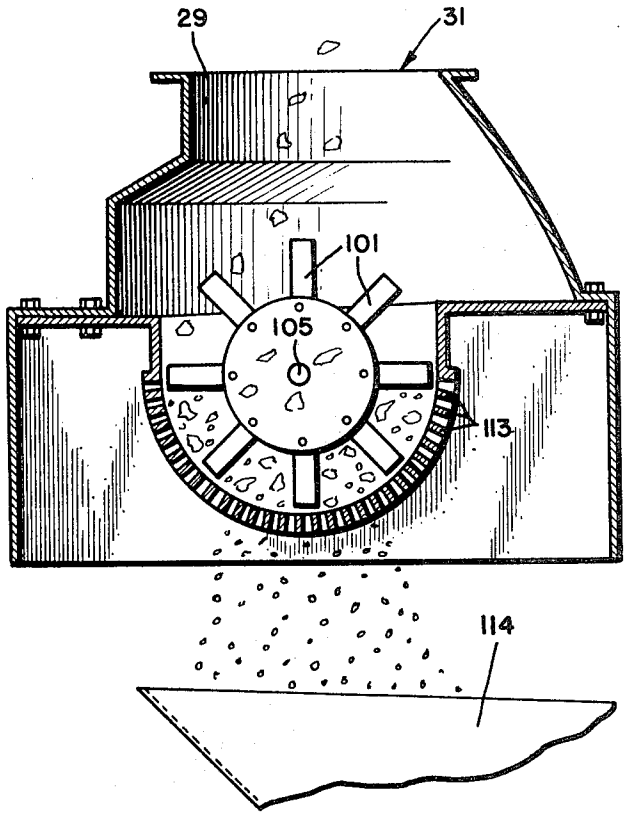
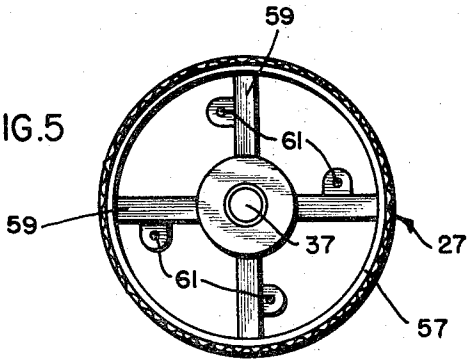


FIG.5



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United States Patent Office 3,532,276 Patented Oct. 6, 1970

3,532,276

DRUM SCREEN FOR FERTILIZER

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Filed Apr. 23, 1968, Ser. No. 723,533
Int. Cl. B02b 1/02; B07b 9/00
U.S. Cl. 241—77 6 Claims

ABSTRACT OF THE DISCLOSURE

Granular or particulate materials are fed into an upper end of a rotating drum mounted at an inclination to the horizontal and on this upper end of the drum is a screen for passing small particles, fines. Coarser particles of less than a predetermined size flow down the fines screen to and through a coarser screen which has its lower edge at a lesser pitch to the horizontal than does the fines screen. The fines may be drawn through the fines screen by an air stream. Particles larger than the predetermined size flow from the coarse screen to means which comminute the large particles and feed the comminuted material to another screener for removing any remaining oversized particles.

This invention relates to screening materials to remove oversized particles therefrom and also to comminuting some of these oversized particles so that they will pass through a separating screen of a given size.

The apparatus is described in connection with the screening of granular fertilizer, but is not limited to this particular material, as the apparatus may be useful for screening various other materials. The screening and comminuting apparatus is particularly useful for granular fertilizers which have been stored or shipped in large quantities; and as a result of such shipping or storing have compacted into large and relatively hard, rock-like masses. Such granular fertilizers are often shipped to a central location and stored in piles which may contain thousands of tons and have a depth of twenty to fifty feet. Fertilizer stored in this manner compacts and forms relatively large clumps which are unsuitable for use by the consumer unless returned to the granular form present before storing.

When it is desired to return the compacted fertilizer to its original granular form, power shovels and hammer mills are used to remove the fertilizer from the pile and to comminute the fertilizer to return it generally into grandular form. While most of the fertilizer returns to grandular form before screening, it is necessary to screen out those particles which were not reduced to the proper size. Typically, such fertilizers are screened on flat vibratory bed screens.

The present invention is directed to screening such granulated materials at a rate which exceeds the rate at which these materials have been screened by flat vibratory bed screens of the prior art and also to reducing the percentage of material which had been considered unsuitable for use. Additionally, the present invention may be made at a lower cost than the flat bed vibratory screener.

Accordingly, an object of the present invention is to provide an improved screening apparatus for granulated materials.

Other objects and advantages of the invention will become apparent from the detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a side elevational view of an apparatus embodying the invention;

FIG. 2 is a plan view of the apparatus of FIG. 1;

FIG. 3 is a diagrammatic, partially sectioned view showing the path of particles moving through a portion of the apparatus of FIG. 1;

FIG. 4 is an enlarged, fragmentary sectional view of a hammer mill, which may be used in the apparatus of FIG. 1, for comminuting oversized particles; and

FIG. 5 is a sectional view taken along line 5—5 of FIG. 2.

As shown in the drawings for purposes of illustration, the invention is embodied in an apparatus **11** which, very generally, includes an elongated, rotatable drum **13** mounted at an inclination to the horizontal with a charging port **15** at its upper end to receive the material, fertilizer in this instance, which is to be screened and comminuated to a given particle or granular size.

At the upper end of the drum is a fines section **17** for quickly removing and collecting the very fine particles called "fines" which are, for the most part, particles of such light density as to be capable of being air-borne by a high velocity stream of air. The fines section **17** includes very fine mesh screens **19** across a portion of which is established a pressure differential, resulting in a suction force for pulling fines through a ductwork **21** to a cyclone separator **23** at which the particles are collected. Most of the incoming material is too coarse to pass through the rotating fines screens and this material flows down and to the left, in FIGS. 1 and 3, into a coarse section **25** having coarse screens **27** which pass particles having a size equal to or less than that of the openings therein. Particles larger than the openings in the coarse screens **27** continue to flow downwardly to the left end of the apparatus as viewed in FIGS. 1 and 3, and are discharged into an inlet **29** (FIG. 3) of a comminuting means such as, for example, a small hammer mill **31** which reduces these large particles and discharges this reduced-in-size material to a secondary screener **33** (FIG. 1) which will screen particles of the same general size as screen by the primary coarse screen **27**.

From an economic standpoint, it is important that as much as possible of the fertilizer be recovered, and significantly, the apparatus **11** has been found to be, as contrasted to other known screeners, more efficient in the amount of material recovered. For example, a typical flat vibratory bed type of screen has a capacity of about 75 tons per hour and a recovery efficiency of about 97%, recovery efficiency being the percentage by weight of the usable fertilizer collected after screening the weight of fertilizer fed into the apparatus. This is in contrast to a 99.77% recovery efficiency experienced for a similar fertilizer with the illustrated embodiment of the invention. Not only is the recovery efficiency of the apparatus of the invention greater than the recovery efficiency of the flat bed vibratory separator, but it processes material at a faster rate than flat bed vibratory screeners. For example, the apparatus **11**, which costs considerably less than a flat bed vibratory screener, separated 163 tons per hour as compared to 75 tons per hour under similar types of operating conditions.

Proceeding now with a detailed description of the individual components of the apparatus, the rotatable drum **13** is preferably mounted for rotation in a frame **35** at an upward angle to the horizontal to facilitate the movement of the material through the respective sections of the drum. More specifically, a mounting shaft **37** extends through the drum **13** and has its opposite ends journaled in bearings mounted in blocks **39** (FIG. 1) fixed to horizontally extending cross beams **41** at the ends of the frame. The lower, left end of the shaft **37** is connected to and driven by a gear reducer **43** which has an input shaft carrying a pulley **45**. Around the pulley is trained a belt **47** which extends upwardly and outwardly to a motor **49** supported on a bracket **51** fixed to the lower rear corner of the frame **35**. It is preferred that the gear reducer **43** step down the rotational speed of the drum **13** and shaft **37** to about 24 r.p.m. in this example.

While the drum **13** is rotating, material is being fed into its charging port **15** through a curved, charging hopper **53** which is fixed to the upper cross support **41** of the frame **35**. Material coming from a belt conveyor (not shown) slides down the hopper **53** and onto the upper end of the rotatable fines screens **19** and then onto the coarse screens **27**. In this instance, the fines section **17** and the coarse section **25** are each formed with a plurality of screens **19** and **27** extending longitudinally between and fixed to axially spaced rings **57**. Fastened to the rings **57** are radially directed spokes **59** extending inwardly and attached to the shaft **37**. Longitudinally extending truss rods **61** extend the length of the drum **13** and between the rings. The rods **61** are angularly spaced from each other to form a skeletal framework or truss. The fines screens **19** and also the coarse screens **27** are carried on the truss rods **61** and spoke-supported rings **57**.

Disposed immediately beneath and about the lower half of the fines section **17** is the inlet mouth of the ductwork **21** which is air tight and which includes an upper duct **63** (FIGS. 1 and 3) fixed at its upper edges to inclined, top side beams **65**. The walls of this duct **63** extend close to and about the lower portion of the fines section **17** and also define a rectangular cross-sectioned passageway. The passageway extends downwardly to a flanged connector **67** which is joined to another flange connector and is in fluid communication with an elbow shaped pipe **69**. The outlet of the pipe **69** is fixed to the inlet port of the cyclone separator **23**.

The cyclone separator **23** includes an internal fan (not shown) for drawing air through the ductwork **21** from the fines section **17**. The fan is fixed to a rotatable shaft **71** carrying on its outer end a pulley **73** driven by a belt **75** and a motor **77**. The motor **77** is supported on a bracket **79** secured to vertical legs **81** of the frame **35** and serves to drive the fan to pull air through the ductwork **21** at a relatively high velocity and rate of flow such as, for example, 5,600 c.f.m. in the described apparatus. A relatively high flow and velocity of air is preferred as it will provide sufficient carrying force to bear and transport not only dust-like particles but also the larger fines which pass through screen **19** during operation. At the separator **23**, the fines are mechanically separated from the air, which is then discharged into the atmosphere. At an appropriate time, the fines are collected and removed from the cyclone separator. In the prior art flat screeners, these air-borne particles were, to a large extent, lost. The capturing of air-borne fines results in a higher recovery efficiency, reduced air pollution and better working conditions in the vicinity of the apparatus **11**. Also, fine particle material passing with the granular product through the flat screws of the prior art led to dusty fertilizer products with objectionable application characteristics when the fertilizer was spread by the ultimate user.

To prevent accumulations of fines on the fine screens **17** which would substantially blind and impede air flow through the screen openings, it is preferred to provide sets of scrapers **85** (FIG. 1) which ride on the outer surface of the fines screens **17** and dislodge dust and particle accumulations from these screens. In this instance, each set of scrapers **85** includes three scrapers **85** of generally block shaped configuration fixed to arms **87** supported on longitudinally extending shafts **89** mounted in upstanding bracket arms **91** fixed to the top side beams **65**. In each scraper set, the outer scrapers are aligned longitudinally (FIG. 1) while an intermediate scraper is offset, i.e., spaced circumferential about the screen from these outer scrapers.

In the preferred and illustrated embodiment of the invention, the cylindrically shaped fines section **17** is about three feet in diameter and about three feet long; the frustro-conically shaped coarse section **25** is about five feet long and tapers uniformly to a right circular cross section at its discharge end which is about one foot in

diameter. The upper left end of the coarse section **25** is three feet in diameter and defines a right circular cross section. This upper end is fixed to the left end of fines section **17**, and this right frusto-conically shaped section **25** tapers uniformly to a one foot diameter at the discharge opening **83** (FIG. 3). The present invention is not limited to any particular size or ratio of lengths of fine section to coarse section to coarse section as these have been varied and satisfactory results have been obtained.

For the fines section **17**, good results have been obtained with a slotted, fine screen sold by W. S. Tyler Company of Cleveland, Ohio and identified as Ty-Rod 9891. The slots are approximately 0.026 inch wide and about one inch in length and the screen is formed of wire having a 0.041 inch diameter and has openings which pass particles about 0.025 inch in diameter. The coarse screens **27** are conventional woven, mesh wire cloth of 0.027 inch diameter wire having substantially square openings about 0.261 inch on a side with about 61.3% of the cloth being open area. The present invention, however, is not limited to these exemplary screens used in the illustrated embodiment of the invention.

It is preferred that the shaft **37** be substantially coaxial with the longitudinal axes of both the fines and coarse sections **17** and **25** of the drum **13** and that the axes of the cylindrically shaped fines section **17** and the frusto-conical coarse screen section **25** be aligned with each other. The inclination of the respective coarse and fines screens to the horizontal and relative to each other has a pronounced effect on the rate at which material flows from the inlet opening **15** for the drum **13** to its outlet opening **83** over the hammer mill **31**. With a greater inclination to the horizontal, the material flows faster by gravity, but very large inclinations do not allow sufficient time for screening most of the particles through the screens. A good balance of flow rate and screening has been obtained with an inclination of the support shaft **37** for the described embodiment of the invention at about 12° to 16° to the horizontal with 13° being shown. Satisfactory results have been obtained with angles of inclination for the shaft **37** ranging between 10° to 45°.

In the illustrated embodiment of the invention, the bottom edge of the fines screens **19** is parallel to the shaft **37** and, hence, also disposed at an angle of 13° to the horizontal. In this instance, the bottom edges of the conically shaped coarse screens **27** are at an angle of 3° to the horizontal. Thus, there is about a 10° differential between the slope of the bottom surfaces of the respective screens in the illustrated apparatus.

Alternatively, the shaft **37** has been inclined at a 10° angle to the horizontal, but in such event the bottom of the coarse screens **27** are then disposed substantially horizontally and the rate of material flow in the axial direction through the coarse section **25** is reduced to below that desired. In another arrangement having a twenty foot long drum **13**, the shaft **37** has been inclined as much as 45° to the horizontal. However, when the shaft is inclined above about 16°, the screening is not as good, as a significant amount of the material does not have sufficient residence time on the screen to align with screen openings and to pass through them before being discharged into the comminuting means **31**. This decreased residence time can be partially compensated for, and increased contact between the material and the screens may be obtained, by rotating the drum **13** at faster speeds. Also, it will be appreciated that the 10° angle between the respective lower surfaces of the screens **17** and **27** may be changed. This angle can vary between 0° and 20°.

As the granules fall through the coarse screens **27**, the particles pass through a discharge duct **93** which is open at its upper end and is disposed adjacent to and generally coextensive with the coarse screens **27**. The discharge duct **93** extends longitudinally from the duct **63** to the adjacent discharge end of the drum **13** and is formed

with downwardly converging sidewalls **94** which lead to a discharge opening **95** (FIG. 1) from which the granular material drops from the apparatus **11** and may, in a suitable manner, be collected and removed. The walls **94** of the duct **93** are attached to and supported by the top edges by a pair of top braces **97** (FIG. 2) which extend downwardly, converge toward one another and are substantially parallel to opposite sides of the conical coarse section **13**.

From the discharge opening **83** at the left end of the drum **13**, oversized particles fall into the inlet **29** of the hammer mill **31** and are comminuted by the rotating hammers **101** having a hub **103** fixed to a rotatable shaft **105** (FIGS. 1 and 3) which is driven by a belt **107** extending to a motor **109** supported on a horizontally disposed bracket **111** fixed to the short rear vertical legs **81** of the frame **35**. The rotating hammers or bars **101** are fastened to the hub and are rotated to break the material to a predetermined size which is small enough to pass through slots between arcuately arranged breaker bars **113**. Passing between these breaker bars, the comminuted material falls into a spout **114** leading a fine screen section **115** of the secondary screener drum **33**. The secondary screener is much smaller in diameter and length than the primary screener drum **13**. The secondary screener drum **33** may be cylindrical in shape throughout its entire length and, in the illustrated embodiment, is about one foot in diameter.

To rotate this secondary drum **32**, a motor **117** (FIG. 1) is supported on a bracket **119** which also supports a rotatable shaft **120** for turning the secondary screener drum. The lower portion of the secondary screener drum is formed with a coarse screen of the same kind as previously described for the larger coarse screens **27**. Particles falling through the respective fine screens or coarse screens fall through a small discharge chute **121** (FIG. 1) which extends downwardly and toward the center of the apparatus to a position adjacent the discharge opening **95** for the large chute. While the amount of material collected from the secondary drum **33** is relatively small in comparison to the amount of material discharged from the primary drum **13**, it is nonetheless commercially significant particularly when considering that the rate of material flow is very large, as for example, 163 tons of fertilizer granules per hour. It is to be understood that fines produced by the hammer mill action will flow through the fines screen portion of the secondary drum and are combined with the discharge coming through from its coarse screens to provide the final mixed product in the discharge chute **121**. A few of the particles passing through the hammer mill **31** into the rotating secondary drum **33** may still be oversized and fail to pass through the secondary drum screens. These oversized particles are periodically removed and discarded and are counted as a waste product.

To facilitate an understanding of the invention, a brief description of the operation of the screening and comminuting apparatus **11** will be given. Material such as fertilizer which has been broken up in a coarse hammer mill (not shown) is usually delivered by an endless belt conveyor to the inlet hopper **53** at the upper end of the primary screener drum **13**. In the illustrated embodiment, the incoming flow is usually continuous from the conveyor belt and at a rate as high as 150 to 200 tons per hour. The fines are pulled downwardly through the fines screens **19** into the ductwork **21** and are carried into the cyclone separator **23** which centrifugally separates the fines from the stream of air and the air is then exhausted.

The fines section **17** of the primary drum **13** is preferred to be shorter and at a steeper angle than the coarse screening section **25** so that the material entering the drum at the fines section flows relatively quickly in the axial direction of the drum from the fines section and onto the coarse screens **27**. The high velocity air stream moving to the cyclone separator will rapidly remove these small particles in a short length while the material is flowing downwardly at a relatively fast rate as compared to the rate of flow in the coarse section.

In the coarse section the material flows sufficiently slowly that a major portion of the granular material has sufficient time and contact with the coarse screens **27** to become aligned with a screen opening and pass through it. The bottom edge of the coarse screen is preferably slightly inclined to the horizontal, for example, an angle of 2–5° (degrees), so that material continues to flow by gravity longitudinally and downwardly to the discharge opening **83** (FIG. 3) at the end of the drum **13**.

The period of residence of the material on the coarse screens and the amount of contact between particles with the respective drum screens can be changed significantly by varying the angle of inclination of the drum **13** to the horizontal and by varying the speed of rotation of the drum **13**. Flow rates of 163 tons per hour and a good screening efficiency and recovery of 99 plus percent have been obtained with the illustrated unit having the shaft **13** at angle 13° to the horizontal and having the bottom edge of the coarse screen at an inclination of three degrees to the horizontal while the drum rotates at a speed of twenty-four r.p.m.

The combination of a cylindrical fines section **17** and a frusto-conically shaped coarse screening section is preferred over a similar drum which is entirely cylindrical in shape for the reason that with a cylindrical drum there is no differential in slope along its bottom edge to obtain the differences in flow rates obtained with the present invention. The same lack of flow rate differentials would also be true in an entirely conically shaped drum for screening.

The rate of flow is such that the particles which fail to pass through the coarse screens **27** are, for the most part, oversized relative to the openings in the coarse screens. These oversized particles are discharged into the inlet of a hammer mill **31** having rotating hammers **101** to comminute the material falling therein. From the hammer mill the comminuted material passes to a secondary rotatable screening drum **33** which also has a fines screen **115** and a coarse screen **123**. Relatively small amounts of fines are collected from the material being discharged from the hammer mill, but most of the material comminuted by the hammer mill will pass through the rotating secondary coarse screen **123** into the chute **121** extending to discharge these particles adjacent the opening **95** for the chute **93**. In the secondary screener, good results have been obtained with both the fines and the coarse screen being cylindrical in shape, disposed at an angle of about 3° to the horizontal, and rotating at a speed of about 24 r.p.m. The material will flow down the fines and coarse screens in the secondary drum at substantially the same rate as they are both at about the same angle to the horizontal. The same rate of flow is used as only a relatively small amount of fines are present and without benefit of a suction force to remove the same.

From the foregoing, it will be seen that the present invention is particularly adapted to screen and comminute granular material at relatively high production rates and with a very high percent of recovery after screening. As contrasted with flat bed vibratory screens of the prior art heretofore used for screening fertilizer, the present invention was found to be not only faster and more efficient, but also to be less costly in its initial construction.

While a preferred embodiment has been shown and described, it will be understood that there is no intent to limit the invention by such disclosure but, rather, it is intended to cover all modifications and alternate constructions falling within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An apparatus for screening granular fertilizer materials comprising a drum having an inlet at one end for initially receiving a charge material to be screened, means mounting said drum at an angle of inclination to the horizontal and for rotating same, a fines screen defining a portion of the periphery of said drum adjacent said inlet, the lower edge of said fines screen being at a predetermined angle to the horizontal, duct means having an inlet mouth disposed about a portion and extending substantially the longitudinal extent of said fines screen, means for generating an air stream to pull said fine fertilizer material through said duct means and said fines screen for transporting said fines to a fines collecting station, said duct means being disposed adjacent the periphery of said rotating fines screen and including a duct for directing said air, a coarse screen defining another portion of the periphery of said drum at a location downstream of said fines screen for passing particles of a predetermined size, the lower edge of said coarse screen being at a lesser angle to the horizontal than said lower edge of said fines screen so that gravity exerts a greater force in the direction of material flow on the material flowing along the fines portion than on the material flowing along the coarse portion, comminuting means disposed beneath said drum means for receiving directly said oversized particles of fertilizer therefrom and for breaking said oversized particles, a secondary screening drum having a coarse and fine screen located in a plane below that of said comminuting means for receiving the discharge from said comminuting means and screening the discharge, and means for separating and collecting said fine fertilizer material from said air stream.

2. The apparatus of claim 1 including scraper means for dislodging dust and particle accumulations on said fines screen.

3. An apparatus in accordance with claim 1 in which said means for separating and collecting said fines includes a cyclone separator.

4. An apparatus in accordance with claim 3 in which said comminuting means comprises a hammer mill.

5. The apparatus of claim 4 in which the variation in angle between the lower edge of said fines and said coarse screens is less than 20°.

6. The apparatus of claim 1 in which said drum has a longitudinal axis disposed between about 10° to 35° to the horizontal.

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FRANK W. LUTTER, Primary Examiner

U.S. Cl. X.R.

209—23, 289, 385

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,532,276 Dated October 6, 1970

Inventor(s) Donald A. Dunn

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 49, "granular" is misspelled;
line 50, "granular" is misspelled;
Column 2, line 12, "comminuted" is misspelled;
Column 3, line 52, "screws" should be --screens--;
Column 4, line 8, "to coarse section" is shown twice;
Column 5, line 29, secondary drum "32" should be secondary drum --33--;
In the references: Beardsley Patent 2,389,715 shows an issue date of 1935 in the patent. The correct year is 1945.

SIGNED AND
SEALED
MAR 2 1971

(SEAL)
Attest:

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Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334