Aug. 14, 1956 H. HARDINGE 2,758,713

PROCESS AND APPARATUS FOR CLASSIFYING MATERIAL

Filed Feb. 27, 1953 3 Sheets-Sheet 1

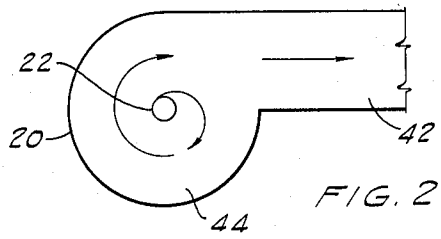


FIG. 2

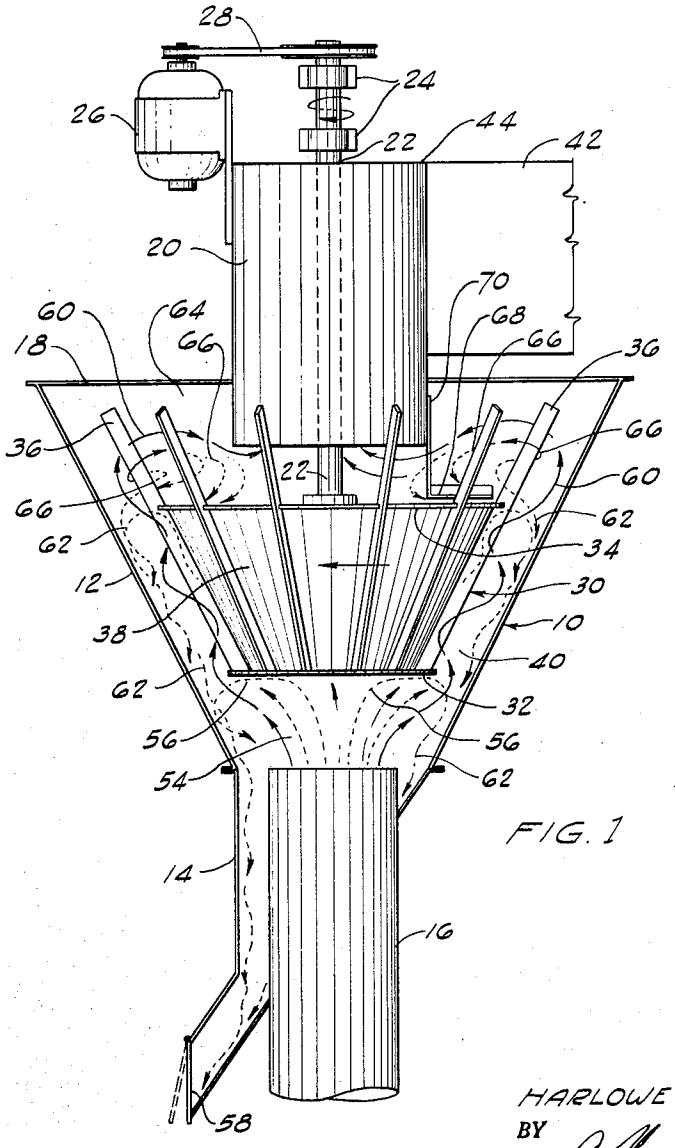


FIG. 1

INVENTOR.
HARLOWE HARDINGE
BY
ATTORNEY

Aug. 14, 1956 H. HARDINGE 2,758,713

PROCESS AND APPARATUS FOR CLASSIFYING MATERIAL

Filed Feb. 27, 1953 3 Sheets-Sheet 2

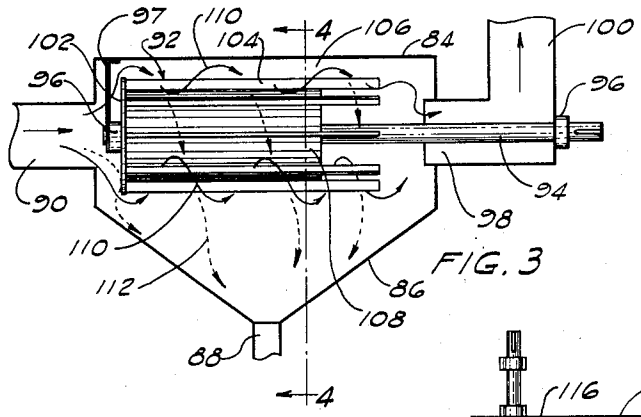


FIG. 3

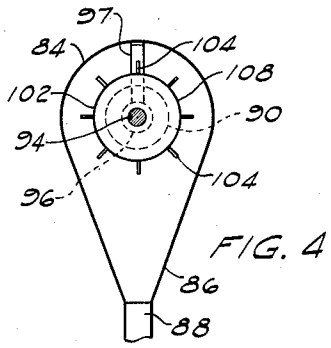


FIG. 4

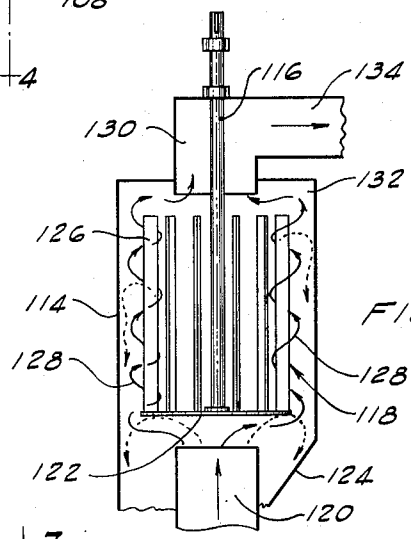


FIG. 5

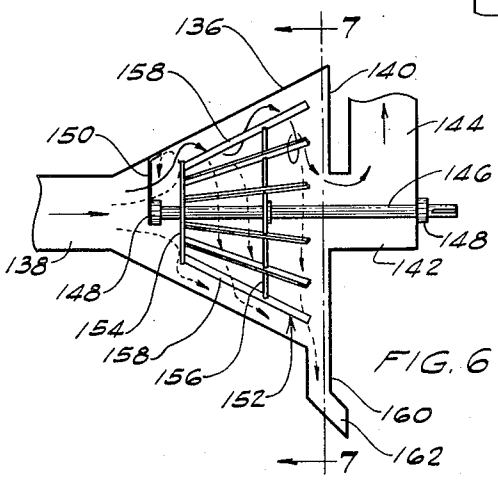


FIG. 6

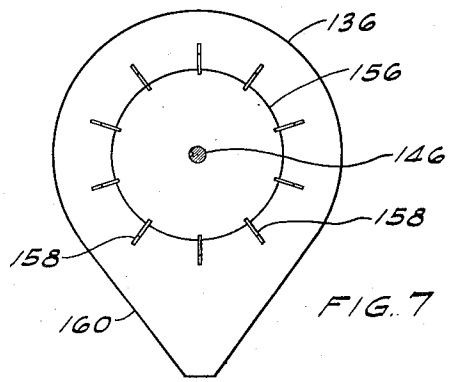


FIG. 7

INVENTOR.
HARLOWE HARDINGE
BY
ATTORNEY

PROCESS AND APPARATUS FOR CLASSIFYING MATERIAL

Filed Feb. 27, 1953 3 Sheets-Sheet 3

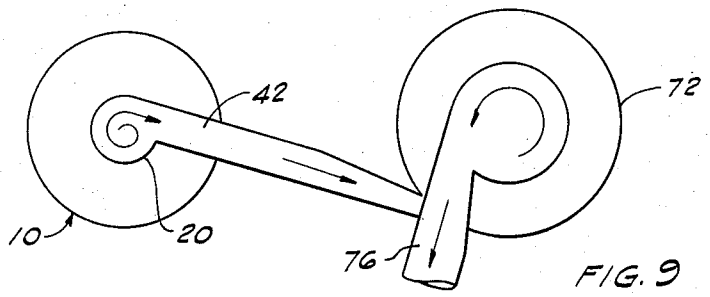


FIG. 9

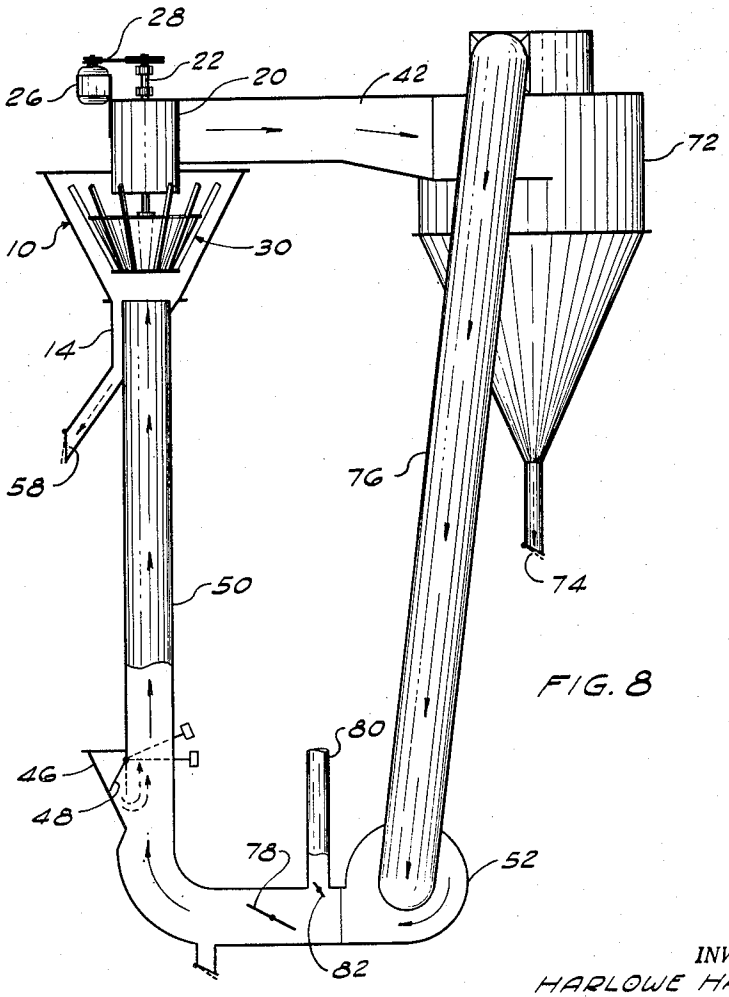


FIG. 8

INVENTOR.
HARLOWE HARDINGE
BY
ATTORNEY

United States Patent Office 2,758,713 Patented Aug. 14, 1956

2,758,713

PROCESS AND APPARATUS FOR CLASSIFYING MATERIAL

Harlowe Hardinge, York, Pa.

Application February 27, 1953, Serial No. 339,271

15 Claims. (Cl. 209—144)

This invention relates to a process and apparatus for classifying pulverized material and particularly for separating relatively coarse particles of material of a predetermined range of sizes from a fluid stream containing a mixture of said particles with relatively finer sizes of material. Said process and apparatus are particularly useful with grinding mills but it is to be understood that the same are not to be restricted to use with such machines and, in fact, have other applications of use.

Many types of material classifiers are in use at present and a large number of the same are of the type in which no moving parts, or substantially no moving parts, are used in the classifier, whereby the force of the incoming stream of fluid must be relied upon to induce all separation action which takes place within the classifier. Classifiers of this type are shown and described, for example, in prior Patents Nos. 1,709,848, 1,721,594 and 2,381,954. While these types of classifiers have proven commercially successful, the present invention offers marked advantage thereover as to efficiency of operation, reduction in wear of the apparatus, and decreased power requirements.

One problem usually encountered in classifiers is that of stratification and agglomeration of the material during the passage thereof through the apparatus. Various attempts have been made to reduce this tendency but thus far the efficiency of said attempts has not been of the desired degree and many of the classifiers have been of expensive and complicated construction.

It is the principal object of the present invention to provide a process and apparatus for classifying pulverized material and particularly for separating relatively coarse material from relatively fine material entrained as a mixture in a fluid stream, said process and apparatus resulting in substantially no stratification and agglomeration of the particles as they pass through the apparatus.

Ancillary to the foregoing object, the process and apparatus of the present invention contemplate the use of a power driven agitator which not only forcibly removes the coarser particles from a fluid stream of material but said stream is also subjected to a winnowing action to render the separation of the coarser from the finer material more efficient, said agitator also producing currents within the stream which move into contact with the agitator means.

Another object of the invention is to introduce a fluid stream containing mixed particles into classifying apparatus preferably under force from a blower, a partial vacuum also being utilized in the preferred embodiment of the invention further to induce movement of the stream through the apparatus, whereby no elevator is required.

A further object of the invention is to provide a process and apparatus by which the coarser particles in a fluid stream of mixed particles are positively separated therefrom by centrifugal force.

As an adjunct of the foregoing object, the process and apparatus contemplate in the preferred embodiment of the

invention the use of deflecting means which initially cause separation of at least the coarsest particles from the stream, whereby the other separating mechanism of the apparatus is not burdened with all of the coarse particles orginally within the stream.

Still another object of the invention is to provide a process and apparatus by which a fluid stream of entrained particles of various sizes is moved into a casing and impeller or agitator means are movable within said casing so as positively to impinge the coarser particles in said stream against the casing walls from which they move preferably by gravity to collecting means.

One further object of the invention is to provide a process and apparatus which may be suitably regulated and varied so as to be capable of producing products over a wide range in fineness, which are maintained quite uniform in size over a substantially wide range in variables as to material loads and size of particles within the stream.

Still another object of the invention is to provide a classifying apparatus, while far more efficient and economical in operation than classifiers heretofore used, is relatively simple and inexpensive to construct, and wear upon the various parts is reduced to a minimum.

An additional object of the invention is to provide in the classifying apparatus a support for the movable agitator or impeller which is so arranged relative to the outlet of the classifier casing, and said outlet is also so constructed, that the fluid stream, which is subjected to rotating action within the classifier, is caused to move in the same general direction of rotation upon entering said outlet, whereby any pressure drop within the stream exiting through said outlet is maintained at a minimum. This arrangement also results in minimizing wear and power consumption in this part of the apparatus and less head room is also required in the outlet mechanism as compared with other classifiers heretofore used.

Details of the foregoing objects and of 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 section, illustrating one embodiment of classifying apparatus incorporating the principles of the present invention.

Fig. 2 is a fragmentary, diagrammatic plan view of the upper portion of the apparatus illustrated in Fig. 1.

Fig. 3 is a side elevation, partly in section, illustrating another embodiment of apparatus utilizing the principle of the present invention.

Fig. 4 is a vertical sectional view of the embodiment shown in Fig. 3 taken on the line 4—4 thereof.

Fig. 5 is a vertical elevation, partly in section, of still another embodiment of the apparatus utilizing the principles of the present invention.

Fig. 6 is a side elevation, partly in section, of one further embodiment of apparatus utilizing the principle of the present invention.

Fig. 7 is a vertical sectional view taken on the line 7—7 of Fig. 6.

Fig. 8 is a vertical elevation, partly in section, of an exemplary classifying system including classifying apparatus embodying the principles of the present invention.

Fig. 9 is a diagrammatic top plan view of the apparatus system illustrated in Fig. 8.

The process comprising the present invention may be performed in a number of different specific types of apparatus, certain embodiments of which are shown in the drawings and described hereinafter, all of said embodiments utilizing the same basic principles of the invention.

Referring to Fig. 1, wherein one embodiment of clas-

sifying apparatus **10** is shown, a casing **12** is provided which is generally frusto-conical in this embodiment, the axis of the casing extending substantially vertically. The lower end portion of the casing **12** is connected to a collector **14** which receives coarser particles separated from a fluid stream in which said particles were entrained as will be described in detail hereinafter.

Extending upward through the collector **14** is an inlet or entrance conduit **16**. Said conduit extends preferably axially of the casing **12**. The top of the casing **12** is closed by cover **18** through which an exhaust conduit **20** extends substantially vertically and preferably in axial alignment with the casing **12**. A shaft **22** extends into the conduit **20** and is rotatably supported by suitable bearings **24** fixed relative to the conduit **20**. A motor **26**, which is preferably of the variable speed type, is fixedly supported relative to the conduit **20** and a belt **28** connects suitable pulleys on the motor **26** and shaft **20** as clearly shown in Fig. 1, whereby the motor drives the shaft **20**.

An agitator or impeller **30** is fixed to the lower end of shaft **22**. Said impeller **30** comprises in this embodiment a pair of plate-like members **32** and **34** which extend transversely to and are also fixed to the shaft **22** in longitudinally spaced relationship to each other. A plurality of elongated vanes **36** extend between and are secured to the plate-like members **32** and **34**, said vanes preferably being spaced peripherally even distances around said members and the outer edges of the vanes **36** are also preferably disposed substantially parallel to the side walls of the casing **12**. In the embodiment shown in Fig. 1, this is made possible by the member **34** having a larger diameter than member **32**.

The impeller will function to achieve desirable results, in accordance with the present invention, which are described in detail hereinafter when only the members **32** and **34** and vanes **36** are fixed thereto, but the efficiency of the apparatus, and correspondingly of the process, is increased by providing a shield means **38** which preferably is a cone of suitable material such as sheet metal and extends between the members **32** and **34** as well as between the vanes **36** adjacent the inner edges thereof. This arrangement produces a well defined annular space or passage **40** between the casing **12** and the impeller **30**. Extending tangentially from and communicating with the outlet conduit **20** is another conduit **42** and the upper end of the conduit **20** is closed by a cover or plate **44** which may be co-extensive with the upper wall of the conduit **42** as shown in Fig. 1.

While a classifier of the type described above and illustrated in Figs. 1 and 2 is useful to perform various kinds of classifying operations, it is particularly useful in a pulverizing and classifying system. One such exemplary system is illustrated in Figs. 8 and 9 wherein the classifier **10** is illustrated in sectional view. Said system may be used in conjunction with a mill, not illustrated, if desired. In any event, it is contemplated that material to be classified is in the form of a fluid stream in which a relatively wide range of particles of pulverized material is entrained and said stream is introduced through entrance **46** to the system. As illustrated herein, said entrance has a balanced airlock **48** operatively positioned so as to control the inlet of material to the uptake conduit **50**. The system also includes a blower **52** which discharges air in a direction to flow upwardly through the conduit **50** and thereby carry the fluid stream in which the pulverized material is entrained to the classifier **10**. It has been found in actual practice that, depending of course upon the force of the exhaust of the blower **52**, the fluid stream discharging from conduit **50** and the classifier **10** is capable of carrying particles of relatively large size of the order of an inch or more in diameter to the classifier **10**. Of course a wide range of smaller sizes of particles are also entrained in said stream moving to the classifier.

Referring particularly to Fig. 1, it will be seen that the fluid stream **54** of entrained particles enters the casing **12** in a substantially vertical path and impinges against the surface of the plate-like member **32** which is preferably planar and imperforate and transverse to the path of the stream. At least the coarsest of the particles within the stream will be deflected transversely and will be impinged against the side walls of the casing **12** as indicated, for example, by the broken line arrows **56**. The rotation of member **32** enhances this function. Said separated coarser particles will hit the sides of the casing **12** and fall by gravity down said sides into the collector **14**. The material collected in collector **14** is discharged through the oversize spout and airlock **58**.

The stream of material from which some of the coarser particles have thus been removed then moves upward through the space **40** which is defined by the casing **12** and the impeller **30**. Said impeller will of course be rotated at a speed suitable to achieve greatest efficiency during the classifying operation. The vanes **36** of the impeller will engage other relatively coarse particles within the stream moving generally upward through the space **40** and will cause them to be thrown or impinged against the sides of the casing **12** and from there said particles will move into the collector **14** by gravity.

It will be noted that the passage **40** is relatively long and the vanes **36** also act continually to disturb and break up any tendency for unbalanced loading of one portion of the classifier as opposed to another, whereby the air velocities are more evenly distributed than is otherwise possible and the air loadings are maintained substantially constant when air is used as the fluid medium. In addition, the buoying effect of the air and the centrifugal force caused by the rotating member **30** is maintained substantially constant with the result that the coarser particles which are thrown out of the stream by the vanes of the impellers are kept substantially clean of the fines which would otherwise tend to be entrained with them in an unbalanced load. Thus, the coarse particles in settling and moving downward into the collector **14** contain a very minimum of fines.

The fines, together with the finer particles of oversize, travel upward between the vanes **36** and through the space **40** as the stream rises toward the outlet conduit **20**. In the particular embodiment shown in Figs. 1 and 8, wherein a conical type casing **12** is shown, the diverging effect of the vanes **36** causes an increase in the velocity of the stream and the centrifugal force produced by the impeller **30**, thus producing further refinements and classification of the particles in this portion of the apparatus without the heavy loading of coarser particles which have been removed from the stream before the material reaches the upper zone thereof.

Vanes **36** also produce a winnowing action which causes the stream to assume a somewhat wavering but generally upward path indicated by the solid arrow lines **60**, said stream containing the fines intermingled with relatively finer particles of oversize. Some of the latter are caused to be thrown from the stream by vanes **36** so as to impinge against the walls of the casing **12** as indicated by the broken line arrows **62**. These particles move down the walls of the casing **12** by gravity as indicated by other broken line arrows **62**. The vanes **36**, in conjunction with the deflecting action of member **32**, cause the stream first to move toward the side walls of the casing **12** and said stream is then waveringly deflected inward toward the impeller **30** which causes engagement of the coarser oversize particles in said stream with the vanes **36**. The centrifugal force of the impeller will also cause diversion of the stream back toward the walls of the casing **12** from which said stream is subsequently deflected back toward the impeller preferably a plurality of times as indicated by the arrows **60** and resulting in a combined winnowing and deflecting effect upon the stream passing through the space **40**. Further, inasmuch as the space **40** is conical and the stream **54**

of entrained particles is introduced at a substantially constant rate, the velocity of said stream in cross-sectional areas will vary as said stream moves upward through the angular path thereof. This also produces variations in the winnowing effect to which the stream is subjected as it moves upward.

As has been stated herein above, the operation of this type of classifier is relatively efficient even when the shield means **38** is omitted. However, a more efficient cleaning of the oversize particles results if the shield **38** is embodied in the impeller **30**. Said shield also more precisely defines the annular space or passage **40** which tends to decrease the consumption of power and wear on parts in this zone by eliminating a space where turbulence is caused but which performs little or no useful purpose.

It has also been found that if the perimeters of the members **32** and **34** extend somewhat beyond the shield **38**, as shown in Fig. 1, the passage of the fluid stream between the edges or perimeters of said members and the casing **12** is restricted to a greater degree than the restriction between shield **38** and casing **12**. Thus, the velocity of the stream past the perimeters of the plate-like members **32** and **34** is increased and such increase in velocity also enhances the winnowing and hindered settling action of the particles within the stream as compared with the operation of a construction in which said members **32** and **34** do not extend beyond the shield **38**.

From Fig. 1 particularly, it will be seen that the upper member **34** is spaced a substantial distance from the cover **18** of casing **12**, as well as outlet conduit **20**. In view particularly of the conical configuration of casing **12**, an enlarged zone **64** is provided in the upper portion of casing **12**. The upper ends of the vanes **36** extend upwardly beyond the member **34** a substantial distance into the zone **64**. Further, in the preferred embodiment of the invention, the lower end of outlet conduit **20** projects into zone **64** so that the fluid stream containing entrained fines which are to be removed through conduit **20** travels upward into zone **64** as shown by the arrows **60**. Said stream then moves downward toward the upper surfaces of member **34** so as to be able to enter the lower end of conduit **20**. Under these circumstances, member **34** acts as a baffle. Portions of said stream are impelled by the upper ends of the vanes **36** particularly in such a way as to produce eddy currents **66** which tend somewhat to wrap around the upper ends of the vanes, as shown by the arrows indicating these currents, and said currents tend also to curve toward the upper surface of the member **34** with the result that the coarser particles thereon are thrown against the upper surface of member **34**.

This deposit of coarser particles may be discharged from the member **34** by centrifugal force induced by the rotation of the impeller **30** if the speed thereof is sufficient for such purpose. However, under some circumstances, depending on the loading of the stream and the speed at which said stream is introduced to the classifier, the rotational speed of the impeller **30** may be such that insufficient centrifugal force is developed to produce the desired amount of discharge of the coarser particles from member **34**. To insure substantially complete removal of said coarser particles from member **34**, scraper **68** is supported adjacent said upper surface, for example, by a bracket **70** fixed to conduit **20**. Said scraper is preferably positioned at a suitable angle within a plane parallel to member **34** so as to insure scraping and discharge of the coarser particles from the upper surface of member **34** and cause the same to fall against the walls of the casing **12** and slide down the same into the collector **14**.

While it is difficult to determine exactly what takes place in the enlarged zone **64** of the classifier, tests in transparent models tend generally to indicate that two forces seem to be exerted upon the stream in said zone. One of these is the force of the stream passing through the classifier from the entrance conduit **16** to the outlet conduit **20** and the other force is centrifugal and created by the rotation of the vanes **36**. The result appears to be an inward and downward thrust of the stream with the finer particles entrained therein that have not previously settled. In this zone, a sharp degree of classification appears to take place due to the difference in the inertia of the particles within the stream. The coarser particles tend to go to the point where there is less agitation and this is near the top of member **34** as indicated by the arrows **66**. At or just above the rotating member **34**, the agitation seems to be greatly reduced with the result that the coarser particles in the stream drop out and are either deposited or are thrown by centrifugal force from the member **34** as described above. These particles move through the vanes **36** and fall to the walls of the casing **12**, down which they slide to the collector **14** as described hereinabove.

The fluid stream from which the coarser particles have been removed and in which fines are still entrained, flows upward through outlet conduit **20** and into take-off conduit **42**. Impeller **30** causes a rotational movement of the stream and said rotation is in such a direction as naturally to enter the take-off conduit **42** which extends tangentially from the side of conduit **20** which would naturally receive the rotating stream, as clearly shown in Figs. 2 and 9. This arrangement results in minimizing any pressure drop at the outlet or exhaust end of the classifier and also minimizes frictional losses, thus resulting in decreased wear and power consumption in this portion of the system. Further, less head room is required as compared with conventional systems of this nature and a very effective and simple mounting for the impeller and drive means therefor is also made possible.

While the outlet conduit and take-off arrangement described above has been shown embodied in a classifier having a power driven impeller, it is to be understood that said arrangement may be included with similar beneficial advantage in classifiers in which no power driven impellers are used but stationary vanes or other means cause whirling of the fluid stream within the classifier. The tangential nature of the take-off conduit which naturally receives the swirling stream as it exits from the classifier casing permits marked reduction in head room of the exhaust conduit, regardless of the specific type of means which produces the swirling of the stream.

Take-off conduit **42** is illustrated in Fig. 8 as conducting the stream of fines into a separator **72** which separates the fine product from the fluid, such as air, in a manner well known in the art. The fine product is then recovered through a suitable airlock **74**. The air thus freed of the fine product is returned to the blower or fan **52** through conduit **76**. Thus, the blower **52**, being in communication with conduit **76**, separator **72**, and conduit **42**, places a suction upon the outlet conduit **20** and thereby facilitates movement of the fluid stream from the classifier **10** into the outlet conduit **20**. Flow of air through the system illustrated in Figs. 8 and 9 is also controllable by damper **78** in a well known manner in systems of this nature. Back pressure produced by the damper **78** is sufficient to create a negative pressure on the other side of the damper **78**, thus putting the system under a partial vacuum as is well known in the art. Any leakage entering the system through the various air-locks or otherwise is vented through a suitable pipe **80**, which venting is controlled by damper **82** at the only point in the system under pressure.

The foregoing description has been concerned with the embodiment of a classifier illustrated specifically in Figs. 1 and 2 and included in a complete exemplary classifying system illustrated in Figs. 8 and 9. Other types of classifiers may utilize the principles of the present invention incorporated in the embodiment of classifier illustrated in Figs. 1 and 2. One such additional embodiment is illustrated in Figs. 3 and 4 wherein a substantially horizontal and cylindrical casing **84** is shown supported by any suitable means, not illustrated. Depending from the lower

portion of and communicating with said casing **84** is a material collecting sump **86**, the walls of which converge at the bottom to communicate with an outlet **88**. Said outlet may have an airlock attached thereto if desired for purposes of controlling the discharge therefrom of coarse particles of material separated from the stream which enters the casing by inlet conduit **90**. The impeller **92** in this embodiment includes a horizontally extending shaft **94** which is supported at its opposite ends by suitable bearings **96**. The inner bearing **96** is supported by a suitable narrow bracket **97** which offers a minimum of impedance to movement of the fluid stream. Shaft **94** extends axially through the outlet conduit **98** which communicates preferably tangentially with take-off conduit **100**.

Impeller **92** has a transversely extending member **102** which is preferably plate-like and corresponds in function to the member **32** of the embodiment shown in Figs. 1 and 2. A plurality of vanes **104** are circumferentially spaced around the impeller and project substantially radially from the axis thereof. Said vanes are also relatively long and preferably substantially parallel to the side walls of the casing **84**. The outer edges of said vanes are spaced from said casing walls so as to provide a substantially annular space **106** which corresponds in function to the space **40** of the embodiment of Figs. 1 and 2. Shield means **108** preferably extend between the vanes **92** adjacent the inner edges thereof and said shield means also extends longitudinally from the member **102** toward the outlet end of the casing **84** but terminates short of the ends of the vanes **92** nearest the outlet end of the casing, as clearly shown in Fig. 3. It will be understood that the shaft **94** and the member connected thereto is driven by suitable power means not shown but which may be similar to that illustrated in Figs. 1 and 8.

In the embodiment shown in Figs. 3 and 4, some of the coarser particles will be deflected from the incoming stream upon engaging the deflecting member **102** and will be impinged against the walls of the casing **84** and fall therefrom into the collecting sump **86**. The stream which is thus relieved of some of said coarser particles then travels in a wavering manner through the space **106** generally as indicated by the solid line arrows **110**. Particles are engaged by the vanes **92** and the coarser sizes are impinged against the sides of the casing while the stream containing the finer sizes continues to move generally longitudinally through the space **106** toward the exhaust conduit **98**. The oversize particles thus separated from the stream fall to the collecting sump **86** as generally indicated by the broken line arrows **112**. The stream thus freed of oversize particles but within which fines are still entrained passes into outlet conduit **98** and associated conduit **100**. From conduit **100** the stream may pass to a suitable mechanism such as separator **72** shown in Fig. 8, for example. Except for the horizontal arrangement thereof, the general function of the impeller and the classifier of the embodiment shown in Figs. 3 and 4, and particularly prevention of agglomeration and stratification, as well as efficiency of separation of the coarser from the fine particles, is similar to the function of the impeller and classifier comprising the embodiment shown in Figs. 1 and 2. Further detailed description of these functions therefore is omitted in order to save repetition.

A still further embodiment of classifying apparatus is illustrated in Fig. 5, this embodiment utilizing a cylindrical casing **114** similar to that shown in Figs. 3 and 4 except that the casing is mounted so as to extend vertically and the coarse particle collector depends from the lower end thereof. The shaft **116** of the impeller **118** also extends vertically. Inlet conduit **120** introduces to the casing **114** the stream containing entrained particles which are to be classified. These particles first encounter a transversely extending deflector **122** which deflects the coarser particles therefrom unto the walls of the casing **114**, as indicated by the broken line arrows, and into a particle collector **124** as in the previously described embodiments. The impeller **118** comprises a series of circumferentially spaced vanes **126** which extend upward from the deflector **122**. In this embodiment, however, no shield is illustrated between the vanes as in the previously described embodiments. However, the deflector **122** first causes the stream to be deflected outward against the walls of the casing **114** and further movement of the stream in an axial direction upward in accordance with the arrows **128** results in said stream moving toward the axis of the impeller so that said stream encounters the vanes **126** with the resulting separation of coarse particles therefrom by impingement as described in regard to the previously described embodiments.

There is also somewhat of an entwining of the upwardly moving stream about the vanes **126** similar to that described relative to the upper ends of the vanes in the embodiment illustrated in Figs. 1 and 2. Thus, in general, the centrifugal force induced by the rotation of the vanes **126** causes movement of the stream outward toward the casing **114** and from there it moves backward toward the vanes farther along the generally longitudinal pathway taken by the stream in moving from the inlet conduit **120** to the outlet conduit **130** at the upper end of the casing **114**. A winnowing action is produced by the impeller and, simultaneously, coarser particles entrained within the stream are physically engaged by the vanes **126** to impinge said particles against the walls of the casing **114** from which they fall into the particle collector **124**, thereby effectively removing said particles from the stream of material ascending generally upwardly through the casing **114**.

The stream of material which contains principally relatively fine particles, as it reaches the upper enlarged zone **132** of casing **114**, enters the outlet conduit **130** with a circular movement induced by the impeller **118**. Take-off conduit **134** communicates tangentially with conduit **130** in a direction naturally to receive the rotatably moving stream with the same benefits as explained above in regard to the previously described embodiments of the invention.

It will be understood of course that the classifying apparatus illustrated in Fig. 5 may be substituted for the apparatus **10** incorporated, if desired, in a classifying system such as that illustrated in Fig. 8, for example. While the impeller **118** has no shield embodied therein, the vanes are nevertheless effective to produce a highly desirable winnowing action and separation of a predetermined range of relatively coarse oversize particles from the stream of material in which they were originally entrained.

One further embodiment of classifying apparatus which includes the principles of the present invention is illustrated in Figs. 6 and 7. In this embodiment, the casing **136** is conical and the same is supported in such a manner that the axis thereof is substantially horizontal. An entrance conduit **138** communicates with the smaller end of the conical casing and a fluid stream in which particles of various sizes are entrained enters the casing through said conduit. The opposite end of the casing **136** is covered by a closure **140** and centrally of said closure an outlet conduit is disposed so as to communicate with the interior of the casing. Take-off conduit **144** tangentially communicates with outlet conduit **142** in the same manner that the outlet conduits of the other embodiments communicate with the additional conduits interconnecting thereto.

An impeller shaft **146** substantially coincides with the axis of the casing **136** and extends into said casing longitudinally through the outlet conduit **142**. Suitable bearings **148** are fixedly supported relative to the casing and outlet conduit for purposes of rotatably supporting opposite ends of the shaft **146**. The bearings **148** which support the inner end of said shaft may be mounted on a suitable bracket **150**, for example, which is connected to the casing **136**. Said bracket is of minimum width so as to afford as little obstruction as possible to the passage of the fluid

stream into the casing **136**. The impeller **152** comprises a plurality of transversely extending members **154** and **156** which are fixed to shaft **146** in spaced relationship to each other, said members being similar to the members **32** and **34** of the embodiment shown in Fig. 1. A plurality of vanes **158** are circumferentially spaced about the perimeters of the members **154** and **156** in parallelism and spaced relationship to the side walls of casing **136**, as in the embodiment shown in Fig. 1.

The larger end of the casing **136** is provided with a depending sump **160** which is provided at its lower end with an airlock **162**. Thus, as the impeller **152** is rotated, it causes a winnowing of the fluid stream which moves generally longitudinally of the casing **136** and said winnowing induces a wavering movement of the stream, as indicated by the solid line arrows in Fig. 6, similar to that described in the embodiment shown in Figs. 3 and 4. Simultaneously, the blades **158** engage the coarser oversize particles within the fluid stream and cause said particles to impinge against the walls of casing **136** and move by gravity to the sump **160** as indicated by the broken line arrows in Fig. 6. Said particles exit through the airlock **162** while the stream containing principally fines of desired predetermined size passes into the outlet conduit **142** and rises through the incoming conduit **144**. From there the stream may pass to any suitable apparatus such as a separator **72** in a classifying system shown, for example, in Fig. 8.

It will be observed that no shield means is shown in the impeller **152** but such impeller nevertheless functions with acceptable efficiency in a manner similar to the embodiment illustrated in Fig. 5 wherein no shield means is embodied in the impeller. It will be understood however that, if desired, shield means may be incorporated in the impellers of both of these embodiments and the efficiency of the classifying function of the apparatus will correspondingly be increased for the reasons stated hereinabove. Otherwise, the separation of the coarser oversize particles from the incoming stream by the apparatus in Figs. 6 and 7, as well as the winnowing action of the impeller, and the prevention of agglomeration and stratification, is similar to that which takes place in the other embodiments and particularly that illustrated in Figs. 3 and 4.

It will be seen from the foregoing that all of the various embodiments described above and illustrated in the drawings incorporate the same basic principles which include, for example, the initial deflection of the coarser particles from the incoming stream upon the same being introduced to the classifier casing so as to decrease the particle burden in the stream as it is subjected to further classification, formation of the stream substantially into an annular configuration and causing said stream to move toward the walls of the casing and from there inwardly toward the impeller as said stream progressively moves generally longitudinally of the casing toward the outlet end thereof, whereby the stream moves generally in a wavering path and winnowing is effected while the coarser oversize particles in the stream are engaged by the vanes of the impeller or are otherwise blown by centrifugal currents induced by said vanes so as to cause said particles to impinge against the walls of the casing, whereupon said particles move downward by gravity along said walls or otherwise to suitable collecting means. The speed of the impeller can be varied in order to render the air velocities within the casing evenly distributed and the air loads maintained substantially constant in order that the buoying effect of the air and the centrifugal force caused by the rotating member is maintained substantially constant. This also results in the coarser particles which are removed from the stream being kept relatively clean of fines which would otherwise tend to mingle with them in an unbalanced load. Further, the higher the speeds, the greater are the forces exerted and the finer the product delivered from the system.

While no specific means other than a variable speed motor have been described herein for varying the speed of the impeller, it will be understod that any one of a number of other standard expedients may be utilized such for example as expansible V-pulleys or a variable gear box between the motor and drive shaft of the impeller.

By including a power driven impeller with the classifier, it is found that power consumption is less than in commonly used classifiers wherein air is passed through the classifier by suitable blower means only for example, and the force of the air itself is required to cause any centrifugal or other action to throw out the oversize particles. Thus, in the herein described classifiers as well as a system embodying the same, there is less wear on the apparatus unit, conduits and the system generally due to the fact that the stream containing entrained particles may be moved through the system at a lower rate of speed than is required in the above described classifiers which have no rotating impellers.

One of the most beneficial results of the process resulting from the various embodiments of classifiers illustrated herein, as well as the classifiers per se, is that, due to the vanes of the impellers of the various classifiers being relatively long and extending longitudinally of the casings in spaced relationship and substantially parallel to the side walls of said casings, said vanes continually disturb and break up any tendency for unbalanced loading of one portion of the classifier as opposed to another, whereby stratifying or agglomeration within the fluid currents while passing through the classifier is minimized to a far greater degree than has been possible in any classifiers heretofore produced.

While desirable results may be obtained by impellers not provided with shielding means, the provision of shielding means in the impellers, as illustrated in the embodiments shown in Figs. 1 and 3, enhances the cleaning of the oversize particles and the power consumption is somewhat reduced which also results in less wear on the movable part of the classifier. The inclusion of shielding means in the impeller also defines a more precise and restricted annular passage for the stream through the classifier and results in an increase in speed of the stream through this more restricted annular passage as compared with the embodiments of classifiers in which no shielding means are included. Such increase in speed of the stream effects greater buoyancy of the particles in the stream without requiring additional impeller or fan power which would be required if no shielding means were included.

Further, the winnowing of the fluid stream while passing through the various embodiments of classifiers is accomplished in such a manner that a wavering of the stream toward and away from the axis of the impeller is caused, thereby insuring engagement of the stream by the vanes of the impeller and the centrifugal current effects produced thereby so as to effect positive removal of the coarser particles from said stream.

A number of embodiments of apparatus have been illustrated herein utilizing the same basic principles of the invention. However, each of the described embodiments includes certain details which produce particular advantages under certain conditions of use and related structure. Thus, while each embodiment is operable to perform the objects of the invention, the described embodiments are not equivalents and the embodiment illustrated in Figs. 1 and 2 is considered the preferred one.

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 method of classifying coarse materials and fine materials comprising feeding a fluid stream containing a mixture of said particles to and through a classifying

area in a direction substantially axially of said stream, subjecting said stream to a selected rate of winnowing by varying the cross-sectional conditions of said stream to cause said stream to waver toward and from the axis thereof to prevent stratification and to effect deflection of coarse material from said stream while being winnowed.

2. Apparatus for classifying coarse and fine material from a mixed fluid stream thereof and comprising an impeller having a shaft, a pair of members fixed transversely to and spaced longitudinally of said shaft, and a plurality of fluid impelling vanes extending between and peripherally spaced around said members, the upper ends of said vanes extending beyond one of said members; means supporting said shaft of said impeller for rotation about its axis; and a casing having side walls surrounding said impeller in spaced relationship to said vanes and substantially parallel thereto, said casing having an entrance at one end arranged to introduce a fluid stream of mixed particles into said casing adjacent one of said transverse members in a direction substantially perpendicularly thereto and said casing having an exit adjacent the opposite end thereof, said one of said transverse members being a baffle arranged to inhibit free movement of said stream in an axial direction.

3. Apparatus for classifying coarse and fine material from a mixed fluid stream thereof and comprising an impeller having a shaft, a pair of transverse members fixed to and spaced longitudinally of said shaft, a plurality of fluid impelling vanes extending between and peripherally spaced around and fixed to said members, and a substantially imperforate shield means extending between said members and also between said blades adjacent the inner edges thereof; means supporting said impeller for rotation about the axis of the shaft thereof; and a casing surrounding said impeller in spaced relationship to said vanes and generally parallel thereto, said casing having an entrance at one end arranged to introduce a fluid stream of mixed particles into said casing adjacent one of said members in a direction substantially perpendicularly thereto for movement through the space between said shield and said casing to an exit adjacent the opposite end of said casing.

4. The classifying apparatus of claim 3 further characterized by one end of said vanes extending beyond the member nearest the exit end of said casing.

5. Apparatus for classifying coarse and fine material from a mixed fluid stream thereof and comprising an impeller having a shaft, a pair of transverse plate-like members fixed to and spaced longitudinally of said shaft, a plurality of fluid impelling vanes extending between and peripherally spaced around said members, and imperforate shield means extending between said members but spaced inwardly from the edges thereof, said shield means also extending between said blades adjacent the inner edges thereof; means supporting said impeller for rotation about the axis of the shaft thereof; and a casing having side walls surrounding said impeller in spaced relationship to said vanes and generally parallel thereto, said casing having an entrance at one end arranged to introduce a fluid stream of mixed particles into said casing adjacent one of said plate-like members in a direction substantially perpendicularly thereto for movement through the space between said shield and said side walls of said casing to an exit adjacent the opposite end thereof, the projection of the peripheries of said plate-like members beyond said shield means serving to restrict said space and thereby increase the speed of said stream through said space.

6. A classifier for separating relatively coarse particles from a fluid stream containing the same intermixed with relatively finer particles and comprising in combination, a casing having an entrance adjacent one end arranged to receive said fluid stream of mixed particles and an exit adjacent the other end, said stream being movable longitudinally through said casing, an impeller extending longitudinally of and mounted for rotation within said casing about an axis extending longitudinally thereof, said impeller comprising vertically spaced substantially flat plates extending transversely to said axis and vanes extending between and fixed to the perimeter portions of said plates and the outer edges of said vanes being spaced from the walls of said casing to provide a substantial annular space defined by said casing walls, the lower plate serving as a baffle to deflect coarser particles laterally from said stream and cause removal thereof by gravity and the vanes of said impeller when rotated serving to impinge other relatively coarse particles from said stream against the walls of said casing and also causing fluid currents to move waveringly from the walls of said casing toward said impeller, thereby to cause said stream to engage said impeller means as said stream moves generally longitudinally of said casing, and means arranged to direct said separated coarser particles from said casing.

7. A classifier for separating relatively coarse particles from a fluid stream containing the same intermixed with relatively finer particles and comprising in combination, a casing having an entrance adjacent one end arranged to receive said fluid stream of mixed particles and an exit adjacent the other end, said stream being movable longitudinally through said casing, an impeller extending longitudinally of and mounted for rotation within said casing about an axis extending longitudinally thereof, said impeller comprising a series of blades extending substantially longitudinally of said casing in spaced relationship thereto and radially to the axis of said impeller, shield means disposed between said blades adjacent the inner edges thereof, said blades being spaced peripherally around said impeller, thereby to provide a substantially annular space between said casing walls and impeller, said impeller when rotated serving to impinge the coarser particles from said stream against the walls of said casing and also causing fluid currents to move from the walls of said casing toward said impeller, thereby to cause said stream to engage said impeller as said stream moves generally longitudinally of said casing, and particle collecting means arranged to receive said separated coarser particles from said casing.

8. The classifier of claim 7 further characterized by said impeller and casing being arranged substantially vertically in use and said impeller also comprising top and bottom walls spaced vertically apart, said walls serving to deflect certain larger particles of material from said stream and cause the same to engage the walls of said casing and move to said particle collecting means.

9. The classifier of claim 8 further characterized by the upper ends of said blades extending above said top wall of said impeller.

10. A classifier for separating relatively coarse particles from a fluid stream containing the same intermixed with relatively finer particles and comprising in combination, a substantially cylindrical casing supported with its axis substantially horizontal and having an entrance adjacent one end arranged to receive said fluid stream of mixed particles, said stream being movable longitudinally through said casing, impeller means extending longitudinally of and mounted for rotation within said casing upon a horizontal axis extending longitudinally thereof, said impeller comprising a shaft having a pair of members fixed transversely thereto and spaced longitudinally thereon, at least one of said members being flat and disposed adjacent the entrance of said casing to serve as a baffle against which incoming material impinges and is deflected to cause removal thereof by gravity, said impeller also having blades extending longitudinally of said casing between said members and fixed thereto and the outer edges of said blades being spaced from the walls of said casing to provide a substantially annular space defined by said casing walls, said impeller when rotated serving to impinge the coarser particles from said stream against the walls of said casing and also causing fluid currents to move from the walls of said casing toward said deflecting

means, thereby to cause said stream to engage said impeller means as said stream moves generally longitudinally of said casing, and a particle discharge sump connected to and depending from the bottom wall area of said casing and arranged to receive the coarser particles separated from said stream as aforesaid.

11. A classifier for separating relatively coarse particles from a fluid stream containing the same intermixed with relatively finer particles and comprising in combination a substantially conical casing operatively supported with the axis thereof extending substantially horizontally and having an entrance in the small end of said casing arranged to receive said fluid stream of mixed particles, said stream being movable longitudinally through said casing, impeller means extending longitudinally of and mounted for rotation within said casing upon a horizontal axis extending longitudinally thereof, said impeller comprising a shaft having a pair of members fixed transversely thereto and spaced longitudinally thereon, at least one of said members being flat and disposed adjacent the entrance of said casing to serve as a baffle against which incoming material impinges and is deflected to cause removal thereof by gravity, said impeller also having blades extending longitudinally of said casing between said members and fixed thereto and the outer edges of said blades being spaced from the walls of said casing to provide a space which is annular in cross-section and is defined by said casing walls, said impeller when rotated serving to impinge the coarser particles from said stream against the walls of said casing and also causing fluid currents to move from the walls of said casing toward said deflecting means, thereby to cause said stream to engage said impeller means as said stream moves generally longitudinally of said casing, and a particle discharge sump connected to the bottom wall area of said casing adjacent the large end thereof and arranged to receive the coarser particles separated from said stream as aforesaid.

12. A classifier for separating relatively coarse particles from a fluid stream containing the same intermixed with relatively fine particles and comprising in combination, a casing substantially circular in cross-section and mounted with its axis substantially vertical, said casing comprising side walls and having an entrance at the lower end thereof arranged to receive a fluid stream of mixed particles and an exit at the upper end thereof, said stream being movable generally vertically through said casing, impeller means extending longitudinally of and mounted for rotation within said casing about an axis extending substantially vertically and comprising peripherally spaced vanes extending longitudinally of said casing and deflector means connected to said vanes to support the same for rotation in spaced relationship to said walls of said casing to provide a substantial annular space between said impeller means and said casing walls, said impeller means when rotated serving to impinge the coarser particles from said stream against the walls of said casing and said deflector means being on the lower portion of said impeller and operable to deflect certain coarse particles from said stream and against the walls of said casing, baffle means fixed to and extending substantially horizontally across said impeller means adjacent the upper end thereof and operable to receive coarser particles of material dropped thereon, the rotation of said baffle means causing discharge of said coarser particles from said plate against the sides of said casing, and means arranged to collect said coarser particles thus discharged.

13. The classifier of claim 12 further characterized by the upper ends of said blades extending above said baffle means and operable to induce eddy currents directed toward the upper surface of said baffle and effective to cause particles of coarser material to be deposited thereon, said particles then being subject to centrifugal force to impinge the same against the walls of said casing.

14. The classifier of claim 12 further including scraper mechanism mounted stationarily relative to said casing and adjacent the upper surface of said baffle means, whereby rotation of said baffle means relative to said scraper serves to scrape accumulated material from said baffle means and into said fluid stream.

15. A classifier for separating relatively coarse particles from a fluid stream containing the same intermixed with relatively fine particles and comprising in combination, a casing substantially circular in cross-section and mounted with its axis substantially vertical, said casing having an entrance at the lower end thereof arranged to receive a fluid stream of mixed particles and an exit at the upper end thereof, said stream being movable generally vertically through said casing, impeller means extending longitudinally of and mounted for rotation within said casing about an axis extending substantially vertically and comprising peripherally spaced blades extending longitudinally of said casing and vertically spaced means extending transversely to said vertical axis, said blades extending between and connected to said transverse means for support in spaced relationship to the walls of said casing to provide a substantially annular space defined by said casing walls, the lowermost of said transverse means also comprising deflector means positioned adjacent the entrance of said casing and extending transversely to the axis of said casing adjacent said entrance, and shield means extending between said blades and said vertically spaced means, said deflector means when rotated serving to deflect the coarser particles from said stream against the walls of said casing and the blades of said impeller when rotated serving to impinge other coarser particles against said casing walls and also induce fluid currents to move from the walls of said casing toward said impeller, the uppermost of said transverse means comprising baffle means fixed to and extending substantially horizontally across said impeller means adjacent the upper end thereof and operable to receive coarser particles of material dropped thereon, the rotation of said baffle means inducing centrifugal force causing discharge of said coarser particles from said plate against the sides of said casing.

References Cited in the file of this patent

UNITED STATES PATENTS

1,664,092	Squires	Mar. 27, 1928
1,810,922	Mills	June 23, 1931
1,898,807	Barnes	Feb. 21, 1933
2,153,270	Osgood	Apr. 4, 1939

FOREIGN PATENTS

535,238	Germany	Oct. 8, 1931