Aug. 31, 1937. A. F. MESTON 2,091,514

CLASSIFYING MATERIAL

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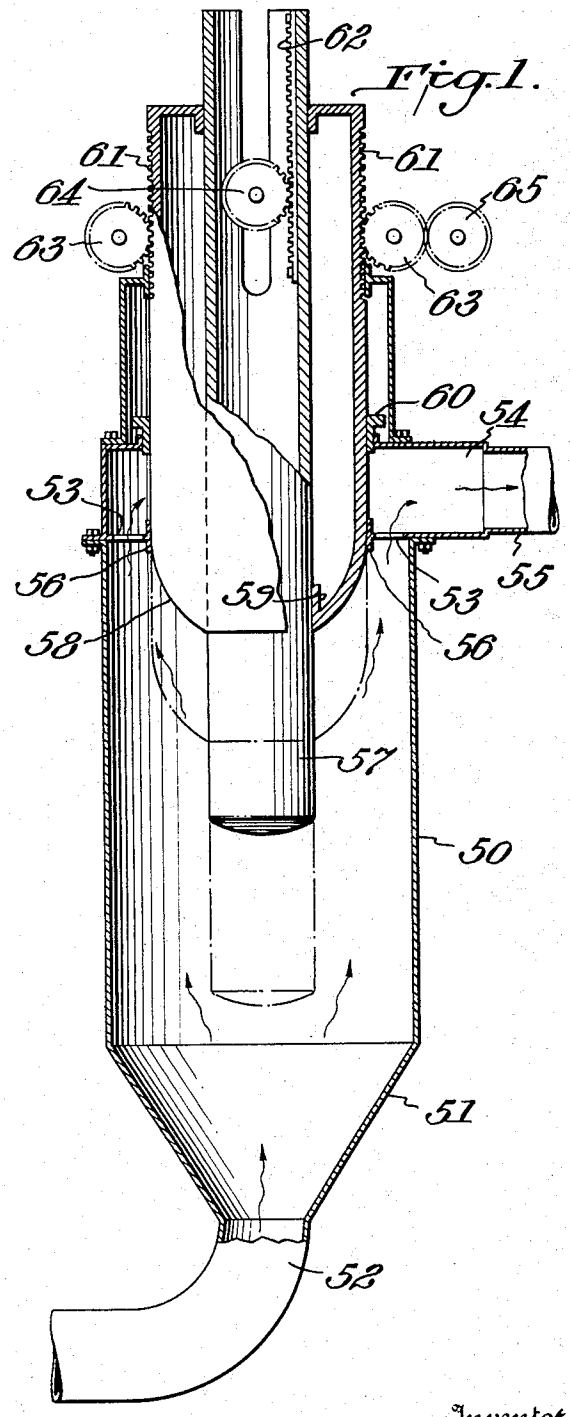


Fig. 1.

Inventor:
Archibald F. Meston

By Byrnes, Townsend + Potter

Attorneys.

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Fig. 3.

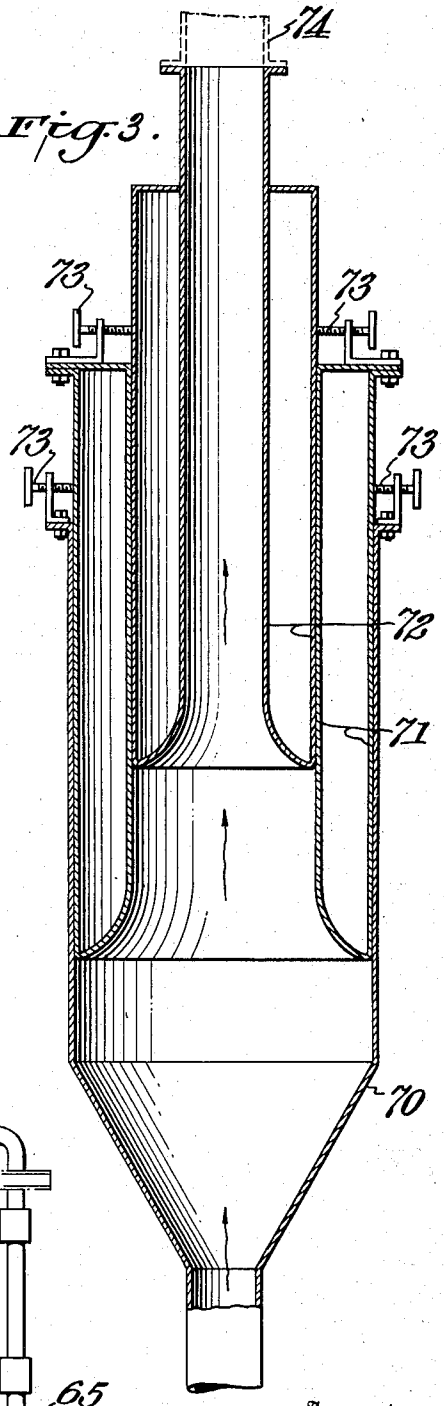


Fig. 5.

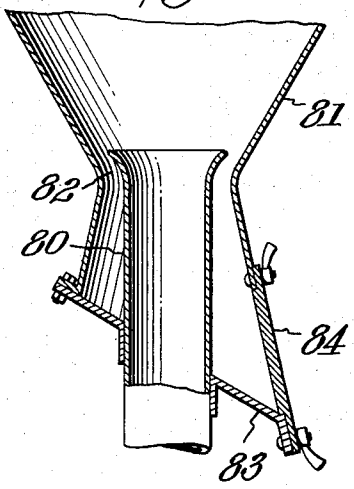


Fig. 4.

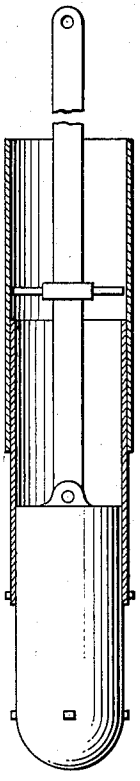
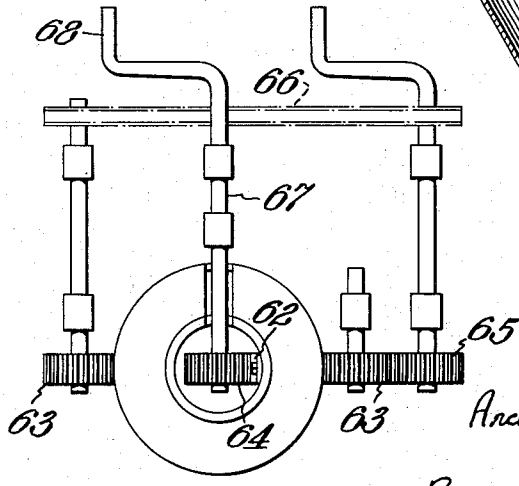


Fig. 2.



Inventor:
Archibald F. Meston

By Byrnes, Townsend & Potter

Attorneys.

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UNITED STATES PATENT OFFICE

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CLASSIFYING MATERIAL

Archibald F. Meston, Middlesex, N. J., assignor to Research Corporation, New York, N. Y., a corporation of New York

Application June 3, 1933, Serial No. 674,228

5 Claims. (Cl. 209—139)

The herein described invention relates to the classification of finely divided material according to size and/or specific gravity. It particularly relates to the art of classifying particles by suspending them in a fluid stream and balancing the force of gravity acting upon the particles with the buoyant and sustaining forces of the fluid stream. A particular branch of this art is known as classification by air flotation and the invention will be illustrated by describing it in terms of this branch of the art.

It is well known that when a small particle of the order of 100 microns in diameter, or less, is allowed to fall freely in a quiet body of fluid, it falls perpendicularly with increasing velocity towards the earth because of the action of the force of gravity, but the increase in velocity or acceleration continues only over a short period of time; the velocity soon becomes constant. This is because the frictional resistance of the fluid to the movement of the particle increases with increase in the velocity of the particle and, at the constant velocity attained, the force necessary to overcome this resistance just equals the force of gravity. The velocity V attained by a particle of radius r and specific gravity S, falling in a fluid of viscosity η and specific gravity S' when the resistance offered by the fluid just balances the force of gravity, here denoted by the gravitational constant g, has been given by Stokes (Applied Colloid Chemistry—Bancroft, page 136), as follows:

$$V=\frac{2r^2(S-S')g}{9\eta}$$

In air flotation, the air in which the particles are suspended is moved upwardly at a velocity V which will prevent all particles smaller in radius than a desired value of r from moving downwards. This value of V which will cause the particles of desired fineness to be carried along with the air stream may be determined by the aid of the above formula, or it may be determined by experiment. Apparatus to carry out air flotation usually consists of a fan to move the air and suspended particles, a vertical chamber in which the classification takes place, a collecting device such as a filter to separate the fine particles from the air stream leaving the chamber, and means for collecting the coarser particles, sometimes called tailings, which drop to the bottom, or collect on the walls, of the chamber.

The main object of the present invention is to make more flexible and useful the chamber in which the classification of the particles takes place. Another object is to provide means that will permit changes in the gas velocity V of the air passing through the chamber and resultant changes in the radius r of the particles without altering the volume of air passing through the chamber per unit of time. Still another object is to make possible various separations in the same chamber by effecting simple changes in the chamber while the classification system is in operation. Further objects include the provision of apparatus in which the area of the separating chamber may be altered, but wherein the cross-section of the chamber will be uniform throughout its length; the provision of apparatus in which the character of the inlet and outlet and the uniform velocity in the separating provide non-turbulent flow of fluids; and the provision in such apparatus of area-changing inserts of telescopic construction whereby the height requirements of the apparatus are limited. Other objects such as the removal from the apparatus, separately and in improved manner, of the air and fine particles and the coarse particles will be pointed out in the following description with the aid of the accompanying drawings.

Referring to the drawings:

Fig. 1 is a side view, partly in section, of one embodiment of the invention;

Fig. 2 is a plan view of the operating mechanism shown in Fig. 1;

Fig. 3 is a sectional elevation of another embodiment of the invention;

Fig. 4 shows a detail in sectional elevation useful in the invention as illustrated in Figs. 1 and 3; and

Fig. 5 is a fragmentary view, in sectional elevation, of a detail useful in employing the invention.

Fig. 1 shows a classifying or separating apparatus comprising a construction for keeping the cross-section of a separating passage substantially constant for most of its length and yet provide means for altering the area of this cross-section. Separating chamber **50** is cylindrical in shape and is used in vertical position as shown. At the bottom of the chamber is a conically shaped section **51** and below **51** is an inlet pipe **52**. The outlet from chamber **50** is through openings in spider **53**, which supports guide **56**, into collecting chamber **54** and therethrough outlet flue **55**. The cross-sectional area of chamber **50** is altered by inserting into the chamber one or more members as those marked **57** and **58**. These members are movable relative to the chamber **50** and to each other and are preferably cylindrical in shape which makes it easy to provide and control such

movements through simple stuffing boxes as indicated at 59 and 60. The mechanism for moving the members 57 and 58 consists of racks 61 and 62 incorporated in or attached to the sides of the members and which mesh with pinions 63 and 64, respectively. The relationship of the various pinions and racks is more clearly shown in Fig. 2. Because it is necessary that the two pinions 63 turn in opposite directions, an auxiliary gear 65 is provided. A chain and sprocket drive for turning pinions 63 simultaneously is indicated by 66. Pinion 64 is turned directly by crank 68 through shaft 67.

Referring to Stoke's law, it is to be noted that the radius of the particle r which will be sustained in a fluid stream moving vertically at velocity V changes according to the relationship $V=r^2$. This makes it apparent that if members 57 and 58 are raised and no members restrict the cross section of passage bounded by chamber 50, the velocity of the air passing (assuming constant volume per unit of time) will be a minimum and the particles that will be held in suspension and carried through the chamber will be of the smallest sizes only. It is not to be expected that the results to be obtained by reducing the cross section of the separating passage by introducing members 57 and 58 can be ascertained precisely by mathematical computations such as the use of Stoke's law, only. Stoke's law is based upon the assumptions that the particles to be suspended are spherical in shape and are suspended in a non-turbulent stream; also that an accurate determination of the specific gravity S of the particles is possible. The shape of the particles is not always the same; they are seldom truly spherical; turbulence and eddies are often present, and the specific gravity of the particles cannot always readily be determined and is not always the same in a single classification problem.

With the invention as shown in Figs. 1 and 2, three different air velocities can be had in chamber 50 as desired with a constant volume of air passing. A greater number of air velocities of smaller differential can be secured by increasing the number of movable inserts, of which members 57 and 58 are merely illustrative examples. All the inserts in use should be brought down to near the bottom of chamber 50 if uniform air velocity is desired, but they can be left in staggered effect, as shown in the figure, if progressive changes in velocity are wanted. The bottom surfaces of the inserts should be rounded off or so shaped that the velocity changes are not too abrupt. Otherwise serious eddies will result in the separating passage and the classification will not be uniform in all the air reaching space 54.

In Fig. 3 a construction is shown which alters the cross-section of the separation chamber by inserting a space occupying member along the periphery of the chamber. The effect of this is very substantial as the area is proportional to the square of the diameter and any decrease in diameter causes a decrease in the chamber area in accordance with this relationship. In Fig. 3 the separating chamber 70 has inserted within it space reducing members 71 and 72. They are preferably made as double walled tubes of smooth surface and are moved up and down by any suitable means such as those already described. They are held in the desired position by clamping screws 73. While other exits for the air may be provided, the inner insert 72 may be made to function as the air outlet and this is connected at the upper end to any flexible tube 74 which will adjust itself to the movements of member 72 and which will confine the air until it reaches the final collecting device that removes the suspended fine particles from the air leaving the classifying apparatus. Here again if separation is to take place in air at constant velocity the inserts in use should be lowered to near the bottom of the chamber 70.

Close separations or classification of particles sometimes require chambers of considerable height. In such chambers inserts which telescope such as that shown in Fig. 4 are useful. This modification makes it unnecessary to provide head room for the withdrawal of full length inserts. Telescope construction can also be used in making up the individual inserts shown in Fig. 3.

While the invention is primarily concerned with reduction in area of separation chambers in the fluid flotation practice of particle separation, it is important that any apparatus intended for this practice should be provided with means for removing the heavy particles or tailings without making frequent shut downs necessary. Fig. 5 shows the inlet 80 of a classifier entering the separation chamber 81 in spaced relation to the walls of the chamber thus leaving an annular space 82 into which the tailings may slide. Space 82 is provided with a bottom 83 and an outlet door 84. Such a device is extremely useful where it is intended to withdraw the tailings with a small amount of air and pass them through an attrition or frictional device, such as a fan, for dislodging fine particles that may be clinging to larger particles and returning them to the separating chamber again, for further classification. For such purpose an outlet pipe, not shown, is inserted through door 84 for continuously or periodically conducting the tailings to the friction device and conducting means are provided to return the worked-over tailings to the classifier.

The above descriptions make clear many of the uses and advantages of the invention. For instance, in many industries the classification of the dusts and powders resulting from plant operations is a minor factor as compared with the major plant operations and altering the major operations to give better control of the classification methods is objectionable. With the apparatus provided by the invention and the method of using it which has been described, it is possible to maintain control of the classification of the particles against changes in the volume of the air (or other fluid) carrying the particles, changes in specific gravity of the fluid or of the particles or in the viscosity of the fluid. If all these conditions are kept constant but changes in size in the floated product are desired these can be secured by altering the velocities at which the separations are made, and these alterations are easily made without interrupting plant operations by manipulating the area changing inserts in the separating chambers.

The invention has been described in terms of air flotation, but it is useful wherever advantage can be taken of the principle defined in Stoke's law. Separation under some conditions is obtained satisfactorily in liquids as well as in gaseous fluids.

I claim:

1. Apparatus for the differential separation of solids from suspension in a fluid medium comprising a vertical cylindrical casing defining a chamber, means for conveying fluid to the lower portion of said chamber, means for withdrawing fluid from the upper portion of said chamber, a

plurality of cylindrical members of differing cross-sectional areas concentrically positioned within said casing so as to close off a portion of the axial space in said chamber against the passage of fluid and to define an annular passage between said members and said casing and vertically adjustable so as to occupy varying portions of the axial space in said chamber said members being shaped and related to provide a substantially continuous confining surface for the fluid at all relative positions of said members.

2. Apparatus for the differential separation of solids from suspension in a fluid medium comprising a vertical cylindrical casing defining a chamber, means for conveying fluid to the lower portion of said chamber, means for withdrawing fluid from the upper portion of said chamber, a plurality of cylindrical members of differing cross-sectional areas concentrically positioned within said casing so as to close off a portion of the peripheral space in said chamber against the passage of fluid and vertically adjustable so as to occupy varying portions of the peripheral space in said chamber said members being shaped and related to provide a substantially continuous confining surface for the fluid at all relative positions of said members.

3. Apparatus for the differential separation of solids from suspension in a fluid medium comprising a vertical cylindrical casing defining a chamber, means for conveying fluid to the lower portion of said chamber, means for withdrawing fluid from the upper portion of said chamber, a plurality of telescoping cylindrical members of differing cross-sectional areas concentrically positioned within said casing so as to close off a portion of the axial space in said chamber against the passage of fluid and to define an annular passage between said members and said casing and vertically adjustable so as to occupy varying portions of the axial space in said chamber said members being shaped and related to provide a substantially continuous confining surface for the fluid at all relative positions of said members.

4. Apparatus for the differential separation of solids from suspension in a fluid medium comprising a vertical cylindrical casing defining a chamber, means for conveying fluid to the lower portion of said chamber, means for withdrawing fluid from the upper portion of said chamber, a plurality of telescoping cylindrical members of differing cross-sectional areas concentrically positioned within said casing so as to close off a portion of the peripheral space in said chamber against the passage of fluid and vertically adjustable so as to occupy varying portions of the peripheral space in said chamber said members being shaped and related to provide a substantially continuous confining surface for the fluid at all relative positions of said members.

5. Apparatus for the differential separation of solids from suspension in a fluid medium comprising a vertical cylindrical casing defining a chamber, means for conveying fluid to the lower portion of said chamber, means for withdrawing fluid from the upper portion of said chamber, a plurality of cylindrical members of differing cross-sectional areas concentrically positioned within said casing and vertically adjustable therein, and means for closing the space between said members at all relative positions thereof so as to provide a fluid passage of variable cross-section having substantially continuous confining surfaces.

ARCHIBALD F. MESTON.