March 3, 1959 — J. B. TRAYLOR — 2,875,895

SIZING MACHINE

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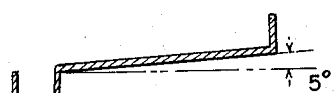

FIG.-3

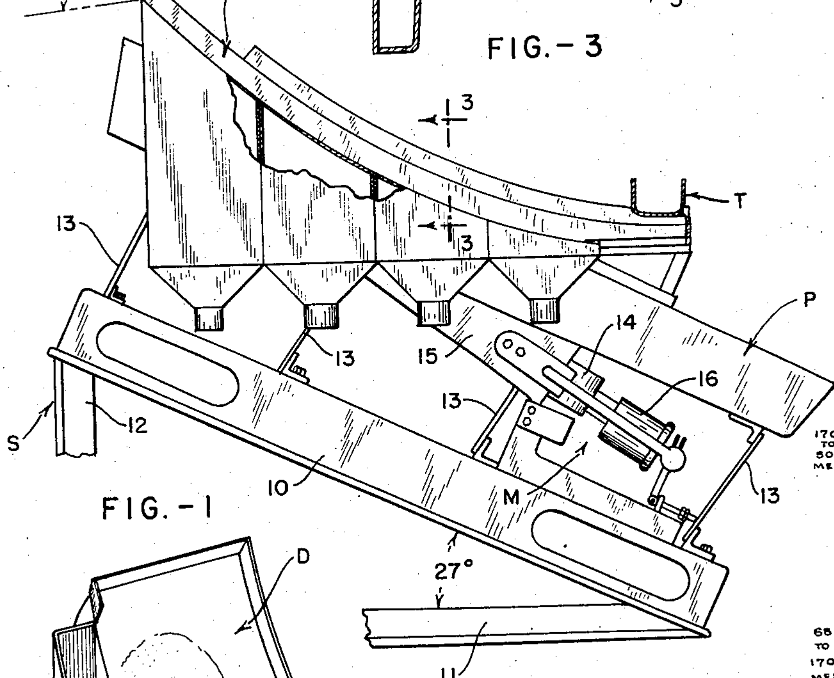

FIG.-1

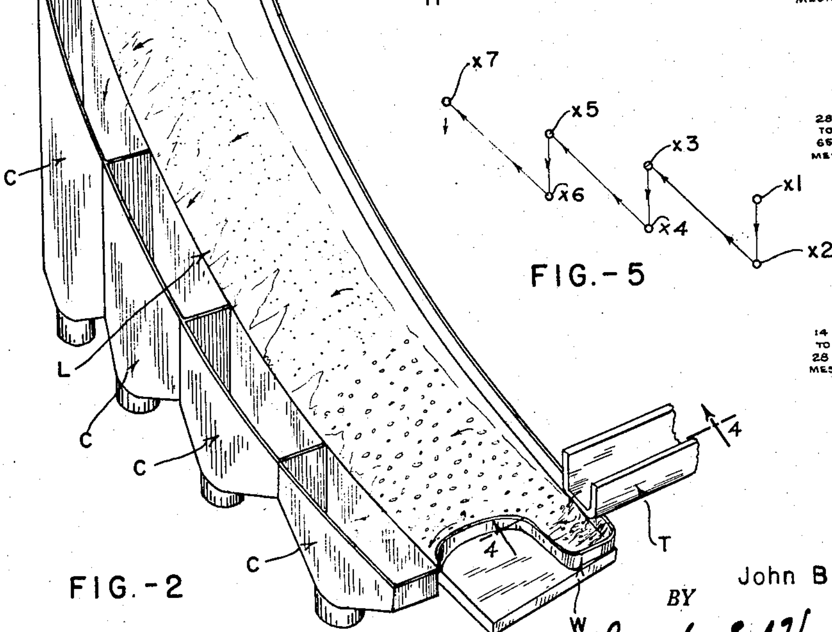

FIG.-2

FIG.-5

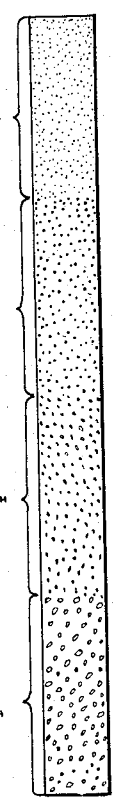

FIG.-6

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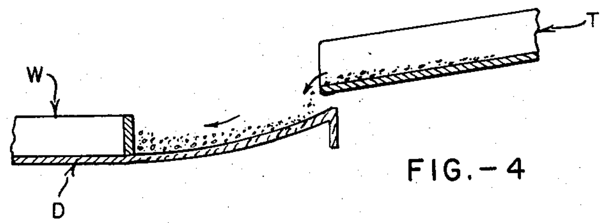

FIG.-4

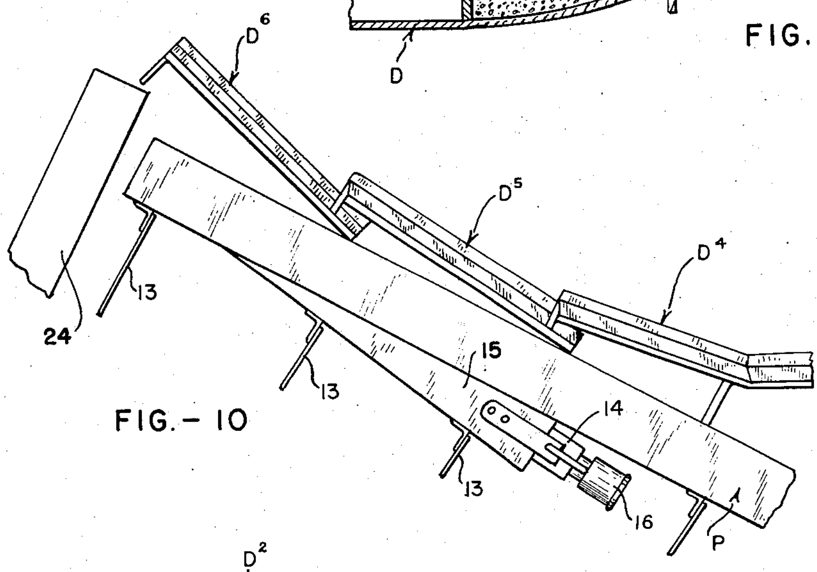

FIG.-10

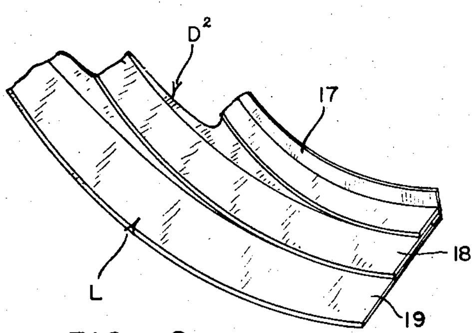

FIG.-8

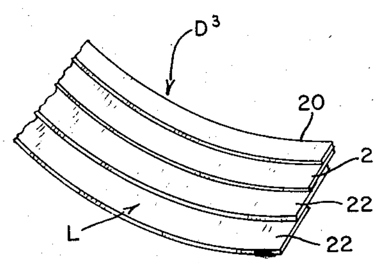

FIG.-9

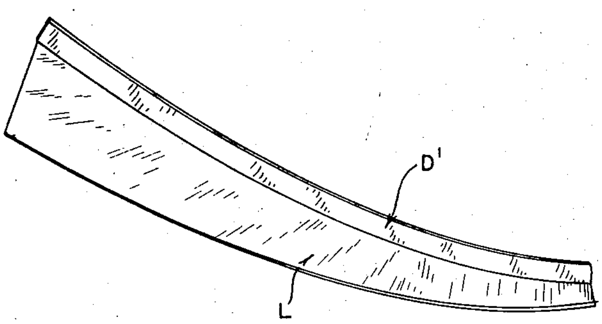

FIG.-7

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SIZING MACHINE

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5 Claims. (Cl. 209—112)

This invention relates to the separating of different size particles of material—true sizing into groups—regardless of the various specific gravities of the particles. By true sizing is meant separation of particles in accordance with the particles volumetric size irrespective of their specific gravity.

One of the objects of my invention is to produce an improved method of sizing material containing different size particles and a machine for carrying out the method.

A further object is to produce a method of sizing particles of different volumetric size by giving to the material while on a surface having a certain inclination, a predetermined motion transmitted through the surface so as to cause the particles to become positioned on the surface and particles of the same volumetric size will reach similar positions.

Another object is to produce a sizing machine that can accurately separate different size particles in a continuous manner by the movement of a surface onto which the material to be sized is continuously fed.

A stull further object is to separate different size particles by imparting to the particles a motion while being associated with a surface having a predetermined slope to the horizontal and extending in the direction of the motion.

A more specific object is to produce a sizing machine which will efficiently obtain separation of different size particles, regardless of specific gravity, by moving a sloping surface in a manner so as to cause particles thereon to reach their respective zeniths or points of balance between the pull of gravity and the surface attraction, which depends upon the volume, such a point being called the culminant point.

Another object of my invention is to so construct and position a sloping surface and so move it that when material embodying different size particles is placed thereon the particles of like volumes will be caused to pass off the surface at different points and thus result in separation of the particles into groups of like volume.

Other objects of my invention will become apparent from the following description taken in connection with the accompanying drawing showing apparatus for accomplishing sizing of particle material and carrying out the steps of the novel method involved.

In the drawings:

Figure 1 is a side view of a sizing machine embodying the invention;

Figure 2 is a perspective view of the sizing deck of the machine shown in Figure 1;

Figure 3 is a sectional view taken on the line 3—3 of Figure 1 showing the slope toward the overflow edge;

Figure 4 is a sectional view taken on the line 4—4 of Figure 2;

Figure 5 is a diagrammatic view illustrating the motion of a particle resulting from the movement of a surface on which is it positioned;

Figure 6 is a strip showing how the machine separates

the material into different sizes at the overflow edge, said strip being cellophane tape placed along the overflow edge of the sizing deck to pick up the sized material;

Figure 7 is a view of another sizing deck of a different surface contour that can be employed if desired;

Figure 8 is a view of still another sizing deck constructed to have a plurality of narrow surfaces of varying foci of curvature in cascade arrangement;

Figure 9 is a view of yet another form of sizing deck also having a cascade arrangement of narrow surfaces all of the same foci of curvature; and

Figure 10 is a view of a machine embodying my invention in which a plurality of successive flat surfaces are employed to make a separation of particles of material into groups, each having a range of sizes.

Referring to the drawings in detail and first to Figures 1, 2, 3 and 4, there is disclosed a sizing machine which is capable of carrying out the improved steps of the process for separating different size particles of a mixture of fine material and is particularly effective in making a true separation of material which may vary from 14 mesh downward to extremely fine particles of 500 mesh and smaller. The particular machine disclosed is capable of making a true volumetric sizing, regardless of whether the material being sized is homogeneous or non-homogeneous.

The particular machine disclosed in Figures 1, 2, 3 and 4 is a test model and is shown by way of example only as a machine which is capable of carrying out the steps involved in my new process. The general principles involved in the machine will be the same as those which will be embodied in commercial machines which may be required to have large capacities.

As shown in Figure 1, the machine has a supporting structure S comprising an inclined member **10**, a base member **11** and an upstanding member **12**. It will be noted that the inclined member **10** is mounted at its lower end on the base member and is supported at the other end of the base member by the upright member **12**. The platform P is connected to the supporting structure so it can be rapidly moved. The connecting structure shown comprises a plurality of resilient bars **13** in the form of leaf spring members, all of equal length and of the same vibratory characteristics. One end of each bar is connected to the inclined member **10** of the supporting structure and the other end is connected to the platform P.

In order to move the platform P in the desired manner there is provided an electromagnet M, the armature **14** of which is connected by a bracket **15** to be rigid with the platform and the coil **16** is carried by the support. The electromagnet can be operated either by alternating current or a pulsating current. If the usual 60 cycle alternating current is used the electromagnet will be energized 3600 times per minute and each time it is energized it will pull the platform rearwardly a slight distance, thus flexing the resilient bars **13**. When the magnet is deenergized during each cycle of the A. C. current, the resilient bars will flex back to their advanced flexed condition and carry the platform with them. Consequently, the result of the operation of the magnet will be a continuous motion of the platform P.

The structure just described including a support **10**, a platform connected thereto by resilient bars and a magnet for operating on the platform is a well known structure in present commercial use and is employed as a feeder or conveyor. In such feeders or conveyors the platform will carry a suitable chute and this platform will be so arranged on the support as to be either horizontal or slightly inclined. With such feeders the motion of the platform will cause material on the platform to be moved forwardly. This is brought about by having the platform pick up particles and move them forward during the forward movement of the platform as the magnet is deenergized. The platform, during this forward movement, is lifted slightly because the bars are returning from a slightly bowed condition to their advanced position. When the magnet becomes energized and pulls the platform rearwardly the platform will move slightly downwardly as the resilient bars become bowed. Both forward and rearward movements of the platform are very rapid and consequently the platform falls away from beneath the particles during such movement before the particles return to the surface of the platform. Upon the next forward movement of the vibrating platform, the particles will again be picked up by the surface and move slightly forwardly and upwardly where again during rearward movement of the platform surface under the action of the magnet the platform will drop away from the particles and the particles will fall back on the platform surface at a point slightly forward from where they were before the previous forward movement took place. Some such type of movement is essential to prevent sliding of the particles, so that friction and the influence of gravity which would nullify true volumetric sizing will be prevented. Thus, this type of movement is close to being frictionless.

The movement of a particle is illustrated in the diagrammatic showing in Figure 5. The particle is indicated by a small sphere. If it is assumed that it is resting on the platform's surface at a point X1, then as the magnet is energized and pulls the platform rearwardly, the platform will move out from beneath the particle and the particle will then drop to the point X2 where it will again be picked up by the forward movement of the platform surface and moved to the point X3. During the next rearward movement of the vibrating platform it will drop to the next point X4 where it will again be picked up by the platform during forward movement and moved to the point X5. Again when the platform moves slightly rearwardly during its next vibratory cycle and falls away from the particle, the particle will drop to the point X6 where it will again be picked up on the forward movement of the platform and be moved to the point X7. It is apparent from this diagrammatic showing, which is very much exaggerated, that the particle is caused to move forwardly as the platform moves. If the platform surface is inclined upwardly the particle will be moved upwardly, providing, of course, that the inclination of the platform is not greater than the culminant point of the particle being moved. The magnitude of such movements is usually rather small. For instance, in a machine constructed in accordance with this invention, the distance between points X2 and X3, X4 and X5, X6 and X7, etc., was approximately 1/16 in., while the distance between points X1 and X2, X3 and X4, X5 and X6, etc., was approximately 1/32 in.

To bring about the proper motion of the platform and consequently a movement of the particles on the surface thereof, the line of pull of the magnet M must be at an angle to the surface upon which the material is being conveyed. It should be noted that the angle which the line of pull of the magnet makes with the deck varies along the deck from point to point. This is essential.

To produce a sizing machine embodying my invention, I employ the vibrating platform P of the old and well known electromagnetic conveyor or feeder, although there are other forms of mechanical vibration equally as effective. Mounted thereon in a particular manner is a curved sizing deck which I have indicated by the letter D. This deck has such curvature so there will be increasing steepness from its lower end to its upper end with the lower end arranged to be substantially horizontal and conditioned so as to receive the material which is to be sized. I have found that the best curvature for this sizing deck should be an arc of a circle or a curve approximating it, although I desire it to be understood that my invention is not limited to the deck being an arc of a circle as this curvature may change, depending upon the material which is to be sized. The curvature may deviate from the arc of a circle and may even approach the curvature of an elipse, a parabola or a hyperbola. I have found that good results have been obtained in the sizing material by having the deck and its platform so positioned that a tangent to the upper end of the curved sizing deck will be approximately 57 degrees with the horizontal and a tangent to the lower end of the sizing deck will be at an angle near horizontal, such as 8 degrees or below, and the platform P which is being vibrated by the magnet will be at an angle of approximately 27 degrees with the horizontal, depending upon the angle of mount of the flexing bars.

With this curved deck the material which will be fed onto the lower end of the deck will be caused to move up the inclined deck as the platform and deck are vibrated simultaneously. The movement of the particles up the surface of the deck will be in the same manner as already mentioned in connection with the operating feeder or conveyor and illustrated by the diagrammatic showing in Figure 5. As the particles of the mixture being sized are caused to move upwardly on the deck which has increasing steepness, the particles will, in a short period of time, reach a culminant point on the deck. This "culminant point" is that point where the pull of gravity is sufficient to balance the surface attraction between the deck and the particle. The particle at this point simply overturns, rolls a short distance back down the slope, is picked up, moved forward, with this cycle repeating itself. If the material being fed onto the sizing machine consists of mixed particles of 14 mesh or smaller, it is known that the culminant points of the particles will vary in accordance with size. In other words, the particles which are 14 mesh will begin to reach their culminant point close to the lower end of the curved deck and then as the particles diminish in size they will reach their individual culminant points progressively up the curved deck. Each particle having the same size will reach the same point and thus the particles will be separated into their different sizes upwardly along the sizing deck. Surface attraction visibility affects all particles below a size approximating 14 mesh. Since the deck moves in a manner already described, it tends to keep the particles always in motion with substantially no frictional drag between the particle and the deck and therefore the particle is assured of reaching its culminant point. The type of motion described heretofore in Figure 5 is essential to the successful operation of the machine. This motion introduces little or no frictional drag which nullifies the effect of specific gravity; a heavy particle will move just as far and just as fast as a light particle of like size. The result will be a true volumetric sizing for all particles.

Of course, after sizing is accomplished by the vibrating movement of the curved sizing deck, it is necessary to remove the particles from the deck with each particle of the same size or approximately the same size being removed in a manner so they will be in one group. I accomplish this by an inclination of the sizing deck laterally toward one of its longitudinal edges, which edge I designate as the overflow lip and indicate such by the letter L in the drawings. The inclination of the sizing deck should be such that each particle will reach its culminant point before it is caused to move over the overflow lip. The inclination angle may vary, depending upon what material is being sized. I have found, however, that a reasonably good angle for the inclination of the deck is around 5 degrees, but this may vary from horizontal up to approximately 10 degrees for different kinds of material. If the inclination is too great, stratification of the material being sized may not take place, and if the inclination is too small there may be bunching of the material and not the desired true sizing. The rate of feed of the material onto the sizing deck must also be considered in determining the best angle of inclination.

Since the deck is to be tilted to produce an overflow lip, the material to be sized should be fed on the deck at the high corner of the bottom thereof. I accomplish this feeding and control by employing an ordinary vibration feeder in the form of a trough T. This trough, shown in Figures 1, 2 and 4, is mounted free of the sizing deck and moves laterally of the deck that is at right angles to the direction of vibration of the deck. It is inclined toward the sizing deck and the surface of the deck on which the material is fed is preferably curved slightly, as shown in Figure 4. The purpose of the trough is to provide for a rough sizing as the material goes onto the deck. When the particles fall onto the deck, the larger size particles roll down against the baffle wall W at the lower end of the deck.

With the inclination of the deck D being such as to cause the material to move to and over the overflow lip L throughout its length and in accordance with the size, the material can be separated by merely placing catcher chutes along this edge of the deck. These chutes can either be attached to the deck or arranged to be slightly below and underneath the edge of the deck so that the particles coming over the lip will fall into the chutes. These chutes are indicated in Figures 1 and 2 by the letter C, there being four in number in the particular machine illustrated. If material is fed to the deck having intermixed particles ranging down from 14 mesh, then with these chutes the material will be separated into four groups. The sizes in this group will vary in accordance with the length of the chute opening along the sizing deck. If a closer grouping of particle size is desired, the chutes can be increased in number with shorter lengths along the overflow lip. In some instances it might be desired to separate material into two groups, such as one group from 14 mesh to 100 mesh and another group including everything below 100 mesh. In such case, only two chutes would be required and the separating wall between the two chutes at the lip would be at the point where particles of 100 mesh size reach their culminant point.

Tests have shown that a sizing machine embodying my invention accomplishes true sizing and this sizing is not in any way affected by different specific gravities of the material being sized or the fact that the material may be non-homogeneous.

In Figure 6 there is illustrated in strip form the results accomplished by the sizing machine in separating the particles of different size. It will be noted that the particles vary progressively down in size from the largest size to the very finest size. The illustrated strip and the sized material was obtained by taking a strip of cellophane tape and pressing it down adjacent the overflow lip after the sizing deck had been vibrated sufficiently to accomplish the sizing.

Some material which may be sized by the machine may not move toward the overflow lip throughout its entire length in the desired manner, if the sizing deck has a uniform inclination toward the overflow lip. In some instances, with a uniform inclination, the coarse material will move rapidly enough toward the lip, but not the finer material. To overcome this objection, a sizing deck of the type shown in Figure 7 could be employed. This deck is indicated by the letter D^1. It has a single smooth surface and the desired increase in steepness from one end to the other. The inclination of the surface of the sizing deck toward the overflow lip, however, is not uniform through the length of the sizing deck. The bottom portion of the deck will have a low inclination angle and the surface of the deck from there toward the steepest end will have a gradual increase in inclination toward the overflow lip. The surface of the deck from the back edge toward the overflow lip may be on a straight line or it can have a slight curvature.

With certain materials it may also be desirable to employ a sizing deck which has a cascade arrangement. Such a cascade arrangement may be found to be very effective in increasing the capacity of the machine for certain material. This is accomplished as a result of the cascade arrangement breaking up lumps and eliminating any tendency toward "bunching." The breaking up of lumps occurs as the material cascades from one deck to another. This "bunching" will occur when too many fines collect together and as a result such fines carry coarser particles along with the bunched fines, thus cascading breaks up the bunches. One type of a cascade form of deck is shown in Figure 8 wherein the deck D^2 comprises a plurality of narrow deck portions **17, 18** and **19**. Each deck portion will have a different radius of curvature in its longitudinal direction, with the deck portion having the shortest radius of curvature at the top and the one with the longest radius of curvature at the bottom and with the intermediate deck positions having radii of curvature progressively increasing from the top portion to the bottom portion. The deck portions may be of the same width or they may be of varying widths. In Figure 8 the deck portions are shown of increasingly greater widths from the top to the bottom. Each deck portion will have a desirable inclination toward the final overflow lip L of the bottom deck portion. With this type of deck the fines will be more closely grouped together and not fully separated because their culminant points will be closer together. The fines will thus be separated in the group from the coarse material and then pass on to the second deck portion where they will be further separated. When they reach the lower deck portion a complete sizing will take place before they pass over the overflow lip. If the material being sized contains a larger percentage of coarser material than fine material, the fine material can be quickly separated from the coarse material and this coarse material quickly sized while the smaller volume of finer material progressively moves from one deck to the other and is more slowly sized. In this cascade arrangement shown in Figure 8, the fines are moved out from the coarser material in a fairly rapid manner, thus increasing the capacity of the machine.

In Figure 9 still another type of cascade deck is disclosed and such deck is indicated by the letter D^3. In this cascade type of deck there are a plurality of deck portions **20, 21, 22** and **22** arranged as a cascade. All of the deck portions will have substantially the same radius of curvature, differing only in the thickness of the deck portions. All deck portions are relatively narrow and if desired the upper deck portion can be the narrowest and then the portions progressively increase in width to the lower deck portion. With this arrangement each deck portion will tend to perform a true sizing, but due to the narrowness of the decks final true sizing will not be accomplished on the upper deck portions. In this type of cascade deck, the deck portions can be made fairly short so the fines can move over the ends of the deck portions and never reach any culminant point. The deck is particularly useful in increasing capacity as it breaks up the material rapidly and thus prevents fines being occluded in coarser material where it is not necessary to have the fines below a certain mesh to be further sized. All of these fines will go over the top into a chute and comprise one group, whereas larger sizes will be truly sized and finally passed over the overflow lip L at the lower edge of the lower deck portion.

If it should be desired to employ my invention in a machine which need only size the material in groups of sizes as, for example, in one group between 48 mesh upward, another group between 48 mesh and 150 mesh, a third group between 150 mesh and 200 mesh and the remainder in a fourth group, then a machine such as that shown in Figure 10 can be employed wherein only flat sizing decks in series are used. In this machine there are three sizing decks, D^4, D^5 and D^6, mounted on the movable platform P. The three decks are inclined toward a side edge to provide the overflow lips. The last or higher deck is so formed that all the fines below 200 mesh go over the top edge into a chute **24**. The first flat sizing deck D^4 is inclined upwardly at the required angle so that all the particles above 48 mesh will move to the side lip edge and the remaining smaller particles will flow over the top edge into the next sizing deck D^5 in the series. This next deck is mounted on the platform at a steeper angle, such as being at an angle required to cause the particles between 48 mesh and 150 mesh to move to the edge overflow lip and the remainder to go over the top edge onto the bottom of the last deck D^6. The last deck is mounted at a steeper angle than the deck D^4 and its angle may be such that all particles below 200 mesh will move to the side lip and the remaining fines will go over the top edge into chute **24**. All particles going over the lower side lips of the three decks can fall into suitable chutes, not shown, which will be similar to the chute C shown in Figures 1 and 2. The number of sizing decks in the series can be increased or decreased and their angles of inclination selected in order to produce the desired group sizing, as is believed to be obvious.

In the machine of Figure 10, it will be seen that the same principles of separation are involved. Instead of having an infinite number of differently inclined surfaces on one curved sizing deck, having continuously increasing steepness as in the machine of Figures 1 and 2, there are selected a limited number of different inclined surfaces only with each surface being flat. All particles having a culminant point which is not reached on one flat inclined surface go over to the next. The fines which have no deck on which they can reach a culminant point go over the top edge of the last deck and into the final chute **24**.

Besides the modifications already described, it is believed to be obvious other modifications can be made without departing from the scope of my invention and still employ the novel steps of the method involved. In working on different materials it may be necessary to change the type of curvature of the sizing deck or a portion thereof, to change the inclination of a sizing deck so that it is either uniform throughout its length or so it varies from one end to the other. Changes may also be required so the best sizing will be accomplished for some particular rate of feed. Tests also show that the sizing deck may be varied either as to curvature from one end to the other or as to inclination or both where it is found that sizing is better accomplished with one particular intensity of vibratory motion than some other particular intensity, or where certain group sizing may be desired.

With my improved sizing machine it is possible to accomplish any desired type of sizing that is needed. The true sizing of particles from one size on down to very small sizes can be accomplished, or the particles in the material can be placed into any desired grouping. Since the sizing is not dependent upon the specific gravity of the particles in the material or the type of material involved, whether homogeneous or non-homogeneous, it is readily apparent that the sizing machine will have many commercial uses. The sizing machine can be used with other known methods of sizing material, particularly those employing screens. Coarse material above 14 mesh can be readily and quite efficiently sized by use of screens, but particles below this size cannot be easily and cheaply separated, either by screening or by elutriation, as these two latter methods or combinations thereof are not too efficient and are costly. It is well known that fine screens clog up and as for elutriation, it is best for sizing homogeneous materials. After using other sizing

methods to take out coarse particles, my sizing machine can be employed on the finer particles.

Being aware of the many changes, variations, combinations and modifications in the sizing decks employed and their manner of vibrations, together with variations in the steps of the sizing method, all without departing from the fundamental principles of my invention, it is not intended that the scope of the invention be limited in any manner except in accordance with the appended claims.

What is claimed is:

1. A machine for volumetrically sizing particles of approximately 10 mesh and less and which have different volumetric sizes and may differ in specific gravity, comprising a surface positioned so as to extend upwardly longitudinally with successive portions of the surface increasing in steepness from the rear to the front and substantially all portions of the surface inclined laterally and downwardly toward one lateral edge; means for supporting said surface so as to be movable longitudinally in opposite directions and have an up and down movement along a general line inclined to the horizontal and upwardly from the rear to the front, said surface extending upwardly at least to a point at which a tangent to said surface is approximately parallel to said general line of movement; means for feeding a succession of said particles onto the rear of said surface; means for imparting to said surface a rapid succession of impulses in a rearward direction and along a line inclined at an angle to the horizontal at least as great as the general line of movement of said surface; means for imparting to said surface a succession of impulses in a forward direction and generally opposite to said rearward impulses, said surface also moving downwardly relative to said general line during rearward movement and upwardly relative to said general line during forward movement; said particles being moved upwardly along said surface and to said lower lateral edge by the successive impacts of the forward and rearward movements of said surface whereby they are adapted to be collected adjacent said one side edge.

2. A sizing machine for material of intermixed particles of different volumetric size comprising sizing deck means provided from the lower end thereof to the upper end thereof with sizing surface means constructed and mounted to have different and increasing angles of inclination from the lower end to the upper end and to have a slope toward one side edge, means for supporting said surface means so as to be movable longitudinally in opposite directions and have an up and down movement along a general line inclined to the horizontal, said surface means extending upwardly at least to a terminal point at which a tangent to said surface means is approximately parallel to said general line of movement, means for feeding a succession of said particles onto the deck means at the lower end thereof, means for reciprocating said deck and surface means along said general line whereby the particles of like volumetric size will move up the surface to like culminant points, said particles being moved upwardly on the surface and to said side edge by movement of said surface in the opposite directions whereby they are adapted to be collected adjacent said one side edge.

3. A sizing machine as defined in claim 2 wherein the feeding means includes an inclined surface onto which material is fed and mounted to move independent of the deck means with its direction of inclination lateral to the direction of longitudinal movements of the deck means.

4. A sizing machine as defined in claim 2 wherein the slope in the surface means gradually increases from the lower end to the upper end.

5. A sizing machine as defined in claim 2 wherein the sizing surface means includes a cascade arrangement of curved surfaces.

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