Dec. 29, 1936. H. E. T. HAULTAIN 2,065,695

METHOD OF AND APPARATUS FOR DETERMINING A DEGREE OF FINENESS OF FINELY DIVIDED MATERIAL

Filed March 6, 1933 3 Sheets-Sheet 1

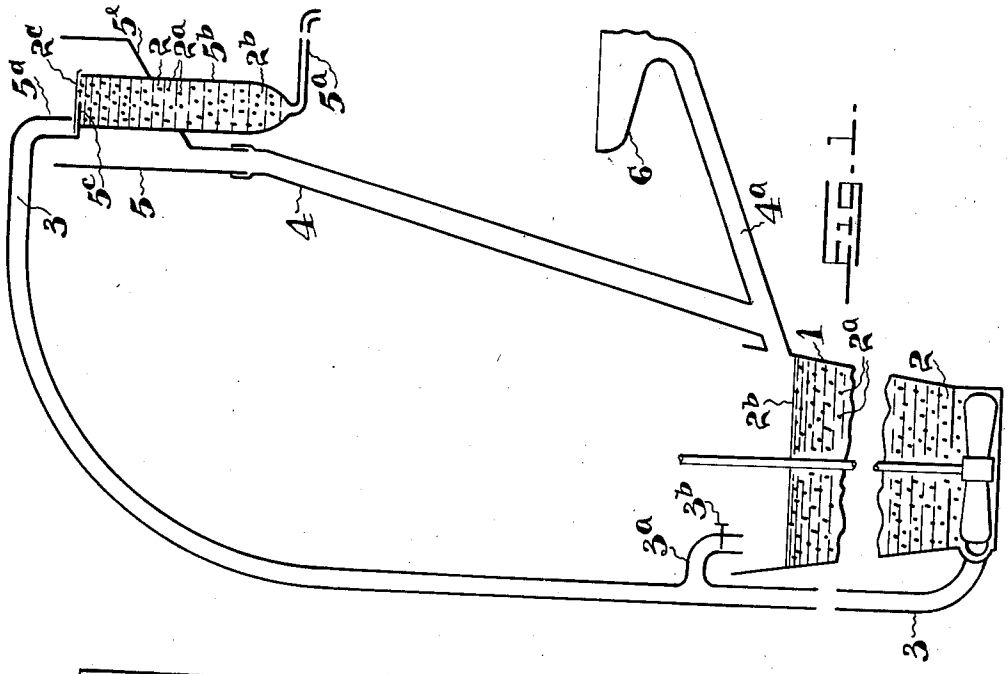


FIG. 1.

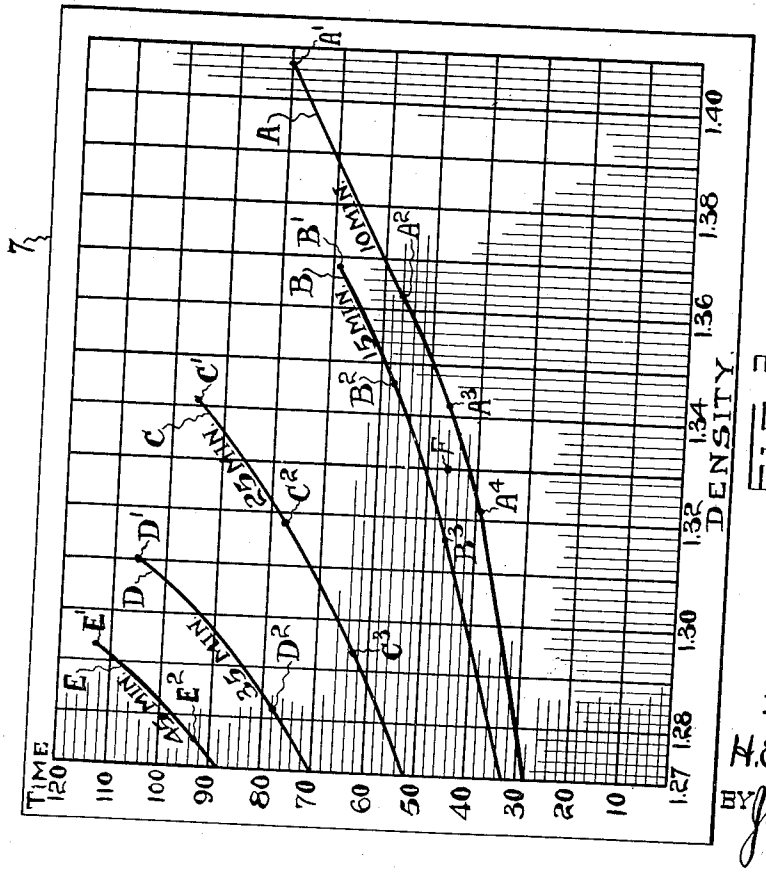


FIG. 2.

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Filed March 6, 1933 3 Sheets-Sheet 2

Fig. 3.

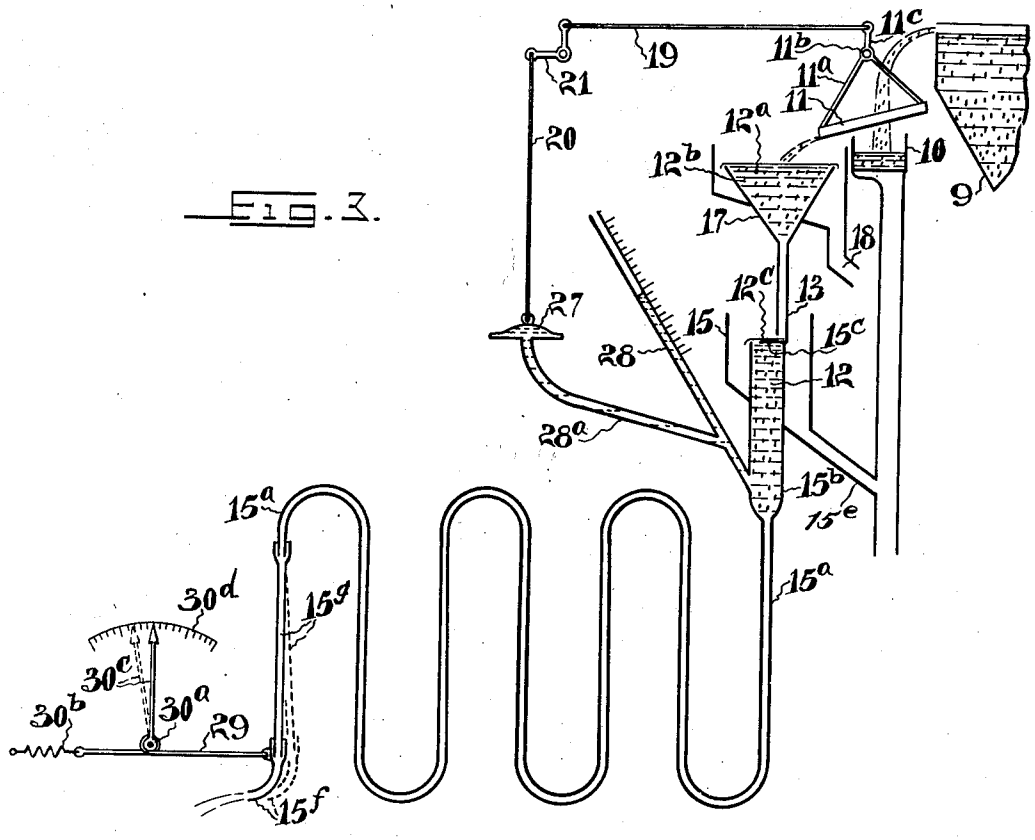
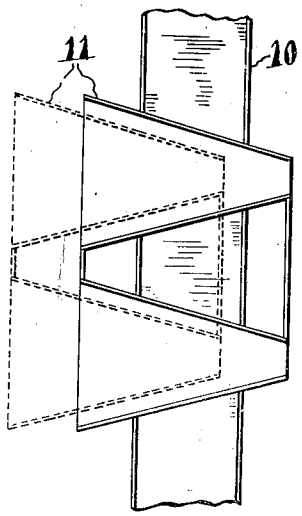


Fig. 4.



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Filed March 6, 1933 3 Sheets-Sheet 3

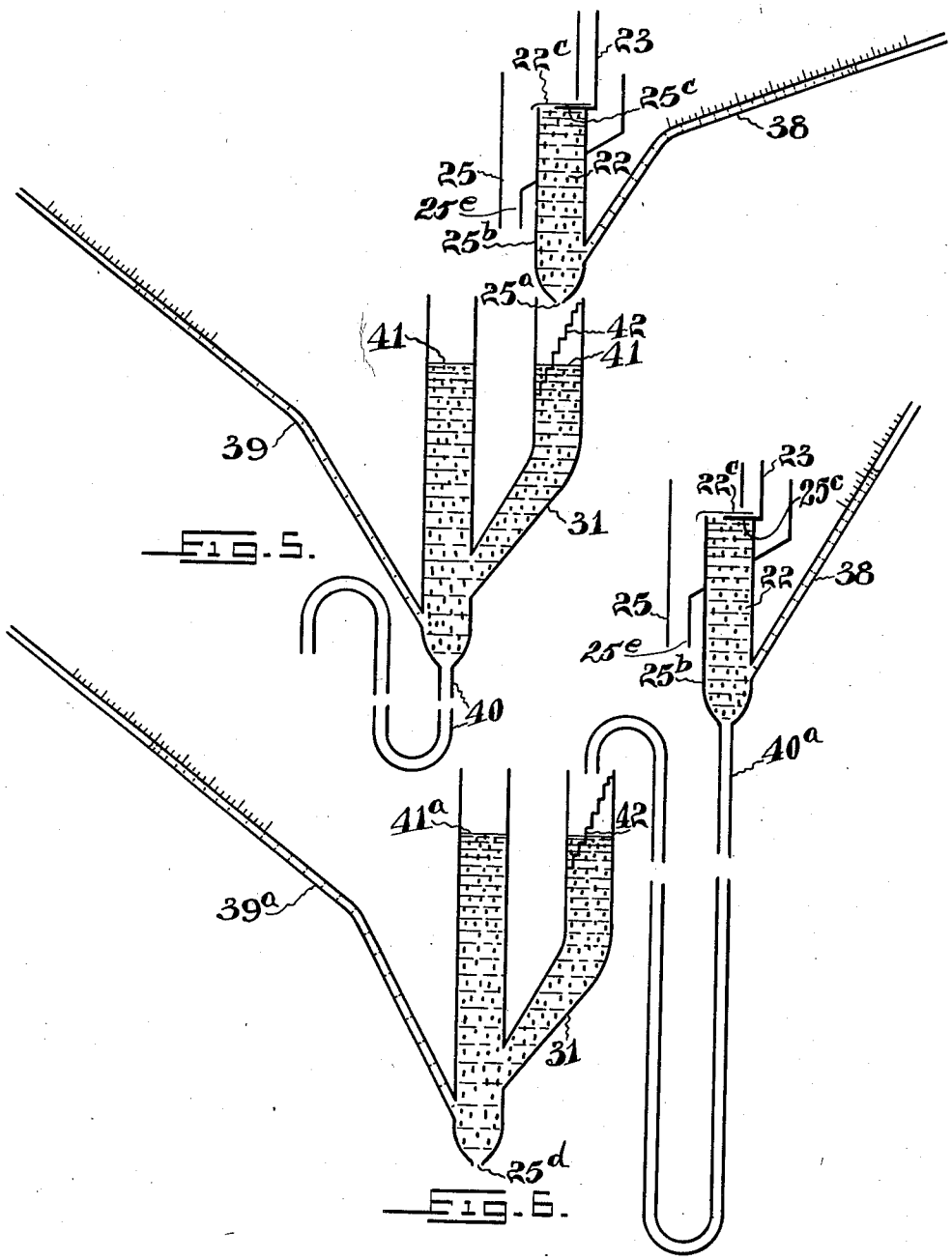


FIG. 5.

FIG. 6.

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UNITED STATES PATENT OFFICE

2,065,695

METHOD OF AND APPARATUS FOR DETERMINING A DEGREE OF FINENESS OF FINELY DIVIDED MATERIAL

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Application March 6, 1933, Serial No. 659,657

11 Claims. (Cl. 265—11)

This invention relates to a method of and apparatus for determining the relative degree of fineness of ground or other finely divided material whereby it may be compared with the fineness of another similar material. In the grinding of ores for cyanidation or flotation, the grinding of cement clinker and in many other cases of pulverizing of mineral or mineral products it is important to know the fineness of the product in order to maintain a standard. In any such product as it comes from the grinding mills the size of particles will vary from the coarser down to colloidal sizes. The object of my invention is to devise a method and means for determining the general fineness or average size of the particles so that uniformity of similar products may be obtained. The invention is based on the principle that the viscosity of a mixture of fine particles of a solid uniformity suspended in a liquid is effected by the size of the particles. Other things being equal the finer the particles the greater the viscosity. By other things are meant the density or liquid-solid ratio of the mixture, the temperature of the mixture, the chemical composition of the liquid and the mineralogical composition of the particles. In most industries involving fine pulverizing the two last are fairly constant. I have found that where these two are kept constant and a high density is maintained then there are definite relations between average size of particle, density, temperature and viscosity.

In general the method of determining the relative degree of fineness is to cause a flow under a constant head of pulp of a uniform mixture of particles and suitable liquid through a small diameter tube such as is used in general practice in determining the viscosity of liquids and thus determine its viscosity and at the same time determine by well known methods the density or liquid-solid ratio and the temperature. Assuming the temperature to be kept constant for a series of tests one product may be compared with another or with a standard product as is common practice in the determination of viscosities of oils and other products.

Experiments repeated with the same products at different temperatures will give a correction factor to be applied in subsequent tests at differing temperatures.

This method of determining relative fineness of finely divided products may be applied in two distinct ways. It may be used for making tests on small samples or batches of a pound or so or it may be applied to a continuous flow of product from an operating wet grinding mill.

Type A

To describe first the apparatus for testing batches. In a simple form it consists of (1) means for keeping in constant circulation the mixture of solid particles and liquid, (2) means of keeping a constant head of this mixture over the viscosity tube through which it is constantly flowing, (3) means of determining the rate of flow—(by determining the time required for a definite volume of flow through the tube), (4) means for determining the density or liquid-solid ratio (i. e. by weighing the volume of mixture collected in the timing process), (5) determining the temperature.

The time required for a definite volume of mixture to flow though the tube is a measure of the viscosity. For any given sample of pulverized product the viscosity increases with the density of the mixture. To interpret the viscosity and density measurements in terms of average size of particle it will be necessary to prepare tables or charts combining these two as is common practice, for example, in connection with hygrometers for determining the relative humidity of the air with wet and dry bulb thermometers.

Type B

Instead of measuring the rate of flow by noting the time required to catch a measured quantity the rate of flow may be indicated by the reaction from the outflowing jet of the viscosity tube. But as it is necessary to know also the density some density indicating device is required or the density must be kept constant.

Type C

Instead of measuring the rate of flow under the effect of a constant head of pulp, the viscosity can be measured by causing a constant rate of flow through the tube and noting the difference in head required to force this flow through the tube if the viscosity varies, or by passing the flow through the tube and noting the difference in head required to force this flow through a given orifice.

Any one of these three forms can be used in connection with a continuous flow from an operating mill. A sample is continuously diverted from some suitable part of the flow as from the lip of a Dorr classifier and this smaller flow re-

places the flow from the circulating means in the batch machine.

In Type A the sample is continuously flowing and at any time an operator may catch a definite volume and time and weigh it and thus measure the viscosity and the density.

In Types B and C the two indications of viscosity and density will have to be noted substantially simultaneously and referred to the tables or the chart for interpretation.

By keeping the density of the mixture flowing to the apparatus constant only one reading that of viscosity, assuming the temperature to be kept constant, is needed.

The methods and apparatus used are hereinafter more fully described and the apparatus is shown in the following drawings in which

Fig. 1 is a diagrammatic view of a simple form of my apparatus;

Fig. 2 a plan view of a chart;

Fig. 3 a diagrammatic view of a modified form of the apparatus used in conjunction with apparatus for automatically controlling the density of the mixture and with apparatus for continuously indicating the degree of average fineness;

Fig. 4 a diagrammatic view in plan of the trough shown in Fig. 3;

Fig. 5 a diagrammatic view of another modification; and

Fig. 6 a diagrammatic view of a modified form of Fig. 5.

In the drawings like numerals of reference indicate corresponding parts in the different figures.

1 is an agitation chamber having any suitable means therein for maintaining the particles 2^a of ground or other finely divided material in uniform suspension in a liquid 2^b and for providing a flow of the uniform mixture 2 of the particles 2^a and liquid 2^b through the discharge and the return tubes 3 and 4. The discharge tube 3 communicates with the lower end of the chamber 1 and with the upper end of a device 5 for maintaining a constant head 2^c of the mixture 2 above a discharge passage 5^a. In this case the discharge passage 5^a is of small diameter and to obtain the best results its length should be not less than twenty times its diameter whereby friction is created to restrict the flow therethrough.

The passage 5^a is preferably formed on the lower end of a tube 5^b at the upper end of which is directed a deflector 5^c carried on the lower end of a nipple 5^d with which is connected the discharge tube 3. Any material running over the upper end of the tube 5^b is caught in a spill-way 5^e and returned to the chamber 1 by means of the return pipe 4. The deflector is adapted to direct a substantially horizontal flow of the mixture across the mouth of the tube 5^b which ensures an even distribution of liquid and finely divided solids from the discharge tube 3 to the tube 5 and also to the spill-way 5^e. In other words, the proportion of liquids and solids in the mixture passing into the tube 5^b will be the same as that of the mixture passing into the spill-way 5^e. Any suitable means such as a conical shaped basin 6 and the branch 4^a of the return pipe 4 may be employed to return the surplus mixture flowing through the passage 5^a to the chamber 1. The basin 6 is spaced from the passage 5^a to permit a vessel to be positioned beneath the passage to collect a measured volume of the mixture 2 therefrom.

Preferably the chamber 1 is provided with a centrifugal pump located in the bottom thereof and the discharge tube 3 is provided with a branch 3^a leading into the top of the chamber. Any suitable means such as a valve 3^b for controlling the flow of the mixture through the branch 3^a will also regulate the flow through the tube 3. The mixture is thus kept in constant circulation throughout the chamber whereby the flow through the friction tube 5^a is maintained uniform at all times.

The time required to collect this measured volume of the said uniform mixture under a constant head is obtained by a stop watch and this time determines the viscosity of the mixture. The viscosity may be calculated by subtracting the time required to collect the same volume of the clear liquid used in the mixture under the same conditions, including temperature, from the time required to collect the mixture. That is to say $V=T-t$ where V is the viscosity, T the time for collecting the mixture, and t the time for collecting an equal volume of only the liquid in the mixture.

The density of the measured volume of this uniform mixture is then obtained in the usual manner and it will readily be seen that, if the density is decreased by adding more liquid 2^b to the mixture 2 in the chamber 1, the time required to collect the new mixture will be decreased. From this it follows that the degree of fineness of the particles 2^a in mixtures of different densities may be indicated by a line A produced on a chart 7 by plotting a number of points A^1, A^2 etcetera thereon so that this line may be used to determine whether other particles from the same source are finer or coarser than those used in producing the line A.

The lines A, B, C, D, E on the chart 7 are formed, as hereinafter described by testing particles which have been ground under certain conditions for known periods of time as indicated on the chart. The said certain conditions include the known quantity of material in a certain grinding unit or in all the units of a grinding mill. That is to say, the finished product of one or more grinding units could readily be varied by varying the quantity of material being ground without varying the time period. After a chart is made by testing particles ground for predetermined periods of time under the above mentioned certain conditions, it is obvious that any variations in the average size of other particles from the same source as those employed to make the chart may be detected by testing the other particles, plotting the results of such test on the chart and comparing the results with the lines made on the chart. Say the line "A" on the chart represents the result of 10 mins. grinding with a predetermined amount of material in a certain grinding unit and the line B represents the result of 15 mins. grinding with the same amount of material in the same grinding unit and it was desired to produce particles of the average size indicated by the line A, it would be obvious that if the results of a test of fresh particles from the same unit were plotted on the chart and the plotted point be between the lines A and B that the average size of such particles would be smaller than that desired and therefore the feed to the unit would require adjusting assuming such particles had been ground for 10 mins. It is also obvious that if one chart 7 be employed for a number of grinding units, sample particles taken from each unit and mixed together will have to be tested while making the lines A, B, etc. on the chart and for comparison therewith to ascertain whether there is any subsequent variation in the

average size of the particles from the units as a whole.

The lines A, B etc. on the chart are determined as follows:—Say 100 c. c. of mixture from the friction-creating passage 5^a flow into a beaker or a bottle in 127.5 seconds and that 100 c. c. of the liquid only in the mixture flows through the passage 5^a into another beaker in 47.5 seconds $\therefore V=80$ in the hereinbefore mentioned equation $V=T-t$.

	Grams
Assuming, also, the weight of the beaker or bottle plus mixture of ore particles and water	186.1
Weight of said beaker or bottle alone	45.4
$\therefore$ the weight of the mixture	140.7
$\therefore$ the density of the mixture	1.407

The point A^1 is plotted at the intersection of the lines 80 and 1.407 on the chart 7. The horizontal lines on this chart indicate time in seconds and the vertical lines 1.27 to 1.41 indicate density of the mixture. Now if the same particles be left in the mixture in the chamber 1 and the mixture be diluted, it is obvious that its rate of flow through the passage 5^a will increase. Assuming it requires only 103.5 seconds to obtain 100 c. c. of the diluted mixture $\therefore V=(103.5-47.5)=56$, and that the density or specific gravity of the mixture is 1.363, the point A^2 will be located at the intersection of the lines 56 and 1.363 on the chart. By further diluting the mixture containing the same particles, testing it and plotting the results of each test, the points A^3, A^4 are determined on the chart. As the points A^1 to A^4 were plotted from tests made of the same particles, it is obvious that by joining these points by a line A passing through them, that this line will indicate the average size of such particles in mixtures whether the mixtures be thick or thin. Each of the other lines B, C, D, and E are formed on the chart by the same method as that described for making the line A except in these cases different averaged sized particles are used which are ground under known different periods of time yet under the same other conditions as those tested to produce the line A.

With this chart it is obvious that the average size of any particles from the same source as those previously charted may be determined by plotting a point on the chart according to the viscosity and density of a fresh mixture containing the liquid used in preparing the chart. Of course, the temperature of the liquid must be maintained constant throughout all the tests otherwise a correction factor must be used as hereinafter described. Assuming the fresh mixture which is desired to be tested for the average size of the particles therein has a viscosity of 46 and a density of 1.33, the point on the chart where the horizontal line from 46 crosses the vertical line from 1.33 is indicated at F and as this point is substantially halfway between the lines A and B, the average size of the particles is approximately midway between the sizes represented by the lines A and B and therefore the feed of the material to be ground would have to be regulated accordingly to bring the particles to the desired size represented by any one of the lines A, B, C, D, or E.

The hereinbefore described apparatus is more particularly adapted for use in a batch machine for determining the relative degree of fineness of particles in different small samples of ground material from different grinding units in a grinding mill or of sample products from different mills. It will be understood that, while the particles of ground material such as ore from different mining districts will differ in shape or pattern, this difference will not affect a comparison between the average sizes of ore particles from the same source of supply. It is also obvious that different temperatures of the liquids in the mixtures would affect the viscosities thereof and therefore it is necessary to bring the temperature of the mixture to be tested to that of the mixtures used in charting the lines A, B, C, etc. or use the hereinafter described correction factor.

As the viscosity varies in proportion to the fineness of the particles and the density of the mixture, the tests may be greatly simplified by maintaining the different mixtures at a constant density. It will be noted that the plotted lines A to E on the chart 7 intersect the vertical line (representing the density 1.27) at the horizontal lines (representing the viscosities 28, 33, 52, 70, and 88), which clearly shows that the smaller the particles, the greater the viscosity. Therefore if the densities of the mixtures being tested were to be maintained constant, it would be necessary only to determine the viscosities of these mixtures to determine the differences in average sizes of the particles in the different mixtures.

Type B (Figs. 3 and 4)

In practice, especially in mills for grinding ore, it is desirable to provide means for continuously indicating the average size of the ground particles 2^a and this may be accomplished as follows. A sample of the flow of ore pulp, which is a mixture of ore particles and water, is continuously withdrawn from any suitable source such as a launder or a classifier 9 and is directed to an automatic density control of any suitable type and then to the device 15 for maintaining a constant head 12^c of a mixture 12 above a discharge passage 15^a. The device 15 corresponds to the previously described device 5 and includes a tube 15^b at the upper end of which is directed a deflector 15^c carried on the lower end of the discharge pipe 13, the tube 15^b, deflector 15^c and pipe 13 corresponding to the tube 5^b deflector 5^c and pipe 3. Any of the mixture 12 running over the upper end of the tube 5^b is caught in a spillway 15^e similar to the spill-way 5^e. The very dilute mixture from the classifier 9 flows into a launder 10 which carries the mixture to the usual settling tanks or cones (not shown). A small portion of the mixture is diverted from the flow by a trough 11 which is positioned above the launder and is adapted to direct its contents into a small settling cone 17 having a discharge 13 and an overflow 18. The surplus clear water from the settling cone 17 rises to the top thereof and flows through the overflow 18.

The thickened mixture 12 of particles 12^a and water 12^b in the cone flows through the discharge 13 and the density thereof is automatically maintained constant by varying the volume of the sample mixture directed to the cone 17 whereby the proportion of solids and liquids therein is varied. This is accomplished by employing a tapered trough 11 and mounting it so that it may be moved relative to the flow of the mixture to increase or decrease the portion thereof directed into the settling cone 17. As the volume of the mixture to the cone 17 is increased, more water flows over the top thereof into the overflow 18 and thus the volume of particles 12^a in the cone

is increased and therefore the density of the mixture through the discharge 13 is correspondingly increased. The trough may be carried on an open frame 11a which is pivoted at 11b and provided with an arm 11c. This arm is connected in any suitable manner such as by the rods 19, 20 and bell crank 21 with a diaphragm 27, the movements of which are controlled by the density of the mixture passing through the tube 15b of the constant head device 15. To the tube 15b is connected a manometer 28 which is provided with a branch tube 28a connected with the chamber of the diaphragm 27. If the density of the mixture flowing through the tube 15b increases beyond a predetermined point the clear liquid in the manometer 28 and in its branch tube 28a rises and actuates the diaphragm to swing the tapered trough 11 so that a portion thereof having a smaller cross-sectional area will be positioned under the flow from the classifier and thus the volume of mixture directed to the cone 17 will be decreased. The volume of particles in the cone is thus correspondingly decreased relative to the liquid therein which results in the density of the mixture flowing through the tube 15b being correspondingly decreased. This decrease in the density will cause the diaphragm to shift the trough 11 again and when the density remains constant the trough remains in its normal position.

Referring to the chart 7, it will be noted that the difference in viscosity between two mixtures is greater at higher densities and consequently it is preferable to maintain the mixture 12 at the highest density at which it will flow freely so that any variation in the viscosity may be readily and accurately determined.

To indicate the viscosity of the mixture 12, I employ a discharge passage 15a having a larger diameter than the hereinbefore described passage 5a but a much greater length than the latter so that, while the volume and the speed of flow through the passage 15a are higher than those through the passage 5a, there will still be a predetermined friction created in the passage 15a whereby the viscosity of the mixture passing therethrough can be accurately measured. The end of the passage 15a is directed into the upper end of a flexible tube 15g the lower end of which is provided with a rigid elbow jet 15f through which the mixture flows. To the lower end of the tube 15g is connected a cord 29 which is wound around a drum 30a and secured to a light spring 30b. The drum has a pointer 30c secured thereto which is adapted to move across a calibrated dial or scale 30d. In operation, the lower end of the flexible tube 15g with its rigid jet 15f is deflected in a direction opposite that of the flow through the jet, which deflection is indicated by the pointer on the dial. With any given density, the deflection of the tube 15g due to the reaction from the outflow at the jet varies with the velocity of the discharge therethrough. The velocity varies with the viscosity and the latter varies with the degree of fineness. Thus a continuous indication on the dial 30d is obtained of the degree of fineness provided that the density of the mixture be kept constant.

Type C

Instead of measuring the rate of flow of the mixture 2 under a constant head 2c through a friction passage 5a by noting the time required to collect a measured quantity, or of the mixture 12 under a constant head 12c through the friction passage 15a by the re-action from the discharge through the outflow jet 15f, the viscosity may be measured by causing a substantially constant rate of flow through a tube and noting the difference in the head required to force the mixture 22 corresponding to the hereinbefore described mixtures 2 and 12 through a tube 25b corresponding to the tubes 5b or 15b if the viscosity varies (see Figs. 5 and 6). It has been discovered that within the range of the mixtures under discussion the viscosity does not materially affect the rate of discharge through a very short passage or orifice such as 25a shown in Fig. 5 or 25d shown in Fig. 6.

Referring to Fig. 5, a discharge tube 23 which may be the tube 13 of Fig. 3 directs the mixture 22 by means of a deflector 25c to the tube 25b of a device 25 (the parts 25c, 25b and 25 being similar to the hereinbefore described parts 5c, 15c; 5b, 15b; and 5, 15 respectively) for maintaining a constant head 22c of the mixture above the discharge orifice 25a. Any overflow at the upper end of the tube is received in a spill-way 25e corresponding to the spill-way 5e or 15e. This orifice at the lower end of the tube 25b is of such dimensions that the rate of flow through the orifice will be substantially constant for mixtures having various densities and viscosities provided a constant head of the mixture is maintained above the orifice. The density of the mixture passing through the tube 25b is indicated on the manometer 38 which is connected with the tube 25b so that the clear liquid in the manometer rises and falls as the density of the mixture in the tube increases and decreases respectively. The orifice discharges into one leg of a Y tube 31, to another leg of which is connected a manometer 39 and to the third leg, which is lower than the other two legs, is connected a discharge passage 40 adapted to create friction. The length of the said passage relative to the diameter thereof is such that the building up of a considerable head 41 in the tube 31 is required to maintain a flow through the tube 40. While the rate of flow through the orifice 25a is substantially constant, any variation in the viscosity of the mixture flowing through the passage 40 will correspondingly vary the head 41 in the Y tube 31. In other words, the greater the viscosity, the greater the head required to force the mixture through the passage 40. Any differences in the head 41 will be indicated by the manometer 39 which thus gives the viscosity of the mixture. By plotting the results of the readings of the density manometer 38 and the viscosity manometer 39 taken substantially at the same time, on a chart such as 7 the degree of fineness of the average sizes of the particles will be determined. It will be understood that the lines or points such as A, B, C etcetera or A^1, A^2, B^1, B^2, C^1, C^2 etc. would have to be plotted on the chart from readings of the manometers 38 and 39 when mixtures of known conditions were being tested so that the results of subsequent tests of unknown mixtures could be compared with the results of the first tests whereby the average size of the particles in the mixture passing through the tube 25b may be obtained at any time.

Preferably the first mentioned leg of the tube 31 is provided with a spreading member 42 having transverse serrations or corrugations on which the discharge from the orifice 25a is directed so that it will be spread over the surface of the head 41 with a minimum of disturbance thereto.

Referring to Fig. 6, it will be noted that the discharge tube 23, deflector 25c, spill-way 25e,

tube 25b and manometer 38 are similar to the correspondingly numbered parts in Fig. 5.

By substituting a discharge passage 40a, adapted to create friction, for the orifice 25a on the end of the tube 25b and substituting an orifice 25d for the passage 40 on the leg of the Y tube 31 as shown in Fig. 6, the discharge from the friction creating passage 40a flows into the tube 31 and through the orifice 25d. The manometer 39a will indicate the level 41a of the head of the mixture in the tube 31 and this level will be a measure of the rate of flow through the orifice 25d and hence a measure of the viscosity of the mixture unless the friction or resistance to the flow of the mixture through the passage 40a is the same as the friction or resistance to the flow of the mixture through the orifice 25d. That is to say, as the dimensions of the orifice 25d are such that the effect of viscosity is nearly negligible, the manometer 39a will in effect measure the viscosity of the mixture and the greater the difference in the relative resistances of the orifice 25d and passage 40a, or orifice 25a and passage 40, the greater will be the variation in the static head 41a or 41 respectively.

It will be obvious from the above description of Figs. 5 and 6 that, so far as measuring the viscosity is concerned, it is immaterial which of the tubes 25b or 31 is provided with the greater resistance. In other words, the long friction passage 40 or 40a may be on either of the tubes 25b or 31 and the orifice 25a, 25d in the other of the said tubes.

It is obvious that a density control such as that hereinbefore described could be operated by the manometer 38 whereby the density of the mixture would remain constant and the reading on the viscosity manometer 39 would then indicate the average degree of fineness. It is also obvious that two or more of the troughs 11 may be used by connecting them together side by side in spaced relationship so that the flow not caught by the troughs would pass on opposite sides of each trough into the launder 10.

The manometers 28, 28a; 38; 39, 39a contain clear liquid such as that in the mixtures in the tubes 15b, 25b and 31 respectively. As the specific gravity or density of the suspension of the particles and liquid in the tubes is greater than the specific gravity of the clear liquid in the manometers, the liquid in the latter will rise above the levels of the mixtures in the tubes in proportion to the differences of the specific gravities or densities.

While water has been mentioned as a suitable liquid in the mixture containing ore particles any other suitable liquid may be used. Of course, when determining the average sizes of cement particles it would be advisable to use a liquid such as butyl alcohol to form the mixture.

It is to be distinctly understood that the absolute sizes of the particles will not be determined by my method and apparatus but the general fineness or average size of the particles will be determined when compared with previous tests of similar particles. In some products such as ore particles the differences between particles from different mining districts are so pronounced that the tests forming the basis for comparison would have to be made with particles from the same source as those being tested.

Of course any difference in temperatures between the mixtures tested to form the basis for comparison and that being tested would affect the relative viscosities and therefore it is important that the temperature of the mixture being tested be the same as that of the mixture used in the tests forming the basis for comparison. If this be not convenient, it would be necessary to obtain a correction factor by experimental tests of the same mixture at different temperatures so that the factor may be applied in subsequent tests if the temperature of the mixture being tested differs from that of the mixture originally tested. In most mills the temperature of the pulp is fairly constant and under such circumstances the temperature may be disregarded. Where there are fluctuations of temperature or where great accuracy is required the temperature must be measured and a corresponding correction factor be used in interpreting the viscosity and density measurements.

By connecting the nipple 5d in Fig. 1 with the thickening cone 17 in Fig. 3 the batch testing apparatus may be used to test the continuously withdrawn sample. In this case, an operator would from time to time make the tests in the same manner as that hereinbefore described in connection with the apparatus shown in Fig. 1.

What I claim as my invention is:

1. Apparatus for determining a degree of fineness of a finely divided product comprising a tube having a friction creating discharge passage; means for maintaining a constant head of a mixture of the product and a suitable liquid in the said tube above the said passage; means for automatically controlling the density of the mixture; and means for indicating variations in the rate of flow through the said passage.

2. The method of determining the relative degree of fineness of a finely divided product which consists in maintaining a constant head of a mixture of a suitable liquid and the product in uniform suspension therein above a friction creating passage, measuring the rate of flow of the mixture through the passage by the time required to collect a measured quantity.

3. The method of determining the relative degree of fineness of a finely divided product which consists in maintaining a constant head of a mixture of a suitable liquid and the product in uniform suspension therein above a friction creating passage, measuring the rate of flow of the mixture through the passage by the time required to collect a measured quantity, measuring the density of the mixture flowing through the passage, and determining the temperature of the mixture.

4. The method of determining the relative degree of fineness of the fine particles in an ore pulp flowing in a mill which consists in diverting a part of the flow in such manner that it will be a representative sample of the flow, removing part of the liquid to increase the density of the sample, passing the sample under a constant head and with the particles in uniform suspension through a friction creating passage, and measuring the rate of flow of the sample flowing through the passage.

5. The method of determining the relative degree of fineness of the fine particles in an ore pulp flowing in a mill which consists in diverting a part of the flow in such manner that it will be a representative sample of the flow, removing part of the liquid to increase the density of the sample, regulating the proportion of particles and liquid in the sample to maintain it at a constant density, passing the sample under a constant head with the particles in uniform suspension through a friction creating passage,

and measuring the rate of flow of the sample flowing through the passage.

6. Apparatus for determining the relative degree of fineness of a finely divided product comprising a container for a mixture of the product and a suitable liquid; a tube having a mouth and a friction creating discharge passage; means for establishing communication between the container and the mouth of the tube; a deflector for directing a substantially horizontal flow of the mixture across the mouth of the tube; and means for agitating the mixture in the container.

7. Apparatus for determining the relative degree of fineness of a finely divided product comprising a container for a mixture of the product and a suitable liquid; a tube having a mouth and a friction creating discharge passage; means for establishing communication between the container and the mouth of the tube; a deflector for directing a substantially horizontal flow of the mixture across the mouth of the tube, the tube being positioned above the container; means for returning the overflow from the mouth of the tube and from the discharge passage to the container; and a centrifugal pump for agitating the mixture and pumping it through the communicating means.

8. The method of determining the average degree of fineness of solid particles of matter which consists in suspending the said particles in a liquid of less specific gravity than the particles, determining the viscosity and density of the suspension and comparing the viscosity and density with predetermined similar data of a standard suspension of similar particles in a similar liquid.

9. Apparatus for determining the relative degree of fineness of finely divided solids comprising a tube having a mouth; means for maintaining a constant head of a mixture of a suitable liquid and the finely divided solids uniformly suspended therein in the tube, the said means including a deflector located substantially parallel to and at the level of the mouth of the tube for directing a substantially horizontal flow of the mixture across the mouth of the tube to maintain an even distribution of liquid and finely divided solids to the tube and over the mouth thereof; and means including a friction creating discharge passage in communication with the tube at a point below the head of the mixture therein for measuring the viscosity of the mixture flowing through the passage to determine any variation in the average size of the solid particles.

10. Apparatus for determining a degree of fineness of a finely divided product comprising a tube having a friction creating discharge passage; means for maintaining a constant head of a mixture of the product and a suitable liquid in the said tube above the said passage; means for automatically controlling the density of the mixture; an indicator; a flexible tube having one end connected with the friction creating discharge passage; a rigid jet carried by the other end of the flexible tube; and means connected with the indicator and jet for actuating the indicator to indicate the deflection of the flexible tube due to the re-action from the outflow at the jet.

11. The method of determining the relative degree of fineness of finely divided solids suspended in a liquid of less specific gravity than the solids, which consists in passing the mixture of solids and liquid under a constant head with the solids in uniform suspension through a friction creating passage, measuring the rate of flow of the mixture flowing through the passage, and comparing the rate of flow with that of a standard mixture of similar liquid and solids.

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