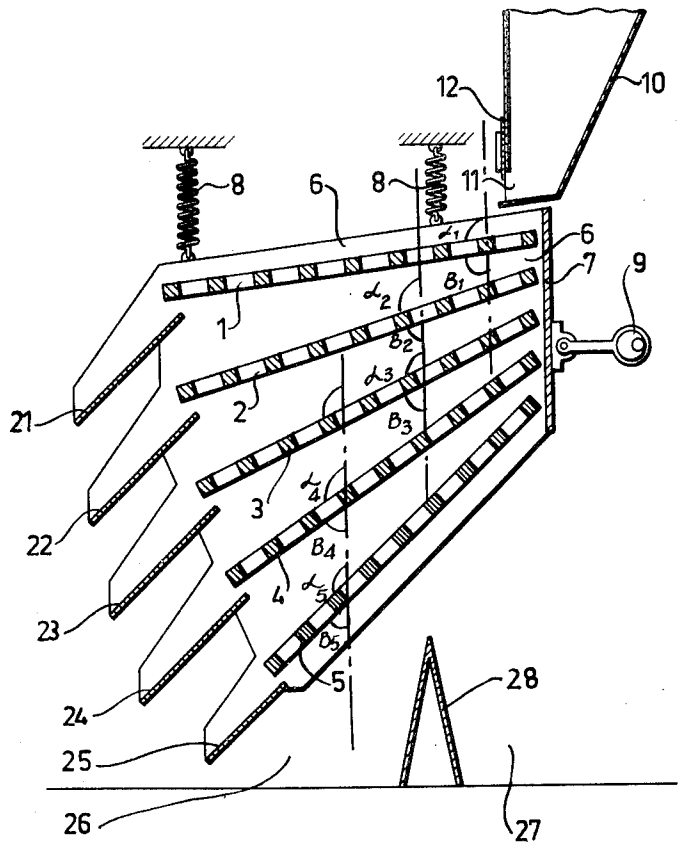
Sept. 23, 1958 F. K. MOGENSEN 2,853,191

METHOD AND APPARATUS FOR CLASSIFYING FINE GRAINED MATTER ACCORDING TO SIZE

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Fig. 1



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Fig. 2a

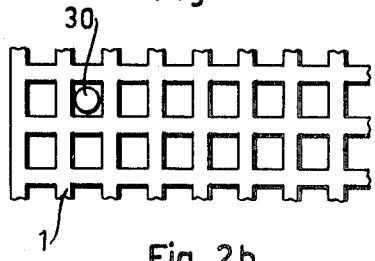


Fig. 2b

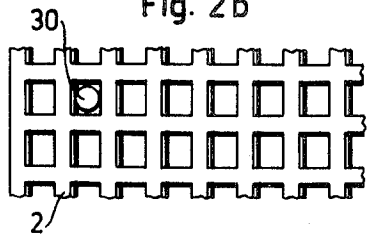


Fig. 2c

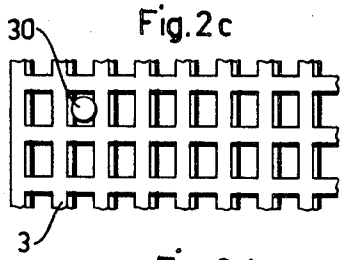


Fig. 2d

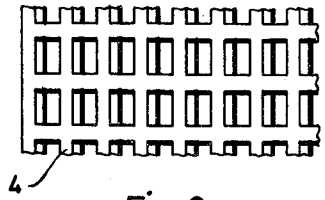
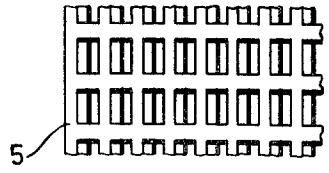


Fig. 2e



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2,853,191

METHOD AND APPARATUS FOR CLASSIFYING FINE GRAINED MATTER ACCORDING TO SIZE

Fredrik Kristian Mogensen, Djursholm, Sweden

Application November 22, 1955, Serial No. 548,479

Claims priority, application Austria November 24, 1954

5 Claims. (Cl. 209—315)

This invention relates to improved methods and apparatus for classifying a mixture of granular particles of different size, such as comminuted ores, metals, and sand, and the like, and it relates more particularly to subdividing such mixture into size fractions by the aid of a system of screens where each screen has a mesh-size greater than the grain-size of the particles retained back by the screen.

In my U. S. patent specification No. 2,572,177 I have described a method of this class, which comprises passing the mixture in a stream through a maze of obstacles, each particle passing freely through the maze and colliding with certain obstacles. The maze may consist of a plurality of superposed screens, the grids of which form the obstacles. During their passage the individual particles are deflected laterally at each collision, the number of collisions being dependent upon the particle size, so that the larger particles are laterally deflected more often and thus to a greater distance than the smaller particles. At the exit places of the maze the particles are collected at points more or less laterally displaced from the points of feed progressively according to size. Thus, if, for instance, the heterogeneous mixture is fed on to the top of a system of superposed screens inclined relative to the horizontal the particles of the mixture will form a stream which widens in a direction towards the lower ends of the screens as it proceeds through the system and where in the smallest particles accumulate at the non-deflected end of the stream and the particle size then continuously increases towards the deflected end of the stream. By means of suitably positioned partition walls it is possible to divide the stream of particles into fractions, having different particle size. This division will always be more or less approximate as any given part of the stream will never consist of particles of only one size, but of sizes, distributed over a more or less wide field of coarseness, for instance contain 80 percent of particles between 0.05 and 0.10 inch.

According to my old method referred to above the distribution of the grain-size along the stream is rather continuous but, generally, it is a desideratum in the art of classifying fine-grained material to obtain discontinuously and sharply divided fractions, each having a very narrow range of particle size.

It is an object of my present invention to provide means for separating the particles of a mixture of particles of different grain-size into discontinuous fractions. A further object is to provide means for subdividing such mixture into fractions substantially free from particles larger than a given grain-size and into fractions substantially free from particles smaller than said given grain-size.

It is also an object of the invention to provide means for separating from a heterogeneous mixture of granular particles one or more fractions, each containing an extremely high percentage of particles of grain-sizes within sharp and narrow limits.

In order to obtain these and other objects and advantages that will be evident to those skilled in the art from the following description my method is carried out by passing the mixture of granular particles in a stream through a system of a plurality of screens arranged in series and so as to form obtuse angles to the general direction of flow of said stream, so that one end of each screen is more advanced in the direction of flow of said stream than the other end, which is the rear end, the apertures of each screen being larger than the grain-size of the particles having passed the preceding screen of said series, arranging at least one of said screens so as to form a greater obtuse angle to said direction of flow than the preceding screen in said series, feeding said mixture on to a part of the first of the screens in said series remote from the advanced end thereof, and collecting dicerent size-fractions of said mixture within a range comprising the space after the last screen in said series and the advanced ends of the screens, said fractions having discontinuously increasing grain-size from the rear end to the advanced end of said last screen and further from the advanced end of the last screen to the advanced end of the first screen. It should be emphasized that this method does not comprise any form of screening in the sense that the screens should hold back the particles owing to their being too large to pass through the apertures of the screens.

It has been found that the separation into discontinuous fractions is mainly dependent on the dimensions of the projections of the apertures of the screens upon a plane perpendicular to the direction of flow of the stream of particles. From a manufacturing point of view it is to be preferred that all screens, which may be made of, for instance, wire-nets or punched plates, are of the same kind and have uniform spaces or apertures therein. When such uniform screens are used the dimensions of the projections upon a given plane of the apertures therein can be varied in two ways. The one way is to alter the inclination of the screen to said given plane, and the other is to rotate the screen a fraction of a revolution in its own plane, it being, of course, possible to combine both ways. Whether the inclination is altered or the screen is rotated, its orientation in space is altered. Two consequtive screens in a series of screens may thus have different orientation relative one another either by inclination or by rotative orientation or by both.

It is to be noted that in contradistinction to the classifier in which all screens have equal space orientation, the classifier according to the present invention, in which at least two screens have different space orientation, operates, as a rule, so that small particles collide more often with the obstacles upset by the screens than larger ones.

The features of the invention will be more readily understood in the course of the following detailed description taken in connection with the accompanying drawing which illustrates diagrammatically one possible arrangement for carrying out the invention.

In the drawing:

Fig. 1 is a diagrammatic representation in section of an apparatus containing five screens for separating a particle mixture into fractions according to particle size.

Figs. 2*a*, 2*b*, 2*c*, 2*d*, and 2*e* show on an enlarged scale projections on the horizontal of fractions of the five screens illustrated in Fig. 1.

This sizing apparatus comprises 5 screens **1**, **2**, **3**, **4** and **5** supported on a suitable frame member which may take the form of a pair of vertical walls **6** and a rear wall **7**. The screens are arranged with progressively increasing obtuse angles α to the direction of particle stream flow or, in other words, with decreasing

supplementary acute angles β as shown in Fig. 1. The frame is suspended by springs **8** and is connected to a vibrator **9** so that the screens can be vibrated for imparting impacts to the particles falling down onto the screens. The particle mixture is fed from a hopper **10** through an opening **11** controlled by a shutter **12** on to the topmost screen **1** near the upper end thereof. The different fractions are discharges through the chutes **21, 22, 23, 24, 25** collecting particles retained by screens **1** through **5**, respectively, and through channels **26** and **27** below the lowermost screen **5** leading to corresponding bins or similar receptacles. The finest particles will have the most direct path of travel through the system of screens and drop through channel **27**, while the coarser particles will be progressively diverted in their passage through the system according to the fact whether their size is above or below the critical sizes which correspond to the inclinations of the screens in their paths.

Figs. 2*a*, 2*b*, 2*c*, 2*d*, and 2*e* illustrate fractions of the projections on the horizontal of screens **1** through **5**, respectively and it will be seen how the dimensions of the projections on the horizontal of the equally large apertures in the screens progressively diminish downwards in the series of screens. The circular areas **30** indicate equally big particles and it is easily understood that particles of this size can only pass through some of the first screens in the series. It should be emphasized, that the direction of the paths of the particles is not regulated only by the number of collisions but more by the inclination of the screens. A coarse particle, leaving the apparatus on the screen **1** may for instance have had 8 collisions while a smaller, leaving the apparatus on the screen **4** may have had 9.

From the above description it will have been understood that in an embodiment of the classifier where the inclination of the screens increases progressively downwardly the particles consecutively will meet the screens under more and more acute angles. The probability of a particle's passing through a screen is dependent upon the relation between the particle size and the projection of each free opening of the screen on a plane perpendicular to the direction of the trajectory of the particle just approaching the screen. This is demonstrated in the Fig. 2, where the particle **30** without difficulty can pass through a screen in the Fig. 2*a*-position, but not in the Fig. 2*e*-position. By means of an adequate orientation of the screens it is thus possible practically completely to prevent particles above a certain critical size, to pass through one of the screens, and these particles will successively move in the direction of the inclination of the screen and ultimately be collected at the lower end. By means of a series of screens it is possible to obtain a series of fractions, when the particle size is discontinuously changing according to the inclination of the screens.

For a better understanding of the invention reference is made to the following classifying experiments, carried out in one and the same classifier (sizer) comprising 8 superposed screens of wire netting with uniform free mesh openings of about 0.16 millimeters, and with the screens arranged so that any two adjacent screens form an acute angle with one another. Three tests, A, B, and C, were carried out with the sizer positioned in each test as indicated by "screen slope" in Tables 1 to 3, respectively, from which it will be seen that the "slopes" in tests B and C are equal and greater than those in test A. In all tests the same kind of metal powder was used but the coarseness of the powder was different in all tests, as will also be seen from the tables. Fractions have been taken out above each screen and below the last screen. In the tables there is stated the screening analysis of the feed powder and the screening analyses of the different fractions calculated in percent of the feed, the vertical lines separating the various columns for the fractions representing the screen indicated on top thereof and the figures to the right of the lines referring to the fraction retained by the screen in question, i. e. the plus-product and the figures to the left thereof to material that has passed through the same, i. e. the minus-product.

TABLE 1

Screen analysis and distribution of particle sizes of fractions in percent of feed

Test A	Fractions								Feed
Screen number	8	7	6	5	4	3	2	1	
Screen slope	45°	38°	31°	27°	23°	20°	18°	16°	
On 200 microns								3.4	3.4
On 150 microns							4.6	3.1	7.7
On 120 microns			0.3	4.6	4.7	8.9	7.5	6.3	2.5	34.8
On 96 microns	0.1	0.7	7.9	8.5	3.2	1.8	0.5	0.1		22.8
On 69 microns	5.0	7.3	4.6	0.9	0.1	0.3				18.2
On 45 microns	6.9	3.5	1.1							11.5
Through 45 microns	1.0	0.5	0.1							1.6
Total	13.0	12.0	14.0	14.0	8.0	11.0	8.0	11.0	9.0	100.0

TABLE 2

Screen analysis and distribution of particle sizes of fractions in percent of feed

Test B	Fractions								Feed
Screen number	8	7	6	5	4	3	2	1	
Screen slope	57°	50°	43°	39°	35°	32°	30°	28°	
On 200 microns									
On 150 microns									
On 120 microns							0.1	0.5	0.6
On 96 microns			0.1	0.5	4.6	3.2	1.8	1.7	0.5	12.4
On 69 microns	0.7	3.3	16.3	24.0	26.0	6.6	1.2	0.2		78.3
On 45 microns	0.3	0.6	3.5	2.4	1.4	0.2				8.4
Through 45 microns		0.1	0.1	0.1						0.3
Total	1.0	4.0	20.0	27.0	32.0	10.0	3.0	2.0	1.0	100.0

TABLE 3

Screen analysis and distribution of particle sizes of fractions in percent of feed

Test C	Fractions									Feed
Screen number	8	7	6	5	4	3	2	1		
Screen slope	57°	50°	43°	39°	35°	32°	30°	28°		
On 200 microns										
On 150 microns										
On 120 microns								0.1	0.3	0.4
On 96 microns					0.1	0.6	0.5	0.3	0.1	1.6
On 69 microns		0.2	0.1	5.6	3.1	0.3	0.1	0.1		9.5
On 45 microns	1.5	8.8	21.7	6.8	0.9					39.7
Through 45 microns	4.7	19.1	23.8	1.2						48.8
Total	6.2	28.1	45.6	13.6	4.1	0.9	0.6	0.5	0.4	100.0

From analyses as those given in the tables and the requirements for the subdivision of a given powder it can be ascertained where to arrange partition walls at the exit of the sizer. It is thus possible, by adequate positioning of the walls of the outlet of the sizer to obtain different products. In the case of test A, a wall at the lower end of screen **6** will, for instance, divide the products into two fractions, a fine with 99% goods finer than 120 microns, and a coarse with 75% goods coarser than 120 microns. Thus a very good minus-120-product is produced, and the recovery of the total amount of minus-120-particles from the feed is 72%, in this fine product. If the dividing wall is moved to the lower end of screen **5**, the total of the minus-product will increase from 39 to 53%, and the product will contain 91% goods finer than 120 microns. The coarse product will contain 87% goods coaser than 120 microns and the recovery of these fine particles from the feed is 89% in the minus-product. If on the other hand a very good coase product is desired, the dividing wall may be placed at the lower end of screen **3**. 28% of the feed will then go into this product, which contains 98% coarser than 120 microns and has 60% of the plus 120 micron material from the feed. The wall may also be placed at the lower end of screen **4**, giving a coarse product with 39% of the weight of the feed and containing 93% coarser than 120 microns and having 79% of the plus 120 microns material from the feed. It is also possible to have two dividing walls, one at each of the lower ends of screens **6** and **3**, thus receiving the very good minus-product with 99% goods finer than 120 microns, a very good plus-product with 98% goods coarser than 120 microns, and a middling which may be refed to the sizer.

The same possibilities are to be found in the other tests. In test C, for instance, a partition wall at the lower end of screen **6** will give a fine product with 100% finer than 69 microns, and a coarse product with 56% coarser than 69 microns. 90% of the minus 69 micron-material from the feed will be recovered in the fine product.

TABLE 4

Number and slope of last screen retaining particles within a given range of size

Particle size, microns	Test	Number of screen	Slope of screen, degrees
150–120	A	6	31
	B	2	30
	C	2	30
120–96	A	8	45
	B	6	43
	C	5	39
96–69	A		
	B	8	57
	C	8	57

A comparison between the three tests A, B and C demonstrates the influence of the slope of the screens, i. e. the projections of the free openings in the direction of flow. In spite of the different coarseness of the fed powders the particles of a certain size are definitely retained when the slope of the screens exceeds a certain value, as shown in Table 4.

It will be seen from the Table 4 that it is rather the slope of the retaining screens than their number that will determine the size effect.

A similar but, from a principle point of view, different effect will be attained when a screen is rotated a certain angle, for instance 45°, in its own plane, before putting it in an inclined position. The projections of the free openings of the screen will then get another form and size. If the openings are squares the projections will be rhombic instead of rectangular, as in the examples demonstrated in the Figs. 2, which has a certain influence, for instance, when dealing with a mixture of elongated and isometric particles, retaining the elongated ones being retained in a much higher degree than the isometric. It is only when the openings are circular that said rotation has no effect.

It should be understood that the foregoing invention can be carried out with the screens submerged in water or some other liquid as well as in the atmosphere or in vacuum or by flushing in air, without departing from the scope thereof. The invention can also be practised in a great many different forms, for instance with screens of conical shape positioned coaxially, preferably with the feed near the centres of the cones and possibly with the assembly arranged so as to rotate about the central axis.

Since certain modifications may be made in the method and apparatus of the invention without departing from the scope thereof, it is intended that all matter contained in the foregoing specification and shown in the accompanying drawing be interpreted merely as illustrative and not in a limiting sense.

What is claimed is:

1. The method of classifying a mixture of particles of different sizes into size fractions which comprises passing freely the mixture in a stream through a system of screens having apertures larger than the particle sizes, the screens of the system being inclined at progressively increasing obtuse angles with respect to the direction of the particle stream flow and having thicknesses of such an extent to substantially reduce the effective aperture widths on increasing inclination of the screens, and collecting the particles from the screen system according to the size fractions.

2. Apparatus for classifying a heterogeneous mixture of particles into size fractions comprising a frame having an inlet at one end thereof through which the mixture is introduced and outlets at the other end thereof through which the classified fractions are removed, a plurality of screens secured in series within said frame intermediate

said inlet and said outlets, said screens being progressively inclined relative to the direction of the particle stream flow from the inlet to the outlets, at least one screen of the series having apertures therein of substantially the same size as the apertures of the preceding screen of the series, said screens having thicknesses of an extent to reduce the effective width of the apertures therein on increasing inclination of the screens.

3. Apparatus for classifying a heterogeneous mixture of particles into size fractions comprising a frame having an opening at one side in the upper portion thereof for the introduction of the mixture therein, a plurality of screens secured in series within said frame in superposed relation so that a portion of the particles flow through each of said screens, said screens having uniform non-circular apertures therein and being progressively inclined in the direction of material stream flow, at least one of said screens having apertures therein of substantially the same size as the apertures of the preceding screen of the series, said screens having thicknesses of an extent to reduce the effective width of the apertures therein on increasing inclination of the screens, outlets in said frame adjacent

the lowermost ends of each of said screens, and outlets in the lower portion of said frame laterally spaced from the point of mixture feed.

4. Apparatus as defined in claim 2, wherein the apertures of each of the screens are uniform and non-circular, and wherein the screens are arranged in their planes to cause the apertures to be similarly oriented.

5. Apparatus as defined in claim 2 wherein the apertures of each of the screens are uniform and non-circular, and further wherein at least one of said screens is angularly arranged in its plane with respect to a preceding screen so that the apertures of said screen are angularly oriented with respect to the apertures of the preceding screen.

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