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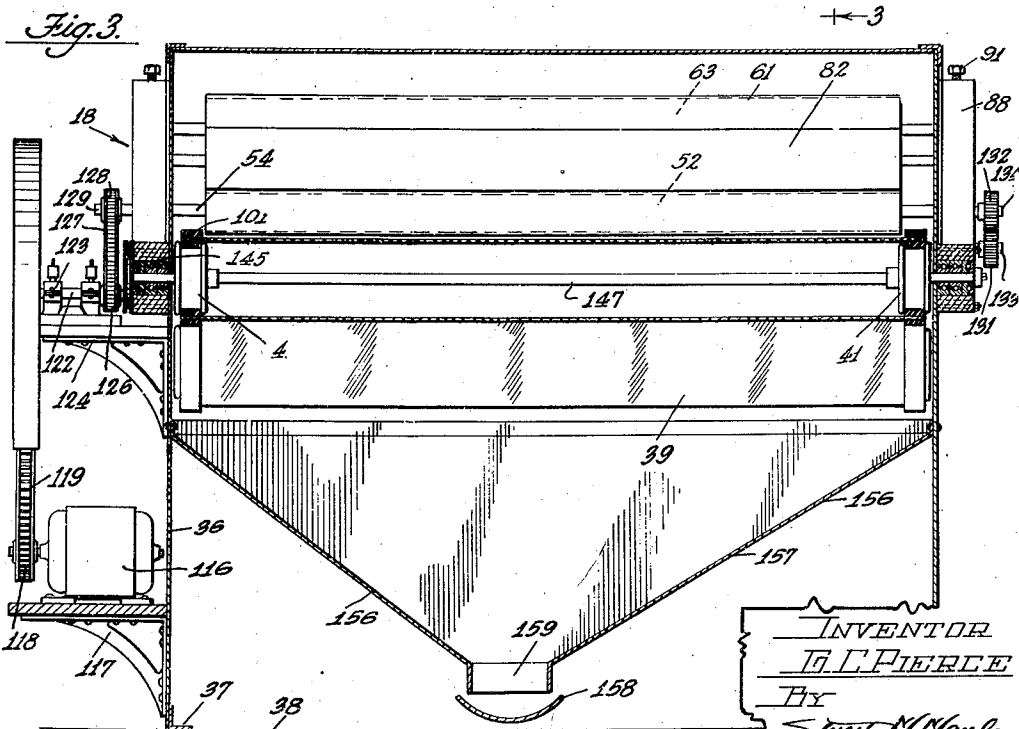
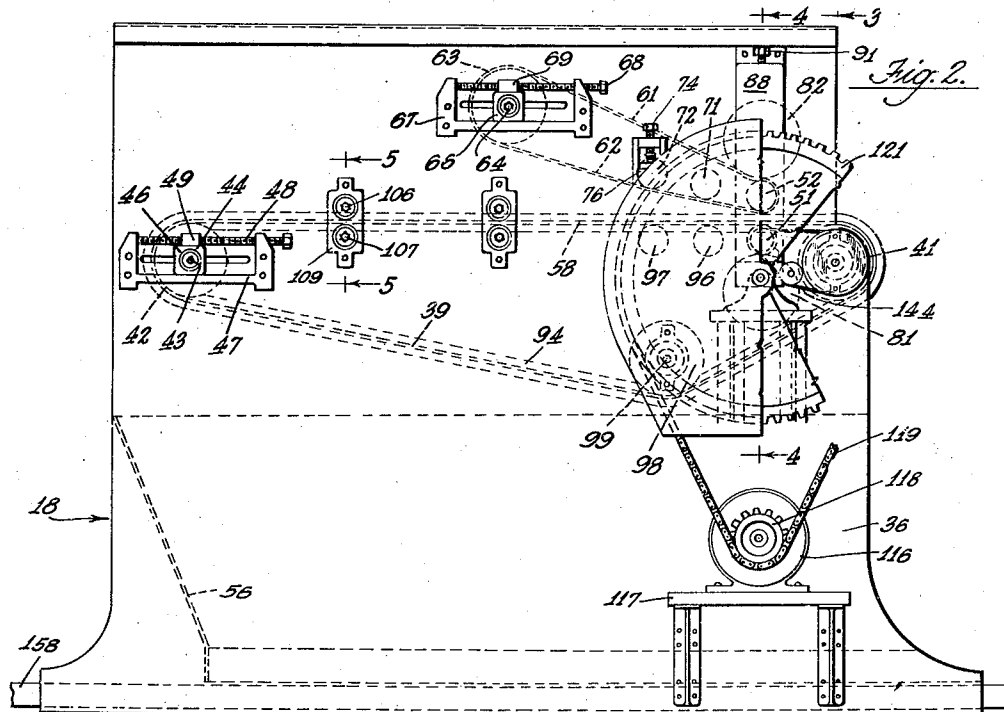
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2,021,376

METHOD OF DISINTEGRATING MATERIAL

Filed Jan. 31, 1933

5 Sheets-Sheet 2



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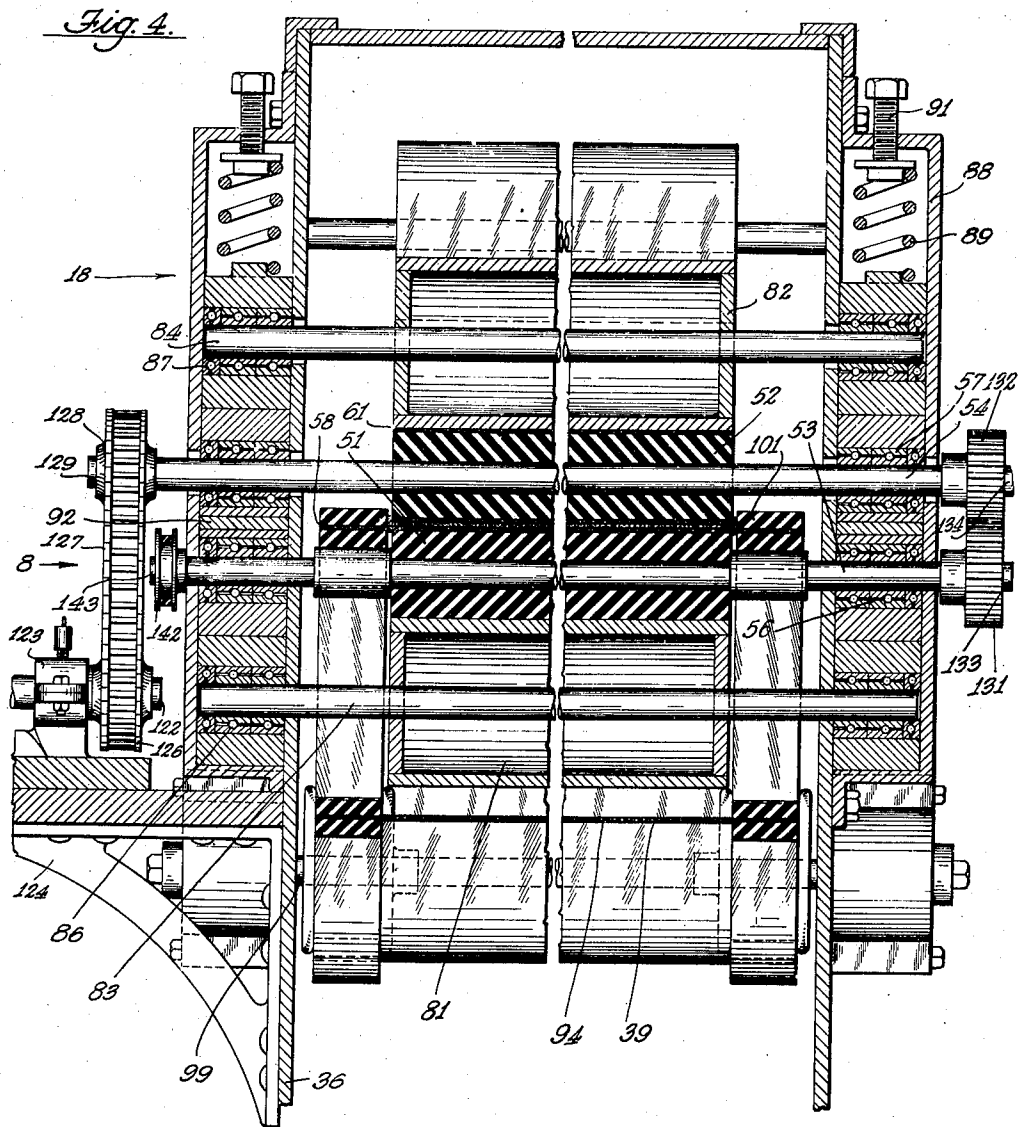
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METHOD OF DISINTEGRATING MATERIAL

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5 Sheets-Sheet 3



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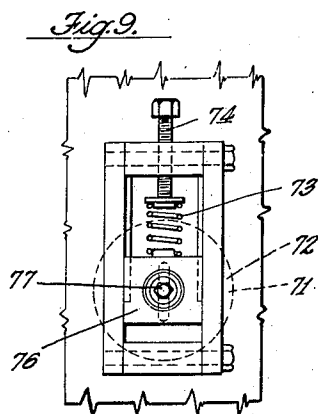
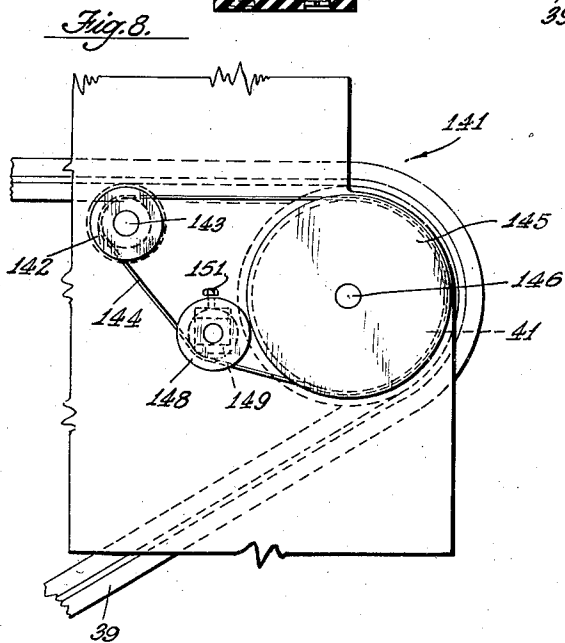
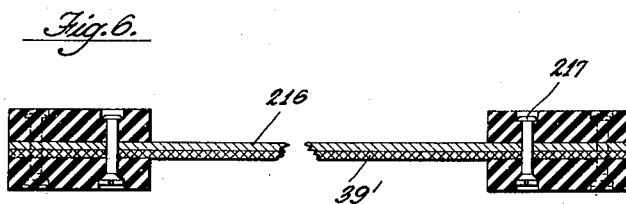
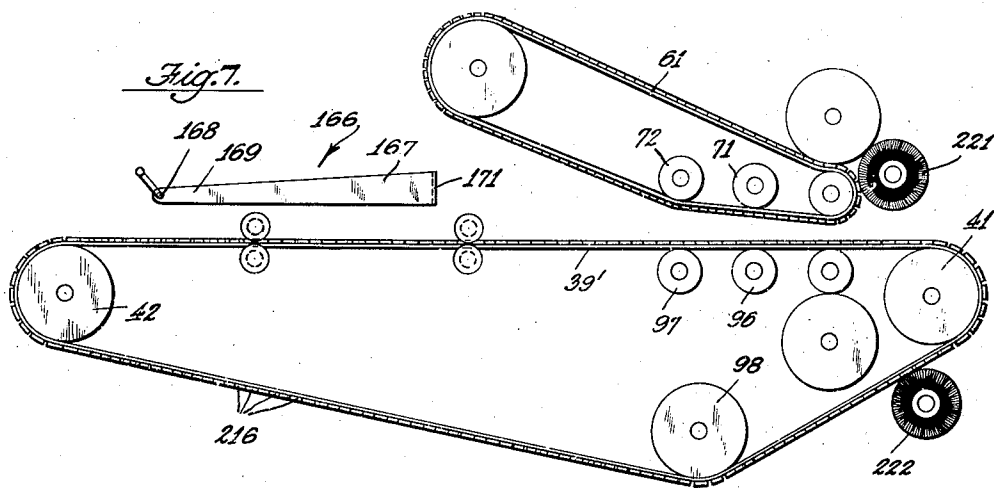
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METHOD OF DISINTEGRATING MATERIAL

Filed Jan. 31, 1933

5 Sheets-Sheet 4



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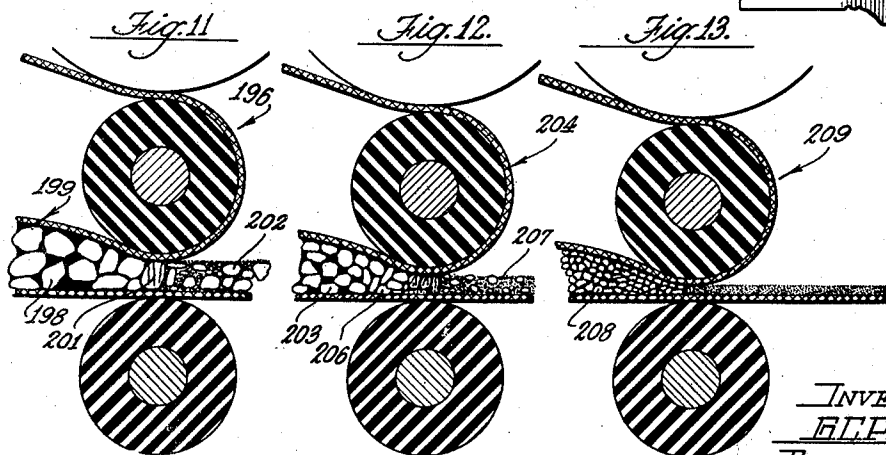
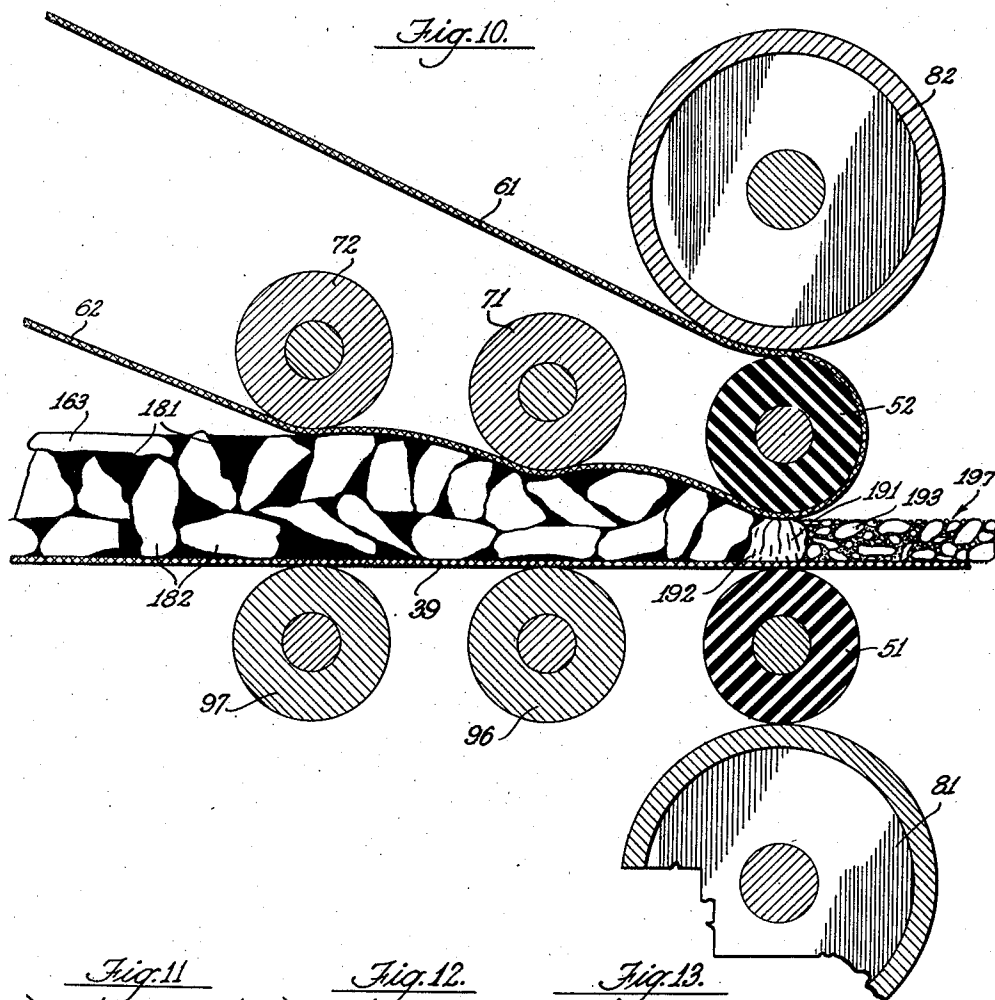
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2,021,376

METHOD OF DISINTEGRATING MATERIAL

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,021,376

METHOD OF DISINTEGRATING MATERIAL

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Application January 31, 1933, Serial No. 654,450

5 Claims. (Cl. 83-94)

This invention relates to disintegrating apparatus and has for an object the provision of a novel type of machine for breaking relatively frangible material, such as diatomaceous earth or decolorizing clay, into granules or particles the size of which makes them suitable for the particular use for which the material is intended.

A further object is to provide a disintegrating device which is an improvement over that disclosed in my co-pending application, Serial No. 495,905, filed November 15, 1930, for the reason that although the device of the present invention is intended to operate upon the same type of material, it operates not only at a much more rapid rate, thereby materially increasing the output capacity of the apparatus, but also a greatly improved product is obtained, as will be explained in detail hereinbelow.

A more detailed object in this connection is to provide a machine for disintegrating material of the general character indicated employing disintegrating rollers which operate similarly to those described in my aforesaid co-pending application, but in which machine the increased output capacity is attained through the expedient of forcing or crowding a greater quantity of the material to be disintegrated to and between the rolls, the effect being to compress the material and thereby increase the density of the mass thereof by forcing the particles or lumps which constitute the mass of material, more closely together prior to its entry between the disintegrating rolls. The effect of causing the material to be more closely compacted as it passes between the rolls is to increase the tendency for the particles to be broken in a shearing action.

A further object is to provide mechanism for performing the compressing hereinabove referred to in a continuous action and in such a manner that even though the lumps or particles to be broken down are composed of very frangible material, the structural formation of which is of the most delicate nature, only an absolute minimum quantity of impalpably fine particles will be produced, the major quantity of the output of the machine being in the form of definite granular particles the structural formation of which is retained after disintegration. This is a feature of particular advantage when dealing with such materials as diatomaceous earth, inasmuch as when this material is disintegrated by the machine and/or according to the method of the present invention, the original diatomic structures of which each particle of the material is composed are in large measure retained intact and each of

the small particles into which the material is broken presents a great profusion of such structures protruding from the surface thereof, and these structures which I am able to retain protruding in this manner are of such greatly increased length that they increase to a very great degree the utility of the material as a filtering medium, as will be explained hereinbelow.

Another object is to provide means forming a suitable support for the conveyor belt whereon the material is fed to the disintegrating rolls so as to compensate for the weight of the belt and of the material carried thereby.

Still another object is to provide means for retaining the material to be disintegrated in operative relation to the feeding belt and also to the belt which cooperates therewith to produce the pre-compacting of the material, thereby overcoming the tendency for a portion of the material to be forced from between the belts as the action of compacting progresses.

A further object is to provide a plurality of disintegrating machines, each of which embodies the improvements heretofore mentioned and which are arranged in series relation so that the material being disintegrated passes through the several machines successively. The machines are so adjusted that each disintegrates to a finer degree than the preceding machines, the result being that the entire process of disintegration proceeds gradually in a series of successive steps.

A still further object in this connection is to provide screening mechanism interposed preferably between each of the several stages of disintegration and so associated therewith that all the particles smaller than those which the next successive stage is intended to operate upon, are removed from the system, sorted, and each of the sorted sizes of particles larger than the smallest desired size is reintroduced to the system at the proper point to cause them to be mixed only with particles of substantially the same size as themselves.

Another object of the present invention is the provision of a disintegrating apparatus which possesses advantages in points of efficiency and durability, is inexpensive to manufacture and at the same time is simple in construction and operation.

The invention possesses other objects and advantageous features, some of which, with those enumerated, will be set forth in the following description of the invention's particular embodiments which are illustrated in the drawings accompanying and forming a part of the specifica-

tion. The form of construction herein disclosed has in actual use proven to be very efficient, capable of facile and rapid operation and generally desirable in other respects. For these reasons the details herein disclosed may be considered as preferred. It should be mentioned, however, that while these details will hereinafter be specifically described, variations may be effected within the scope of the invention as set forth in the appended claims.

Referring to the drawings:

Figure 1 is a diagrammatic representation of a battery of disintegrating machines embodying the principles of the present invention;

Figure 2 is an enlarged view in side elevation of one of the disintegrating machines, a portion of the figure being broken away the better to reveal certain portions of the operating mechanism;

Figure 3 is a transverse vertical sectional view taken substantially upon the line 3—3 of Fig. 2 with the direction of view as indicated;

Figure 4 is an enlarged transverse vertical sectional view taken substantially upon the line 4—4 of Fig. 2, portions of the figure being broken away to reduce its size;

Figure 5 is a highly enlarged detail view in transverse vertical section, the plane of section being indicated by the line 5—5 of Fig. 2, with the direction of view as indicated by the arrows; this figure, a portion of which is broken away to reduce its size, illustrates the means for supporting the conveying belt by imposing lateral tension thereupon;

Figure 6 is an other transverse sectional view taken through a slightly modified form of conveying belt;

Figure 7 is an enlarged diagrammatic view of one of the disintegrating machines having the modified form of belt of Fig. 6 incorporated therewith;

Figure 8 is an enlarged view in side elevation of a portion of one of the disintegrating machines, showing mechanism for driving the lower, or conveyor belt thereof; the direction of view is indicated by the arrow 8 of Fig. 4;

Figure 9 is an enlarged detail view showing the means for adjusting the relatively light pressure exerted by the compacting or compressing rollers;

Figure 10 is an enlarged diagrammatic view indicating the action of the compressing rollers and belt upon the lump material prior to its being operated upon by the disintegrating rolls;

Figures 11, 12, and 13 are also diagrammatic views indicating the action of the disintegrating rolls of successive stages of the apparatus in operating upon successively smaller sizes of particles.

The methods and apparatus now commonly employed for the commercial disintegration of such materials as diatomaceous earth, decolorizing clays, and the like, are deficient in that they involve the disintegration of the material to particles of such extremely small size that it is reduced to an impalpable powder. In common practice no attempt whatsoever is made to preserve the structural formation of the material. For example, in disintegrating diatomaceous earth according to the methods now in common use, the most valuable feature of the material is completely destroyed. Diatomite is composed of skeletons of microscopic plants which have become silicified and compressed into a compact mass by being subjected to tremendous sub-

aqueous and/or subterranean pressures for long periods of time. One of the principal uses to which diatomaceous earth is put is that of filtration; and the common practice in preparing the material for this use is to disintegrate it to the finest possible degree, i. e., reduce it to an impalpable powder (although in some instances attempts are made to reassemble the extremely fine particles by chemical treatment and heat) in the belief that in order for the material to be able to filter out exceedingly fine particles of matter suspended in a liquid the filtering material itself would have to be composed of such fine particles that the voids or interstices therebetween are smaller than the particles to be filtered out. However, when acting under this assumption, the most valuable feature of the diatomite as a filter medium has been overlooked and completely destroyed. This feature is the microscopically fine diatomic structures, toward the preservation of which no attempt is made in the disintegration processes now commonly employed. However, I have found that if the structural formation of diatomite is preserved, the filtering qualities of the material are greatly improved. This capability of disintegrated diatomite having its diatomic structures retained intact or substantially so, to filter out exceedingly fine suspended matter, is in all probability due to the fact that the diatomic structures and/or fragments thereof which protrude from the body portions of the granules become entangled, i. e., interlaced, with like structures which protrude from adjacent bodies, thus forming a lace-like superscreen which presents exceedingly fine foramina through which liquid can flow, whereas the solid bodies suspended in the liquid cannot. Consequently, if the structural formation of the diatomite can be preserved during the disintegration process, there is no necessity of disintegrating the material to such a finely divided state in order to enable it to entrap very fine solid particles suspended in liquid filtered therethrough. In fact, I have been able by using material prepared in accordance with the method of the present invention, to filter dyes out of liquids and suspended carbon out of oil, even though the diatomaceous earth employed was in the form of granules much larger than anything previously considered adaptable to such use.

One of the advantages of using a filtering medium composed of large instead of small particles is that the filter bed is much more open, owing to the larger interstices between particles, thereby permitting a much more rapid rate of flow through the filter bed, diminishing the amount of pressure required to force the liquid through the filter bed, and greatly increasing the length of time during which a filter bed can be used before it becomes so clogged as to be unfit for further use.

However, even had the desirability of relatively large granules as contrasted with the impalpably small sizes commonly used, been appreciated in the industry, such material would not have been available for use for the reason that the very nature of the diatomite has precluded its disintegration, when using the only methods commonly known, without actually pulverizing at least the major portion to an impalpable powder. This is due to the extreme fragility of diatomite, which causes it to shatter when it is struck (as in the conventional "hammer mill" and cyclone separators which are commonly used in its disin-

tegration), or when it is crushed; and the result of such shattering is to reduce by far the greatest portion of the diatomite to such a fine powder that it will pass through a 200 mesh screen. In fact, actual practice has proven that when the common methods of disintegration of diatomite are employed, less than 5% of the material so handled will be retained upon a 200 mesh screen.

The method and apparatus forming the subject matter of my co-pending application identified hereinabove, make it possible commercially to disintegrate diatomaceous earth and similar materials in such a manner that a large portion of the product is in granular sizes, ranging from 30 mesh to 150 mesh, and retain, furthermore, a large proportion of the structural formation of the material, thus preserving at least some of the highly desirable qualities of the material as a filtering medium, as has been discussed hereinabove. As heretofore stated, the present invention provides a method and apparatus which represent an improvement over the subject matter of the said co-pending application. Substantially the same general principle of disintegration is resorted to, i. e., the pieces of material which are to be broken down to smaller size have pressure applied thereto in highly localized areas by passing between rollers of very small diameter. Moreover, the pressure exerted by the rollers against the pieces is accurately regulated as determined by the crushing strength of each type of material being operated upon; and by permitting each stage of disintegration to be supplied with particles all of which are of substantially uniform size, pulverization of the material to very small size of particles is greatly reduced. The present invention, however, improves the quality of the output of the apparatus as well as the quantity thereof by overcoming certain limitations of the apparatus disclosed in my said co-pending application. This is accomplished by providing means for compacting the materials to be disintegrated by increasing the volume thereof.

The particular embodiment of apparatus for performing this work which has been chosen for illustration comprises a group or battery 16 of disintegrating machines 17, 18, 19, etc., arranged in series, i. e., a portion of the product of each machine except the last of the battery 16 is delivered, either directly or otherwise, to the next successive machine, there to be disintegrated further. Only the coarsest portion of the product of each machine, however, is passed to the next successive machine, the smaller portions being separated out therefrom by screening devices 21, 22, etc., interposed between each two adjacent disintegrating machines. These smaller particles are sorted in the screening devices 21, 22, as by screens 24, 26, 27, and each size is conducted either to a suitable storage bin (not shown) or directly to the disintegrating machine 18, 19, as the case might be, to which particles of that same size are being fed. Figure 1 illustrates diagrammatically conveyor belts 28, 29, 31, and 32, leading from the screening devices 21, 22, so as to conduct the various sorted sizes of particles either to the appropriate storage bin or to the appropriate stage of the disintegrating apparatus. This sorting of the product of each of the machines 17, 18, etc., insures that each of the several machines, 18, 19, etc., of the battery 16 operates only upon particles or lumps which are all of substantially a uniform size.

Moreover, since each step of disintegration will produce a wide range of sizes of particles, some

of which are as small as it is desirable to produce, and only a small portion of which are so large as to require their being passed through the next successive stage of disintegration, the preferable arrangement is to provide for each machine 19 handling the smallest size of particles, a greater number, say two, of the machines 18 handling the next larger size, a still greater number, say four, of the machines 17 handling the next larger size, and so on, the number of machines in each stage of disintegration being regulated so that their combined products when screened to remove all save the largest particles will supply a sufficient quantity of material to keep the machines in the next stage operating substantially at capacity. Thus it may be understood that by so adjusting the machines of the entire series 16 that those of each stage disintegrate to a finer degree than those of the preceding stage, the most economical operating conditions will obtain. It should be explained, furthermore, that whereas I have illustrated but three stages of disintegration in the battery 16, as many more may be employed as any particular set of operating conditions may require. For example, different species of diatomite require a more gradual disintegration than others, thus necessitating a greater number of stages with a lesser degree of differentiation in the adjustment between machines of adjacent stages. Variation in the moisture content is another factor which has influence upon the number of stages of disintegration required in order to obtain the best results.

However, the principal means for increasing the quantity of material disintegrated lies in the construction of each of the several machines of the battery 16 instead of in their relative arrangement, and since in the preferred embodiment they all are of substantially identical construction differing from each other only in the matter of adjustment, it will suffice for the purpose of the present disclosure to describe but one of them, say the machine 18.

This disintegrating machine 18 comprises a pair of spaced sidewalls 36 disposed in parallel arrangement and mounted rigidly by any suitable anchoring device such as angle irons 37 upon a supporting structure 38. A conveyor belt 39 extends longitudinally of the machine 18, being mounted upon rollers 41 and 42 which extend between the two sidewalls 36 and which are revolvably mounted therein as by means of anti-friction bearings 43 engaging the shaft 44 which carries each of the rollers 41, 42. Preferably the anti-friction rollers 44 for the shaft 43 of one of the rollers, say the roller 42, are carried by blocks 46 which, instead of being rigidly mounted on the sidewalls 36 are slidably adjustable by being carried in suitable trackways 47 and are provided with means for adjusting, such as a screw 48 rotatably mounted in the trackway 47 and engaging a nut 49 carried by the block 46, such a screw 48 and block 46 being provided for each end of the shaft 44. Thus it may be seen that the longitudinal tension imposed upon the belt 39 may easily and accurately be adjusted. This belt provides the means for conveying material to be disintegrated to and between the rolls 51 and 52, which perform the actual disintegration.

The disintegrating rolls 51 and 52 which may be composed of rigid material, such as metal, or of resilient material such as rubber, or a composition of rubber and fabric, depending upon the particular type of material to be disintegrated, are carried by shafts 53 and 54 respectively, which

in turn are journaled in sidewalls 36 through the expedient of suitable anti-friction bearings 56 and 57 respectively. The disintegrating rolls 51 and 52 are disposed one above the other with the lower of the two, i. e., the roll 51, in such position that the upper run 58 of the conveyor belt 39 just touches the uppermost portion of the roll 51, so as to extend tangentially thereacross.

It will be observed that the disintegrating roll 51 is disposed between the rollers 41 and 42 and is closer to the roller 41 which is at the discharge end of the machine. This causes the material which passes between the disintegrating rollers 51 and 52 to continue on in horizontal movement upon the upper run 58 of the belt 39 after having passed between the disintegrating rolls and before it is dropped from the conveyor belt 39.

A pre-compacting belt 61 is disposed above the conveyor belt 39 and is so arranged that the lower run 62 of the belt 61 converges with the upper run 58 of the conveyor belt 39, as clearly shown upon Figures 1 and 2. This pre-compacting belt is under tension between the upper disintegrating roll 52 and an idler roll 63 carried by a shaft 64, each end of which is mounted in a block 65 which is adjustable longitudinally of the machine 18 on a trackway 67 and is provided with an adjusting screw and nut 68 and 69 respectively. This mechanism permits imposing the desired degree of longitudinal tension upon the compacting or compressing belt 61. The compacting belt 61 is provided with preferably a plurality of compacting rollers 71 and 72, which extend transversely across the machine 18 in contact with the upper surface of the lower run 62 of the belt 61. These rollers 71 and 72 are disposed nearer the lower end of the belt 61 but are spaced slightly from each other and from the roller 52 about which the lower end of the belt 61 extends. Each of the compacting rollers 71 and 72 is pressed downwards against the run 62 of the belt 61 as by a coil spring 73 (see Figure 9) associated with each end of each roll 71, 72. Each of these springs 73 is under compression between an adjusting screw 74 and a block 76 within which is journaled the associated end of the shaft 77 which carries the associated compacting roll 71 or 72, as the case might be. However, inasmuch as it is desired that only a relatively gentle force be exerted by the compacting rolls 71 and 72, each of the springs 73 is of relatively light construction.

Each of the disintegrating rolls 51 and 52 is provided with a reinforcing or backing roll 81, 82, respectively, mounted in rolling contact therewith. Each of the disintegrating or shearing rolls 51 and 52 is of relatively small diameter, the result being that relatively little bending moment need be imposed thereagainst in order to cause flexure of the roll. Particularly true is this when the machine 18 is of considerable width, say to accommodate a belt 8 feet wide, as is contemplated in machines intended to produce large commercial quantities of disintegrated diatomite. It is for the purpose of avoiding such flexure, which would interfere seriously with the satisfactory operation of the machine, that the reinforcing rolls 81, 82, are provided. Consequently each of these reinforcing rolls 81 and 82 is of considerably greater diameter than the shearing roll 51, 52, with which it is associated. The rolls 81 and 82 are carried by shafts 83, 84, respectively, which are journaled in anti-friction bearings 86 and 87 respectively. Inasmuch as all of the rolls 51, 52, 81, and 82 are arranged with

their axes in a vertical plane, a convenient arrangement is to provide a single, vertically elongated housing 88 upon each sidewall 36 of the machine 18 to accommodate all four bearings 56, 57, 86, and 87, which are disposed on that sidewall.

Preferably the upper disintegrating roll 52 is pressed downwards toward the lower disintegrating roll 51 so as to resist their separation, with a predetermined degree of force. This is accomplished through the expedient of a coil spring 89 disposed within the upper end of each of the bearing housings 88 and compressed between an adjusting screw 91 and the uppermost bearing 84 within that housing 88. However, inasmuch as it is desirable to limit the approach of the roll 52 toward the roll 51 to a predetermined minimum distance, a spacing block 92 of appropriate thickness is interposed between the bearings 56 and 57 within each of the housings 88. Preferably the springs 89 are of considerably heavier construction than the springs 73, for the reason that it is desirable to resist separation of the shearing or disintegrating rolls 51 and 52 with a considerably greater force than that which resists upward motion of the compacting rolls 71 and 72.

Inasmuch as the upper belt 61 extends around the upper disintegrating roll 52, it is an entirely satisfactory construction to provide space for the compacting rolls 71 and 72 merely by using an idler roller 93 which is of greater diameter than the roll 52 upon which the lower end of the belt 61 is engaged. However, the lower belt 39 is so arranged that it extends beyond the lower disintegrating roll 51 before returning to the idler roll 42 at the opposite end of the belt. Accordingly it is necessary to provide space between the upper and lower runs 58 and 94 respectively of the belt 39 to accommodate not only the shearing rolls 51 and the backing rolls 96 and 97 which are disposed below the upper run 58 and directly opposed to the compacting rolls 71 and 72 respectively, in addition to the lower reinforcing roll 81. This is accomplished through the expedient of an idler roll 98 carried by a shaft 99 the ends of which also are journaled in the sidewalls 36 but in such position that the axis of the idler roll 98 can be disposed considerably below the horizontal plane which includes the axes of the rolls 41 and 42, as clearly indicated upon Figure 2.

Owing to the relatively great width of conveyor belt 39 which is contemplated in machines capable of handling relatively great quantities of material, I have found it desirable to provide means for imposing lateral tension upon it, so as to compensate for the weight of the material carried thereby which might otherwise cause too extensive sagging thereof. For this purpose, each lateral edge of the conveyor belt 39 is provided with a flexible strip 101 upon each surface thereof (see Figures 4 and 5). These strips 101 are fastened to the belt 39 as by rivets 102 extending through the belt and through both strips 101, and owing to their flexibility permit flexure of the belt 39 around the rolls 41, 42, and 98 without interference. However, owing to the fact that the inner face 103 of each strip 101 lies substantially at right angles with the belt 39, a continuous abutment or shoulder is provided thereby which faces inwards with respect to the belt 39 and toward the shoulder 103 similarly defined by the inner face 103 of the corresponding strip 101 associated with the opposite edge of the belt 39.

Preferably at each of several points between the rolls 41 and 42 each sidewall 36 is provided with

a pair of opposed pins 106, 107, which extend across and preferably make contact respectively with the upper and lower strips 101 carried by the associated edge of the belt 39. Each of these 5 pins 106, 107, is journaled in a suitable anti-friction bearing 108 mounted upon the associated sidewall 36 as by a bearing block 109. Upon the inner end of each pin 106, 107, a head 111 is provided, which on account of its greater diameter 10 than the pin by which it is carried, extends part-way across the face 103 which is presented by the inner edge of the associated strip 101. Thus it may be seen that each of the revolvably mounted pins 106, 107 and the head 111 carried thereby 15 co-operate to provide a roller which is adapted to engage the inside face of each strip 101 so as to resist any tendency for the associated lateral edge of the belt 39 to move inwards towards the other edge of the belt; this being the motion of the 20 lateral edges of the belt which would be produced if the belt were to sag.

Any suitable means may be provided for driving the disintegrating rolls 51 and 52 and causing the opposed belts 61 and 39 to move in such a manner 25 that their proximal runs 62 and 58 respectively move in the direction in which they converge, i. e., to the right as viewed upon Figs. 1 and 2. One convenient type of mechanism for driving the machine comprises any suitable prime mover, such 30 as electric motor 116 mounted upon a bracket 117 on one of the sidewalls 36 and carrying a sprocket 118 which is connected by a driving chain 119 to a relatively large sprocket 121 which is carried by a countershaft 122. This shaft 122 is journaled 35 in suitable bearings 123 carried by another bracket 124, and is provided with a sprocket 126, which is connected as by a chain 127 with a sprocket 128 carried by an extension 129 of the shaft 54 of the upper disintegrating roll 52. In order to insure that both disintegrating rolls 51 40 and 52 shall rotate at the same speed, I prefer that they be interconnected by some positive driving means such as gears 131 and 132 carried by extensions 133 and 134 of the shafts 53 and 54 45 respectively of the rolls 51 and 52 respectively. It should be explained that the maximum separation of the roll 51 and 52 against the action of the springs 89 will, under all normal operating conditions, be less than that which will be necessary 50 to cause the teeth of the gears 131 and 132 to become disengaged.

Inasmuch as the upper or compacting belt 61 extends around the upper disintegrating roll 52, the rotation of this roll 52 will impart the desired 55 motion to the compacting belt 61. However, the only contact which the lower disintegrating roll 51 makes with the conveyor belt 39 is that which results from the mere tangential engagement of the upper run 58 of the belt 39 because the run 58 simply extends across and beyond the roll 51. Accordingly, it is desirable to provide more positive means for imparting motion to the belt 39 60 and this may be accomplished by means of an auxiliary driving mechanism 141, illustrated to best advantage upon Figure 8 and comprising a pulley 142 rigid with an extension 143 (see Fig. 4) of the shaft 56 of the lower disintegrating roll 51. This pulley 142 is connected as by a belt 144 65 with another pulley 145 rigid with an extension 146 of the shaft 147 which carries the rolls 41 around which the belt 39 extends. Although the rolls 142 and 41 are of different diameter, this may be compensated for by selecting pulleys 142 and 145 of appropriate size. It is desirable that the 70 belt 144 be relatively loose and preferably rela-

tively narrow, so as to permit it to slip when force in excess of a predetermined value resists movement of the belt 39. Preferably the tension of the belt 144 is adjustable, for which purpose an idler pulley 148 is rotatively mounted in position 5 to engage one of the runs of the belt 144. This idler pulley 148 is journaled in a block 149, the position of which is determined by an adjusting screw 151.

I prefer that each of the disintegrating machines be provided with means for collecting any material which may adhere to the belt 39 after it has passed around the roller 41 and drop from the lower run 94 of the belt 39. This may be in the form of a collector 156, the sidewalls 157 of 15 which incline downwards and inwards so as to deposit any material falling thereupon upon a conveyor belt 158, which is disposed below a longitudinally extending opening 159 in the collector 156. 20

The material to be disintegrated is deposited upon the upper run 58 of the conveyor belt 39 of the first disintegrating machine 17 of the battery 16, or upon that run of the conveyor belt 39 of each of the disintegrating machines in the 25 first stage, in the event that there be more than one machine, as explained hereinabove. Figure 1 illustrates diagrammatically a hopper 161 having a restricted mouth 162 whereby material in suitable lump size, say of approximately one-quarter inch diameter is deposited upon the conveyor belt 39 of the first machine 17. The preferable arrangement is such that the material thus deposited is disposed in a relatively smooth layer 30 163 (see Figure 10), which corresponds substantially in thickness to the spacing between the runs 62 and 58 of the belts 61 and 39 respectively at the point where the first compacting roller 72 engages the upper belt 61. This may be accomplished by the precise arrangement of the mouth 40 162 of the hopper 161, and/or by means of a leveling device or spreader 166, which is illustrated upon Figure 7 in conjunction with a slightly modified form of conveyor belt 39', which will be described hereinafter. This leveling device 45 166 comprises a blade 167 extending transversely of the belt 39 or 39' as the case might be and supported by means of a rod 168 the ends of which are rotatably mounted in the sidewalls 36 of the machine in such position that the blade 50 167 may be supported at the desired elevation above the associated conveyor belt somewhat in advance of the first compacting roll 72. Preferably only the ends 169 of the blade 167 are connected to the rod 168, whereas the central 55 portion 171 is positioned considerably more closely to the first compacting roll 72, the result being that the blade 167 is substantially V-shaped in plan. When the material to be disintegrated is deposited upon the belt 39 or 39', as the case might be, in a layer the thickness of which is in excess of that which is desired, as explained hereinabove, the blade 167 tends to level or smooth 60 the layer by crowding all such excess material toward the center, causing any hollows in the upper surface of the layer to be filled as will readily be understood. Since the rod 168 is rotatably mounted in the sidewalls 36, the blade 167 may be elevated out of operating position when desired. 70

Operation

The disintegrating apparatus of the present invention is intended to operate upon material which is in lumps of from approximately one- 75

quarter to one-half inch in size, although it should be understood that by suitable modification of the hereinabove described apparatus different sizes of lumps may be disintegrated satisfactorily. The lumps to be disintegrated are deposited upon the belt 39 as by the mouth 162 of the hopper 161, and since the belt 39 is in motion due to the inter-engagement of the pulley 41 around which the belt 39 extends and the pulley 142 carried by the lower disintegrating roll 51, the material deposited upon the belt 39 will be carried toward the opposed disintegrating rolls 51 and 52. As mentioned hereinabove, the mouth 162 and the leveling device 166, if such be employed, are so arranged that the material to be disintegrated is deposited in a layer the thickness of which substantially coincides to the spacing between the opposed belts 61 and 39, where they intersect the vertical plane which includes the axis of the first compacting roll 71. Owing to the irregular configuration of the many lumps constituting the mass of material, and owing to the relatively recent agitation thereof resulting from its having been tumbled onto the belt from the bin 161, the material so deposited upon the belt 39 and carried toward the disintegrating rolls will be relatively loosely compacted, the result being that the voids or interstices 181 between the lumps 182 (see Fig. 10) will in most instances aggregate about as much volume as the total volume of the lumps themselves. The function of the compacting belt 61 and the compacting rollers 71 and 72 is to overcome this condition and cause the mass of lumps 182 to be more closely compacted, i. e., crowd the lumps 182 more closely together, before they pass between the disintegrating rolls 51 and 52. This result is attained through the convergency of the belts 61 and 39 because after the material passes between the first compacting roll 72 and the backing roll 91 associated therewith, a limited amount of pressure is brought to bear thereupon. The stages of compacting, however, are not abrupt, but are gradual and merge one into the other owing to the interconnection of the rolls 72, 71 and 52 by the lower run 62 of the compacting belt 61 which is moving to the right, as viewed upon Figure 10. Thus it may be seen that as the layer 163 approaches the disintegrating rolls 51 and 52, the density thereof is gradually increased and reaches its maximum just at the position where the layer 163 enters between the disintegrating rolls 51 and 52. Very little if any actual breaking of the lumps 182 will occur until they actually enter between the disintegrating rolls 51 and 52, owing to the relatively light pressure with which the compacting rolls 71 and 72 are pressed downwards.

This accounts for the principal difference between the respective manners of operation of the device of my aforesaid copending application and that of the present invention. In the device described in application Serial No. 495,905, it was necessary to pass the material between the disintegrating rolls in a relatively thin layer in order to insure that the upper shearing roll would make contact with the smallest possible number of the particles at any given time. Otherwise the relatively loosely compacted particles would tend to pile up in back of the shearing roll, under which circumstances a large proportion of the diatomic structures protruding from the particles would be rubbed off. However, by precompacting the layer before it enters between the disintegrating rolls, the particles are prevented from slipping

one on the other, and it is in this manner that the shearing action between particles so necessary for the satisfactory disintegration of the material is greatly increased when such frangible material as diatomaceous earth is being disintegrated.

As in the case of the disintegrating apparatus disclosed in my co-pending application, the rolls 51 and 52 are prevented from moving more closely together than a predetermined minimum spacing through the expedient of the spacing blocks 92; and Figure 10 indicates the manner in which the disintegrating rolls act upon each particle 182 as the result of this limitation in their movement toward each other. It will be observed that a large number of cracks or planes of severance 191 have developed in the lump 192 which is actually engaged between the rolls. Owing to the sharp curvature of the small rolls they press their respective belts against the lump 192 in relatively small areas of contact, causing the force which they exert against the lump to be highly localized; and since the material is of such a brittle nature, the cracks 191 are formed therein in a shearing action separating the lump into a plurality of smaller lumps. However, as the lump 192 is disintegrated in this manner, the smaller particles 193 thus produced are not crushed because of the fact that the disintegrating roll 52 cannot move closer to the opposed roll 51. Instead the sheared or cracked lump 192 simply falls apart with relatively little grinding or sliding motion occurring between the several smaller particles 193, with the result that the diatomic structures which protrude from the newly formed surfaces of the small particles are in large measure preserved; i. e. not rubbed off, as they would be if sliding or grinding motion occurred between the small particles.

Whereas, Figure 10 illustrates but one lump 192 between the disintegrating rolls 51 and 52, under actual operating conditions the layer 163 will in most cases consist of several lumps superimposed one upon the other as it passes between the disintegrating rolls 51 and 52. However, the action in shearing each of the several lumps 192 will be substantially the same as described, owing to the fact that the layer 162 has been precompact, the result of which is to hold the lumps 192 firmly against slipping one against the other as they enter between the disintegrating rolls. Such action would tend to wipe off any protruding structures, but instead of slipping past each other in this manner they are prevented from doing so by having been precompact, so that when the final pressure is brought to bear against the layer it will cause each of the superimposed particles to press against each other in highly localized areas (owing to the irregular configuration of the particles) until the same shearing action takes place. Immediately this has occurred the pressure exerted against the particles will be relieved, thus precluding the possibility of any crushing and permitting the particles merely to fall apart without detriment to the diatomic structures which protrude from the newly formed surfaces thereof.

The reinforcing rolls 81 and 82 serve to prevent any flexure of the relatively small disintegrating rolls 51 and 52 which, owing to their relatively great length in a disintegrating machine designed to operate upon commercial quantities of material, would in all probability be caused to bend apart between their respective bearings and thus destroy their alignment. The reinforcing rolls

81 and 82, however, disposed in rolling contact with the disintegrating rolls 51 and 52 respectively and being of much greater diameter, will serve effectively to prevent any such flexure of the disintegrating rolls and thus insure perfect operation of the disintegrating rolls throughout their entire length by holding them in true parallelism with each other.

Undue sagging of the conveyor belt, as induced by the weight of the belt and of the material carried thereby, is effectually prevented by the engagement of the heads 111 of the pins 106 and 107 with the inner faces 103 of the strips 101. These strips serve an additional purpose, however, in some of the latter stages of disintegration, where the separation between the disintegrating rolls 51 and 52 is so slight that the lower end of the upper belt actually enters the space between the strips 101 on the upper surface of the lower belt 39, as shown upon Figure 4. In these latter stages of disintegration, the particles being conducted past the compacting rolls and the disintegrating rolls are so fine that the mass of material is possessed of a considerable degree of fluidity and consequently has a great tendency to be squeezed out from between the converging belts. This tendency is overcome by the strips 101 upon each side edge of the lower belt and extending upwards past the lower run of the upper belt at the place where the greatest degree of compacting and the actual disintegrating take place.

Whereas the battery 16 illustrated upon Figure 1 contains but three stages of disintegration, Figures 10, 11, 12, and 13 illustrate four successive stages, it being understood that as many stages of disintegrating may be employed as may be necessary in the case of any particular material. However, instead of passing directly from one stage (say that illustrated in Fig. 10) to the next stage 196 (say that illustrated in Fig. 11), the stream 197 of particles 193 of mixed sizes is screened as by the screening apparatus 21 after it issues from the disintegrating rolls 51 and 52 of the first stage, and only the largest particles 198 of the stream 197 are conveyed to the disintegrating rolls 51 and 52 of the next stage 196. However, the pre-compacting of these lumps or particles 198 occurs in identically the same manner as in the case of the first stage, so that the density of the layer 199 of particles 198 entering between the disintegrating rolls of the second stage is increased to such an extent that slipping of the particles one on the other cannot occur as the planes 201 of shear develop. In this manner the particles 198 constituting the layer 199 entering the second stage are further reduced in size, producing a stream 202 of particles of mixed size. This stream 202 is again screened and only the largest particles 203 are permitted to enter between the disintegrating rolls of the next successive stage 204 (see Fig. 12), where identically the same process of disintegration occurs, where the largest particles 206 which have issued from the second stage 192 are further reduced in size to a stream 207 of particles of mixed size, which are again screened so as to permit only the largest particles 208 thereof to be passed to the disintegrating rolls of the next stage 209 (see Fig. 13), and so on. The process of disintegration continues on in this manner until all the stages of disintegration have been completed.

It will be observed, however, that the disintegrating rollers of the successive stages are adjusted so that the disintegrating rolls of each

stage are disposed more closely together than those of the preceding stage, thereby making it possible for each stage to disintegrate to a finer degree than the preceding stage.

As stated hereinabove, each of the screening operations between successive stages of disintegration removes all the particles which are smaller than those which are to be operated upon by the next successive stage. These smaller particles are sorted, as by the screens 24, 26, and 27, and each of the several sizes is transported by the appropriate conveyor belt 28, 29, 31, or 32 to a suitable storage bin, or is reintroduced into the battery 16 at such point that those particles are mixed with others of substantially the same size. The segregation of the particles into the several different sizes so that each stage of disintegration operates upon only one size of particle is another important feature of the apparatus of the present invention, inasmuch as it avoids the tendency of the larger particles to grind or crush the smaller particles to an impalpable powder, as would be the case were a mixture of the sizes to be fed through any one of the stages of disintegration.

As stated hereinabove the conventional methods of disintegrating diatomaceous earth cause in excess of 95% of the material to be reduced to such a fine powder that it passes through a 200 mesh screen. Not only this, but they also completely destroy the structural formation of the material; i. e., the silicified diatome skeletons, which I have found to be of such extreme value when the material is used for filtration purposes.

Actual application of the principles of disintegration described hereinabove has made it possible to disintegrate diatomaceous earth into graded sizes ranging from 20 mesh to 150 mesh with less than 10% of the total quantity of material reduced to impalpable powder. Furthermore, of these mesh sizes of disintegrated diatomaceous earth it has been found by actual observation under the microscope that at least 85% carry a great profusion of diatomic structures which protrude from the body portions of the particles, and moreover that in most cases these protruding structures are of much greater length than I had been able to produce by the apparatus disclosed in my aforesaid co-pending application. I attribute this improvement in the quality of the product of the apparatus at least partially to the fact that the lumps or particles to be reduced in size are compacted before being actually disintegrated, thereby preventing slipping between the particles and producing new surfaces by shearing, as the particles are broken into smaller particles, which are not permitted to rub or grind against each other to the detriment of the structures protruding from such newly formed surfaces. Furthermore, a greater quantity of material, i. e., number of particles, is caused to pass between the disintegrating rolls of each stage, thereby increasing the proportionate number of particles which are not in contact with either of the belts 61 or 39. This is another feature which presumably accounts for an increase in the number and length of protruding structures retained on the smaller particles produced because of the fact that contact of any of the particles with either of the belts will probably tend to break off at least some of the structures which protrude from the surface of that particle, which makes contact with the belt. Thus it may be seen that by increasing the thick-

ness of the layer the number of particles which do not make contact with the belt and yet which are disintegrated in the highly desirable shearing action of one particle against another, is increased, whereas the number of particles which do make contact with the belt is not materially increased, and thus the proportionate number of particles which have their protruding structures preserved is greatly increased.

The precise degree of separation of the disintegrating rolls 51 and 52 in each stage is a detail of adjustment to which particular attention should be paid in order to insure the most satisfactory operation of the machine. It is desirable to pass the material through the disintegrating rollers in as thick a layer as possible, not only because the quantity of material acted upon is in this manner increased, but because the smallest percentage of impalpable sizes is produced when the layer is of maximum thickness, and more and longer protruding structures are preserved upon the particles. This is true, however, only up to a certain point, for I have found that by exceeding a certain thickness of layer almost all the material is reduced to an impalpable powder, and practically all the diatomic structures are destroyed. Moreover, the maximum thickness of layer is not a constant factor, but varies with each type of diatomite or other material being disintegrated, the result being that the proper adjustment of the shearing rolls 51 and 52 in each stage of disintegration and for each class of material should be predetermined, and the several machines then adjusted accordingly, in order to obtain the most satisfactory results. After determining the most desirable thickness for the mass or layer of material passing between the shearing rolls, it then remains to ascertain how thickly the loosely compacted material should be spread upon the feeding belt. The most desirable thickness is that which will result in such a degree of compacting of the mass of material by the compacting rolls 71 and 72, that the maximum force exerted is just slightly less than that which will cause disintegration of the particles comprising the mass. It then remains only for the shearing rolls 51 and 52 to impose relatively slight additional force upon the material to develop the desired shearing of the particles.

I have found that the quality of the output of the machine is so dependent upon the thickness of the layer of material passing between the shearing rolls 51 and 52 and upon the degree of compacting thereof prior to the entry between the shearing rolls, that it is possible to control the percentage of the number of particles which carry protruding diatomic structures by varying either or both of those factors, and also to predetermine quite accurately how high a percentage of a given class of material will carry protruding structures, after these two factors are known.

From the above description, it will be understood that the increase in volume of material disintegrated per unit of time as a result of the use of the converging belts is merely one of the incidental improvements in the art which are attained by my present invention, the betterment of the quality of the material being the improvement of paramount importance. Whereas there is no need of going into detail in respect to the far more efficient filtration which can be performed by means of diatomaceous earth disintegrated according to the present invention, suf-

fice it for the purpose of the present disclosure to recite that when using diatomaceous earth disintegrated according to the methods commonly used in the art, for the purpose of filtering crude oil from the Santa Fe District for the simultaneous removal of wax and carbon, it required two hours and thirty minutes for a given quantity of the crude to pass through the filter cake, and after the filtration was complete the filter cake was of a dirty yellow color, showing that practically no carbon had been removed thereby. When the same quantity of the same type of crude was filtered by means of diatomaceous earth disintegrated according to the disclosure in my aforesaid co-pending application, Serial No. 495,905, it passed through a filter cake of the same size in twenty-two minutes and after the filtration the filter cake was absolutely black, showing that a large proportion of the carbon had been removed from the oil; and by weighing the filter cake before and after filtration the quantity of carbon removed was ascertained. Then the same test was made, using diatomaceous earth disintegrated in accordance with the hereinabove described method, and the same quantity of the same type of oil passed through the same size of filter cake in eighteen instead of twenty-two minutes, even though it required only fifteen pounds pressure, whereas the former test had required twenty pounds pressure to cause the oil to flow through the filter cake, and the quantity of carbon removed in the last test was found to be 4% more than in the preceding test. This improvement in filtering capabilities of diatomite when disintegrated in accordance with the present invention can be explained only by the fact that more and longer protruding diatomite skeletons are retained intact upon the granules into which the material has been disintegrated.

I have found it desirable when disintegrating certain species of diatomite and other material which are comparatively hard such as certain species of decolorizing clays, to employ a modified form of conveyor belts 39' and 61' (see Figs. 6 and 7), which are the same as the belts 39 and 61 previously described with the exception that their outer surfaces are armored, thereby avoiding the danger that the lumps of material will rupture the belt when compacted and/or when sheared by the disintegrating rolls. One method of accomplishing this is to provide the working surfaces of the belts with a plurality of metal strips 216 fastened as by rivets 217 to each belt in such position that they extend transversely thereacross in close proximity to each other. The fact that the strips 216 are relatively narrow permits the belts thus armored to bend as they pass around their respective pulleys. This type of belt will, under most circumstances, be necessary only in the first stage of disintegration where the lumps to be broken are relatively large and consequently require considerably more pressure on the part of the disintegrating rolls to effect the desired shearing. Under most circumstances of operation, it is preferable that the shearing rolls 51' and 52' used in conjunction with armored belts, be composed of metal or other non-resilient material.

Another detail of construction, which may be employed with either type of belt, is also illustrated upon Fig. 7. This is a pair of rotary cylindrical brushes 221 and 222, respectively, mounted in brushing contact with the belts 61 and 39 or 39', as the case might be. The engagement of the brushes with their respective belts is quite

light and their bristles are relatively soft. Their function is to remove any of the disintegrated material which might tend to adhere to the belt after it has passed around the associated pulley at the discharge end of the machine. It is not necessary to use these brushes in connection with all types of diatomite, but if the material being disintegrated is relatively moist, they are usually advantageous because a high moisture content of the material being broken down increases the tendency thereof to adhere to the belt. For this reason the brushes are quite important, inasmuch as the method and apparatus hereinabove described for disintegrating diatomaceous earth and similar material permits disintegrating material while it contains a high percentage of moisture. This is an improvement in the disintegrating art, inasmuch as other types of disintegration require that the material be absolutely dry, which not only makes the material itself more brittle and therefore much more difficult to disintegrate without complete pulverization, but also practically precludes the possibility of disintegrating even to a slight degree without complete destruction of the diatomic structure.

I claim:

1. The method of disintegrating diatomaceous earth from particles of a given size to particles of a smaller size, each of said particles being composed of a highly compacted mass of diatomic structures; said method comprising compressing a mass of said particles of given size to increase the density of the mass by crowding the particles thereof more closely together by a compressing pressure less than that necessary to effect disintegration of said particles, and then applying shearing force to said compacted mass whereby the particles thereof are sheared into particles of smaller size.
2. The method of disintegrating diatomaceous earth from particles of a given size to particles of a smaller size, each of said particles being composed of a highly compacted mass of diatomic structures; said method comprising compressing a mass of said particles of given size to increase the density of the mass by crowding the particles thereof more closely together, and then applying

shearing force to said compacted mass, said shearing force being applied to said mass over a very small area thereof, whereby the shearing forces acting upon each particle are applied thereto in greatly restricted areas.

3. The method of disintegrating diatomaceous earth from particles of a given size to particles of a smaller size, which comprises gradually compacting a mass of said particles of given size to a predetermined degree of compression which is slightly less than that which effects fracture of said particles, and then applying sufficient additional force to said compacted mass of particles to produce fracture of the particles, said additional force being applied over a relatively small area of said mass and being released immediately after the particles are fractured, whereby the fracture thereof occurs in a shearing action and the smaller particles thus produced are not caused to grind one against the other.

4. The method of disintegrating aggregate material which comprises spreading said material in a sheet of predetermined thickness, subjecting said sheet to gradually increasing pressure to compact it to greater density by crowding the particles of the material more closely together and then applying shearing force to said compacted material, said shearing force being applied to said material over a very small area of said sheet, whereby the forces acting upon each particle are applied thereto in greatly restricted areas whereby said particles are sheared into particles of smaller size.

5. The method of disintegrating diatomaceous earth from particles of a given size to particles of a smaller size, each of said particles being composed of a highly compacted mass of diatomic structures; said method comprising spreading a mass of said particles in a sheet of predetermined thickness, subjecting said sheet to gradually increasing pressure to compress the particles more closely together, and then applying sufficient force to said compacted mass to disintegrate said particles, said disintegrating force being applied to said mass in a highly restricted area to produce a shearing effect upon said particles.

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