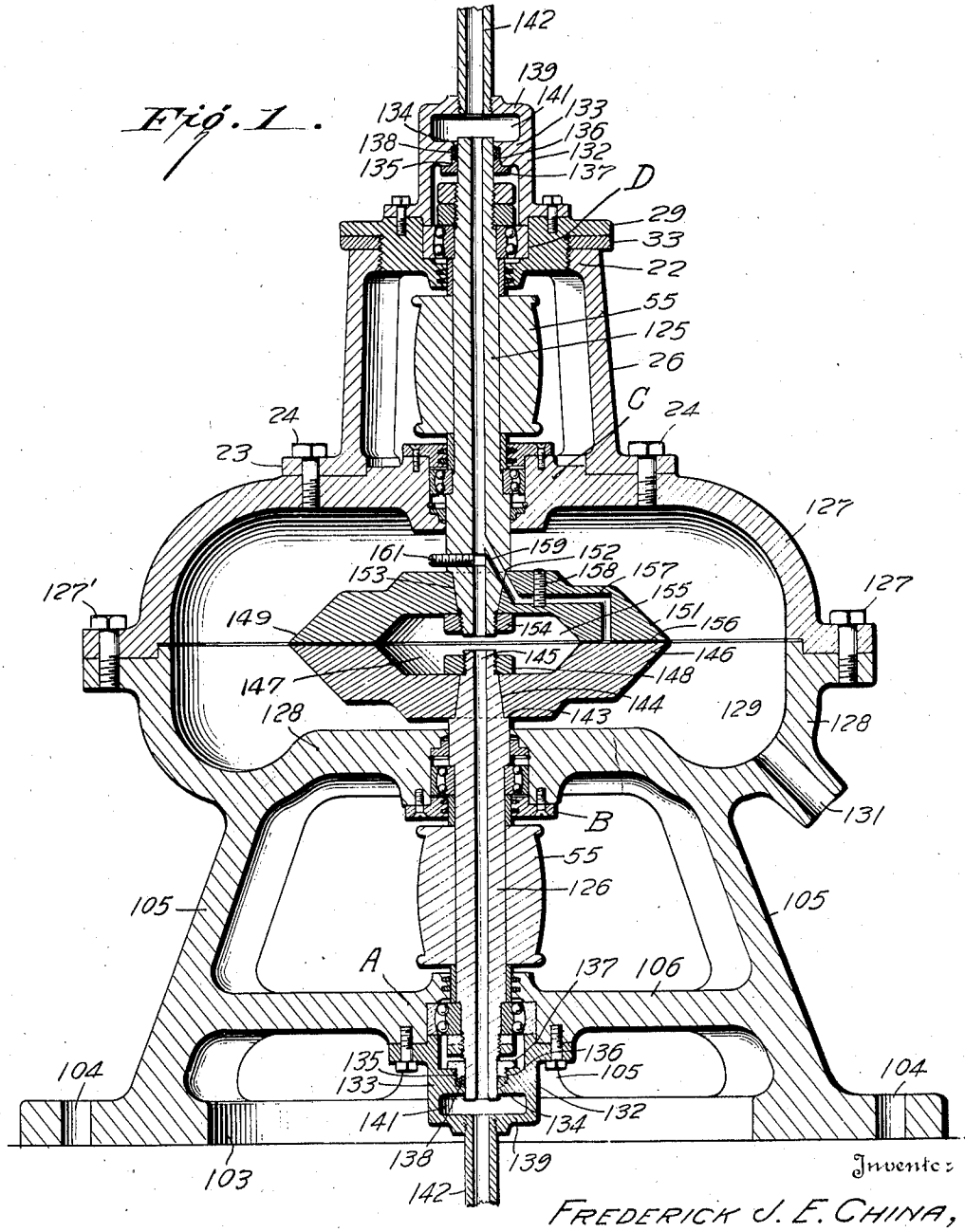
Nov. 6, 1928. 1,690,668

F. J. E. CHINA

DISINTEGRATING DEVICE

Original Filed Dec. 10, 1923 2 Sheets-Sheet 1

Fig. 1.



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DISINTEGRATING DEVICE

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Fig. 4.

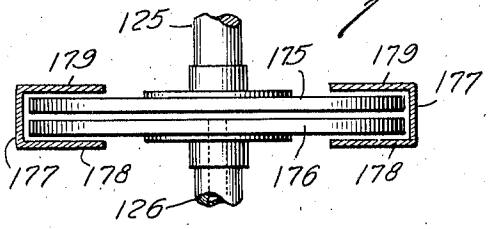


Fig. 9.

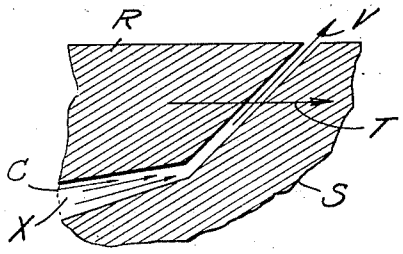


Fig. 5.

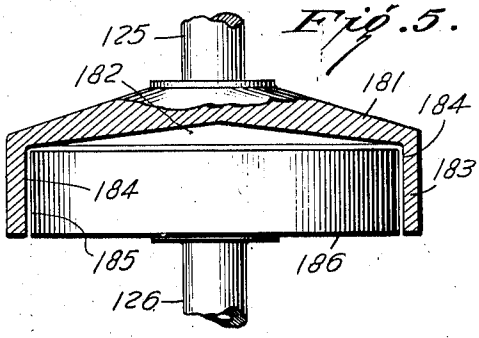


Fig. 2.

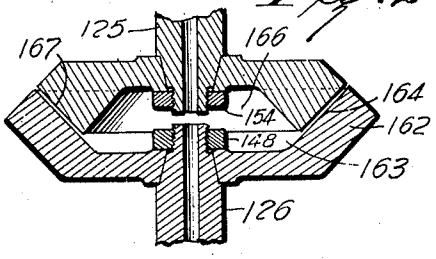


Fig. 8.

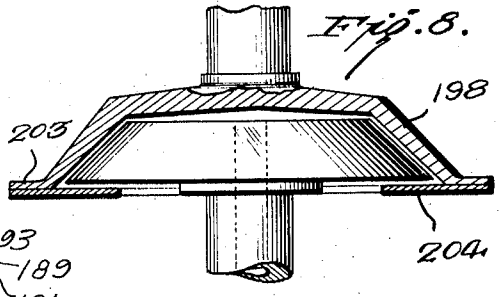


Fig. 6.

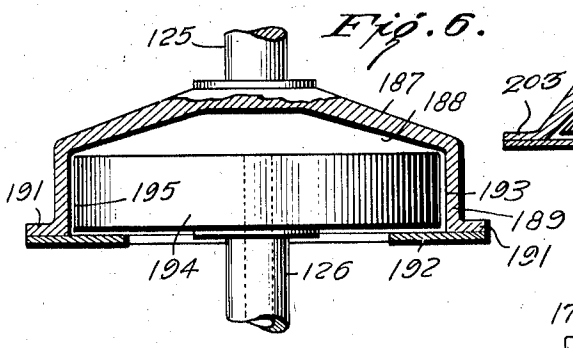


Fig. 3.

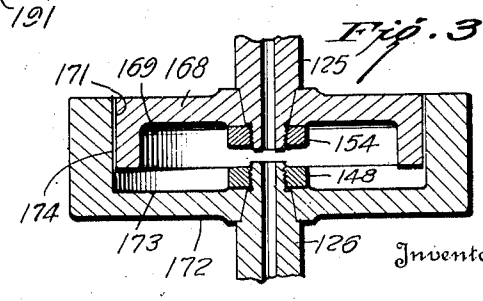
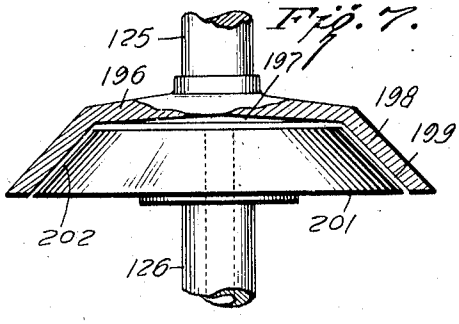


Fig. 7.



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UNITED STATES PATENT OFFICE.

FREDERICK JOHN EDWIN CHINA, OF ESHER, ENGLAND.

DISINTEGRATING DEVICE.

Original application filed December 10, 1923, Serial No 679,748, and in Great Britain March 8, 1922. Divided and this application filed March 12, 1926. Serial No. 94,349.

My invention relates to improvements in mills adapted to act on suspensions in liquids, and is a division of my application, Serial No. 679,748, filed December 10, 1923. The present application also embodies in part my British applications Nos. 14,864/23 and 8,284/24, both filed on the 6th day of June 1923.

An object of my invention is to increase the forces acting in a thin film of the liquid containing the particles, liquid or solid, which are to be acted upon, which exist between surfaces closely adjacent to each other and relatively movable one past the other at high velocity.

A further object of my invention is to increase the efficiency with which the forces act, whereby a larger output may be obtained with relatively small increase in power.

A still further object of my invention is to show how to construct such a device so that it will be easy and cheap to manufacture and simple and inexpensive to repair and replace.

With these and other objects in view which may be incident to my improvements, the invention consists in the parts and combinations to be hereinafter set forth and claimed, with the understanding that the several necessary elements comprising my invention, may be varied in construction, proportions and arrangement, without departing from the spirit and scope of the appended claims.

In order to make my invention more clearly understood, I have shown in the accompanying drawings means for carrying the same into practical effect, without limiting the improvements in their useful applications to the particular constructions, which for the purpose of explanation, have been made the subject of illustration.

In the drawings:

Figure 1 is a longitudinal sectional view taken on the axis of the rotor of my device:

Fig. 2 is a detail view of a modification of rotors which may be employed in connection with the form of invention disclosed in Fig. 1;

Fig. 3 is a detail view of another modification of rotors which may be employed with the form of invention diclosed in Fig. 1;

Fig. 4 is a detail view of another modification of rotors which may be employed with the form of invention disclosed in Fig. 1;

Fig. 5 is a detail view of a further modification of rotors which may be employed with the form of invention disclosed in Fig. 1;

Fig. 6 is a detail view of yet another modification of rotors which may be employed with the form of invention disclosed in Fig. 1;

Fig. 7 is a detail view of a further modification of rotors which may be employed with the form of invention disclosed in Fig. 1;

Fig. 8 is a detail view of a still further modification of rotors which may be employed with the form of invention disclosed in Fig. 1;

Fig. 9 diagrammatically indicates the direction of some of the forces acting on the liquid in my device.

In the drawings is illustrated a form of mill in which both of the working surfaces may be rotated in either the same or in opposite directions.

Referring particularly to Figure 1, I have shown two rotating hollow shafts, the upper hollow shaft being numbered 125 and the lower hollow shaft 126. For supporting my machine, I have provided upright supports 105 which are obliquely inclined and preferably integrally formed with an annular support 103 having bolt holes 104 through which the annular support may be firmly bolted to a suitable base. Between the upright obliquely inclined supports 105 is a connecting web 106 which carries the lower bearing structure A, which is adapted to support the shaft 126 and prevent it from any axial movement.

There is also provided an upper bearing structure B for the lower hollow shaft 126, which is housed in the lower base casting 128, which may be integrally formed with the supports 105. The bearing structure for the lower shaft 126, which I have shown in Figure 1, comprising upper bearing structure B and lower bearing structure A, is adapted to support the lower shaft 126 without longitudinal movement, and in the form shown, the shaft is not adjustable. This might well be changed and the lower shaft made adjustable, as such may be found desirable.

Resting on the lower base casting is an upper cover plate structure 127 which is suitably bolted by bolts 127′ to the lower base casting 128. An upper support 22, provided with a flange 23, rests on the cover plate structure 127, and is firmly bolted thereto by means

of bolts 24. Adapted to slidably fit within an aperture in the cover plate structure is a lower bearing structure C, which allows the shaft 125 to slide longitudinally when adjustment is made.

Supported on the support 22 at its top is a bearing support piece 29 which is screw-threaded into the support 22 and carries with it an upper bearing structure D. The upper bearing structure firmly prevents any possible axial displacement of the upper shaft 125 with respect to the bearing support piece 29. However, by rotating the bearing support piece 29, by reason of its screw-threaded engagement with the support 22, the whole upper bearing D and the shaft with it may be moved axially to effect adjustment between the working surfaces of the rotors (as will later be apparent). The shafts 125 and 126 are rotated by pulleys 55.

The lower base casting 128 which may be integrally formed with the supports 105 forms with the cover plate 127 an output chamber 129 having an outlet 131. The upper end of hollow shaft 126 and the lower end of hollow shaft 126 are provided with similar journal box covers 132. The journal box covers 132 are provided with partitions 133 through which the ends of the hollow shafts 125 and 126 project. The partitions 133 have formed in them packing glands comprising frusto-conical surfaces 134, surrounding the shafts. Adapted to engage with screw-threads 135 formed on the interior of the packing glands, are screw-threads 136 formed on packing compressor members 137. Between the frusto-conical surfaces 134 and the packing compressing members 137 is placed packing 138, which will prevent leakage of any material along the outside of the shafts 125 and 126.

Between the partitions 133, formed in the journal box covers 132, and cover plates 139 preferably integrally formed with the journal box covers, are receiving chambers 141. Screwed into the cover plates 139 are input pipes 142 leading from pumps or other sources of feed pressure (not shown) into the receiving chambers 141. The packing gland structure in the journal box covers 132 permits liquid that is introduced through the input pipes 142 into the chambers 141 to flow through the hollow shafts 125 and 126, without coming in contact with any of the bearing structure.

The upper end of the shaft 126 is formed with a shoulder 143, and above the shoulder the shaft is tapered to form a frusto-conical surface 144. The tip end of the shaft has screw-threads 145 formed thereon. Adapted to have its lower face rest against the shoulder 143 on the shaft 126 is a lower rotor 146 having a hollowed out section 147 into which projects the upper extremity of the hollow shaft 126. A nut 148 fits over the screw-threaded portion 145 of the shaft 126, and holds the lower rotor member 146 tight against the shoulder 143 so that the rotor will rotate with the shaft without any give or vibration.

Formed on the upper surface of the lower rotor 146 is an annular smooth working surface 149, which in the form I have shown, extends substantially at right angles to the axis of rotation of the shaft 126. The lower end of the shaft 125 has a complementary upper rotor 151, whose upper surface abuts against a shoulder 152 formed on the shaft 125. In this construction, the shaft 125 is formed with a frusto-conical surface 153, similar to the frusto-conical portion 144 formed on the shaft 126. The lower end of the shaft 125 is formed with screw-threads to receive a nut 154. My upper rotor 152 has a hollowed out portion 155 into which projects the lower end of the shaft 125, and the nut 154 holds the upper rotor 151 firmly in place on the shaft 125. The upper rotor is provided with a working surface 156 adapted to lie parallel to the working surface 149 of the lower rotor 146.

It is obvious that close adjustment between the working surfaces may be effected by adjusting the position of the upper shaft 125, as has previously been explained in connection with the other modifications described. Passing through the upper rotor is an inlet duct 157, whereby the material to be disintegrated may be fed directly on the film itself which exists between the working surfaces. A screw valve 158 can be used to regulate or prevent the flow of liquid through the duct 157, or the duct may be omitted entirely, if desired.

The duct 157 communicates with a duct 159 leading from the duct passing down the middle of the hollow shaft 125. By this system of ducts, material may be fed directly from the center of the shaft 125 to the film itself. A screw valve 161 located below the entrance of the duct 159 into the central aperture of the shaft 125 can be used to regulate the flow of liquid down the center of the shaft 125, and the flow of liquid through the end of the shaft into the chamber formed by the hollowed out spaces 147 and 155 of the lower and upper rotors, respectively, can thus be regulated or entirely prevented.

By reason of the screw valves 158 and 161, material can be fed through the center of the shaft or directly on the film, or both, as desired. Since the working surfaces can be rotated in opposite directions, it is possible to obtain an extremely high relative velocity. The working surfaces, however, are held fixedly apart, and the distance between them can be accurately adjusted by means of regulating the position of the upper working surface. As this modification of the mill is designed, the lower working surface is not adjustable. It is possible to hold one of the working surfaces stationary, or even to re-

volve both in the same direction, for so long as their relative velocity is high, the necessary film shear can be obtained.

Referring to Fig. 2, I have shown in detail types of working surfaces which may be employed in connection with the type of mill shown in Figure 1. In the form shown in Figure 2, the shaft 126 supports a rotor 162, having a hollowed out portion 163, and a smooth frusto-conical working surface 164. The upper shaft 125 supports a rotor 165 having a hollowed out portion 166, and a frusto-conical working surface 167.

As in the type of working surfaces shown in Fig. 1, it is possible to rotate the working surfaces in the same or in opposite directions, or to maintain one of them at rest. By these various changes in the relative speeds of the working surfaces, different effects may be obtained, since by rotating the working surfaces in the same direction, but at different speeds, the total centrifugal effect may be increased.

Ordinarily in the form shown in Fig. 2, however, the working surfaces are adapted to be rotated in opposite directions. The centrifugal force acts outwardly and presses the particles tightly against the working surface 164, which is the outer working surface. The centrifugal force then operates to hold the particles tightly in contact with the moving surface instead of tending to push the particle away from the moving surface, as for instance is the case in the form of mill having a conical rotor surrounded by a conical stator. The particle, therefore, since it is held against a moving working surface is more strongly acted upon by the disruptive forces existing in the film. To express the idea roughly, the particle is held to its job by the forces exerted upon it and the particle and the film are given a greater circumferential velocity than is the case where the outer working surface is stationary.

It was found by computation based upon experimentation, as before stated, that in the form of mill where the outer or enclosing surface is stationary, the velocity of the particle along its path between the working surfaces was considerably less than half the velocity of the moving working surface. Even at high speeds, the forces at work within the film, in this type of mill having an outer enclosing stator, were generally not sufficient to disintegrate hard substances such as barytes.

The essential feature of any apparatus producing disruptive forces in films of liquid, or suspensions of substances in liquid, confined between closely adjacent surfaces, moving relatively to one another at high speeds, is to bring about the disruptive forces at as high a speed as possible. The form of mill shown in Fig. 2, and other forms working on a similar principle, since it holds the particles to the moving surface, tends to bring about the disruptive forces at a greater speed for any given speed of rotation, than is the case where centrifugal force tends to carry the particles away from the moving surface.

To make this plain, referring to Fig. 9, it can be stated that liquid entering the film or clearance space between the surface R or S moves in the direction shown by the arrow X. When inside the film, the main forces at work on the liquid are as follows: When the liquid comes in contact with the rotor, the latter imparts to it a velocity in a circumferential direction, and in fact, tends to carry the film around with it. Centrifugal force, however, is also imparted to the liquid, tending to throw the liquid against the surface S, as indicated by the arrow T. The final component of this force along the direction indicated by the arrow V ejects the liquid from the film confines.

If instead of rotating the portion R of the apparatus diagrammatically illustrated in Fig. 9 of the drawings, this portion is allowed to remain stationary and the portion S is rotated, it will be found that the conditions will be changed when liquid passes through the film. The liquid entering the film now comes in contact with the revolving surface S, which tends to carry the film around with it circumferentially, as did the rotor R of the type in which R moved and S was stationary. Where the portion S is rotating, the centrifugal force tends to force the liquid on the rotating surface S. It is clear, therefore, that the forces at work are all helping to maintain and increase the circumferential velocity of the liquid within the film.

The essential point in the improved method of producing disruptive forces in films of liquid, or suspensions of liquids, confined between closely adjacent surfaces rotating relatively to one another at high speeds, is that the outside surface shall revolve and not the inner. This insures that centrifugal force aids the production of high velocity by holding the liquid or suspension on to the rotating surface.

This improved method of producing disruptive forces becomes more marked as the diameter of the rotating member is reduced and the relative peripheral speeds kept the same.

It can be very simply shown that in two extreme cases as mentioned below, the centrifugal forces at work are scarcely comparable.

Take the case of one machine in which the rotor is 1″ in diameter and rotating at sixty thousand revolutions per minute and that of a rotor 15″ diameter and rotating at four thousand revolutions per minute. While the peripheral speeds are the same, the centrifugal forces at work in the case of the small rotor are many times that in the case of the large rotor.

It is becoming more and more necessary to produce machines of small diameter, and

this invention shows that by adopting the principle described herein, small machines can be made which will give excellent results.

The type of mill in which the outer working surface rotates causes, as has been explained, a particle acted upon by the disruptive forces to be tightly pressed against such working surface and in many instances there has been found to be an appreciable increase in efficiency of the mill by reason of this fact.

In Fig. 3 I have shown forms of rotor adapted to be used in connection with the modification of the mill shown in Fig. 1. The upper shaft 125 supports an inner rotor 168, having a hollowed out portion 169 and a cylindrical working surface 171. The lower shaft 126 supports a rotor 172, having a hollowed out portion 173, and a cylindrical working surface 174 adapted to lie adjacent to and overlap the working surface 171. In this form of mill it is obvious that an adjustment of the thickness of the film has to be determined before the parts are assembled, since the longitudinal adjustment of the shafts will not vary the distance between the working surfaces. In this form of mill, as in Fig. 2, when the outer working surface only is rotated, such surface generates the entire centrifugal force, and such force tends to hold the particles tightly against this surface. Even where both rotors are rotated, whatever centrifugal force is generated tends to press the particles against a surface which is itself moving, and under certain conditions the form of mill shown in Fig. 3 has been found to have increased efficiency over the form in which the outer rotor is stationary.

In the form shown in Fig. 4, the material is adapted to be fed between the working surface of a disk shaped upper rotor 175, fastened to the upper shaft 125, and the working surface of a lower disk shaped rotor 176, fastened to the lower shaft 126. The disk surfaces, as in other forms of the mill having two rotors adapted to rotate, may be made to rotate in the same or opposite directions or one of them may be held still; the working surfaces must move relatively at high velocity. Surrounding the outer peripheries of the disk shaped rotors is a confining band 177, having preferably integrally formed therewith a lower confining flange 178, and an upper confining flange 179. The confining band 177 and the upper and lower confining flanges fit closely around the periphery of the disk shaped rotors, and around the upper surface of the upper rotor, and the lower surface of the lower rotor.

This confining structure retards the issuance of the film with the material to be disintegrated therein, and tends to retain the film between the working surfaces for a greater length of time than would ordinarily be the case. Thus, the operator is enabled to subject the particles to be acted upon to the disruptive forces for a considerable length of time, and the action of the film may thereby be increased.

In Fig. 5 I have shown a form having an upper rotor 181 with a cone shaped hollowed out portion 182, which latter constitutes the input chamber of the mill. The rotor 181 is fastened to the upper shaft 125, which in this particular type is not shown as hollowed out, though it may be provided with a duct. In all forms having two movable working surfaces, ducts may be provided through both supporting shafts. The rotor 181 is made with a downwardly projecting flange 183, having a smooth cylindrical working surface 184 enclosing a smooth cylindrical working surface 185, of a rotor 186 mounted on the lower shaft 126.

In Fig. 6 I have shown a type of mill in which the members having the working surfaces may both be rotated. An upper rotor 187 is mounted on the upper shaft 125. A hollowed out portion 188 provides the intake chamber of the mill. The intake chamber is shown somewhat larger than the type shown in Fig. 5, and is of frusto-conical shape. The upper rotor 187 is provided with a downwardly projecting annular flange 189 having a horizontally projecting flange 191 at its bottom. Suitably attached by means of bolts or screws (not shown) to the flange 191, is an annular retarding member 192 whose inner edge projects beyond the cylindrical working surface 193 formed on the interior of the downwardly projecting flange 189 of the upper rotor.

Mounted on the lower shaft 126 is a lower rotor 194, whose working surface 195 is adapted to lie adjacent the cylindrical working surface 193 of the upper rotor. The annular retarding member 192 retards the passage of the film with its suspended particles therein from between the confines of the working surfaces.

In the forms shown in Figs. 5 and 6, the outer working surface may be rotated, which causes the particles acted upon to be firmly held against the outer moving surface by means of centrifugal force which, as has been explained, increases the efficiency of the action of the mill, since the particle is held tightly pressed against the surface which is producing the film shear.

In the form shown in Fig. 7, the outer working surface is also adapted to rotate and the centrifugal force acts to hold the particles against the surface which is generating at least a portion of the film shear. In Fig. 7 I have shown an upper rotor 196 mounted on the upper shaft 125. The upper rotor 196 is provided with a small conical

input chamber 197, and a frusto-conical downwardly flaring wall 198. On the interior of this downwardly flaring wall is a smooth frusto-conical working surface 199. Adapted to rotate within the smooth frusto-conical working surface 199 is a lower rotor 201, having a smooth frusto-conical working surface 202 adapted to lie adjacent the working surface 199. The lower rotor 201 is mounted on the lower shaft 126.

In Fig. 8 is illustrated still another type of mill which combines the frusto-conical features. The form shown in Fig. 8 is practically the same as the form shown in Fig. 7, with the addition that the downwardly extending wall 198 is provided with a horizontally extending flange 203 at its lower end, to which is fastened an annular retarding member 204, which lies adjacent to the lower surface of the lower rotor and tends to hold the film for a relatively longer period within its confines between the working surfaces.

If the inner edge of the annular retarding member 204 be so arranged that it is vertically below the entrance to the clearance space between the two coacting working surfaces, then the centrifugal force will no longer have a tendency to dispel the contents from the film confines, and the pressure of liquid in the film will be dependent upon the centrifugal force imparted to the liquid by virtue of its coming in contact with the rotating surface. To pass the liquid or suspension through the confines of the film, it will not be necessary to apply pressure to it, or to suck the liquid through the film from either side.

In the form of mill shown in Figure 1 and described above, with both rotors having equal working surfaces and rotating at the same speed in opposite directions, it is apparent that the centrifugal action of one rotor on the liquid film is offset and neutralized by the centrifugal action of the other rotor and the net result is that there is no tendency for the liquid fed into the mill to be retarded or accelerated in its passage through the mill by the action of the rotors. This being the case, mills of the construction shown in Figure 1 are not self-feeding, but the feed is controlled entirely by pressure applied to the liquid in the input pipes. The rate of feed being, in this case, independent of rotor speed, it follows that the time during which the material is subjected to the action of the rotors is controlled entirely by pressure applied to the liquid in the input pipes before it enters the mill. In this way, the rotor speed and time of treatment can be made to bear almost any relation desired. For example, in treating very resistant material, it may be desired to have a high rotor speed and at the same time a long period during which the material is under the action of the working surfaces of the rotors. This combination is only possible when rate of feed is independent of rotor speed, as in the form of mill shown in Figure 1.

While I have shown and described the preferred embodiment of my invention, I wish it to be understood that I do not confine myself to the precise details of construction herein set forth, by way of illustration, as it is apparent that many changes and variations may be made therein, by those skilled in the art, without departing from the spirit of the invention, or exceeding the scope of the appended claims.

I claim:—

1. An apparatus for disintegrating particles, liquid or solid, comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing the liquid with suspended particles therein in a thin film between the working surfaces at their inner peripheries, whereby the particles are disintegrated by reason of the disruptive forces within the film.

2. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid, comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, hollow shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing the liquid in a thin film between the working surfaces at their inner peripheries, whereby the particles are disintegrated by reason of the disruptive forces within the film.

3. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, hollow shafts upon which the rotatable members are mounted, means for introducing substances directly on the working surfaces, and means for rotating the shafts so that the working surfaces move past each other at high velocity, whereby particles subjected to the film of liquid existing between the working surfaces are disintegrated by reason of the disruptive forces within the film.

4. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having annular working surfaces and coacting hollowed portions, means for fixedly spacing said surfaces in very close proximity, hollowed shafts upon which the rotatable members are mounted and through which substances may be introduced into a chamber formed between the hollows in said rotatable members, and means for rotat-

ing the shafts so that the working surfaces move past each other at high velocity.

5. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having frusto-conical working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts on which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces at their inner peripheries whereby the particles are disintegrated by reason of the disruptive forces within the film.

6. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members, having frusto-conical working surfaces provided with an input chamber between said members, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

7. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having smooth frusto-conical working surfaces provided with an input chamber between said members, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

8. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having cylindrical working surfaces, means for fixedly spacing said surfaces in close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

9. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having cylindrical working surfaces, an input chamber between said members, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

10. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having smooth cylindrical working surfaces, an input chamber between said members means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

11. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and impeding means adjacent the output side of the working surfaces for preventing the free flow of the film from between the surfaces.

12. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, disk shaped rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and a confining band closely adjacent to the output side of said working surfaces for preventing the free flow of the film from between said surfaces.

13. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, disk shaped rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, a confining band adjacent the output side of the working surfaces, and confining flanges projecting inward towards the axis of rotation of said members beyond their periphery and adjacent to their outer surfaces.

14. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, two members with closely adjacent cylindrical working surfaces, the working surface of one member surrounding the working surface of the other member, means for causing said surfaces to move in opposite directions at high velocity, means for intro-

ducing the liquid in a film between said surfaces, and a retarding member adjacent the point of egress of the film, whereby the particles are disintegrated by reason of the disruptive forces within the film.

15. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid, comprising, rotatable members having cylindrical working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and an annular retarding member adjacent the output side of the working surfaces.

16. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having conical working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and a retarding member adjacent the point of egress of the film from its confines between the working surfaces.

17. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having smooth conical working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and a retarding member adjajent the point of egress of the film from its confines between the working surfaces.

18. An apparatus for disintegrating particles, liquid or solid, comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing the liquid with suspended particles therein in a thin film between the working surfaces at their inner peripheries, whereby the particles are disintegrated by reason of the disruptive forces within the film.

19. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, hollow shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces at their inner peripheries, whereby the particles are disintegrated by reason of the disruptive forces within the film.

20. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, closely adjusted adjacent surfaces both relatively movable in either direction past the other at high velocity, means for holding the surfaces fixedly spaced, means for causing such movement of said surfaces, and means for introducing the fluid in a film between said surfaces whereby the particles are disintegrated by reason of the disruptive forces within the film.

21. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, smooth closely adjacent surfaces both relatively movable in either direction past the other at high velocity, means for holding the surfaces fixedly spaced, means for causing such movement of said surfaces, and means for introducing the fluid in a film between said surfaces whereby the particles are disintegrated by reason of the disruptive forces within the film.

22. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, closely adjacent equi-distantly spaced surfaces both relatively movable in either direction past the other at high velocity, means for holding the surfaces fixedly spaced, means for causing such movement of said surfaces, and means for introducing the fluid in a film between said surfaces whereby the particles are disintegrated by reason of the disruptive forces within the film.

23. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, smooth closely adjacent equi-distantly spaced surfaces both relatively movable in either direction past the other at high velocity, means for holding the surfaces fixedly spaced, means for causing such movement of said surfaces, and means for introducing the fluid in a film between said surfaces whereby the particles are disintegrated by reason of the disruptive forces within the film.

24. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising two rotatable members having smooth annular working surfaces closely adjacent to each other, means for holding the surfaces fixedly spaced, means for causing both members to rotate with respect to the other, and means for introducing the liquid in a film between said working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

25. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid, comprising a member having a smooth annular working surface, a second member having a smooth annular working surface, closely adjacent to, coextensive with, and equi-distantly spaced from the first mentioned sur-

face, means for holding the surfaces fixedly spaced, means for causing each member to rotate in either direction with respect to the other, and means for introducing the liquid in a film between said working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

26. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid, comprising a member having a smooth annular working surface, a second member having a smooth annular working surface, closely adjacent to, coextensive with, and equi-distantly spaced from the first mentioned surface, but having no points of contact therewith, means for holding the surfaces fixedly spaced, means for causing each member to rotate in either direction with respect to the other, and means for introducing the liquid in a film between said working surfaces whereby the particles are disintegrated by reason of the disruptive forces within the film.

27. An apparatus for disintegrating particles, liquid or solid, comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing the liquid with suspended particles therein in a thin film between the working surfaces at their peripheries, whereby the particles are disintegrated by reason of the disruptive forces within the film.

28. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid, comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts, one of which is hollow, upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing the liquid in a thin film between the working surfaces at their peripheries, whereby the particles are disintegrated by reason of the disruptive forces within the film.

29. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts, one of which is hollow, upon which the rotatable members are mounted, means for introducing substances on the working surfaces, and means for rotating both the shafts in either direction, so that the working surfaces move past each other at high velocity, whereby particles subjected to the film of liquid existing between the working surfaces are disintegrated by reason of the disruptive forces within the film.

30. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having annular working surfaces and coacting hollowed portions, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means whereby substances to be treated may be introduced into a chamber formed between the hollows in said rotatable members, and means for rotating both the shafts so that the working surfaces move past each other at high velocity.

31. An apparatus for disintegrating particles liquid or solid, suspended in a liquid comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in very close proximity, shafts on which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces at their peripheries, whereby the particles are disintegrated by reason of the disruptive forces within the film.

32. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members, having annular working surfaces provided with an input chamber between said members, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

33. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having smooth annular working surfaces provided with an input chamber between said members, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating both the shafts in either direction so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

34. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having annular working surfaces, means for fixedly spacing said surfaces in close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working

surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

35. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having cylindrical working surfaces, an input chamber between said members, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, means for passing the liquid with suspended particles therein into and out of the input chamber, and means for introducing said liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

36. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, rotatable members having smooth annular working surfaces, an input chamber between said members, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating both the shafts in either direction so that the working surfaces move past each other at high velocity, and means for introducing liquid in a thin film between the working surfaces, whereby the particles are disintegrated by reason of the disruptive forces within the film.

37. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, disk shaped rotatable members each having a bevelled edge and an annular working surface, means for fixedly spacing said surfaces in very close proximity, shafts upon which the rotatable members are mounted, means for rotating the shafts so that the working surfaces move past each other at high velocity, and means whereby one of said members may be adjusted with reference to the other so as to vary the space between their working surfaces.

38. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, two members with closely adjacent annular working surfaces, the working surface of one member being coextensive with the working surface of the other member, means for causing said surfaces to move in opposite directions at high and equal velocities, means for introducing the liquid in a film between said surfaces, and means for axially adjusting one of said members with reference to the other to vary the thickness of the film, whereby the particles are disintegrated by reason of the disruptive forces within the film.

39. A method of disintegrating particles suspended in a liquid comprising applying the liquid containing the particles to the peripheries and adjacent surfaces of two closely adjacent, annular members each rotating at high and equal velocity in opposite directions, whereby the liquid is reduced to a thin film and the centrifugal action of said surfaces on the liquid film is substantially neutralized, and said liquid film is subjected to the shearing action of the rapidly moving closely spaced working surfaces of the annular members and the particles disintegrated by the disruptive forces within the film itself.

40. A method of disintegrating particles suspended in a liquid, comprising passing the liquid containing the particles between two closely adjacent, annular members each rotating at high and equal velocity in opposite directions whereby a very thin film of the liquid is subjected to the action of the closely adjacent working surfaces of the annular members, the centrifugal action of said surfaces on the liquid film is substantially neutralized and the particles of said liquid film are disintegrated by reason of the disruptive forces within the film itself.

41. A method of disintegrating particles suspended in a liquid comprising the subjection of a very thin film of the liquid with the suspended particles therein to the action of closely adjacent fixedly spaced surfaces each relatively movable one past the other in either direction at high velocity, applying pressure to the liquid entering the film and retarding by back pressure the ejection of the film to increase internal friction in the film, whereby the particles are disintegrated by reason of the disruptive forces within the film itself.

42. A method of disintegrating particles suspended in a liquid comprising the subjection of a very thin film of the liquid with the suspended particles therein to the action of closely adjacent fixedly spaced surfaces each relatively movable one past the other in either direction at high velocity, applying pressure to the liquid entering the film and additionally impeding the ejection of the film by a resisting pressure, the particles being disintegrated by the disruptive forces thus created within the film itself.

43. A method of disintegrating particles suspended in a liquid comprising the subjection of a very thin film of the liquid with the suspended particles therein to the action of closely adjacent fixedly spaced surfaces each movable one past the other in either direction at high velocity, applying pressure to the liquid entering the film and additionally reducing the speed of ejection of the film by a counterpressure whereby the particles are retained between the working surfaces for a longer time than when normal flow of the film is permitted, and the disruptive forces within the film are thereby increased.

44. A method of disintegrating particles

suspended in a liquid comprising the subjection of a very thin film of the liquid with the suspended particles therein to the action of closely adjacent fixedly spaced surfaces each relatively movable one past the other in either direction at high velocity, applying pressure to the liquid entering the film and partially obstructing the normal flow of the film between the moving surfaces by a resisting counterforce so as to increase the action of the disruptive forces within the film itself.

45. A method of disintegrating particles suspended in a liquid comprising the subjection of a very thin film of the liquid with the suspended particles therein to the action of closely adjacent fixedly spaced surfaces each movable one past the other in either direction at high velocity, applying pressure to the liquid entering the film and additionally impeding the velocity of ejection of the film by a counter pressure, the particles being disintegrated by the disruptive forces within the film, said disintegration increasing with the increase of said counter pressure by reason of the increased time during which said disruptive forces act on the particles within the film.

46. A method of disintegrating particles suspended in a liquid comprising the subjection of a very thin film of the liquid with the suspended particles therein to the action of closely adjacent fixedly spaced surfaces each movable one past the other in either direction at high velocity, and substantially neutralizing the centrifugal action of the moving surfaces on the film by rotating them at the same speed in opposite directions.

47. A method of disintegrating particles suspended in a liquid comprising the subjection of a very thin film of the liquid with the suspended particles therein to the action of closely adjacent fixedly spaced surfaces each movable one past the other in either direction at high velocity, substantially neutralizing the centrifugal action of the moving surfaces on the film by rotating them at the same speed in opposite directions and applying pressure to the liquid entering the film to force it between said moving surfaces and control the rate of flow of said liquid.

48. A method of disintegrating particles suspended in a liquid comprising the subjection of a very thin film of the liquid with the suspended particles therein to the action of closely adjacent fixedly spaced surfaces each movable one past the other in either direction at high velocity, substantially neutralizing the centrifugal action of the moving surfaces on the film by rotating them at the same speed in opposite directions, and controlling the time of action of said moving surfaces on said film by pressure applied to the liquid entering the film.

49. An apparatus for disintegrating particles suspended in a liquid film comprising closely adjacent fixedly spaced working surfaces, both movable in either direction past the other at high velocity, means for causing such movement of such surfaces, and means for substantially neutralizing the centrifugal action of the moving surfaces on the film.

50. An apparatus for disintegrating particles suspended in a liquid film comprising closely adjacent fixedly spaced working surfaces, both movable in either direction past the other at high velocity, and means for moving said surfaces at high and equal velocities in opposite directions so as to substantially neutralize the centrifugal effect of the moving surfaces on the film.

51. An apparatus for disintegrating particles suspended in a liquid film comprising closely adjacent fixedly spaced working surfaces, both movable in either direction past the other at high velocity, means for moving said surfaces at high and equal velocities in opposite directions so as to substantially neutralize the centrifugal effect of the moving surfaces on the film, and means for applying pressure to the liquid entering the film to force it to flow between said working surfaces and control the rate of flow of said liquid film.

52. An apparatus for disintegrating particles suspended in a liquid film comprising closely adjacent fixedly spaced working surfaces, both movable in either direction past the other at high velocity, means for moving said surfaces at high and equal velocities in opposite directions so as to substantially neutralize the centrifugal effect of the moving surfaces on the film, and means for controlling the time of action of said working surfaces on said film independent of the motion of said moving surfaces.

53. An apparatus for disintegrating particles suspended in a liquid film comprising closely adjacent fixedly spaced working surfaces, both movable in either direction past the other at high velocity, means for moving said surfaces at high and equal velocities in opposite directions so as to substantially neutralize the centrifugal effect of the moving surfaces on the film, and means for controlling the time of action of said working surfaces on said film by applying pressure to the liquid entering the film.

54. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, two members with closely adjacent annular working surfaces, the working surface of one member being coextensive with the working surface of the other member, means for causing said surfaces to move in opposite directions at high and equal velocities, pressure producing means for producing pressure on the liquid in the film between the surfaces, and means for axially adjusting

one of said members with reference to the other to vary the thickness of the film, whereby the particles are disintegrated by reason of the disruptive forces within the film.

55. An apparatus for disintegrating particles, liquid or solid, suspended in a liquid comprising, two members with closely adjacent annular working surfaces, the working surface of one member being coextensive with the working surface of the other member, means for causing said surfaces to move in opposite directions at high and equal velocities, means for putting pressure on the liquid to force the film between said surfaces, and means for axially adjusting one of said members with reference to the other to vary the thickness of the film, whereby the particles are disintegrated by reason of the disruptive forces within the film.

In testimony whereof I affix my signature.

FREDERICK JOHN EDWIN CHINA.