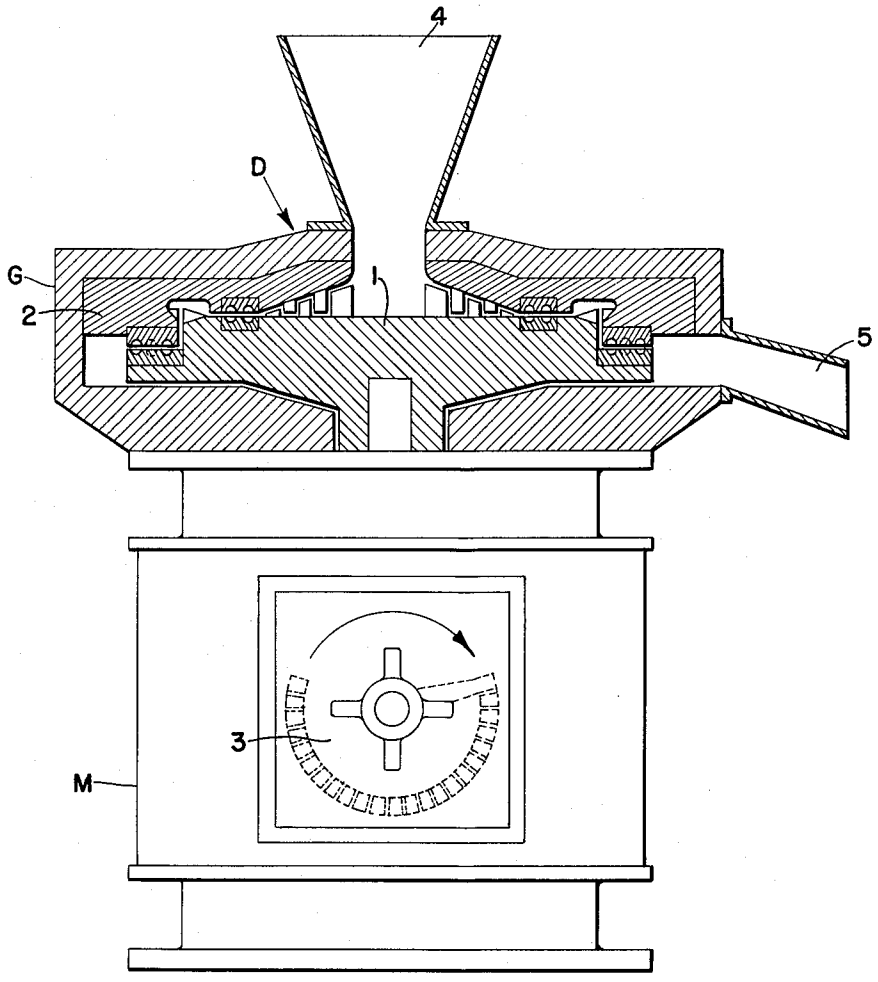
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COMMINUTING APPARATUS AND METHOD

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FIG. 1



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FIG. 2

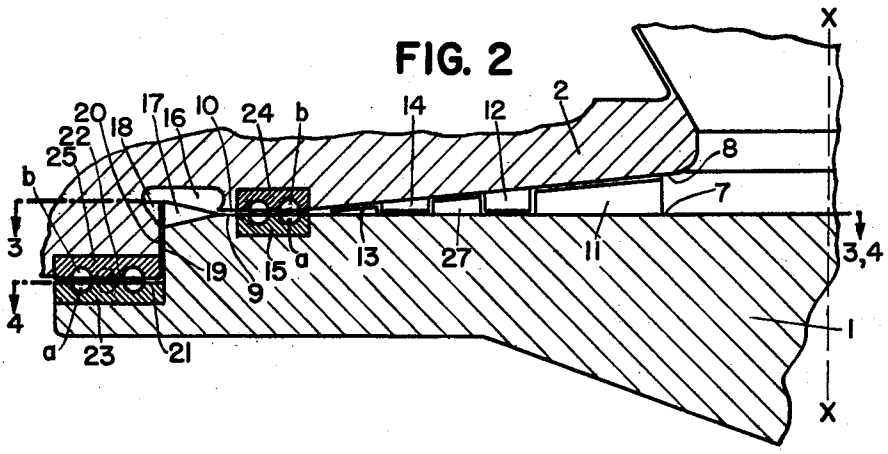


FIG. 3

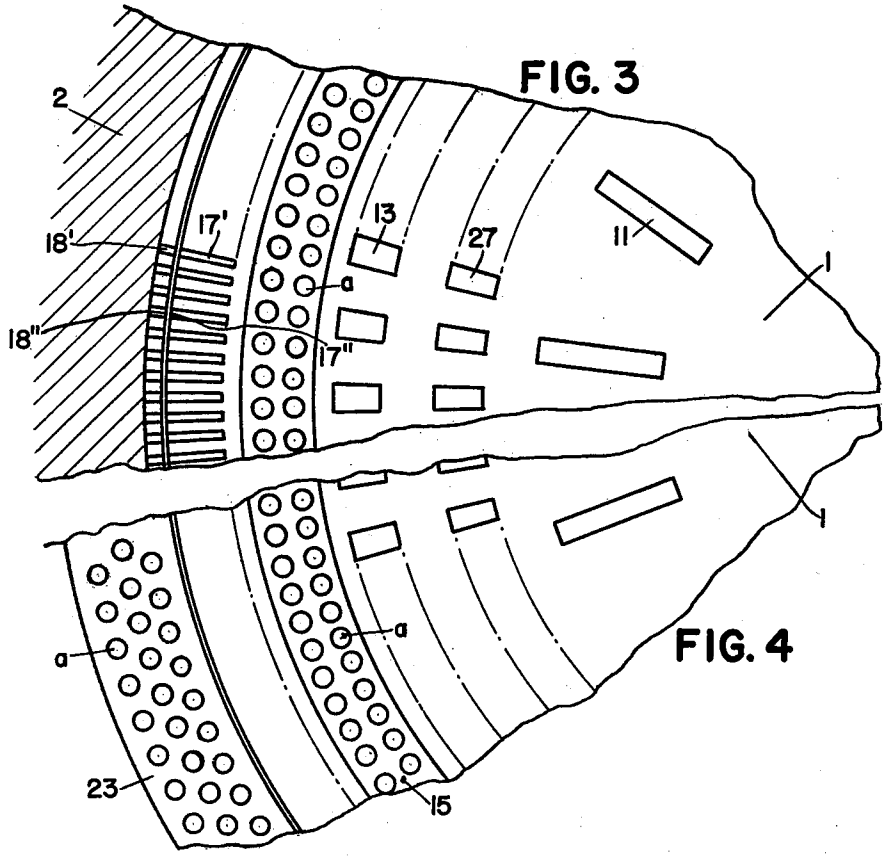


FIG. 4

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COMMINUTING APPARATUS AND METHOD

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This invention relates to a method and apparatus for finely subdividing materials for producing finely subdivided stable and intimate mixtures, such as emulsions, suspensions or dispersions.

For this purpose there are already known many methods and machines which operate on the material to be treated by applying external forces thereto. By these methods subdivision into particles of colloidal size is attained only by excessive expenditure of energy or by an extended time of treatment of the material.

Furthermore it is known to produce finely subdivided intimate mixtures in fluid phase by ultrasonic means. According to the prevalent theory the subdividing is principally caused by the external influence on the outer zones of the material under treatment of the sound energy causing cavitation effects in these zones. However the cavitation not only effects the desired subdivision of the material to be treated but also tends to deteriorate the surfaces of the container walls. Therefore ultrasonic installations have but a short life. Furthermore there is always the danger that the subdivided product will be contaminated by traces of foreign material. Ultrasonic treatment is also disadvantageous with regard to the high sound energy and the long time of treatment needed.

The primary object of this invention is the provision of an improved apparatus and method of mechanically subdividing materials by forces acting directly upon the single or individual particles thereof.

A further object of the invention consists in imposing the subdividing forces in such a manner that the material will readily disintegrate by operation of resonance effects.

According to a feature of the invention, the material to be subdivided is subjected to internal forces such as cavitation and/or underpressure implosion by moving it through a system consisting of narrow spaces or gaps and roomy spaces or exciter chambers regularly alternating with each other.

The method of subdividing material according to the invention is differentiated from the prior art cited above in that the forces do not act externally and therefore indirectly but internally and throughout the body of the material under treatment. According to my present theory these disintegrating forces are believed to be cavitation or underpressure implosion respectively. However, these cavitational effects are produced not only indirectly such as by a sound generator in the outer zones of the material but directly and mechanically in the very core of the material. Therefore subdividing and mixing occur very efficaciously and in the shortest time, the material not being contaminated by particles of the container or of other parts of the installation. Another advantage of the improved method consists in that the subdividing internal forces are not bound to the use of ultrasonic frequencies but can also act at substantially lower frequencies. Thus even material difficult to disintegrate can be changed into finely divided, stable and intimate mixtures by internal forces generated in small vessels and with small energy input.

In apparatus according to the invention chambers of hemispheric or hemicylindrical form have been found to generate exceptionally strong internal subdividing forces.

The term "moving the material through an area consisting of alternating narrow spaces and roomy spaces" is intended to comprise all kinds of relative movement between the material and the system of gaps and exciter chambers. Therefore the invention can be performed by moving the mass through an existing system of alternating gaps and exciter chambers or by generating the alternating of gaps and exciter chambers with regard to the single mass particles during operation.

Another feature of the invention consists in adjusting the frequency of the passage of the exciter chambers or the speed of passage of the material through the gap space to the qualities of the material in such a way that the material is disturbed in its textural strength and especially brought into resonance. In this sense materials of high internal strength such as metals or highly polymeric substances are treated under conditions of frequency of the ultrasonic range. However the term "ultrasonic frequency" does not at all mean that ultrasonic energy, namely vibration, is generated. It only says that the forces generated in the interior of the material are changing with a frequency having the numerical range of ultrasonic vibrations.

The invention will now be described in detail with reference to the accompanying drawings which illustrate a preferred exemplary embodiment of a comminuting apparatus according to the invention. In the accompanying drawings:

Fig. 1 is a view in side elevation, partly in section, of a comminuting apparatus according to the invention;

Fig. 2 is a sectional view at an enlarged scale of apparatus of Fig. 1;

Fig. 3 is a fragmentary plane sectional view taken on the line 3—3 of Fig. 2; and

Fig. 4 is a fragmentary plane sectional view taken on the line 4—4 of Fig. 2.

The minutely dispersing machine according to Figure 1 comprises a driving motor supported in upright position inside a pedestal or motor housing M, and the dispersion or comminuting machine proper, generally indicated at D. The speed of the motor may be adjusted by any appropriate means such as the rheostat 3. The casing G of the comminuting machine is fixed on the motor flange in the usual way, for instance by means of screw bolts. The rotor 1 of the dispersion device is coupled to the shaft of the motor M. In the casing G of the dispersion device an insert 2 is provided, which acts as the carrier of the stationary part of the dispersing system or systems. On the upper side of the dispersion machine is the hopper 4 for the material to be treated and at the periphery of the casing G is the outlet branch 5 for the finished product. In the constructional form according to Figure 1 the rotor 1 rotates within the stationary part 2 of the dispersion system.

Referring particularly to Fig. 2, the operating parts of the comminuting or dispersing machine are seen to include the relatively rotatable members 1 and 2, 1 being a rotor in the example illustrated and 2 being a stator. The axis of relative rotation of the members is illustrated at X—X. These members present to each other surfaces of revolution 7 on the rotor and 8 on the stator which define between them a rotationally symmetric space of dimension parallel to the axis X—X which diminishes with increasing distance from that axis. Of the disk-shaped juxtaposed faces 7 and 8, one or both are concave; in the embodiment shown face 8 is concave, being of essentially conical shape, while face 7 is plane.

Radially outside the space between the conical face **8** and the plane face **7** both members are provided with an annular surface conforming to a common surface of revolution. These annular surfaces, **9** on the rotor and **10** on the stator, are in the embodiment illustrated plane surfaces. The members **1** and **2** are supported, by means of the casing G in Fig. 1 and the bearings (not shown) which support the rotor **1** with respect to the casing, so that the members **1** and **2** rotate relatively to each other with close clearance at the surfaces **9** and **10**.

Radially inside the annular portions **9** and **10**, which form an outer limit to the conical space between members **1** and **2**, there are provided on members **1** and **2** a plurality of ring-shaped arrays of teeth or projections concentric in the machine axis. In Fig. 2 arrays of teeth **11, 27** and **13** project from the rotor and arrays of teeth **12** and **14** project from the stator, the rotor arrays alternating in radial position with those of the stator, the teeth of each array projecting from the member on which they are mounted to pass with close clearance the face **7** or **8** as the case may be of the other member.

Radially outside the annular portions **9** and **10** the members are shaped, by the provision of an annular depression in at least one member, as at **16** in stator **2**, to define an annular cavity between the two members. Each of the members **1** and **2** is provided within the annular cavity so defined with a multiplicity of teeth, **17** on the rotor and **18** on the stator, which project into cavity **16** and which present thereto faces indicated at **17'** and **18'** respectively in Fig. 3. Teeth **17** and **18** move past each other with close clearance at edges or faces thereof, identified at reference characters **17''** and **18''** in Fig. 3, which extend perpendicularly to the plane of Fig. 3 and transversely to the clearance between the members at the annular surfaces **9** and **10** so that the material undergoing comminution in its flow through the machine tends to pass from between adjacent rotor teeth **17** across the clearance between teeth **17** and **18** and into the spaces between adjacent teeth **18** one or more times before passing out of the chamber **16**.

On opposite sides of the narrow clearance or working gap between the annular surfaces **9** and **10** the rotor and stator may be provided with insert rings **15** and **24** affixed therein. These rings have concentric series of hemispherical hollows *a* and *b* respectively on their opposed faces which form part of the annular surfaces **9** and **10**. These hollows, which in effect constitute exciter chambers or cavities, open only toward the working gap. They are limited in two dimensions and are similarly arranged on the facing rings **15** and **24** with a linear distance on each of the rings of substantially the cavity width between successive cavities and between the rows of cavities.

The rotor is provided with an annular shoulder **19**, and the stator has an annular rim **20** in closely spaced relation with the shoulder **19**. The rim and the shoulder define a further narrow gap between rotor and stator which extends in a direction parallel to the axis of the machine and through which the material under treatment flows from chamber **16**. At the end of the gap between the cylindrical surfaces **19** and **20** remote from the chamber **16** the members **1** and **2** are provided with an additional pair of mating annular surfaces **21** and **22**, which may also be set with insert rings, **23** on the rotor and **25** on the stator. The surfaces of the rings **23** and **25** are provided with concentric rows of depressions or cavities *a* and *b*, similar to the cavities *a* and *b* in the insert rings **15** and **24**. In embodiments of the invention which have them the groups of cavities *a* and *b* of the rings **15, 24** and **23, 25** periodically change from positions of full coincidence to positions wherein the cavities *a* on the rotor are staggered with respect to the cavities *b* on the stator. The periodic changes in pressure imposed by this alternation on the material in the cavities *a* and *b* generate cavitational effects which disperse the material. Adjustment of the speed of the rotor, as by means of the rheostat **3** (Fig. 1) adjusts the frequency of the alternate confining and releasing action to the textural qualities of the material being treated so that the textural strength thereof is disturbed by resonance effects. The inserts **15, 24, 21** and **23** with their cavities or depressions are however not necessary to all embodiments of the invention, the scope of the invention being set forth in the appended claims.

What I claim is:

1. Method of producing very finely divided intimate mixtures such as dispersions, suspensions and emulsions and the like comprising the steps of subjecting the material to be treated to a sequence of changes of internal stresses effecting local implosions generated by moving it through a system consisting of narrow spaced gaps and roomy spaced exciter chambers opening only towards the gaps, said gaps and exciter chambers alternating with one another, and adjusting the frequency of alternation to the textural qualities of the material in such a way that its textural strength is disturbed by resonance effects.

2. Method of producing very finely divided intimate mixtures such as dispersions, suspensions and emulsions and the like comprising the steps of subjecting the material to be treated to a sequence of changes of internal stresses effecting local implosions generated by moving it through a system consisting of narrow spaced gaps and roomy spaced exciter chambers opening only towards the gaps, said gaps and exciter chambers alternating with one another with ultrasonic frequency.

3. Method of producing very finely divided intimate mixtures such as dispersions, suspensions and emulsions and the like comprising the steps of mixing the material to be treated with fluid materials of low temperature and subjecting the mixture to a sequence of changes of internal stresses effecting local implosions generated by moving the same through a system consisting of narrow spaced gaps and roomy spaced exciter chambers opening only towards the gaps, said gaps and exciter chambers alternating with one another, and adjusting the frequency of alternation to the textural qualities of the material in such a way that its textural strength is disturbed by resonance effects.

4. Apparatus for producing very finely divided intimate mixtures such as dispersions, suspensions, emulsions or the like comprising rotor and stator members having cooperating faces relatively movable at high speed between which materials are fed for treatment, a central opening in one of said members through which the material is fed, one of said bodies having an annular shoulder defining a surface perpendicular to the axis of the bodies in a plane spaced from the major surface of the cooperating faces and the other of said bodies having an annular rim terminating in a surface in closely spaced relation with respect to the surface of said shoulder and said rim and shoulder defining a narrow working gap between the bodies extending in a direction parallel with the axis of the bodies, the cooperating faces radially outward of said central opening defining a conical space for a substantial distance outwardly of the opening and a narrow working gap radially outward of said conical space, one of said bodies having an annular channel with a depth in excess of the working gap and extending radially between said rim and said second mentioned narrow working gap, concentrically arranged spaced rows of teeth extending in alternate arrangement from the respective faces in a direction generally parallel with the axis of the rotor and the teeth of the rows of teeth having decreased extent outward of the opening, said teeth constituting a shearing stage in the treatment of the material, the cooperating faces of said members having concentric rows of depressions therein between the teeth and said annular cavity, radially extending teeth provided on the cooperating faces of the members within the confines of the annular cavity, and the cooperating facing surfaces of the

rim and shoulder having additional concentric rows of depressions therein, all the depressions during relative movement of the members generating a sequence of changes of internal stresses effecting local implosions in the material to be treated as it passes between the cooperating faces.

5. Apparatus for producing very finely divided intimate mixtures such as dispersions, suspensions, emulsions or the like comprising rotor and stator members having cooperating facing surfaces, means for driving the rotor at a high speed, one of said members having a central opening through which material is fed so as to pass between the surfaces, said surfaces extending relative to the axis of rotation of the rotor such that the area thereof radially outward of the central opening defines a conical space between the surfaces for a substantial distance outwardly of the opening, and a narrow working gap radially outward of the conical space, concentrically arranged spaced rows of teeth extending in alternate arrangement from the respective facing surfaces in a direction generally parallel with the axis of the rotor and the teeth of the rows of teeth having decreased extent in a radial direction outwardly of the central opening, said teeth constituting a shearing stage in the treatment of the material, and the cooperating surfaces further having concentric rows of depressions therein radially outward of the teeth whereby the depressions during relative movement of the members generate a sequence of changes of internal stresses effecting local implosions in the material to be treated as it passes between the cooperating surfaces.

6. Comminuting apparatus comprising two relatively rotatable members, each of said members having a surface conforming to a separate surface of revolution, said members being mounted for relative rotation with their said surfaces facing each other in coaxial relation, said surfaces being shaped to permit the mounting of said members with a narrow clearance therebetween at portions thereof displaced from their axis of relative rotation, one of said members being apertured adjacent the axis of relative rotation of said members for admission of a material to be comminuted to the space between said members radially inside said portions, a plurality of ring-shaped arrays of projections arranged on each of said surfaces radially inside of said portions, an annular depression in one of said surfaces radially outside said portions, and a multiplicity of teeth arranged on each of said members to present a face to said depression, the multiplicity of teeth on one of said members moving with close clearance past the multiplicity of teeth on the other of said members at faces of said teeth extending transversely to the flow of material through said depression.

7. Comminuting apparatus comprising two relatively rotatable members having substantially disk-shaped juxtaposed faces, at least one of said faces having a portion of concave shape, said members having each a plane annular portion radially outside the limit of said concave portion, one of said members having an annular cavity formed therein radially outside its annular portion, said members being shaped to have close clearance therebetween radially outside said cavity when supported with close clearance between said annular portions, each of said members having disposed radially inside its annular portion a plurality of circular arrays of teeth concentric with the axis of relative rotation of said members and projecting from its said face to the vicinity of the face of the other of said members, means supporting said members for relative rotation with close clearance between said annular portions, one of said members being apertured adjacent said axis of relative rotation for the supply of a material to be comminuted to the space between said members, and a multiplicity of teeth on each of said members having a face presented to the interior of said cavity, the teeth of each of said multiplicities having an additional face mating with a face of the teeth of the other of said multiplicities, said additional faces extending transversely of said plane annular portions.

8. Comminuting apparatus comprising rotor and stator members, said members having unlike facing surfaces coaxial in the axis of relative rotation of said members, one of said members being apertured adjacent said axis for the admission of material to be comminuted to the space between said surfaces, one of said surfaces having a concave portion, said surfaces each having radially outside said concave portion an annular portion, said annular portions both conforming substantially to a single surface of revolution, means to support said members for relative rotation with close clearance between said annular portions, a pluraliy of circular arrays of teeth arranged on each of said surfaces radially inside said annular portions, one of said members having formed therein an annular cavity radially outside said annular portions, and a multiplicity of teeth on each of said members projecting into said cavity, the teeth of one of said multiplicities being disposed radially farther from the axis of relative rotation of said members than the teeth of the other of said multiplicities, the teeth of said multiplicities moving past each other with close clearance between faces thereof extending transversely to the clearance between said annular portions.

9. Comminuting apparatus comprising rotor and stator members, said members having unlike surfaces coaxial in the axis of relative rotation of said members, at least one of said surfaces having a substantially conical concave portion, means to support said members for relative rotation in said axis with close clearance therebetween at the radially outer limit of said portion whereby there is defined between said members a rotationally symmetric space of dimension parallel to said axis diminishing with increased distance from said axis, a plurality of circular arrays of projections arranged on each of said surfaces within said space, said members being shaped to define therebetween an annular cavity radially outside said outer limit, and a multiplicity of teeth arranged on each of said members, each of said teeth having a face presented to the interior of said cavity and a face presented to the teeth on the other of said members, said last-named faces extending transversely of the clearance between said members at said outer limit.

10. Comminuting apparatus comprising rotor and stator members, said members having coaxial surfaces facing each other, one of said surfaces having a substantially conical concave portion, the other of said surfaces having a substantially plane portion of the same diameter as said conical portion, said members having each an annular portion of the same shape radially positioned adjacent the radially outer limit of said conical portion, means to support said members for relative rotation about an axis in which said surfaces are coaxial with close clearance between said annular portions, one of said members being apertured adjacent said axis of relative rotation for the admission of a material to be comminuted to the space between said surfaces, a plurality of ring-shaped arrays of teeth disposed on each of said members radially inside said annular portions, the teeth of said arrays projecting from their respective members to pass with close clearance the facing coaxial surface of the other of said members, the arrays on one of said members alternating in radial position with the arrays on the other of said members, an annular depression in one of said members radially outside the annular portion of its said surface, said depression having as inlet the clearance between said annular portions and having as outlet a close clearance between said members angularly disposed with respect to the clearance between said annular portions, and a multiplicity of teeth on each of said members disposed on opposite sides of said outlet and projecting into said depression, the teeth of said multiplicities moving past each other with close clearance

between faces thereof extending transversely of the clearance between said annular portions.

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