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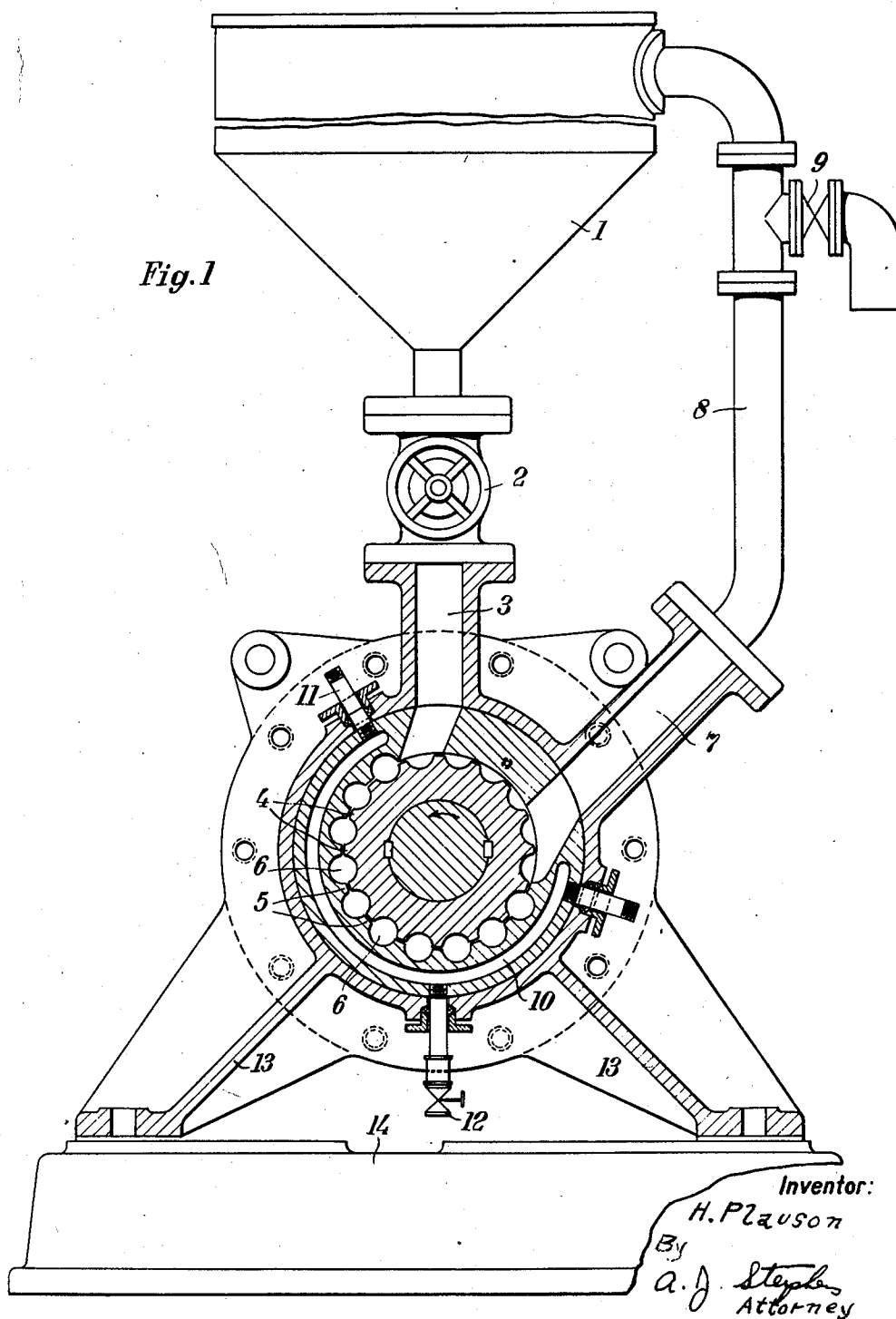
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2,225,797

COLLOIDAL MILL

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2 Sheets-Sheet 1



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Fig. 2

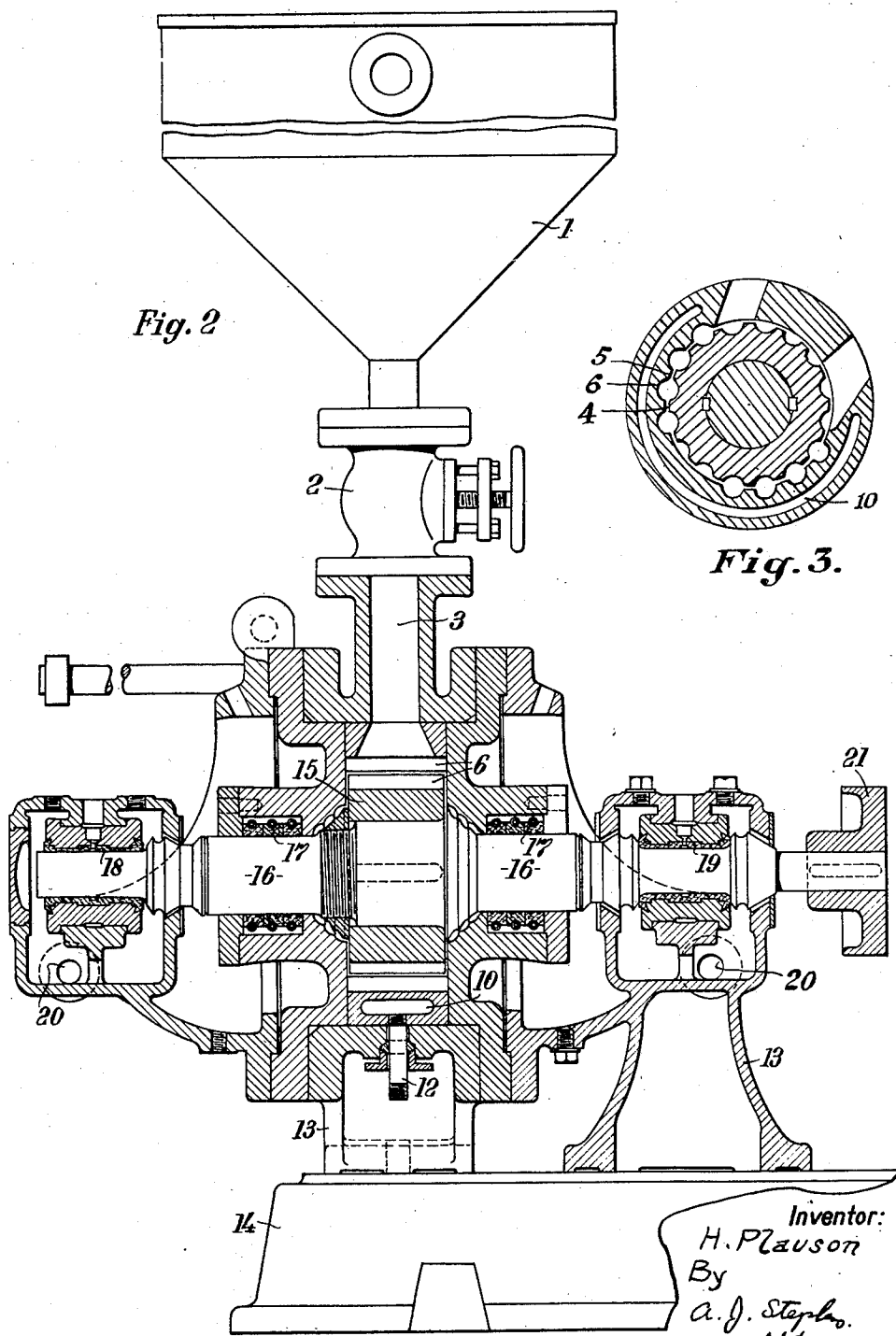


Fig. 3.

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COLLOIDAL MILL

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Colloidal mills are known in which one or two toothed wheels are mounted within a fixed counter-beater provided with similar teeth. In all these colloid mills the breadth of the teeth is equal or approximately equal to the intermediate spaces between individual teeth.

Such arrangements suffer from the following serious disadvantages:

The mill allows too little or almost too little of the material being treated between the toothed wheels, if the material runs continuously through the mill in the direction of rotation. The through flow capacity is too small even when the rotor teeth lie opposite the intermediate spaces of the counter-beater, because the breadth of the rotor teeth bridges over the opposite intermediate spaces. To overcome this disadvantage it has already been proposed to employ cross recesses cut in the toothed wheels in the direction of rotation.

Such a construction does indeed permit large quantities of material to be passed through the mill; but the efficiency is too low because a part of the fluid can pass through the intermediate spaces without being beaten.

A further deficiency of the known construction is that the vibrations occurring during the grinding have too small an amplitude for the principle of the colloid mill to be regarded as a vibration principle.

As a result of many experiments a new kind of colloid mill, forming the primary object of the present invention, has been developed, in which the grinding or dispersing action is produced by a very high rate of vibration or oscillation up to that of ultra sound waves, this amounting to the discovery of an entirely new principle of colloid milling.

On the basis of the experiments it has been established that an entirely new effect in colloid milling is obtained, if the ratio of tooth breadth to the intermediate spaces cut in the rotor and in the stationary casing serving as counter-beater, is not as hitherto usual 1:1, but is made 1:2 or still better in large machines 1:3 (the figures 2 and 3 indicating the ratio of the intermediate spaces cut between the individual teeth), and the material under treatment is carried in and out in the direction of rotation. With such a construction it is possible that the material under treatment at the instant that the rotor teeth are in the centre of the empty spaces between adjacent casing teeth, flows between the rotor and casing in a free zig zag path to the point of outflow. The feeding of the material from the inlet

to the outlet is effected by the rotation of the rotor, and this gives such a powerful pumping effect that the material can be pumped back from the outlet to the inlet funnel without any additional pump. In this way a multifold uninterrupted automatic circulation of the material through the mill and continuous rhythmic vibration of the material are made possible. The material can be pumped directly into the discharge receiving vessel through a separate pipe. In practice the circulating pipe will always remain more or less open even during discharge, to moderate the internal pressure on the stuffing box packing.

The action of the new vibratory colloid mill is based upon the feature that when the proportions of teeth and intermediate spaces are for example 1 cm. and 3 cm. (the depth of the intermediate spaces is about equal to the breadth of the teeth both in the rotor and the casing) two phases occur in each period. The first phase occurs when a casing tooth is opposite a rotor tooth. The greatest pressure and milling action then occurs. The flow of the fluid stream is however almost entirely interrupted. The second phase occurs when the tooth surface of the rotor is opposite the centre of the intermediate space between two tooth surfaces of the casing. Then the pressure action on the fluid material is least and a passage for the flow of fluid of 1 cm. cross section has been set free. The change from the one to the other phase proceeds in regular succession. The material during these periods must flow in a zig zag path through the free space opened from period to period between the rotor and casing and is thus subjected to periodic vibrations or oscillations of high rate which are produced by regularly alternating pressure and release.

Even with normal rates of the periods these colloid mills can work as reaction and dispersion apparatuses with high output. It is possible however to build machines which effect a raised rate of vibration which approaches the rate of ultra sound waves. In such constructions the new effects characteristic of the invention, which are similar to the effects of ultra sound waves, come into play.

A colloid mill is known in which a grooved cylindrical or slightly coned grinding rotor runs concentrically within a stator having the same number of grooves. An uninterrupted rhythmic vibratory action on the material under treatment as is obtained in the present construction of vibratory colloid mill by the arrangement of the inlet and outlet openings, is not possible in the

known mill even if the grooves are wider than the ribs because the feed direction for the material in this known mill is axial, so that the material is kneaded between the grooves and ribs in a helical path but a continuous rhythmic vibratory effect on the material is prevented by interference phenomena. In contradistinction the major advantage of the present vibratory colloid mill lies in the employment of continuous rhythmic vibration of the material. By the entry of the material, according to the invention, in the direction of rotation and its outflow after traversing say $\frac{3}{4}$ of the periphery of the casing before a final, smooth quarter, the vibratory colloid mill is at the same time given the ability to pump, which is of great importance for its technical employment and is unattainable with the known colloid mills.

One of the known colloid mills in addition has different numbers or pitches of tooth surfaces on the rotor and casing so that rhythmic vibrations as are obtained according to the present invention, are interrupted by interference phenomena.

The new colloid mill will be further described by the aid of examples.

Example 1

Rotor and casing each have 25 tooth surfaces of 1 cm. breadth 1 cm. depth, with 3 cm. intermediate spaces. A squirrel cage induction motor running at 3000 R. P. M. is directly coupled to the mill.

With this construction a periodic vibratory effect of $25 \times 3000 = 75000$ periods or 150000 amplitudes per minute acts on the material under treatment. A desired chemical reaction or dispersion which is subjected to such a rate of rhythmically occurring vibration, namely 2500 single amplitudes of vibration or 1250 periods per second, is by this mechanical force, given a high-value impetus and acceleration so that the apparatus according to the invention can render valuable service both as an excellent dispersing machine and for carrying out chemical reactions.

If this colloid mill is driven by the aid of toothed gearing at 6,000 R. P. M., then 150,000 periods or 300,000 single amplitudes per minute are obtained, equalling 2500 periods or 5000 single amplitudes per second.

This does not represent the limits of possibility however. The colloid mill can be driven at 9000 R. P. M. or, by the use of a high speed turbine, at 12,000 R. P. M.; in the latter case $25 \times 12,000 = 300,000$ periods or 600,000 amplitudes per minute are obtained, representing an extremely high periodicity per second. Phenomena similar to those on the boundaries of ultra-sounds now come into play and with them entirely new possibilities and new actions in the production of dispersions and the forwarding of chemical reactions by mechanical power.

Example 2

In order to achieve ultra-sound-like effects for particular purposes with the new, vibration principle, colloid mill, the tooth surfaces of the rotor and the casing are made with a breadth of but 5 mm. and the intermediate spaces between them of a breadth of 1 cm. and a depth of about 1 cm. If a rotor diameter of 300 mm. is used, which corresponds to a periphery of approximately 943 mm., then 63 periods are obtained per revolution. With a speed of only 6,000 R. P. M. accordingly

378,000 periods per minute are obtained, equalling 6,300 periods or 12,600 single amplitudes per second. Using a speed of 18,000 R. P. M. which is technically quite feasible and has already been employed, $63 \times 18,000 = 1,134,000$ periods and 2,268,000 amplitudes per minute are obtained equalling 37,800 amplitudes per second.

If the diameter is increased to 500 mm. and a driving speed of 18,000 R. P. M. is used, $104 \times 18,000 = 1,892,000$ periods or 3,744,000 amplitudes per minute, i. e. 62,400 amplitudes per second, are obtained. The working range of ultra sound waves is thereby attained. But in practical use excellent technical results are already obtained with considerably lower rates of vibration. It is desired to point out however that it is possible within the scope of the invention to obtain vibrations akin to ultra sound waves by means of the present vibratory colloid mill.

The present colloid mill is best constructed with a funnel having a regulating valve, arranged over the casing which itself is provided with a cooling or heating jacket. After starting the machine the material under treatment flows through the regulating valve and over $\frac{3}{4}$ of the periphery of the counter-beater casing, over the beater teeth and intermediate spaces, to the outlet. In a construction according to Example 1 the material in this time undergoes 25 pressure and release actions, that is 25 periods in unbroken succession. Shortly before the last quarter of the casing periphery the material is forced out by the pumping action of the toothed wheel and is returned through a pipe to the filling funnel, as long as the procedure is to be repeated. For discharge a suitable discharge fitting is provided in the return pipe. The interior of the casing is toothed to correspond with the rotor only over $\frac{3}{4}$ of its periphery. The quarter of the casing beyond the outlet is made smooth to permit pumping out or increase the pumping effect.

A heating or cooling jacket is provided in the casing of the vibratory colloid mill, through which for example in the treatment of pasty material steam or hot water can be led.

Colloid mills the action of which rests upon the principle of vibration were unknown hitherto. That vibration effects akin to ultra sound waves could be produced on liquids, gases or vapours by mechanical action was not known and above all how such effects were to be obtained in practice was not to be foreseen.

With the use of high periodicities, it is not necessary to extend the casing teeth according to the invention over the whole distance from inlet to outlet. On the contrary only say a half of this part of the casing or separate portions of it can be provided with teeth. For example closely after the inlet of a group of say 10 teeth can be provided and closely before the outlet another group of 10 teeth. Groups of teeth could however be provided at 3 or 4 places. Such a construction is necessary with very high periodicities to regulate the through flow rate.

In the accompanying drawings one construction according to the invention is shown by way of example.

In this drawing:

Fig. 1 is a cross section and

Fig. 2 is a longitudinal section through a colloid mill according to the invention.

Fig. 3 is a cross sectional view of a modified stator.

The material to be treated is supplied to the mill by way of a funnel 1 and a cock or valve 2.

The latter controls the feed of the material to be treated which reaches the vibratory space by way of a conduit 3. The vibrations are produced by a toothed wheel having teeth 4 rotating in the also toothed stationary casing having the same pitch teeth 5 as the toothed wheel. The teeth of both members are of the same shape and so constructed that for instance a space 6 of a width of 3 cm. follows a width of tooth of 1 cm. This construction and these proportions of size are essential to obtain the rhythmic vibratory action of uniform nature upon the liquid material to be treated.

Only $\frac{3}{4}$ of the circumference of the stationary casing is provided with the above mentioned toothings. No teeth are provided between the discharge or pumping out point 7 and the supply point 3, but these intermediate spaces are metallically filled. Due to this construction, the automatic pumping necessary for the vibratory colloidal mill is obtained and thereby a longer vibratory action of uniform and continuous character is possible on the material to be treated.

From the discharge point 7 a conduit 8 having a discharge valve or cock 9 leads back to the funnel 1 so that the material to be treated may continuously be acted upon until the desired state of quality is obtained.

The machine is provided with a cooling space 10, having inlet and outlet connections 11 and 12, and its lower frame 13 rests upon a foundation plate 14.

Fig. 2 illustrates the colloidal mill in an axial section showing the funnel 1, the feed control valve or cock 2 and the supply pipe 3. The spaces between the teeth 5 on the rotating inner toothed wheel and on the stationary casing are designated 6. The edges of the teeth are indicated on the drawing. The body of the toothed wheel and the axis are designated 15 and 16 respectively. The water cooling or heating space and the feed connection are again designated 10 and 11 respectively.

The shaft 16 is, at the points where it passes through the wall of the vibratory space, sealed by means of a metal-graphite-packing 17. The shaft 16 ends on the one hand behind a pressure oil bearing separated from the machine and on the other hand is passed through a pressure oil bearing and ends in a coupling projection 21. The pressure oil bearings are designated 18 and 19 and are connected to pumps (not shown) through 20. The oil pump constantly and automatically effects lubrication under pressure. By means of the coupling projection 21 the machine is connected to the motor either directly or by way of a gear changing the speed of revolution.

What I claim is:

1. A colloid mill comprising a casing, internal teeth in said casing over about three quarters of its periphery, the remainder being smooth and at the height of said teeth, an inlet to said casing located at one end of said smooth remainder and directed peripherally away therefrom, an outlet from said casing at the other end of said smooth remainder, a rotor journaled in said casing, and teeth on said rotor running with small clearance past said casing teeth, the casing teeth and rotor teeth being equally pitched and their thickness being substantially less than the spaces between adjacent teeth.

2. A colloid mill comprising an internally toothed casing and a toothed rotor therein, the teeth of said casing and rotor being equally pitched but having a thickness substantially less than the spaces between adjacent teeth, the casing only being toothed in groups over a fraction of its periphery and provided with an inlet in front of said fraction to direct supplied fluid material in the peripheral direction and with an outlet beyond said fraction and the untoothed portion of said casing between said inlet and outlet embracing a substantial angle and lying close to the teeth of said rotor.

3. A peripheral flow colloid mill comprising a rotating toothed rotor and an internally toothed casing surrounding said rotor, the rotor and casing having equally pitched teeth, the tooth width of the rotor and casing being in a ratio of about 1:2 to 1:3 to the spaces between the teeth and the casing only having teeth over $\frac{3}{4}$ of its periphery and being smooth and close to said rotor teeth over the remaining quarter, an inlet for the material being provided immediately after the smooth quarter of the periphery of the casing, and an outlet for the material being provided immediately before said smooth quarter.

4. A colloid mill comprising a casing having smooth arcs of substantial length and tooth groups alternating, the tops of the teeth being level with said smooth arcs, an inlet to said casing located at one end of one of said smooth arcs and directed peripherally away therefrom, an outlet from said casing located at the other end of said last mentioned smooth arc, a rotor journaled in said casing, and teeth on said rotor running with small clearance past said casing teeth, the casing teeth and rotor teeth being equally pitched and their thickness being substantially less than the spaces between adjacent teeth.

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