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GRINDING APPARATUS

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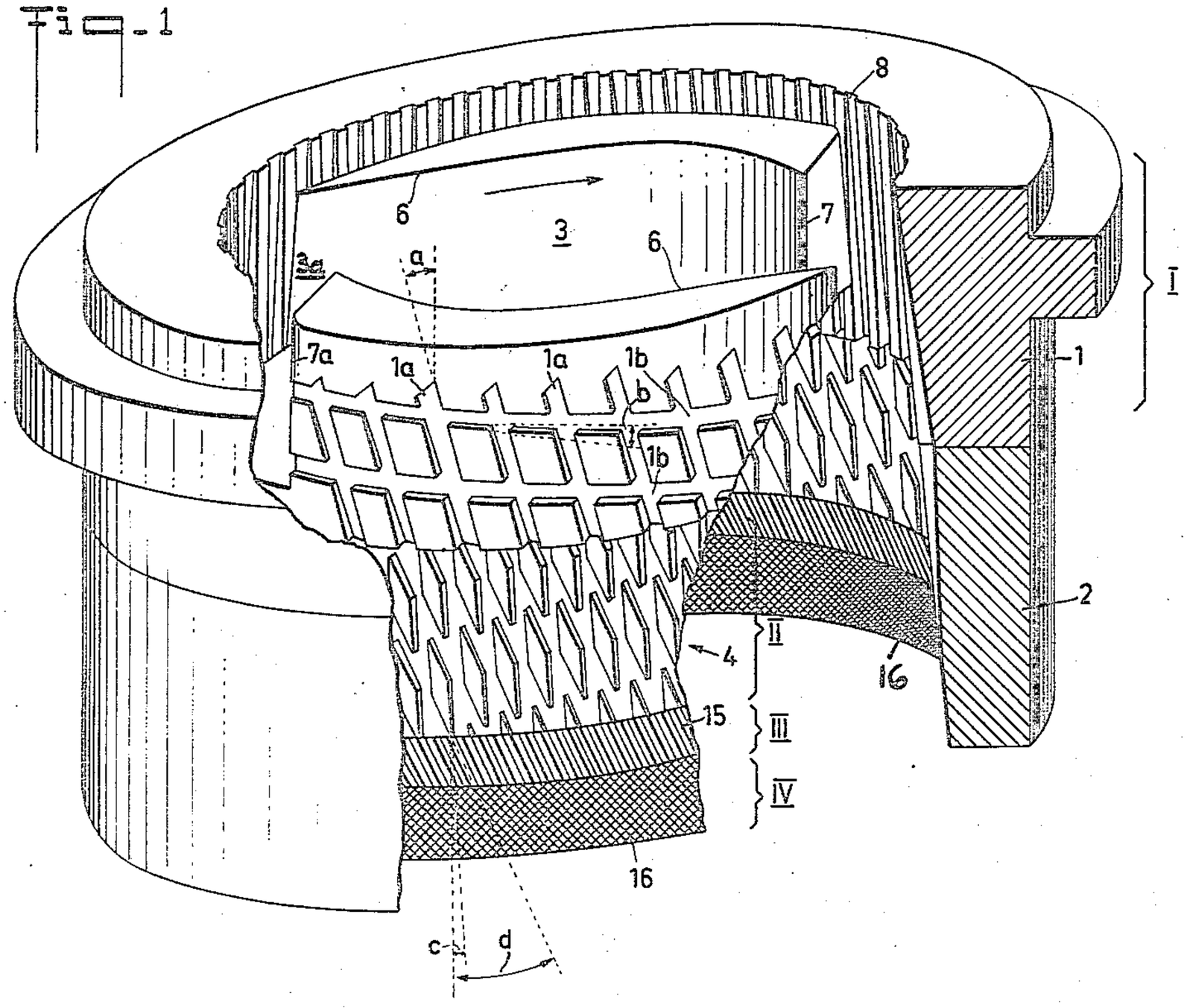
Fig. 1



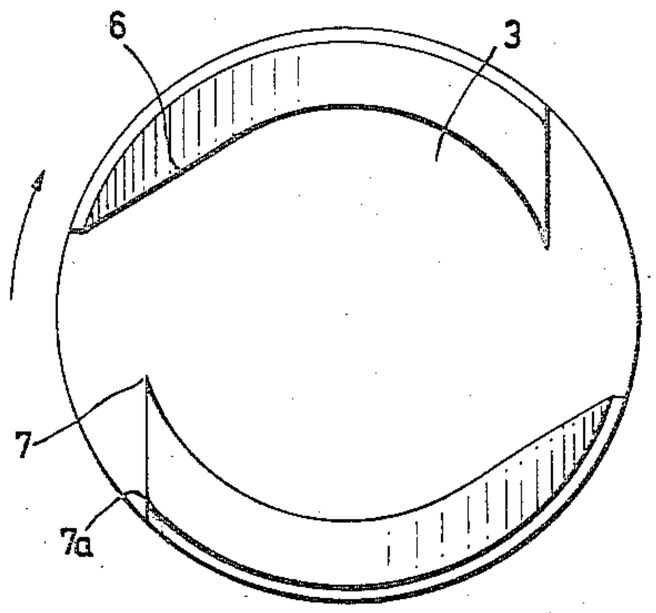


Fig. 3

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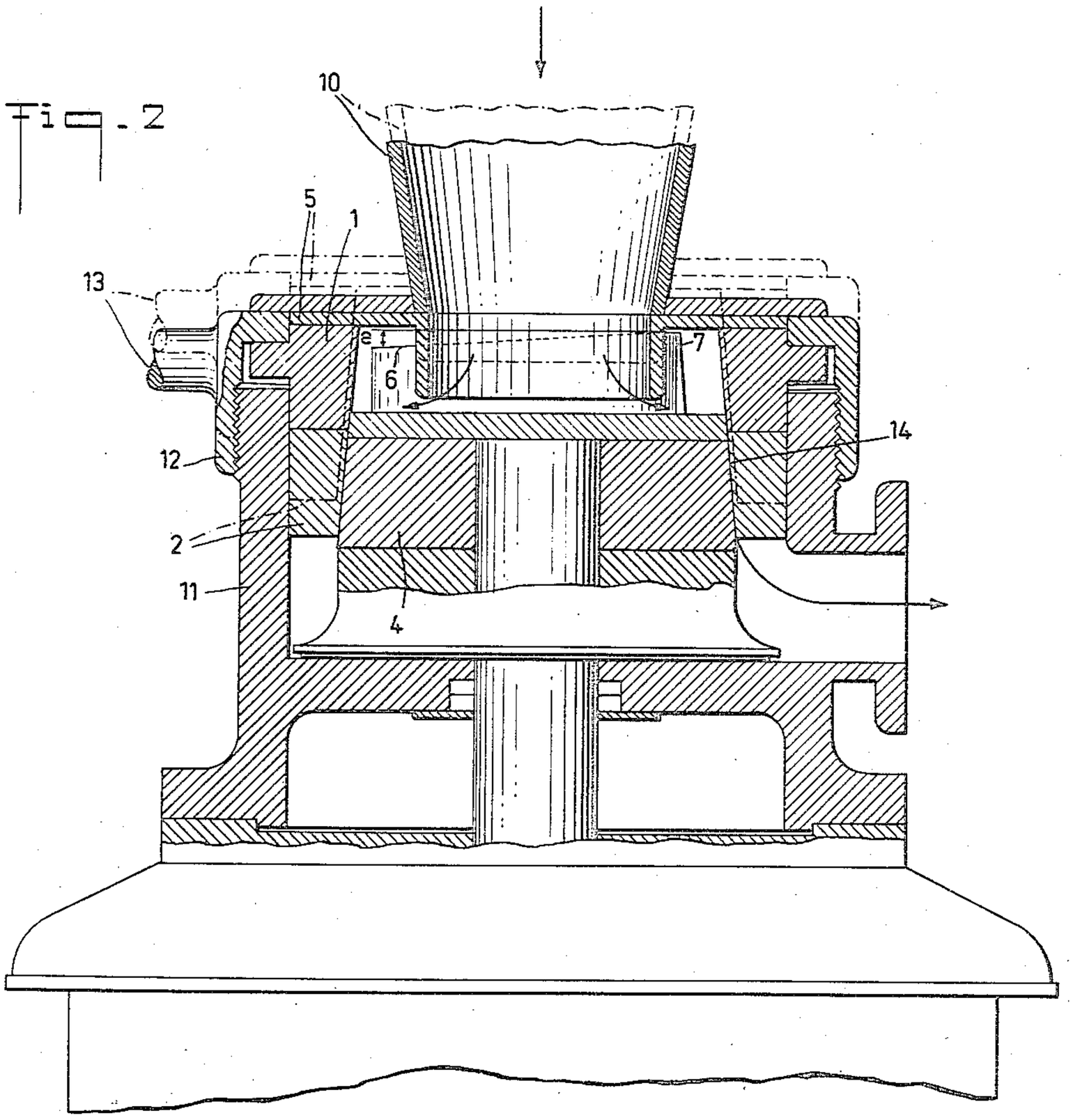
Fig. 2



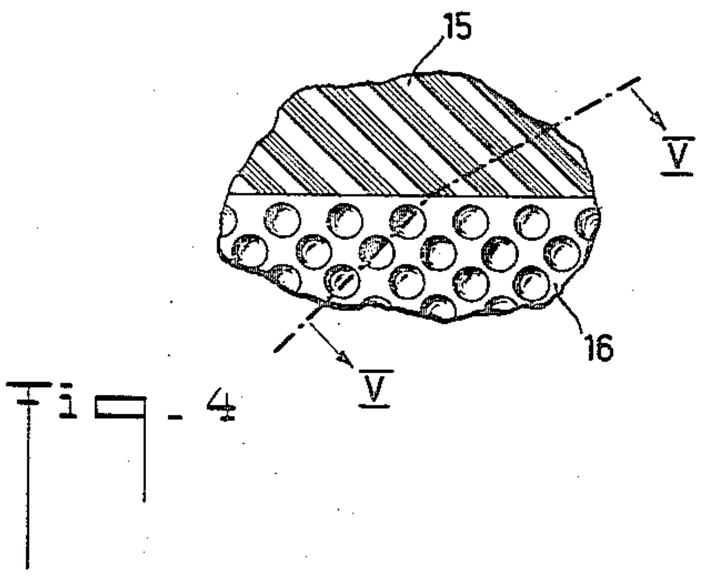
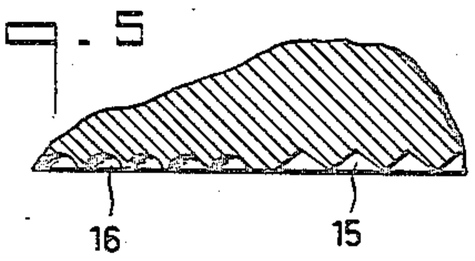


Fig. 4

Fig. 5



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GRINDING APPARATUS

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9 Claims. (Cl. 241—162)

The present invention relates to colloid mills with stationary and rotating conical grinding elements, wherein grinding is effected in a plurality of grinding zones.

Colloid mills, which have found wide use in the chemical and food industries to comminute, homogenize and emulsify a variety of substances, work either with hard grinding disks or with serrated grinding elements. The arrangement, size and direction of the serrations determines the degree of comminution obtainable by the mill.

It is one of the disadvantages of known mills of the above types that relatively large particles of the substance to be ground reach the zone of fine milling, whereby the grinding elements are unnecessarily and prematurely worn out.

It is the principal object of the present invention to overcome the above disadvantage and to provide a grinding machine for the finesh milling, having a long useful life.

To obtain the above and other objects and advantages, milling is performed according to this invention in separate and succeeding grinding zones, the ground material being transferred from one zone to the next without backing up and the finest grinding being effected with the least demand on the machine and under low heat development.

The above and other objects, advantages and features of the invention will be more particularly described in connection with one now preferred embodiment of a colloid mill illustrated in the accompanying drawing, wherein

Fig. 1 is a perspective view, partly broken away, of the stator and rotor of a colloid mill showing four milling zones;

Fig. 2 is a vertical section of the colloid mill with vertical adjustment of the milling elements, the uppermost position of the stator being shown in broken lines;

Fig. 3 is a top view of the rotor;

Fig. 4 is an enlarged top view of a portion of the grooved transfer zone and the roughened fine milling zone; and

Fig. 5 is a section along line V—V of Fig. 4.

In the illustrated embodiment of the grinding apparatus according to the invention, four milling zones are used as follows:

Zone I: Pre-grinding
Zone II: Coarse grinding
Zone III: Transfer and sorting
Zone IV: Fine milling

The operation of the colloid mill will best be understood by referring to the accompanying drawing:

Pre-grinding

The material is charged into pre-grinding zone I by hopper 10 whence it arrives in chamber 3 and is thrown radially outwardly by the rotating grinding element along tangential surface 6. The material is partially seized by the serrations of stator 1 and is partially engaged by cutting edge 7 of chamber 3, being led to the stator

1 along surfaces 7, 7*a* (see Fig. 3). The material accumulating in the corners will be pulled by the rotor 4 directly into the serrations 8 of stator 1 and will there be subjected to a pre-grinding operation. The coarsely cut material will travel downwardly in the vertical grooves 1*a* as well as in the oblique grooves 1*b* inclined from the horizontal under an angle *b*. Upward displacement of the material will be substantially eliminated by upwardly tapering vertical serrations 8 of stator 1 and the vertical serrations of the rotor in the pre-grinding zone I. In this zone, the material will be subjected less to a crushing action than to grinding and cutting. The upper edge of the potlike pre-grinder inclines under an angle *e* from cutting edge 7 to tangential surface 6 to prevent the material from adhering to the grinder at these areas.

Cylindrical collar 5 is mounted on stator 1 and partially covers the lateral openings or windows 3*a* in chamber 3. This arrangement has the purpose of controlling the amount of material immediately before it enters the serrations. As is known, the grinding size in such colloid mills may be adjusted by vertically adjusting the spacing of stator 1 and the rotor 4. For this purpose, stator 1 is mounted on the mill housing 11 by means of threaded adjustment ring 12. When the ring 12 is rotated by handle 13, the stator 1 is vertically moved on the mill housing to narrow or widen milling gap 14 between the rotor and stator (see full and broken lines in Fig. 2).

The novelty of the above-described arrangement lies primarily in the provision of tangential surface 6, cutting edge 7, the oblique upper edge of the pre-grinder under angle *e* and the oblique grooves forming angle *b* which form tooth segments with the vertically sloping grooves forming angle *a*. Upwardly tapered serrations 8 of stator 1 and cylindrical collar 5 are also essential features of the invention.

Coarse grinding

The coarse grinding zone begins where the serration grooves 1*a* and 8 have the greatest depth. The transfer from the pre-grinding zone is effected without jamming or additional heat development. The milling is effected in this zone by serrations whose grooves form respective angles *c* and *d* with the vertical axis. The direction is determined by the direction of rotation of rotor 4. The material is seized by the tooth segments of the serration and is further comminuted between stator 2 and rotor 4. The grooves are tapered downwardly so that the grain size of the material becomes constantly smaller.

In this portion of the grinding apparatus, the essential feature is the grooves which cross each other at predetermined angles to form tooth segments therebetween. The total cutting surfaces of these segments are larger, the grinding is more thorough and the milling more uniform than in known apparatus of this type. Prior art mills have the disadvantage that most of the material is cut only once, slides immediately downwardly through the vertical grooves and is then finely ground by closely-spaced serrations, placing an added load on the mill and causing concomitant development of considerable heat. These disadvantages are avoided with the above-described arrangement.

Transfer and sorting

The coarsely ground material is sorted in Zone III which is so constructed that only material of a predetermined grain size is received therein while larger particles are comminuted in the slot 14 between the stator and rotor. This will considerably reduce the mechanical and thermal load on the grinders. Therefore, no serrations with cutting action are provided in this zone. If desired, the upper edges of the transfer grooves 15 may be bevelled.

Fine milling

The uniformly ground material prepared in accordance with the above-described procedure is thus transferred into the fine milling zone IV. The roughened surfaces **16** of stator **2** and rotor **4** prevent sliding of the material between these surfaces and thus eliminate undesirable heating. The material is turned about in the milling slot itself and is thus further comminuted, which produces a grain size below the width of the slot. It is essential for the fine milling according to the present invention that the rotor and stator are merely provided with rough surfaces in this zone and serrations are eliminated since they would not meet the requirements of fine milling. The surface roughening may be effected mechanically, chemically or electrically.

In contrast to the above, known mills of this type have serrations which end at the lower horizontal edge of the grinding element and, thus, permit free egress of the material in the grooves. Frequently, undesirably large particles are, thus, discharged from the mill, which is impossible with the roughened surfaces of the grinding elements in the fine milling zone of the present invention.

What is claimed is:

1. A multiple stage colloid mill comprising, in combination: a stationary mill housing having a frusto-conical interior wall with grinding teeth separated by grooves, a hollow rotor with a frusto-conical exterior wall and an interior wall defining a material inlet chamber, said rotor being mounted within said housing for rotation about a substantially vertical axis and the interior wall of the mill housing being spaced from the exterior wall of the rotor to define a milling gap therebetween, the wall of the rotor surrounding the material inlet chamber defining openings for passage of material from the chamber to the milling gap by centrifugal force upon rotation of the rotor and the exterior rotor wall surrounding said chamber having grinding teeth forming an acute angle to the vertical and separated by corresponding grooves, the above mentioned grinding teeth of the housing and the rotor forming a pre-grinding zone of the mill, a coarse grinding zone arranged below the pre-grinding zone, the latter zone being formed by substantially parallelogram-shaped grinding teeth defined by two sets of parallel grooves in the exterior wall of the rotor, each set of grooves being inclined in the same direction but at a different angle in relation to the vertical, and corresponding grinding teeth in the interior wall of the mill housing; a third zone below the coarse grinding zone and receiving the coarsely ground material therefrom, the third zone being formed by generally downwardly extending channels in the exterior wall of the rotor and the interior wall of the housing, the channel cross sections being so correlated with the preceding grinding teeth that they correspond to the grain size of the coarsely ground material; and a fourth or fine milling zone formed by roughened surfaces of irregular formation and finer grain than the said grinding teeth on the exterior wall of the rotor and the interior wall of the housing.

2. The multiple stage colloid mill of claim 1, wherein said openings for passage of material from the chamber to the milling gap are defined by an interior rotor wall portion forming an obtuse angle with the interior wall of the housing at one side of the opening and an exterior rotor wall portion forming an acute angle with the interior wall of the housing at the opposite side of the opening, said exterior rotor wall portion constituting a cutting edge for the material passing from the inlet chamber to the milling gap.

3. The multiple stage colloid mill of claim 2, wherein the upper edge of the rotor wall is obliquely inclined from the cutting edge of one opening to the obtuse angle wall portion of an adjacent opening.

4. The multiple stage colloid mill of claim 1, wherein the grooves in the interior wall of the housing in the pre-grinding zone taper upwardly.

5. A multiple stage colloid mill comprising, in combination: a stationary mill housing having a frusto-conical interior wall with grinding teeth separated by grooves; a hollow rotor with a frusto-conical exterior wall and an interior wall defining a material inlet chamber, said rotor being mounted within the housing for rotation about a substantially vertical axis and the interior wall of the mill housing being spaced from the exterior wall of the rotor to define a milling gap therebetween, the wall of the rotor surrounding the material inlet chamber defining openings for passage of material from the chamber to the milling gap by centrifugal force upon rotation of the rotor and the exterior rotor wall surrounding said chamber having substantially parallelogram-shaped grinding teeth defined by two sets of parallel grooves, one set of grooves forming acute angles to the vertical and the other set forming acute angles to the horizontal, the above-mentioned grinding teeth of the housing and the rotor forming a pre-grinding zone of the mill; a coarse grinding zone arranged below the pre-grinding zone, the latter zone being formed by substantially parallelogram-shaped grinding teeth defined by two sets of parallel grooves in the exterior wall of the rotor, each set of grooves being inclined at a different angle in relation to the vertical and in relation to the angles of the grooves in the pre-grinding zone, and corresponding grinding teeth in the interior wall of the mill housing; a third zone below the coarse grinding zone and receiving the coarsely ground material therefrom, the third zone being formed by generally downwardly extending channels in the exterior wall of the rotor and the interior wall of the housing, the channel cross sections being so correlated with the preceding grinding teeth that they correspond to the grain size of the coarsely ground material; and a fourth or fine milling zone formed by roughened surfaces of irregular formation and finer grain than the said grinding teeth on the exterior wall of the rotor and the interior wall of the housing.

6. The multiple stage colloid mill of claim 5, wherein said openings for passage of material from the chamber to the milling gap are defined by an interior rotor wall portion forming an obtuse angle with the interior wall of the housing at one side of the opening and an exterior rotor wall portion forming an acute angle with the interior wall of the housing at the opposite side of the opening, said exterior rotor wall portion constituting a cutting edge for the material passing from the inlet chamber to the milling gap.

7. The multiple stage colloid mill of claim 6, wherein the upper edge of the rotor wall is obliquely inclined from the cutting edge of one opening to the obtuse angle wall portion of an adjacent opening.

8. The multiple stage colloid mill of claim 5, wherein the grooves in the interior wall of the housing in the pre-grinding zone taper upwardly.

9. The multiple stage colloid mill of claim 5, comprising a cylindrical collar mounted on the mill housing and projecting into the hollow rotor.

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