

June 24, 1941.

I. BENCOWITZ ET AL

2,246,567

GRINDING APPARATUS

Filed Jan. 7, 1939

5 Sheets-Sheet 1

Fig. 1,

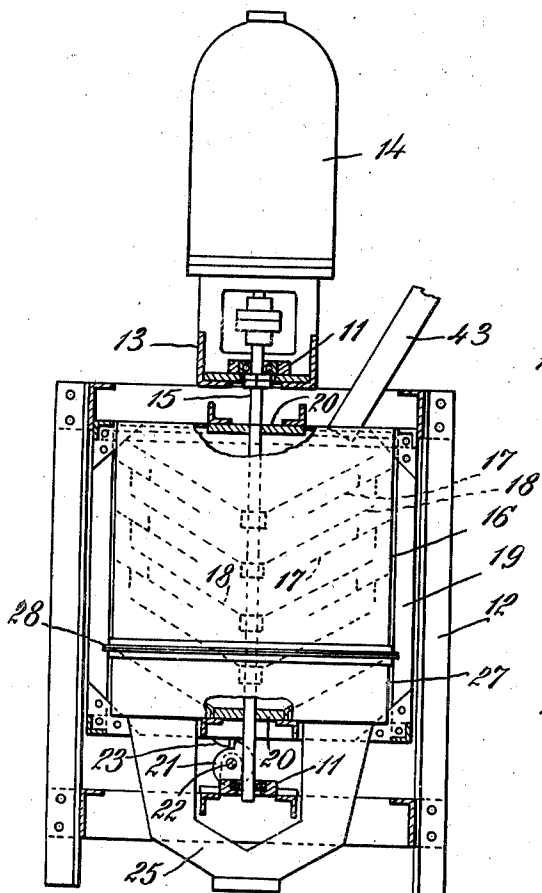


Fig. 2,

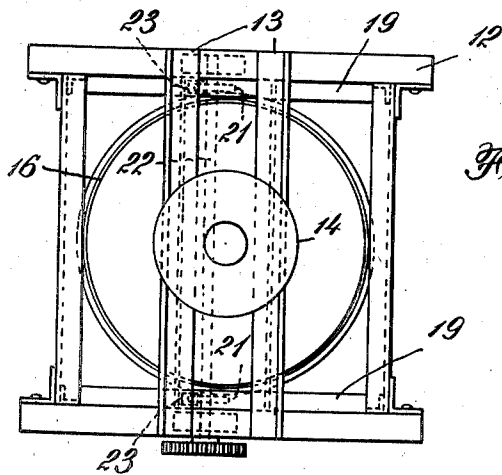
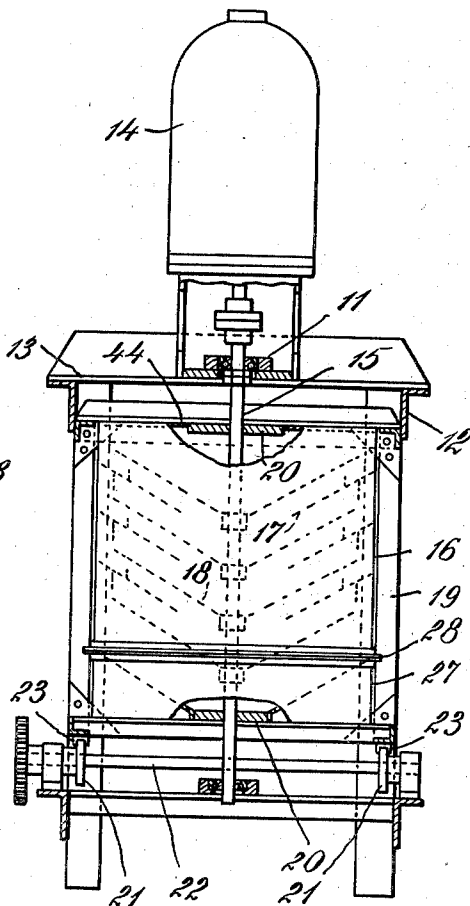


Fig. 3,

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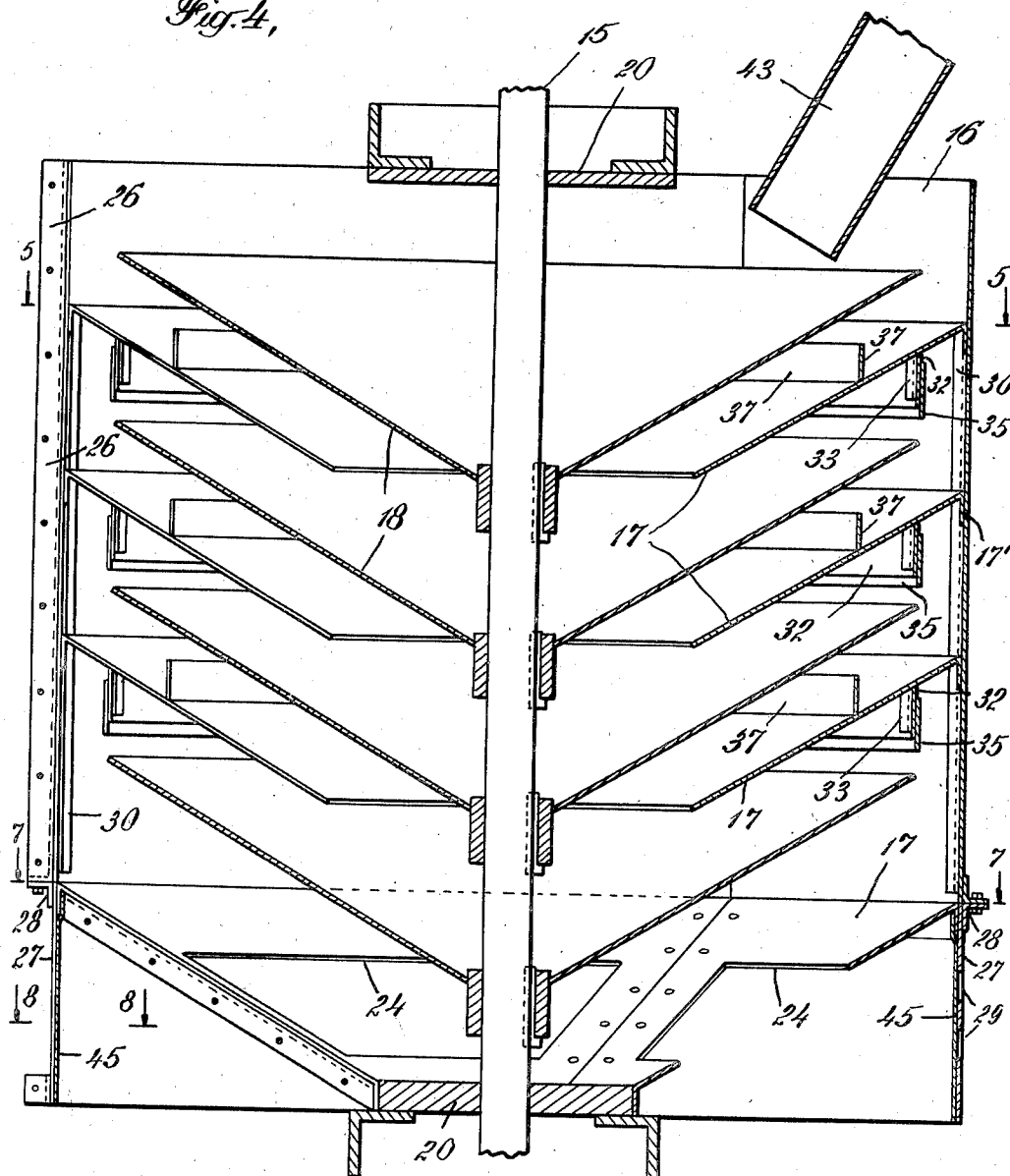
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5 Sheets-Sheet 2

Fig. 4,



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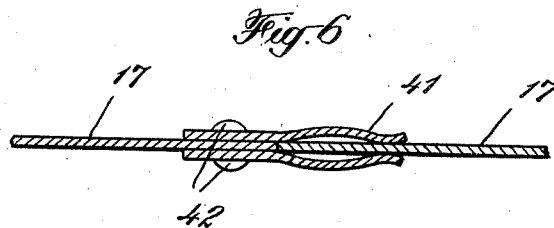
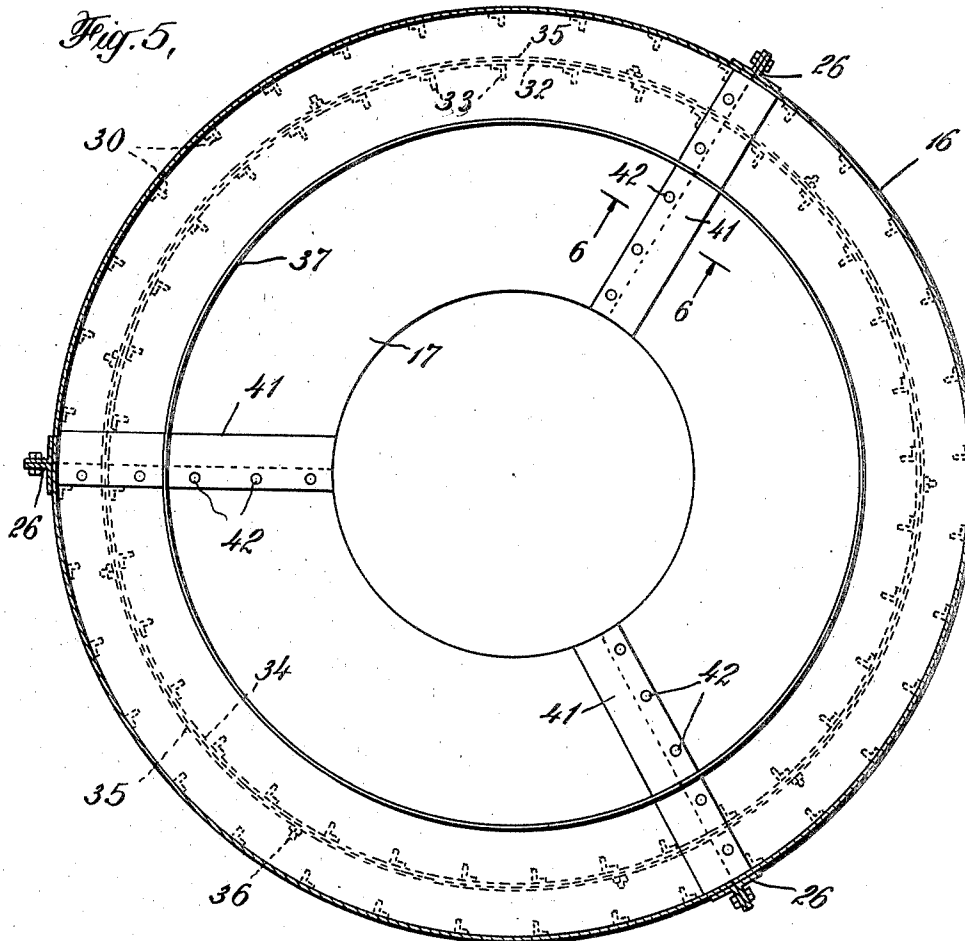
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GRINDING APPARATUS

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5 Sheets-Sheet 3



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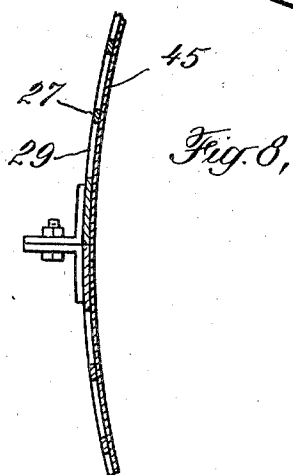
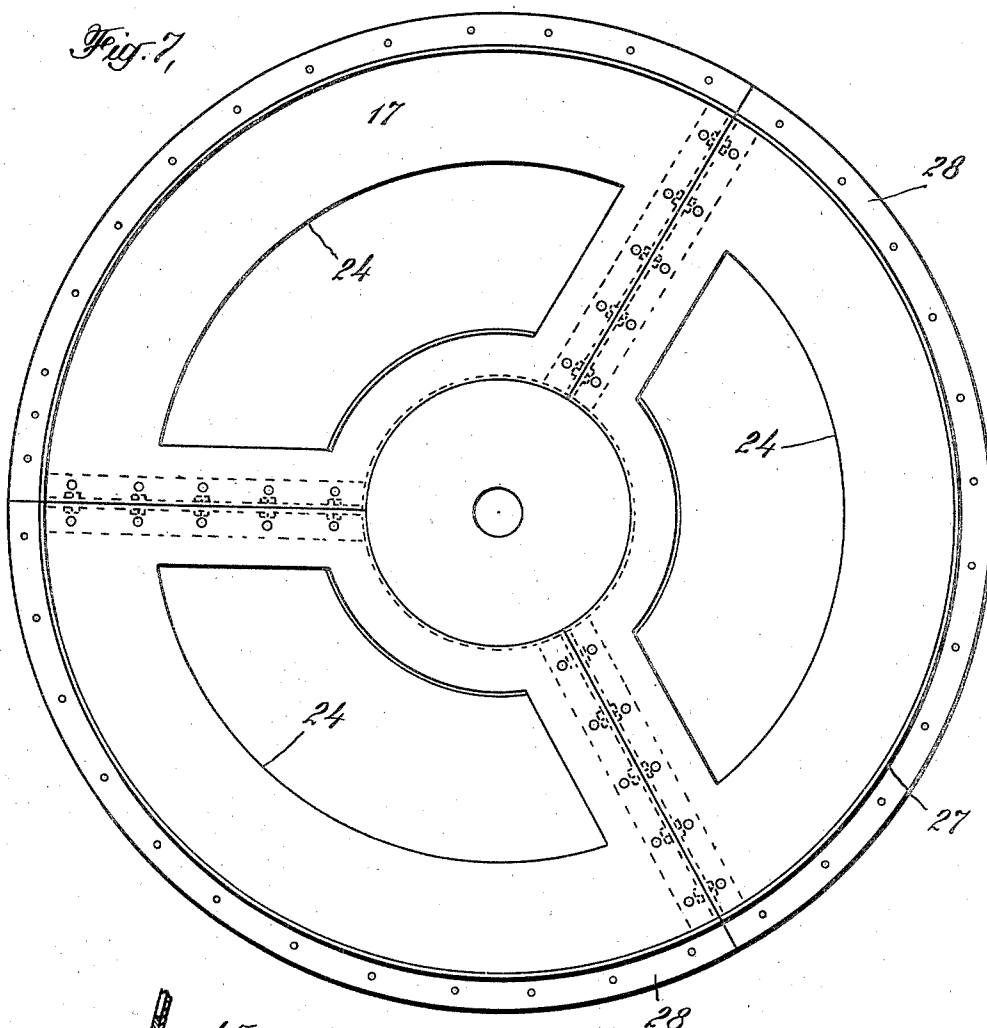
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GRINDING APPARATUS

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5 Sheets-Sheet 4



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GRINDING APPARATUS

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5 Sheets-Sheet 5

Fig. 9,

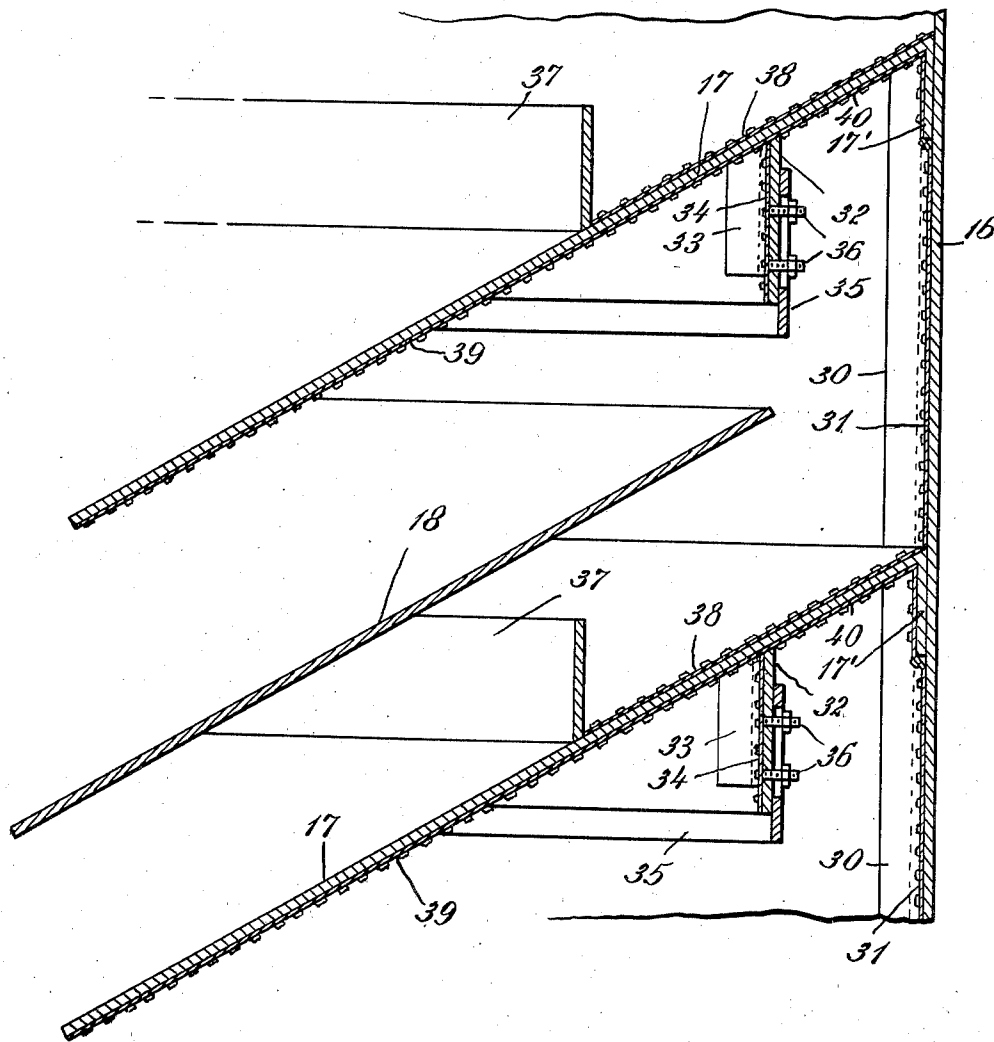
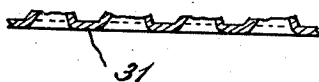


Fig. 10.



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UNITED STATES PATENT OFFICE

2,246,567

GRINDING APPARATUS

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Application January 7, 1939, Serial No. 249,708

9 Claims. (Cl. 83—46)

This invention relates to grinding apparatus and particularly to that type of apparatus in which the material to be ground is thrown by centrifugal force against impact or grinding surfaces. The invention aims to provide an improved apparatus of this type, especially adapted for grinding sulphur and similar materials.

The improved grinder of the invention comprises a set of spaced and superposed revolving discs secured to a rotatably mounted vertical shaft driven by an overhead motor. This rotor element is housed in a metallic shell. The revolving discs impart to the material to be ground the necessary kinetic and potential energy and the surrounding shell provides the impact and abrasive surface. In its preferred form, the grinder has a set of superposed stationary discs alternately disposed with respect to the revolving discs, serving to direct material thrown against the impact surfaces by one revolving disc onto the revolving disc next below. The improvements of the invention reside in the novel construction and arrangement of the revolving discs and impact surfaces. In addition to the surrounding shell, the improved grinder is provided with other impact surfaces on the stationary discs. The impact surfaces are roughened to improve the abrasive action. In its preferred form, the grinder is provided with a partial classification device, and with positively actuated means for preventing the accumulation of material tending to stick to the stationary elements.

The foregoing and other novel features of the invention will be best understood from the following description taken in conjunction with the accompanying drawings, in which

Figs. 1 and 2 are front and side elevations, respectively, partly in section, of the improved grinding apparatus,

Fig. 3 is a top plan view of the apparatus,

Fig. 4 is a sectional elevation of the grinding mechanism of the apparatus,

Fig. 5 is a horizontal section on the section line 5—5 of Fig. 4 (with the revolving disc next above removed),

Fig. 6 is a sectional detail on the section line 6—6 of Fig. 5,

Fig. 7 is a horizontal section on the section line 7—7 of Fig. 4,

Fig. 8 is a sectional detail on the section line 8—8 of Fig. 4,

Fig. 9 is an enlarged sectional elevation of part of the grinding mechanism, and

Fig. 10 is an enlarged sectional detail of the beveled strips of the grinding surfaces.

Referring to Figs. 1, 2 and 3 of the drawings, the rotor and stator members of the grinding apparatus are operatively mounted on a rectangular main frame 12. The frame 12 supports a transverse platform 13 upon which is mounted an over-

head or vertical electric motor 14 having a depending drive shaft 15 which passes through upper and lower guide bearings 11 mounted on the frame 12. The stator member consists generally of a cylindrical sheet metal shell 16 from the inner periphery of which depend a plurality of superposed spaced discs or cones 17, in the form of conical frustrums. The rotor member is suspended from and supported by the motor 14 and consists of a plurality of superposed spaced conical discs or cones 18, alternately disposed with respect to the stationary discs 17, secured at their centers or apexes to the shaft 15.

The shell 16 is mounted in a frame 19, and the assembly of frame and shell is adapted to be reciprocated vertically on the vertical shaft 15 and within the main frame 12. The shaft 15 extends through transverse bearing blocks 20 secured to the top and bottom of the frame 19. The assembly of shell 16 and cooperating frame 19 is supported by two cams 21 secured to a transverse rotatable shaft 22 mounted in the lower part of the main frame 12. Cam-followers 23 are secured to opposite lower sides of the shell frame 19 and rest on the cams. As the shaft 22 is slowly rotated (from a source of power not shown), the shell 16 and cooperating frame 19 are periodically lifted to a predetermined height by the cams 21 and then allowed to drop sharply, thereby imparting an intermittent shaking action to the shell for preventing the accumulation of material tending to stick thereto.

Each stationary disc 17 is secured at its outer periphery to the shell 16. To this end, the disc may advantageously have a downwardly depending peripheral apron 17' which may be welded or otherwise appropriately secured to the inner surface of the shell 16. Good results have been attained with an angular relationship of approximately 60° between the shell and the downwardly depending disc 17. Each disc is made of three similar sections or segments having their abutting edges clamped or otherwise appropriately joined together. In the apparatus illustrated in the drawings, the end of one section is secured between the spring fingers 41 of a clamp riveted at 42 to the abutting end of the adjacent section (see Figs. 5 and 6).

The rotor discs 18 are keyed or otherwise appropriately secured to the rotatable center shaft 15. The discs 17 and 18 are equally spaced and parallel. The outer circular peripheral edges of the rotor discs 18 are spaced from the shell 16 an appropriate distance to permit the passage of material therefrom to the stationary disc immediately below. The inner circular peripheral edges of the stationary discs 17 are spaced from the shaft 15 an appropriate distance to permit the passage of material therefrom to the rotor

disc immediately below. Each of the three segments of the lowermost stationary disc 17 has an elongated opening 24 permitting the passage of the ground material to a discharge funnel 25 (Fig. 1).

The cylindrical shell 16 is made of three segments having their abutting edges fastened together by vertical angle irons 26. A depending perforated sheet metal apron 27 is fastened to the lower edge of the shell 16 by circular angle irons 28. The inside cylindrical surface of the apron 27 is covered or lined with easily frangible material 45, such as paper or the like, to normally close the perforations or holes 29 of the apron (Figs. 4 and 8).

Spaced vertical ribs 30, preferably of angle iron, are welded or otherwise appropriately secured to the interior surface of the shell 16, between the stationary discs 17. In the apparatus illustrated in the drawings, there are thirty-six such vertical ribs circumferentially spaced, between each adjacent pair of stationary discs. Between the ribs 30, the shell is lined with burred or perforated sheet metal strips 31, with the sharp edges of the burrs or perforations towards the inside to provide a rough surface for promoting abrasion and impact (Figs. 9 and 10). If desired, the top of the shell 16, above the uppermost stationary disc 17 may similarly be provided with spaced vertical ribs and burred strips.

A depending metal band 32 is welded or otherwise appropriately secured to the underside of each stationary disc 17 (except the lowermost disc 17), approximately above the outer periphery of the rotor disc 18. Spaced vertical ribs 33, preferably of angle iron, are secured by welding or otherwise to the inside of the band 32, and between the ribs the band is lined with burred sheet metal strips 34. A depending band 35, of aluminum or other suitable non-sparking material, is adjustably secured by bolts 36 to each band 32. The band 32 may advantageously terminate about midway between the adjacent stationary and rotor discs, and the band 35 is adjusted to suitably control the annular discharge opening between its lower edge and the periphery of the adjacent rotor disc. The band 32, which is a depending circular wall, and particularly the band 35 are so arranged with respect to the revolving disc next below that they serve as impact surfaces for material thrown outwardly by the said disc.

An upright cylindrical barrier or band 37 is secured by welding or otherwise to the top surface of each stationary disc 17 (except the lowermost). The bands 37 are positioned inwardly a suitable distance from the periphery of the adjacent rotor disc. The height of the bands 37 may advantageously be about half the vertical distance between the stationary and rotor discs. The annular upper surface of each stationary disc, between the band 37 and the periphery of the disc is lined with burred sheet metal strips 38. The underside of each stationary disc 17 (except the lowermost) is lined with burred strips 39 and 40 (Fig. 9).

The material to be ground, which for purposes of illustration we will assume to be sulphur, is fed onto the uppermost revolving disc 18 from a feed chute 43 extending through the cover 44 of the shell 16. As the particles fall upon this disc they are thrown with a rapidly accelerating velocity against the wall of the stationary shell. The force of impact (as well as

the glancing abrasion) of the particles against the wall is converted into crushing. The particles, partly crushed, fall from the surface of impact upon the stationary disc immediately below, and are delivered by gravity to the next lower revolving disc, where again an accelerated force is imparted to them, and when they strike the surface of the shell at a lower lever further grinding is brought about. The crushing and grinding treatment is repeated as the material is fed by gravity from one disc downwardly onto another, until at the exit, at the lower part of the shell, a ground product of the desired fineness is obtained. By a suitable arrangement of the number and sizes of discs, the speed of revolution of the rotor and the roughness of the abrading surfaces, it is possible to grind sulphur so that it passes through a 325 mesh screen without the auxiliary aid of classifying gases such as air or carbon dioxide.

The upright band 37 serves as a barrier to pile up sulphur, or other material being ground, at this position on the stationary disc. Thus, the band acts as a partial classifier. Large particles are retained somewhat at this point and are moved about by the "wind" created by the revolving discs and are further reduced in size. Fine particles are not retained because they are swept over this barrier. The band 37 also serves as a "catch" for any foreign material, such as iron, which is likely to cause an explosion if allowed to progress beyond the uppermost revolving disc. Likewise, any relatively large chunks of sulphur accumulated in the grinder during its operation and breaking away are retained by the bands 37 within the grinder until they are either ground fine or until the grinder is cleaned out. The bands 37 further act as fins and serve to conduct the heat generated in grinding away from the interior of the grinder.

The upper surface of each stationary disc outwardly beyond the band 37 is roughened to increase grinding by attrition of large particles retained by the band. Inwardly, beyond the band, the stationary disc is smooth to permit free downward passage of the material to the next lower revolving disc.

The vertical ribs 30 and 33 serve to promote the grinding action in several ways. Firstly, they provide impact surfaces at right angles to the direction of movement of the particles due to the tangential velocity of the revolving discs. They also help to augment the existing turbulence and thereby assist the desired moving-about of the larger particles retained by the upright bands 37. They serve further as fins to conduct heat away from the interior of the grinder.

The aluminum band 35 is a safety device to prevent the formation of sparks due to the presence of loose iron which is occasionally introduced into the grinder with the sulphur. Any other suitable non-sparking material may be used in place of aluminum.

The grinder of the invention, because of the fact that it creates an atmosphere of dust, displacing and keeping out most of the air, provides a maximum factor of safety against possible explosion. Should an explosion occur, the increased pressure within the grinder is relieved by breaking or tearing of the frangible lining 45 of the depending apron 27, thereby eliminating any possible damage to the grinder. The shock of the explosion is further reduced by

the movement of frame 19 acting as a recoil device.

The ribs 30 and 33, as well as the burred surfaces (31, 34, 38, 39 and 40) of the roughened portions of the shell and stationary discs, serve as supports upon which sulphur accumulates as a hard rough crust yielding a surface which is very effective for grinding by attrition. This coating of the abrasive and impact surfaces with a thin layer of tenaciously adhering sulphur minimizes wear due to grinding, and permits the apparatus to be built of relatively light material, thus reducing the cost of construction and maintenance. Since the revolving discs are of a continuous surface, without projections, holes or other obstructions, the power consumption is very small. The primary bearings of the rotor member of the grinder are housed in the vertical motor 14 outside the atmosphere of dust, thus minimizing maintenance expense and prolonging the operating life of the grinder.

Although the grinder is so constructed that no auxiliary classifying gases are necessary, the finished product of sufficient fineness being discharged into or through the discharge funnel 25, a classifying gas may be used if so desired. This gas may be blown into the discharge funnel 25 and so regulated that only the coarse particles may pass downward and out against the current of gas. The finished product is swept upwards and out through the feed chute 43. This may increase the capacity of the grinder when capacity is of greater consideration than the cost of the auxiliary gas.

For grinding sulphur, we have obtained excellent results with an apparatus constructed substantially as illustrated in the drawings having four revolving discs and four stationary discs. The shell 16 was about 34 inches in diameter and about 23 inches high. The apron 27 was about 8 inches high and the perforations 29 were $1\frac{1}{8}$ in. in diameter on $1\frac{1}{2}$ in. centers. The rotor discs were about 31 inches in diameter (at the upper periphery), and the center opening of the stationary discs was about 9 inches in diameter. The vertical distance between the rotor and stationary discs (except the lowermost) was about 3 inches. The upright barrier 37 was $1\frac{1}{2}$ inches high and was spaced about 4 inches from the shell. The depending band 32 was 2 inches in depth and was spaced $1\frac{3}{4}$ inches from the shell. The shell, discs, and bands were made of 16 gauge sheet (galvanized) iron, and the burred strips were made of 26 gauge sheet iron. The ribs 30 and 33 projected inwardly about $\frac{1}{2}$ inch. The shaft 15 was rotated at 1800 R. P. M. by a 25 H. P. motor, thereby imparting to the revolving discs 18 a peripheral speed of approximately 14,500 feet per minute. In general, the peripheral speed of the revolving discs should be not less than about 10,000 feet per minute. The kinetic energy of the particles, with the same revolving disc, increases as the square of the speed of rotation.

While it is now our preferred practice to make the stationary and revolving discs conical and inclined at an angle of about 60° to the vertical wall of the shell, these discs may be flat surfaces or cones of any desired angle, provided it is not so small that most of the imparted energy is converted into overcoming the excessive drag of the particles against the disc, and into heat caused by excessive friction. A cone of a large angle, such as a half angle of 60° , is preferable to a flat disc because on the cone the par-

ticles are compelled to hug the surface as they are being thrown out towards the outward rim of the disc and thus attain the maximum velocity, whereas on a flat disc the particles may leave the surface at the slightest unevenness thus losing momentum before they reach the grinding surface of the stationary shell. When the discs are of uniform diameter, the stationary shell is a cylinder, but when the discs are of increasing diameter (from top to bottom) the stationary shell is most advantageously a cone. In the latter case, it is unnecessary to provide intermediate stationary discs for the delivery of material from one revolving disc to the revolving disc below, since the conical shape of the shell and increasing diameters of the discs permit material to be dropped directly from any revolving disc to the revolving discs below. With a cylindrical shell and discs of uniform diameter, the particles are compelled to reach the surface of the next lower revolving disc by passing over the intermediate stationary disc, rather than by sliding down the wall of the stationary shell.

It will be understood that we have herein particularly described what we now consider the preferred form of our invention. The construction materials and the dimensions recited in connection with the apparatus specifically referred to are merely illustrative and are not to be considered as limitations of the invention. The invention may be modified in any manner compatible with the limitations imposed by the appended claims.

We claim:

1. A grinding apparatus comprising a series of spaced and superposed revolving discs secured to a rotatable shaft, a series of superposed stationary discs alternately disposed with respect to said revolving discs, and a housing surrounding said discs and disposed to direct material thrown thereagainst by the centrifugal action of any revolving disc onto the stationary disc next below, said stationary discs having central openings for permitting the delivery of material thereon to the revolving discs next below respectively, an upright band secured to the upper surface of at least one of the stationary discs surrounding the opening and spaced inward from the peripheral outer edge of the revolving disc next above, and means for imparting an intermittent shaking action to the housing and to the stationary discs to prevent accumulation of the material thereon.

2. A grinding apparatus comprising a plurality of spaced and superposed revolving discs secured to a rotatable shaft, a plurality of superposed stationary discs alternately disposed with respect to said revolving discs, a housing surrounding said discs in spaced relation with the peripheries of the revolving discs and in contact with the peripheries of the stationary discs, said stationary discs having central openings for permitting the delivery of material thereon to the revolving discs next below respectively, an upright barrier secured to the upper surface of the uppermost stationary discs in spaced relation with said housing for retaining coarse material on such discs, and means for imparting an intermittent shaking action to the housing and to the stationary discs to prevent accumulation of material thereon.

3. A grinding apparatus comprising a vertically disposed rotatable shaft, a series of superposed spaced discs secured to said shaft, a housing operatively surrounding said discs, a series of superposed stationary discs alternately dis-

posed with respect to said revolving discs, and a depending circular wall secured to the lower side of at least one of the stationary discs, said wall being spaced inward from the housing and above and substantially in alignment with the edge of the revolving disc next below, whereby material thrown outward by the centrifugal force from the rotatable disc next below may strike the said wall.

4. A grinding apparatus comprising a vertically disposed rotatable shaft, a series of superposed spaced discs secured to said shaft, a housing surrounding said revolving discs in spaced relation with the peripheries thereof, a series of superposed stationary discs alternately disposed with respect to said revolving discs having their outer peripheries in contact with said housing and having central openings for permitting the delivery of material thereon to the revolving discs next below respectively, and a depending circular wall secured to the lower side of at least one of the stationary discs, said wall being spaced inward from the housing and above and substantially in alignment with the edge of the revolving disc next below, whereby material thrown outward by the centrifugal force from the rotatable disc next below may strike the said wall.

5. A grinding apparatus comprising a vertically disposed rotatable shaft, a series of superposed spaced discs secured to said shaft, said discs being conical and inclined upward and outward thereby causing the particles being ground to hug the surface and be given relatively great velocity as they are thrown outward, a housing operatively surrounding said discs, a series of superposed stationary discs alternately disposed with respect to said revolving discs, said stationary discs being conical and inclined downward in the direction of the shaft to direct material towards the disc next below, a depending circular wall secured to the lower side of the uppermost stationary discs in spaced relation with the housing and the revolving disc next below, and a plurality of spaced and inwardly projecting ribs secured to the inner side of said wall in the path of movement of material thrown by centrifugal action from the revolving discs.

6. A grinding apparatus comprising a vertically disposed rotatable shaft, a series of superposed spaced discs secured to said shaft, said discs being conical and inclined upward and outward thereby causing the particles being ground to hug the surface and be given relatively great velocity as they are thrown outward, a housing operatively surrounding said discs, a series of superposed stationary discs alternately disposed with respect to said revolving discs, said stationary discs being conical and inclined downward in the direction of the shaft to direct material towards the disc next below, a depending circular wall secured to the lower side of the uppermost stationary discs and spaced inwardly from the housing, and a circular member of non-sparking metal adjustably connected to said wall and having its lower edge in adjustable spaced relation with the revolving disc next below.

7. A grinding apparatus comprising a vertically disposed rotatable shaft, a series of superposed spaced discs secured to said shaft, a housing surrounding said revolving discs in spaced relation with the peripheries thereof, a series of superposed stationary discs alternately dis-

posed with respect to said revolving discs having their outer peripheries in contact with said housing and having central openings for permitting the delivery of material thereon to the revolving discs next below respectively, a depending circular wall secured to the lower side of the uppermost stationary discs and spaced inwardly from the housing, a circular member of non-sparking metal adjustably connected to said wall and having its lower edge in adjustable spaced relation with the periphery of the revolving disc next below, and a plurality of spaced and inwardly projecting ribs secured to the inner side of said circular wall in the path of movement of material thrown by centrifugal action from the revolving discs.

8. A grinding apparatus comprising a plurality of spaced and superposed revolving discs secured to a rotatable shaft, a plurality of superposed stationary discs alternately disposed with respect to said revolving discs, a housing surrounding said discs in spaced relation with the peripheries of the revolving discs and in contact with the peripheries of the stationary discs, said stationary discs having central openings for permitting the delivery of material thereon to the revolving discs next below respectively, an upright barrier secured to the upper surface of the uppermost stationary discs in spaced relation with said housing for retaining coarse material on such discs, a depending circular wall secured to the lower side of the uppermost stationary discs in spaced relation with the periphery of the revolving disc next below and the housing, and a plurality of spaced and inwardly projecting ribs secured to the inner side of said circular wall in the path of movement of material thrown by centrifugal action from the revolving discs.

9. A grinding apparatus having a rotor member suspended from and supported by an overhead motor and comprising a depending vertical shaft having secured thereto a plurality of superposed spaced discs, a plurality of superposed stationary discs alternately disposed with respect to said revolving discs, a housing surrounding said discs in spaced relation with the peripheries of the revolving discs and in contact with the peripheries of the stationary discs, said stationary discs having central openings for permitting the delivery of material thereon to the revolving discs next below respectively, an upright barrier secured to the upper surface of the uppermost stationary discs in spaced relation with said housing for retaining coarse material on such discs, a depending circular wall secured to the lower side of the uppermost stationary discs in spaced relation with the periphery of the revolving disc next below, a plurality of spaced and inwardly projecting ribs secured to the inner surface of said housing in the path of movement of material thrown by centrifugal action from the revolving discs, a plurality of spaced and inwardly projecting ribs secured to the inner side of said circular wall, the impact surfaces of said housing and cooperating stationary elements being roughened by inwardly projecting burrs, a frangible element cooperating with said housing for minimizing injurious effects to the apparatus of internal explosions, and means for periodically shaking said housing.

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