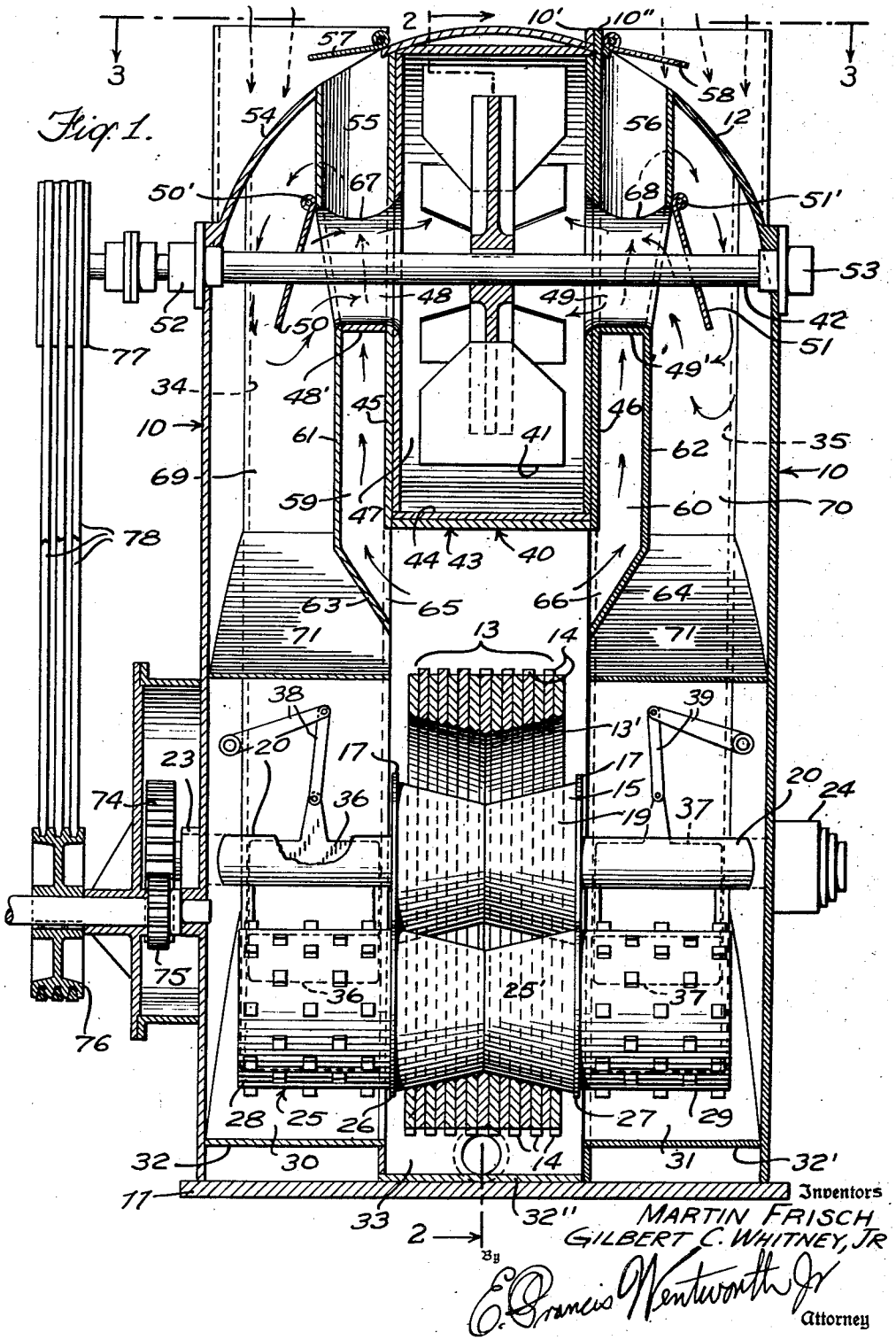
July 7, 1953 M. FRISCH ET AL 2,644,643

LAMINATED-RING AND MULTIPLE INTERNAL-ROLL MILL

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Fig. 1.



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LAMINATED-RING AND MULTIPLE INTERNAL-ROLL MILL

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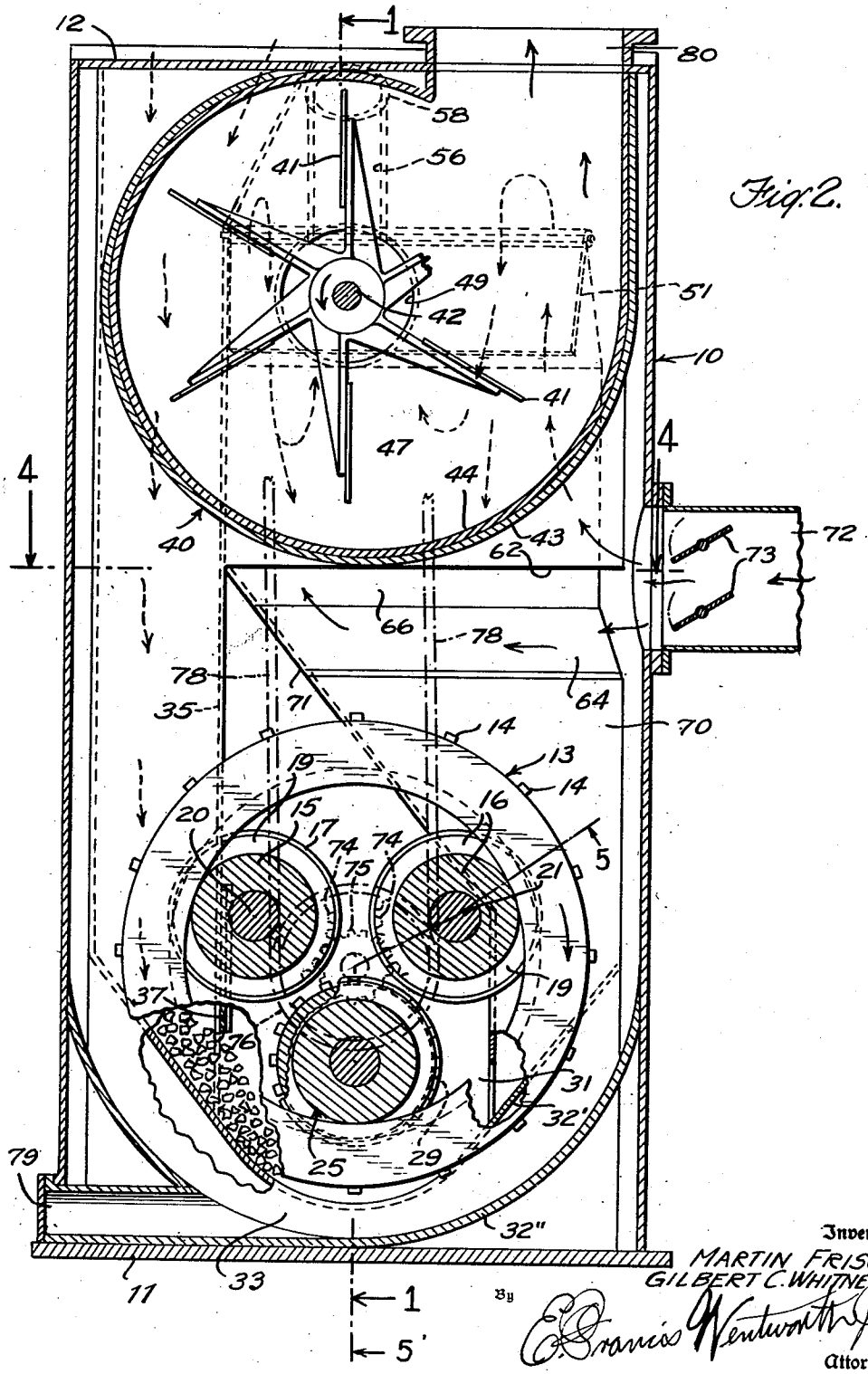



Fig. 2.

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LAMINATED-RING AND MULTIPLE INTERNAL-ROLL MILL

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Fig. 3.

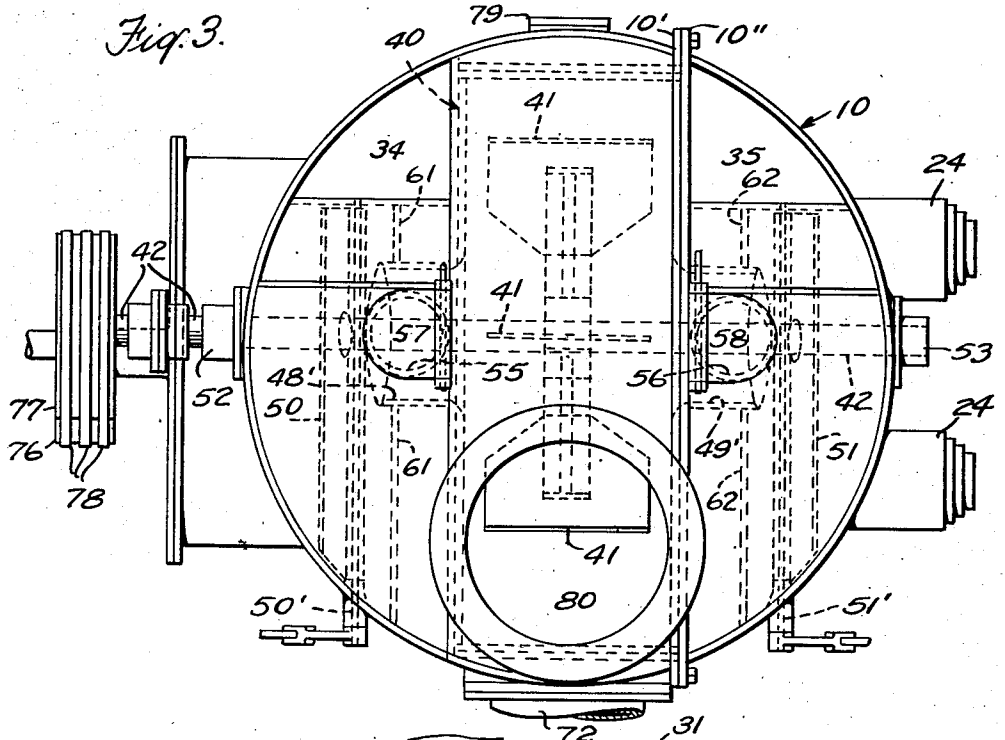
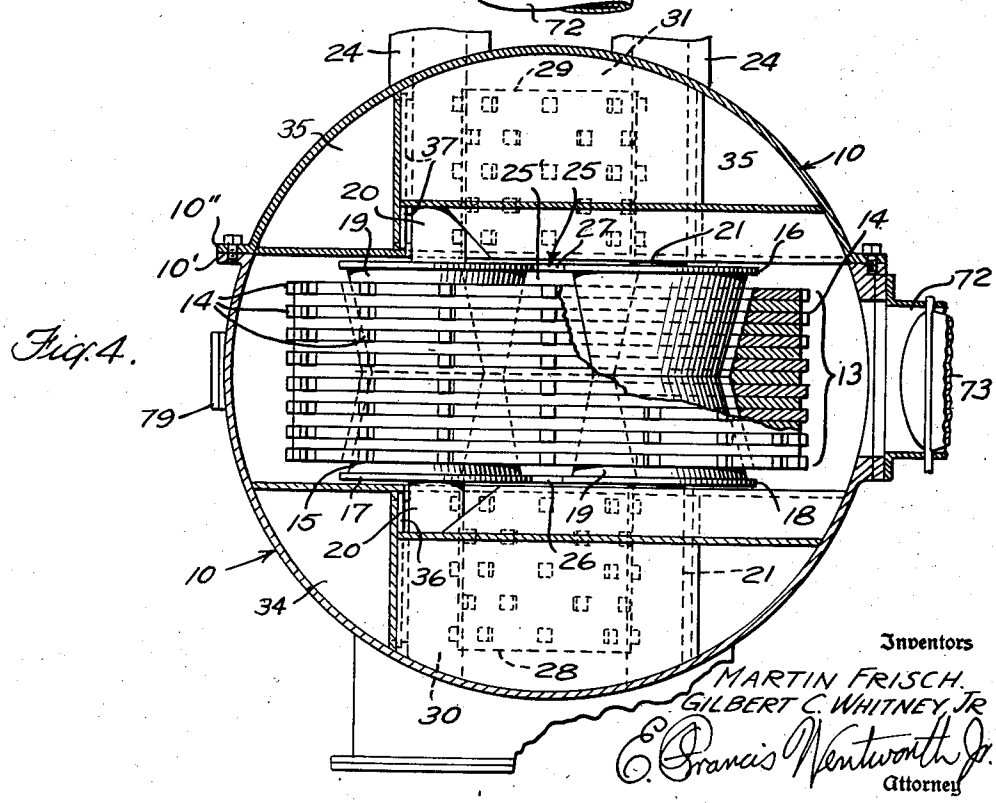



Fig. 4.




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LAMINATED-RING AND MULTIPLE INTERNAL-ROLL MILL

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Fig. 5.

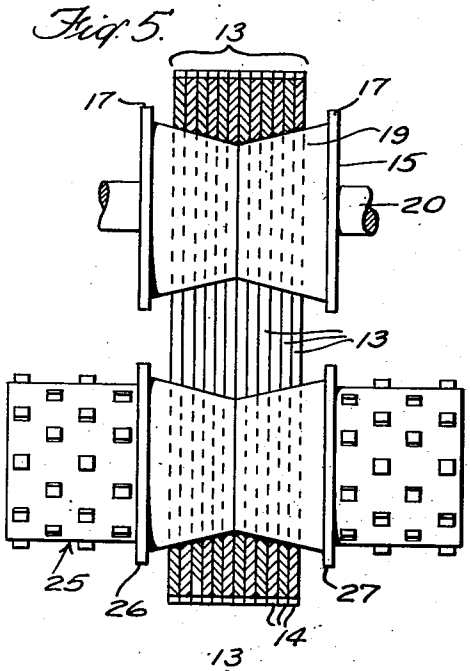



Fig. 6.

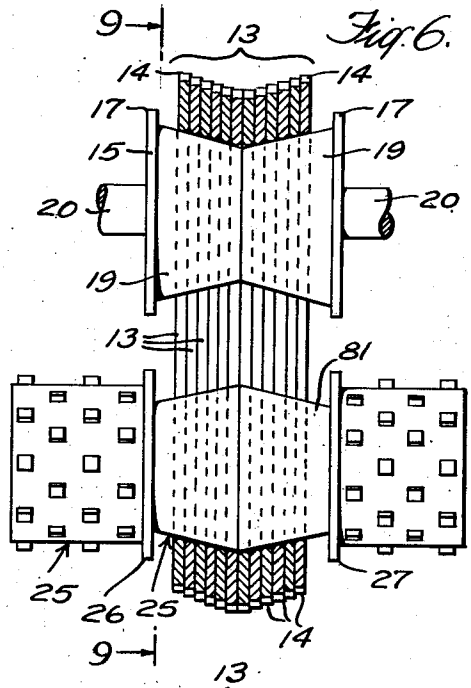



Fig. 7.

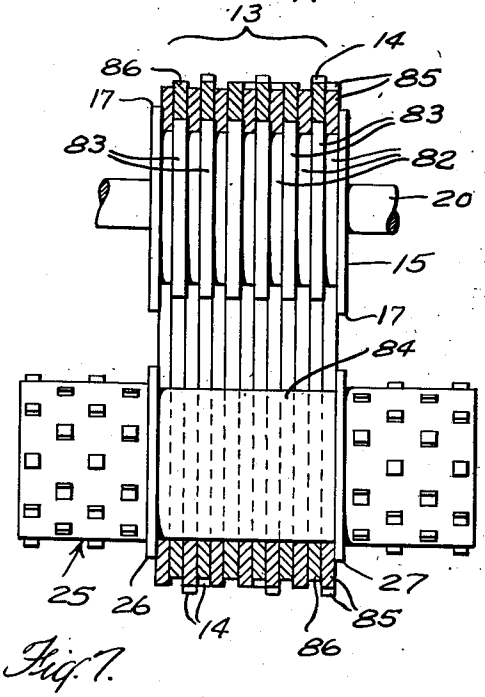
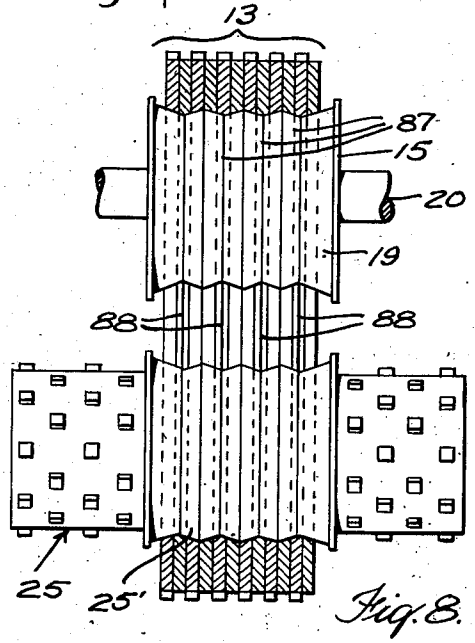



Fig. 8.




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LAMINATED-RING AND MULTIPLE INTERNAL-ROLL MILL

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Fig. 10.

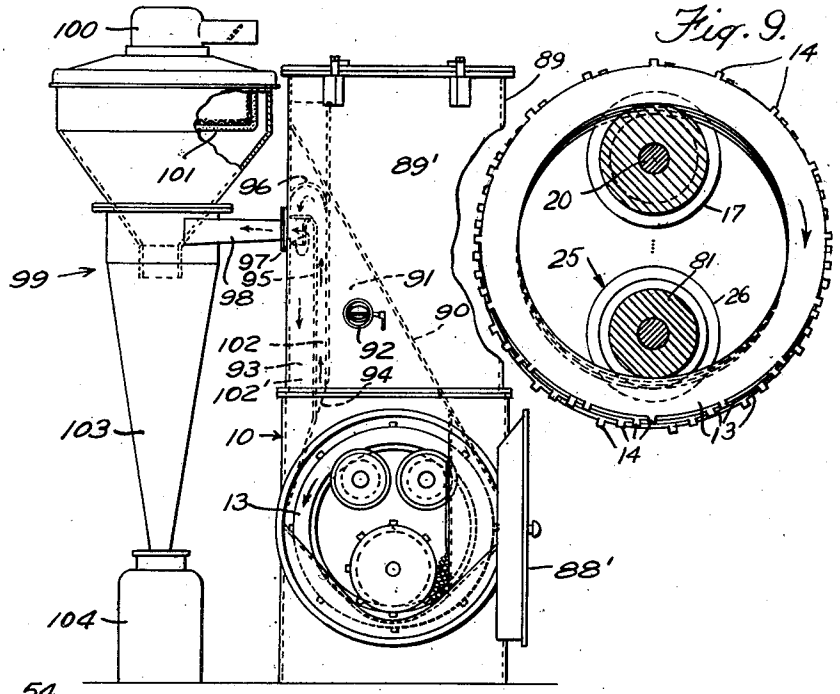
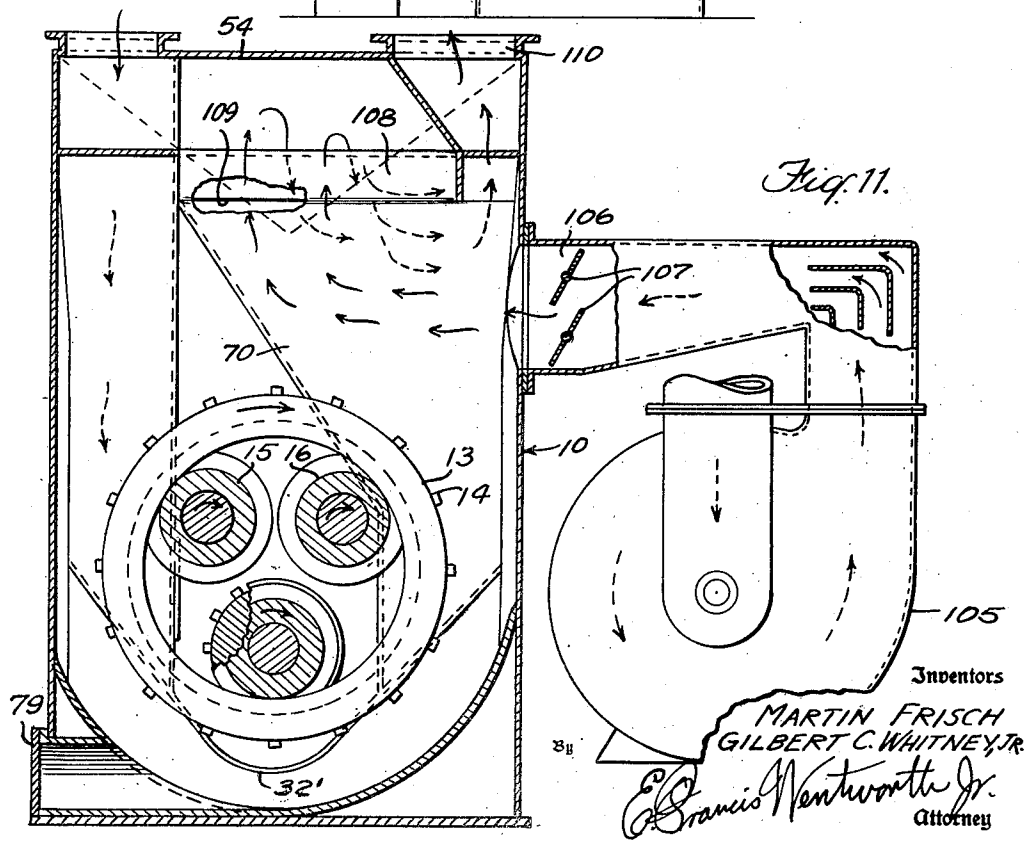



Fig. 9.




Fig. 11.




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2,644,643

# UNITED STATES PATENT OFFICE

2,644,643

## LAMINATED-RING AND MULTIPLE INTERNAL-ROLL MILL

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Application April 19, 1949, Serial No. 88,412

21 Claims. (Cl. 241—122)

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This invention relates to pulverizers or pulverizing mills for grinding or crushing ores, fuels, minerals and various other types of materials. More particularly, the invention pertains to improvements in mills of the ring and roller type wherein the material is crushed and pulverized by action of the rings and rollers and the pulverized product is delivered to a point of use or storage by a fluid carrier such as a stream of air.

It is an object of the present invention to provide a mill of high pulverizing efficiency and low power consumption.

Another object of the invention is to provide a pulverizing mill which does not require mechanical feeding devices.

A further object of this invention is to provide a pulverizing mill in which the output rate is readily controlled by varying the flow of fluid carrier which fluid carrier may be heated for the drying of wet materials while being pulverized or cooled to prevent the overheating of materials which tend to soften.

A still further object of the invention is to provide a pulverizer in which the size of the material fed thereto is not critical and in which relatively coarse material may be pulverized.

The present invention provides a pulverizer wherein material to be crushed is fed into crushing compartments by gravity and is crushed by extensions on a gravity loaded roller and by lugs on the outer peripheral surface of a plurality of laterally adjoining rings having lateral and rotative movement in relationship to one another. The gravity loaded roller is supported on the inner peripheral surface of said rings which rings are, in turn, supported and driven by a driving roller or rollers. The driving rollers are engaged by the rings at slightly different diameters and are, therefore, rotated at slightly different speeds. Rotation of the rings also rotates said gravity loaded roller. As the gravity loaded roller rotates, lugs on the extensions thereof break the pieces of material fed into the crushing compartments and project the broken pieces in many directions within the mill. The projected pieces return by gravity into the crushing compartments until material in said compartments is reduced to such fineness that it becomes fluidized. Lugs on the outer periphery of the rings plowing through the fluidized material sustain the fluidization, cause further disintegration of material, and continuously project the crushed fine material in several directions in the mill. The fluidized material in the crushed compartments overflows onto the inner surface of the rings and is

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centrifuged and transported in a thin ribbon of material which is squeezed between the adjoining side surfaces of the ring and between the inner periphery of said rings and the rollers. The high pressure thus developed on the ribbon of material continuously forces and squeezes material between adjacent side surfaces of adjoining rings which due to their relative speed of rotation, mull and rub the particles together until they become extremely fine. This extremely fine material is ejected radially from between the rings and is entrained by a gas or air stream and carried through a classifier wherein any oversize material is rejected and returned to the crushing compartments and the fine material is carried to a point of use or storage.

The invention will be understood from the following description when considered in connection with the accompanying drawings forming a part thereof and in which:

Fig. 1 is a vertical sectional view of a pulverizer of one embodiment of the invention taken on the line 1—1 of Fig. 2;

Fig. 2 is a vertical sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a plan view taken on the line 3—3 of Fig. 1;

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

Fig. 5 is a vertical sectional view on broken line section 5—5 of Fig. 2, the upper portion being swung into the plane of projection of pulverizing elements as shown in Fig. 1.

Fig. 6 is a view similar to Fig. 5 but of another embodiment of the pulverizing elements;

Fig. 7 is a view similar to Figs. 5 and 6 but of a further embodiment of the pulverizing elements;

Fig. 8 is a view similar to Figs. 5, 6 and 7 but of a still further embodiment of the pulverizing elements;

Fig. 9 is a side view taken on the line 9—9 of Fig. 6;

Fig. 10 is a side elevational view of a portion of another embodiment of the invention with parts thereof broken away and

Fig. 11 is a view similar to Fig. 10 but of a further embodiment of the invention.

Like reference numerals refer to like parts throughout the several views.

Referring to the drawings, the pulverizer or pulverizing mill of the present invention comprises a cylindrically-shaped vertically extending casing 10 closed at the bottom by a bottom plate 11 and at the top by a curved top plate 12. The

casing, as shown in Figs. 1 and 3, is divided vertically into two sections one section having a flange 10' and the other a flange 10'' which flanges are bolted together. In this manner, one portion of casing may be removed from the other to expose the pulverizing elements hereinafter described. Ring and roller pulverizing or grinding elements are positioned in the lower portion of casing 10. As shown in Figs. 1 to 4, a pulverizing ring assembly which comprises a plurality of laterally adjoining rings 13 forming a laminated ring assembly is positioned within the casing in spaced relationship to bottom plate 11 and in the central portion thereof in spaced relationship to the inner periphery of the casing laterally of the ring assembly and also as the periphery thereof. The assembly is so positioned in the chamber as to turn on a horizontally extending axis. The rings in said assembly have relative rotative and lateral movement in relationship to one another and also have a plurality of spaced lugs 14 extending radially from the outer periphery thereof. The rings of said group, as shown in Figs. 1 to 6, are of decreasing inside diameter from the outer ring at opposite sides of the assembly inwardly to the central portion of the group and are supported on driving rollers 15 and 16 which rollers have outer rims 17 and 18. The inner peripheral edge of the rings are of substantially semi-circular shape in cross-section so that a substantially V-shaped groove 13', the apex of which points toward the outer periphery of the ring, is formed between adjacent rings. The outer periphery of rollers 15 and 16 is of decreasing diameter from said rims inwardly to a central point so as to thereby form a substantially double frusto-conical-shaped peripheral surface 19 thereon in which the apices of said cones abut one another. With this form of roller, there will be a normal tendency of the rings 13 of the assembly to be laterally urged toward the center of the ring assembly, as will hereinafter be fully described. Roller 15 is mounted on drive shaft 20 so as to turn therewith, while roller 16 is mounted on drive shaft 21 to turn therewith. The drive shafts 20 and 21 extend transversely of the chamber within casing 10 in a horizontal plane and are mounted at the opposite ends thereof in bearings 23 and 24 which bearings are located in casing 10.

A gravity loaded crushing roller 25 is supported by the ring assembly in the lower portion thereof. Roller 25 has opposite side rims 26 and 27 spaced apart substantially the same distance as rims 17 and 18 of rollers 15 and 16 and also has extensions 28 and 29 which project axially thereof into crushing compartments 30 and 31 which flank the ring assembly. Roller 25, in the form of the invention shown in Figs. 1 to 5, has a peripheral surface 25' of the same shape as peripheral surface 19 of rollers 15 and 16. Extensions 28 and 29 have a plurality of radially extending lugs thereon. Crushing compartments 30 and 31 have curved bottom plates 32 and 32' which are curved on a horizontal axis extending in a horizontal plane parallel to the axis of rotation of rings 13 and rollers 15, 16 and 25, said plates engaging the inner periphery of casing 10 at the opposite ends and along one side of the plates. Plates 32 and 32' are in spaced relationship with bottom 11 of casing 10 in the crushing compartment portions thereof, plate 32'' engaging bottom plate 11 in the central portion beneath the ring assembly thereby forming a trough 33 beneath said assembly.

Vertically extending feed chutes 34 and 35 flank the ring assembly adjacent one end thereof and communicate with crushing compartments 30 and 31 respectively from bottom plates 32 and 32' upwardly through the pulverizing chamber and outwardly thereof through top plate 12. The chutes 34 and 35 have outlet openings at a level substantially even with the top of roller 25, said outlets facing parallel to the ends of the ring assembly. The passage of material from chutes 34 and 35 through the outlet openings into compartments 30 and 31 is controlled by guillotine gates 36 and 37 respectively, which gates are raised or lowered by means of cam rods 38 and 39 respectively extending outwardly of casing 10.

In the form of the invention shown in Figs. 1 to 4, a stream of air is caused to flow through the mill by means of an exhauster 40 positioned above the ring assembly in substantial vertical alignment therewith in the upper central portion of the mill. Exhauster 40 comprises a plurality of radially extending blades 41 mounted on a shaft 42 so as to turn therewith. The shaft 42 extends in a horizontal plane parallel to the horizontal plane in which rollers 15, 16 and 25 rotate. Blades 41 are enclosed in a housing 43 comprising a curved end plate 44 and spaced opposite side plates 45 and 46 forming a chamber 47 therebetween. The chamber 47 formed within housing 43 is in communication with the interior of casing 10 through inlet passages 48 and 49 formed around shaft 42 by tubular members 48' and 49' respectively, which members communicate with the chamber 47 through opposite side plates 45 and 46 and extend outwardly from the walls into the interior of casing 10 parallel to shaft 42. Inlet passages 48 and 49 are controlled by dampers 50 and 51 over the outer end of said passages respectively. The dampers comprise baffle plates which are actuated by shafts 50' and 51' on which the baffles are pivoted at the top respectively so that when the shafts are turned in one direction the baffles move outwardly at the bottom thereof away from the passage to open them and when turned in the opposite direction move inwardly at the bottom thereof toward said passages to close them. Shaft 42 is mounted at the opposite ends thereof in bearings 52 and 53 respectively which bearings are positioned in casing 10.

The top plate 12 of casing 10, as shown in Fig. 1, is curved at 54 on a horizontally extending axis which extends in a horizontal plane transversely of the axis of rotation of shaft 42.

Inlet passages 48 and 49 are in communication with the atmosphere outside of casing 10 respectively through vertically extending auxiliary air supply passages 55 and 56, the inlet openings of which are in top plate 12. Passages 55 and 56 are controlled respectively by dampers 57 and 58.

Pulverized material is classified by passing said material upwardly through classifying chutes 59 and 60 along the opposite sides of plates 45 and 46 of housing 43. Chutes 59 and 60 are formed at the outer side thereof by vertically extending plates 61 and 62 and on the inner side by side plates 45 and 46 of the exhauster housing. The chutes are closed at one end between side plates 45 and 46 by a plate of feed chutes 34 and 35 and at the opposite end by the inner periphery of casing 10 and extend from a point above the ring assembly to a point in spaced relationship with curved portion 54 of top plate 12. Plates 61 and 62 have inclined portions 63 and 64 which are

inclined inwardly toward the ring assembly, while the chutes 59 and 60 have inlets 65 and 66 above the inclined portions and the ring assembly and outlets 67 and 68 at the upper part of the chutes in spaced relationship to curved portions 54 of top plate 12. Reject passages 69 and 70 are formed laterally of plates 61 and 62 and between said plates and the inner periphery of casing 10 respectively. Passages 69 and 70 extend at one end thereof vertically adjacent feed chutes 34 and 35 and at one side thereof laterally along classifier chutes 59 and 60 and have inclined bottom plates 71 which direct the rejected material into crushing compartments 30 and 31.

The main supply of air for the fluid carrying stream enters the chambers within casing 10 through inlet conduit 72 which supply of air is regulated by dampers 73. Air entering casing 10 through conduit 72 may be heated to dry wet materials being pulverized or cooled to prevent overheating of materials as required.

As shown in Fig. 1, shafts 20 and 21 of rollers 15 and 16 respectively, each has a driving gear 74 fixed thereon adjacent one end thereof which gears 74 are enmeshed with a pinion gear 75 on the shaft of a motor not shown, which shaft has a pulley 76 fixed thereon while shaft 42 of the exhauster fan has a pulley 77 fixedly mounted on the end thereof above pulley 76. A belt 78 engages said pulleys. Rotation of the motor shaft will directly drive shafts 20 and 21 through gears 75 and 74 and indirectly drive the exhauster fan through pulleys 76 and 77 and belt 78.

In operation, material flows by gravity downwardly through the feed chutes 34 and 35 and into crushing compartment 30 and 31. Guillotine gates 36 and 37 are adjusted to admit the material to the desired level in said compartments, the gates when fully opened permitting material to flow into the crushing compartments to a level approximately even with the top of roller 25. The motor drives shafts 20 and 21 and the driving rollers 15 and 16 thereon respectively and also rotates shaft 42 of the exhauster, as hereinbefore described. Rotation of shafts 20 and 21, as shown more particularly in Fig. 2, is in a clockwise direction as is the direction of rotation of the rings 13 of the ring assembly. Rotation of the ring assembly in a clockwise direction also rotates roller 25 in such direction. As the crusher roller 25 rotates, the lugs on extensions 28 and 29 thereof break up the lumps of material and project the pieces thereof into free space within casing 10. The projected pieces fall back into the crushing compartments, the pool of material therein becoming fine and fluidized by such action. The lugs on extensions 28 and 29 of roller 25 continue to plow through the fluidized pool during the rotation of the roller and thereby sustain the fluidization, cause further disintegration of the material and continuously project fine material into the free space within the casing.

The fluidized material in crushing compartments 30 and 31 overflows therefrom onto the inner peripheral surface of the rings 13 of the ring assembly and is centrifuged and conducted by centrifugal force in a thin ribbon of material on said inner peripheral surface of the rings in the direction of rotation thereof. The thin ribbon of material on the inner surface of the ring assembly is squeezed between said surface and the double frusto-conical shaped peripheral surface 19 of rollers 15, 16 and the surface of roller 25, Figs. 1 to 5. The pressure developed on the ribbon of material forces and squeezes material



into V-shaped grooves 13' between adjacent rings 13 thence between the adjacent side surfaces of adjoining rings.

In the form of the ring and roller assembly shown in Figs. 1 to 5, as material is squeezed between adjacent rings, the rings are moved apart outwardly along the inclined surfaces 19 of rollers 15 and 16 toward the rims 17 and 18 thereof and along the inclined surfaces of roller 25 toward rims 26 and 27 thereof against the normal tendency of the rings to move laterally downwardly along the inclined peripheral surface toward the center of the assembly due to the shape of the periphery of the rollers. Due to the different inside diameters of the rings 13, said rings rotate at different speeds, the relative rotation thereof mulling and rubbing the particles between said rings together until they become extremely fine. The extremely fine material is projected radially from the ring assembly by further material being squeezed between said rings by the rollers from the ribbon of material. Any material in trough 33 is subjected to breaking up by lugs 14 on rings 13, some of the material being dragged around on the periphery of the ring assembly by said lugs as the assembly rotates. The speed of the circulating material is somewhat less than the circumferential speed of the peripheral lugs on the extensions of the crushing roller and on the rings causes a classifying action due to centrifugal force which tends to cause the larger pieces in the feed and heavy foreign matter such as, tramp iron, gravel, sand, rock and pyrites to slowly be forced outwardly from the peripheries of the roller and rings toward trap 79. As the crushable pieces of material in the feed are crushed by the rapid blows from the projections on extensions 28 and 29 of roller 25 and the projections 14 on the rings 13, the crushed pieces work their way to the top of the pool in compartments 30 and 31 to thereafter overflow into the ring assembly while the uncrushable material remains in the bottom of the compartments to thereafter be removed therefrom through a trap 79. In this manner, tramp rock and iron is effectively rejected from the grinding elements.

The fines projected radially from the ring assembly and any fines from compartments 30 and 31 are carried into classifier chutes 59 and 60 by a stream of air which is drawn into casing 10 through inlet conduit 72 by operation of the exhauster 40 which draws air upwardly through inlets 65 and 66 of chutes 61 and 62 outwardly of said chutes through outlets 67 and 68 thence into exhauster chamber 47 through passages 48 and 49 after passing under the lower edges of baffles 50 and 51. The stream of air entrains the fines carrying them upwardly through chutes 59 and 60 thereafter discharging them through outlets 67 and 68 of the chute. The stream of air and entrained fines impinges against curved portion 54 of top plate 12 and is caused to pass downwardly within the casing by the curvature of said liner. The stream of air and entrained fines is again caused to change its direction of flow to pass under the lower edge of baffles 51 and 52 to enter chamber 47 in exhauster housing 43 through damper controlled inlet passages 48 and 49. The changes of direction of flow of the stream of air and entrained material after leaving outlets 67 and 68 of chutes 59 and 60 prior to entering the passages 48 and 49 causes the heavier entrained material to be rejected from the stream. The rejected oversize material drops downwardly into

crusher compartments 30 and 31 through reject passages 69 and 70. Since the ratio of rejected oversized material to the material fed into compartments 30 and 31 through chutes 34 and 35 is great, the rejected material, since it has been dried in the air stream, is dry and will therefore blot away free moisture on the surface of the incoming feed and minimize the retarding effect of said moisture in the feed.

Pulverized material of the desired fineness is blown outwardly of exhauster chamber 47 through exhauster outlet 80 in the top of the casing. Upon the closing of passages 48 and 49 by dampers 50 and 51, any pulverized material may be scavenged from said passage and the exhauster with dampers 57 and 58 in an open position so that air may pass downwardly through auxiliary air passages 55 and 56 into inlet passages 48 and 49 thence to outlet 80 through chamber 47, said air entraining pulverized material as it flows through the inlet passages and exhauster chamber to the exhauster outlet.

In the embodiment of ring and roller assembly illustrated in Figs. 6 and 9, only one drive roller is shown. The roller 15 is positioned at the top of the ring assembly and is shaped as in the embodiment disclosed in Figs. 1 to 5, that is, with the peripheral surface 19 thereof inclined downwardly from the rims 17 to a point in the roller centrally of the rims, as hereinbefore described, so as to normally urge the rings 13 of the ring assembly together. The peripheral surface of the roller 25 in this embodiment of the invention, however, is so shaped as to normally urge the adjacent rings apart. In the embodiment of roller 25 shown in Fig. 6, the peripheral surface 81 is inclined in opposite directions outwardly and downwardly from a central point between rims 26 and 27 to said rims. With this arrangement, the adjacent rings 13 of the ring assembly are urged together by roller 15 so that material is crushed between the adjacent rings but the rings are urged apart adjacent the bottom of the ring assembly by surface 81 of roller 25 so that the pressure on the material crushed by the adjacent rings is lower than in the embodiment shown in Fig. 5. Urging apart of the rings at the lower portion also causes a forcing together of the rings at the upper portion of the assembly. The rings 13 are all of the same outside diameter and inside diameter.

In the embodiment of the ring and roller assembly shown in Fig. 7, roller 15 is also positioned at the top of the ring assembly but is cylindrically-shaped and has spaced peripheral grooves 82 therein which grooves are separated by circular projections 83 of greater outside diameter than the grooves 82. Roller 25 has a cylindrically-shaped peripheral surface 84. Adjacent rings 85 and 86 are of different inside diameter but the outside diameter of the rings are the same. The inside diameter of rings 85 is less than the inside diameter of rings 86, the inside diameter of rings 85 being such that the rings are suspended in grooves 82, while the inside diameter of rings 86 is such that the rings are suspended on projections 83. In this manner, the rings are maintained in a spaced relationship with one another and, since rings 85 and 86 are of different inside diameters, they are rotated by roller 15 at different rates of speed.

In the embodiment of the ring and roller assembly illustrated in Fig. 8, the peripheral surface 19 of driving roller 15 and the peripheral surface 25' of roller 25 are cylindrically-shaped and have circumferentially extending rings at the opposite ends thereof. Surfaces 19 and 25' in Fig. 8 respectively have a plurality of laterally adjoining substantially V-shaped grooves 87 extending peripherally of said surfaces with the apices of the grooves extending toward the axis of rotation of the rollers.

While only one driving roller 15 is shown in the embodiments of ring and roller assemblies shown in Figs. 5 to 8, it will be understood that more than one of such rollers may be utilized. Roller 25 in all forms of the invention is of substantial weight so that it will frictionally engage the inner periphery of the ring assembly and apply a pulverizing force by force of gravity to the material therein and to the material in the crushing compartments. Roller 25 maintains its position at the bottom of the ring assembly and forces the inner periphery thereof and the outer periphery of the driving rollers into engagement.

In the embodiments of the invention shown in Figs. 10 and 11, the ring and roller pulverizing elements are substantially the same as those illustrated in Figs. 1 to 4. However, the means for causing a stream of air to flow through the casing and the arrangement of various other elements within the casing is substantially different.

As illustrated in Fig. 10, the lower portion of the casing 10 has a door 89' opening outwardly adjacent the pulverizing elements. A cylindrically-shaped hopper 89 is disposed on top of the casing 10, which top is open, and extends upwardly therefrom. Hopper 89 has an inclined bottom 90 in communication with feed chutes 34 and 35, the inclined bottom 90 thereof separating hopper portion 89' from an air chamber 91 which communicates with the interior of casing 10. Chamber 91 has a damper controlled air inlet conduit 92 in communication therewith. A classifier comprising a tubular member 93 extends vertically in chamber 91 in substantial vertical alignment with the ring assembly and has an inlet 94 communicating with said chamber and the interior of casing 10 adjacent the upper portion of the periphery of the ring assembly. Tubular member 93 is partitioned transversely thereof by a partition plate 95 extending substantially vertically of the tubular member from the inlet 94 to a point short of a curved baffle 96 in the upper portion of the tubular member and also extending substantially diametrically thereof. Plate 95 has a downwardly projecting flange 97 which projects in spaced relationship with the body of the plate. An outlet conduit 98 communicates at one end thereof with the space between flange 97 and the body of plate 95 intermediate the opposite ends of said space and extends outwardly of hopper 89. At the opposite end, conduit 98 communicates with the whirl chamber of a cyclone separator 99 tangentially thereof. Air is drawn upwardly through the whirl chamber by an exhauster fan 100 which draws air through a filter 101.

In operation of the embodiment of the invention shown in Fig. 10, air is drawn through air inlet conduit 92 into chamber 91 and inside casing 10 thereafter to flow upwardly in passage 102 in tubular member 93, impinge on baffle 96 to be turned downwardly in a curved path thereafter to flow outwardly of member 93 through conduit 98 after passing upwardly under the lower edge of flange 97 into the space between the flange and the body of partition 95 and into said conduit. The air in flowing from conduit 92 to conduit 98 entrains pulverized material in chamber 91 and in

casing 10 carrying the entrained material upwardly in passage 102 thereafter impinging on baffle 96. Impingement thereof on baffle 96 causes the stream to flow downwardly in passage 102' of tubular member 93. Change of direction of flow of the stream of air and entrained material by baffle 96 and by flange 97 separates oversized material from the stream which oversized material flows downwardly in passage 102' onto the periphery of the ring assembly. Entrained material is separated from the stream in the whirl chamber of cyclone separator 99, the separated material flowing downwardly through spout 103 into a container 104. Any material not separated from the stream in the whirl chamber is filtered out by filter 101.

In the embodiment of the invention shown in Fig. 11, a blower 105 is used to create the fluid stream by means of which pulverized material is conducted from the mill. Blower 105 at its outlet communicates with the pulverizing chamber within casing 10 through air inlet 106 which inlet is damper controlled at 107 and is positioned in substantial horizontal alignment with the ring assembly. The classifier in this embodiment of the invention comprises an upwardly extending projection 108 of the innermost walls of reject chutes 69 and 70 which walls flank the ring assembly, said innermost walls and projections extending at right angles to the axis of rotation of the ring assembly. Projections 108 form a baffle which extends slightly inwardly toward inlet 106 of the blower thence upwardly to a point above the blower inlet. The projections are thence inclined slightly in a direction away from said blower inlet thence downwardly to form a depending flange 109 which flange is in spaced relationship with the portion of the projection 108 which is inclined in a direction away from the blower inlet. The uppermost point of projections 108 is in spaced relationship with curved portions 54 at the top of the casing while flanges 109 project downwardly in spaced relationship with the inner periphery of the casing and in vertical alignment with reject chutes 69 and 70. Pulverized material outlet 110 communicates with the space between flange 109 and the inwardly inclined portion of projection 108.

In operation, air is blown by blower 105 through inlet 106 into casing 10 wherein it entrains pulverized material. The stream of air and pulverized material passes upwardly, impinges against curved portions 54 at the top of the casing where it is deflected downwardly. After being deflected downwardly by the curved portions, the stream changes its direction of flow to pass under the lowermost edge of flange 109 into the space between said flange and the upwardly inclined portion of projections 108 and thence outwardly through outlet 110. The changing of the direction of flow of the stream causes the oversized material to be rejected from the stream, said rejected oversized material passing downwardly through reject chutes 69 and 70 into compartments 31 and 30 respectively. The stream containing material of the desired particle size flows outwardly of casing 10 through outlet 110.

Although various preferred forms of the invention have been disclosed herein, it is to be understood that changes may be made in the form and relative arrangement of the parts of the apparatus described without departing from the principles of the invention which are not to be limited excepting by the scope of the appended claims.

What is claimed is:



1. Pulverizing apparatus comprising ring and roller pulverizing elements having at least one fixedly supported upper drive roller mounted to rotate on a substantially horizontal axis, said drive roller having a peripheral driving surface, a plurality of laterally adjacent rings each separately pendantly mounted upon said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings and the diameter of the driving roller at the point of engagement of each of said rings with the peripheral driving surface of said drive roller being such that the distance between the axis of rotation of the drive roller and the point of engagement of said driving surface and said inner peripheral surface of one ring and the distance between said axis of rotation of the drive roller and the point of engagement of said driving surface of the roller and said inner peripheral surface of a ring laterally adjacent said one ring are unequal, and a pulverizing roller resting within the plurality of rings at the bottom thereof so as to exert a downwardly force on the rings, the configuration of the peripheral driving surface of said drive roller, the configuration of the peripheral surface of the pulverizing roller and said downwardly force exerted on the rings by said pulverizing roller being such as to maintain the rings in parallelism and in grouped relationship with each other around the peripheral driving surface of said driving roller.

2. The apparatus of claim 1 wherein the pulverizing roller is gravity loaded.

3. The apparatus of claim 1 wherein spaced rims are provided on said drive roller and spaced rims are provided on said pulverizing roller, said rims being positioned on the rollers to prevent lateral movement of said rings beyond said rims.

4. Pulverizing apparatus comprising ring and roller pulverizing elements having at least one fixedly supported upper drive roller mounted to rotate on a substantially horizontal axis, said drive roller having a peripheral driving surface, a plurality of laterally adjacent rings each separately pendantly mounted upon said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings and the diameter of the driving roller at the point of engagement of each of said rings with the peripheral driving surface of said drive roller being such that the distance between the axis of rotation of the drive roller and the point of engagement of said driving surface and said inner peripheral surface of one ring and the distance between said axis of rotation of the drive roller and the point of engagement of said driving surface of the roller and said inner peripheral surface of a ring laterally adjacent said one ring are unequal, a pulverizing roller resting within the plurality of rings at the bottom thereof so as to exert a downwardly force on the rings, the configuration of the peripheral driving surface of said drive roller, the configuration of the peripheral surface of the pulverizing roller and said downwardly force exerted on the rings by said pulverizing roller being such as to maintain the rings in parallelism and in grouped relationship with each other around the peripheral driving surface of said driving roller, axial extensions on said pulverizing roller, said extensions projecting laterally beyond the group of rings from the opposite ends of the pulverizing roller, and a plurality of projections extending

radially from said extensions in spaced relationship to one another and spaced from one another circumferentially of the extensions.

5. Pulverizing apparatus having a pulverizing chamber, ring and roller pulverizing elements in the chamber comprising at least one fixedly supported upper drive roller having a peripheral driving surface, a plurality of laterally adjacent rings each separately pendantly mounted upon said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings and the diameter of the driving roller at the point of engagement of each of said rings with the peripheral driving surface of said drive roller being such that the distance between the axis of rotation of the drive roller and the point of engagement of said driving surface and said inner peripheral surface of one ring and the distance between said axis of rotation of the drive roller and the point of engagement of said driving surface of the roller and the inner peripheral surface of a ring laterally adjacent said one ring are unequal, a pulverizing roller resting within the plurality of rings at the bottom thereof so as to exert a downwardly force on the rings, the configuration of the peripheral driving surface of said drive roller, the configuration of the peripheral surface of the pulverizing roller and said downwardly force exerted on the rings by said pulverizing roller being such as to maintain the rings in parallelism and in grouped relationship with each other around the peripheral driving surface of said driving roller, driving means for rotating the driving roller, and feeding means for feeding material to be pulverized to said pulverizing elements, the chamber having a pulverized material outlet.

6. The apparatus of claim 5 wherein the rings have a plurality of lugs on the outer periphery thereof projecting radially therefrom and in spaced relationship to one another circumferentially of the rings.

7. A pulverizing mill comprising a casing having a substantially vertically extending pulverizing chamber therein, ring and roller pulverizing elements located in the lower portion of the chamber comprising at least one fixedly supported upper drive roller having a peripheral driving surface, the roller being mounted to rotate on a substantially horizontal axis, a ring assembly in spaced relationship circumferentially with the periphery and bottom of the chamber and laterally with said chamber periphery, the ring assembly having a plurality of laterally adjacent rings each separately pendantly mounted upon said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings and the diameter of the driving roller at the point of engagement of each of said rings with the peripheral driving surface of said drive roller being such that the distance between the axis of rotation of the drive roller and the point of engagement of said driving surface and said inner peripheral surface of one ring and the distance between said axis of rotation of the drive roller and the point of engagement of said driving surface of the roller and the inner peripheral surface of a ring laterally adjacent said one ring are unequal, a pulverizing roller resting within the plurality of rings at the bottom thereof so as to exert a downwardly force on the rings, the configuration of the peripheral driving surface of said drive roller, the configuration of the peripheral surface of the pulverizing roller and said downwardly force exerted on the rings by said pulverizing roller being such as to maintain the rings in parallelism and in grouped relationship with each other around the peripheral driving surface of said driving roller, and feed chutes extending vertically in said chamber and having an inlet adjacent the top and an outlet adjacent the bottom of the chamber, said chutes being disposed in the chamber so as to flank said ring assembly, the chamber having a pulverized material outlet.

8. The apparatus of claim 7 wherein the feed chutes are positioned in the chamber laterally adjoining opposite sides of the ring assembly adjacent the periphery thereof at one side of the chamber with said outlet of each chute disposed so as to face toward the opposite side of said chamber, and wherein a control damper is associated with the outlet of each chute so as to control the flow of material therefrom, the chamber having a pulverized material outlet in the upper portion thereof.

9. A pulverizing mill comprising a casing having a substantially vertically extending pulverizing chamber therein, ring and roller pulverizing elements disposed in the lower portion of said chamber, said elements having an upper fixedly supported drive roller mounted to rotate on a horizontal axis, a ring assembly in spaced relationship circumferentially with the periphery, and bottom of the chamber and laterally with said chamber periphery the ring assembly having a plurality of laterally adjacent rings each separately pendantly mounted upon said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings and the diameter of the driving roller at the point of engagement of each of said rings with the peripheral driving surface of said drive roller being such that the distance between the axis of rotation of the drive roller and the point of engagement of said driving surface and said inner peripheral surface of one ring and the distance between said axis of rotation of the drive roller and the point of engagement of said driving surface of the roller and the inner peripheral surface of a ring laterally adjacent said one ring are unequal, a pulverizing roller resting within the plurality of rings at the bottom thereof so as to exert a downwardly force on the rings, the configuration of the peripheral driving surface of said drive roller, the configuration of the peripheral surface of the pulverizing roller and said downwardly force exerted on the rings by said pulverizing roller being such as to maintain the rings in parallelism and in grouped relationship with each other around the peripheral driving surface of said driving roller, extensions of substantially the same diameter as and rotatable with said pulverizing roller, the extensions extending axially from the opposite ends thereof and into the pulverizing chamber, a plurality of lugs projecting radially from said extensions in spaced relationship to one another and extending circumferentially of the extensions, driving means for rotating the driving roller, and feed chutes extending vertically in said chamber and having an inlet adjacent the top and an outlet adjacent the bottom of the chamber, said chutes being disposed in the chamber so as to flank said ring assembly, the chamber having a pulverized material outlet.

10. Pulverizing apparatus comprising ring and

roller pulverizing elements having at least one fixedly supported upper drive roller mounted to rotate on a substantially horizontal axis, said drive roller having a peripheral driving surface of waisted shape, a group of pulverizing rings comprising a plurality of laterally adjacent rings each separately pendantly mounted upon said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings of said group of rings decreasing from opposite sides of the group to a point intermediate the opposite sides thereof, and a pulverizing roller resting within the group of rings at the bottom thereof so as to exert a downwardly force on the rings, the pulverizing roller having a peripheral surface of similar waisted shape adapted to frictionally engage the inner peripheral surfaces of the rings so that the rings are maintained in parallelism and grouped toward each other around the peripheral driving surface of said driving roller.

11. The apparatus of claim 10 wherein the ring and roller pulverizing elements have two fixedly supported drive rollers of substantially identical waisted shapes on which the plurality of rings are each separately pendantly mounted.

12. The apparatus of claim 10 wherein the inner peripheral edge of the rings are substantially semi-circular in cross-sectional configuration.

13. The apparatus of claim 10 wherein spaced rims are provided on said drive roller and spaced rims are provided on said pulverizing roller, said rims being positioned on the rollers to prevent lateral movement of said rings beyond said rims.

14. The apparatus of claim 10 wherein the pulverizing roller has axial extensions projecting laterally beyond the group of rings from the opposite ends of the pulverizing roller, and a plurality of projections extending radially from said extensions in spaced relationship to one another and spaced from one another circumferentially of the extensions.

15. A pulverizing mill comprising a casing having a substantially vertically extending pulverizing chamber therein, ring and roller pulverizing elements disposed in the lower portion of said chamber and comprising two fixedly supported upper drive rollers mounted to rotate on a substantially horizontal axis, said drive rollers each having a peripheral driving surface of substantially identical waisted shapes, a ring assembly comprising a plurality of laterally adjoining rings each separately pendantly mounted upon said rollers, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings of said group decreasing from opposite sides of the group to a point intermediate the opposite sides thereof, said pulverizing elements being so positioned in the chamber that the ring group is in spaced relationship circumferentially with the periphery and bottom of the chamber and laterally with said chamber periphery, a plurality of lugs on the outer periphery of the rings projecting radially therefrom and in spaced relationship to one another circumferentially of the rings, a pulverizing roller resting within the group of rings at the bottom thereof so as to exert a downwardly force on the rings, the pulverizing roller having a peripheral surface of similar waisted shape adapted to frictionally engage the inner peripheral surface of the rings so that the rings are maintained in parallelism and grouped toward each other around the peripheral driving surface of said driving rollers, driving means for rotating the driving rollers and material feeding means for feeding material to be pulverized to said pulverizing elements, the chamber having a pulverized material outlet.

16. The apparatus of claim 15 wherein feed chutes extend vertically in the chamber and have an inlet adjacent the top and an outlet adjacent the bottom of the chamber, the chutes being positioned laterally adjoining opposite sides of the ring assembly adjacent the periphery thereof at one side of the chamber with said outlet of each chute disposed so as to face toward the opposite side of said chamber, and a control damper is associated with the outlet of each chute so as to control the flow of material therefrom, the chamber having a pulverized material outlet in the upper portion thereof.

17. A pulverizing mill comprising a casing having a substantially vertically extending pulverizing chamber therein, ring and roller pulverizing elements disposed in the lower portion of said chamber and comprising two fixedly supported upper drive rollers mounted to rotate on a substantially horizontal axis, said drive rollers each having a peripheral driving surface of substantially identical waisted shapes, a ring assembly comprising a plurality of laterally adjoining rings each separately pendantly mounted upon said rollers, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings of said group decreasing from opposite sides of the group to a point intermediate the opposite sides thereof, said pulverizing elements being so positioned in the chamber that the ring group is in spaced relationship circumferentially with the periphery and bottom of the chamber and laterally with said chamber periphery, a plurality of lugs on the outer periphery of the rings projecting radially therefrom and in spaced relationship to one another circumferentially of the rings, a pulverizing roller resting within the group of rings at the bottom thereof so as to exert a downwardly force on the rings, the pulverizing roller having a peripheral surface of similar waisted shape adapted to frictionally engage the inner peripheral surface of the rings so that the rings are maintained in parallelism and grouped toward each other around the peripheral driving surface of said driving rollers, extensions of substantially the same diameter as and rotatable with said pulverizing roller, the extensions extending axially from the opposite ends thereof and into the pulverizing chamber, a plurality of lugs projecting radially from said extensions in spaced relationship to one another and extending circumferentially of the extensions, driving means for rotating the driving roller, and feed chutes extending vertically in said chamber, said chutes each having an inlet adjacent the top and an outlet adjacent the bottom of the chamber, the chutes being positioned in the chamber laterally adjoining opposite sides of the ring assembly adjacent the periphery thereof at one side of the chamber with said outlet of each chute disposed so as to face toward the opposite side of said chamber, the chamber having a pulverized material outlet.

18. Pulverizing apparatus comprising ring and roller pulverizing elements having a fixedly supported upper drive roller mounted to rotate on a substantially horizontal axis, said drive roller having a peripheral driving surface of waisted shape, a plurality of laterally adjacent rings each separately pendantly mounted upon said roller,

the rings having substantially flat contiguous surfaces for pulverizing materials therebetween, the inside diameters of the rings being equal, and a pulverizing roller resting within the plurality of rings at the bottom thereof so as to exert a downwardly force on the rings, the pulverizing roller having a crown-shaped peripheral surface adapted to frictionally engage the inner peripheral surfaces of the rings so that the rings are maintained in parallelism and grouped around the peripheral driving surface of said driving roller.

19. Ring and roller pulverizing elements for a pulverizing mill comprising an upper drive roller fixedly supported to rotate on a horizontal axis, a ring assembly suspended on said driving roller so that the inner peripheral surface of the rings frictionally engage the driving surface of the roller, said assembly having a plurality of laterally adjoining rings each separately pendantly mounted on said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameters of the rings being equal, a portion of the driving roller extending axially beyond the opposite sides of the ring assembly, the peripheral surface of the driving roller decreasing axially thereof from the opposite ends thereof to a point intermediate said opposite ends at substantially the same angle as said decrease of the inside diameter of the rings, the diameter of said extending portion of the driving roller being greater than the diameter of the roller directly adjacent and axially within the ring assembly, and a pulverizing roller resting interiorly of the rings so that the peripheral surface of said roller frictionally engages the inner periphery of the ring assembly by force of gravity and exerts a pulverizing force between said peripheral surface of the pulverizing roller and the inner peripheral surface of the rings, the peripheral surface of the pulverizing roller decreasing axially from a point intermediate said opposite ends towards said ends, the angle of decrease of the peripheral surface of said pulverizing roller being such as to permit the peripheral surface of the pulverizing roller to frictionally engage the inner peripheral surfaces of the rings.

20. Ring and roller pulverizing elements for a pulverizing mill comprising an upper cylindrically-shaped driving roller fixedly supported to rotate on a horizontal axis and having a plurality of axially spaced circumferentially extending grooves therein, a ring assembly having a plurality of laterally spaced rings suspended on said roller, each separately pendantly mounted on said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of adjacent rings being different, the inside diameter of one ring engaging the bottom of said groove and the inside diameter of the next adjacent ring engaging the outer peripheral surface of the roller adjoining said groove, and a cylindrically-shaped pulverizing roller resting interiorly of the rings so as to frictionally engage the inner periphery of the ring assembly by force of gravity and exert a pulverizing force between the outer peripheral surface of the pulverizing roller and the inner peripheral surface of the rings.

21. Ring and roller pulverizing elements for a pulverizing mill comprising an upper cylindrically-shaped driving roller fixedly supported to rotate on a horizontal axis and having a plurality of substantially V-shaped circumferentially extending grooves therein, a ring assembly having a plurality of laterally adjacent rings each separately pendantly mounted upon said roller, the rings having substantially flat contiguous facing surfaces for pulverizing materials therebetween, the inside diameter of the rings and the diameter of the driving roller at the point of engagement of each of said rings with the peripheral driving surface of said drive roller being such that the distance between the axis of rotation of the drive roller and the point of engagement of said driving surface and said inner peripheral surface of one ring and the distance between said axis of rotation of the drive roller and the point of engagement of said driving surface of the roller and said inner peripheral surface of a ring laterally adjacent said one ring are unequal, and a gravity loaded pulverizing roller resting interiorly of the rings so as to frictionally engage the inner periphery of the ring assembly by force of gravity and exert a pulverizing force between the peripheral surface of the pulverizing roller and the inner peripheral surface of the rings, the pulverizing roller being of cylindrical shape, the outer peripheral surface thereof having a plurality of circumferentially extending V-shaped grooves therein similar to said V-shaped grooves in the driving roller.

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