

Oct. 4, 1966

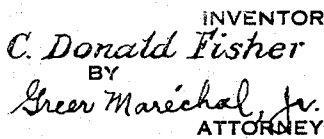
C. D. FISHER

3,276,701

ATTRITION MILL APPARATUS

Original Filed Jan. 15, 1962

7 Sheets-Sheet 1



Oct. 4, 1966

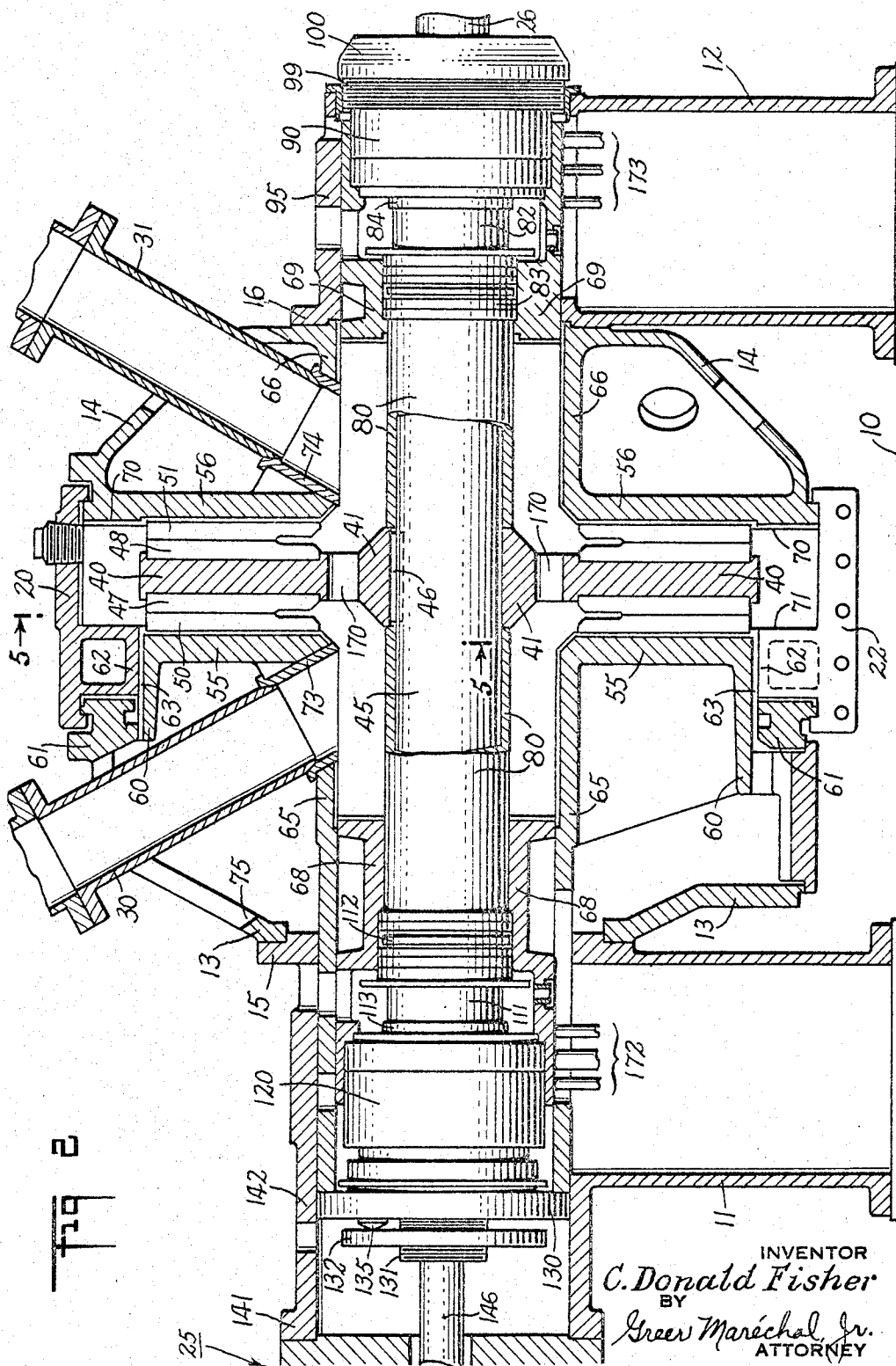
C. D. FISHER

3,276,701

ATTRITION MILL APPARATUS

Original Filed Jan. 15, 1962

7 Sheets-Sheet 2



INVENTOR
C. Donald Fisher
BY
Green Maréchal, Jr.
ATTORNEY

Oct. 4, 1966

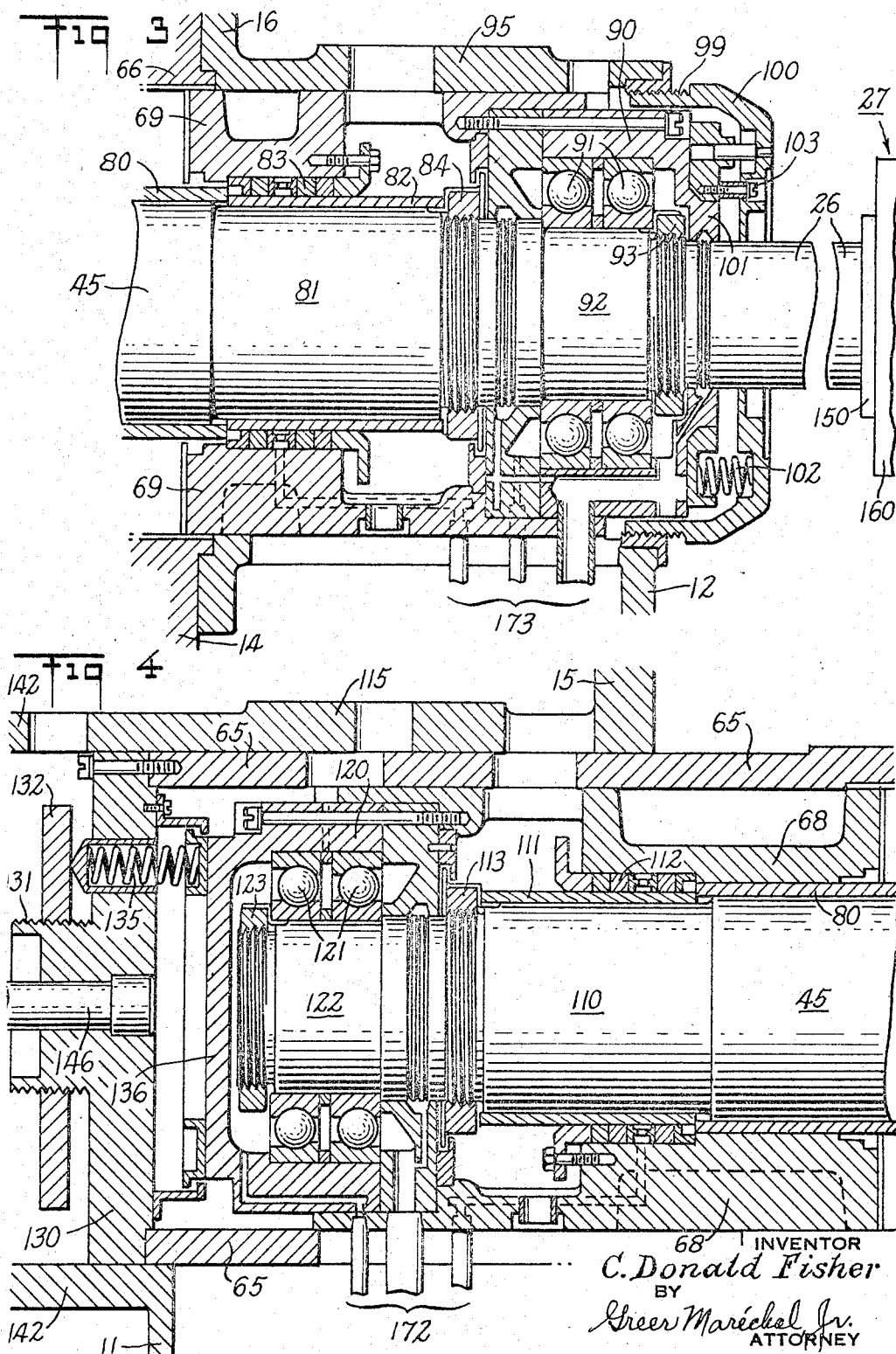
C. D. FISHER

3,276,701

ATTRITION MILL APPARATUS

Original Filed Jan. 15, 1962

7 Sheets-Sheet 3



Oct. 4, 1966

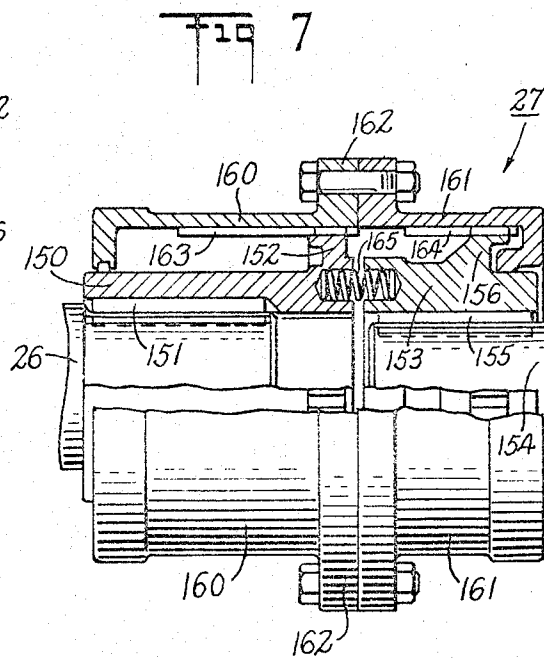
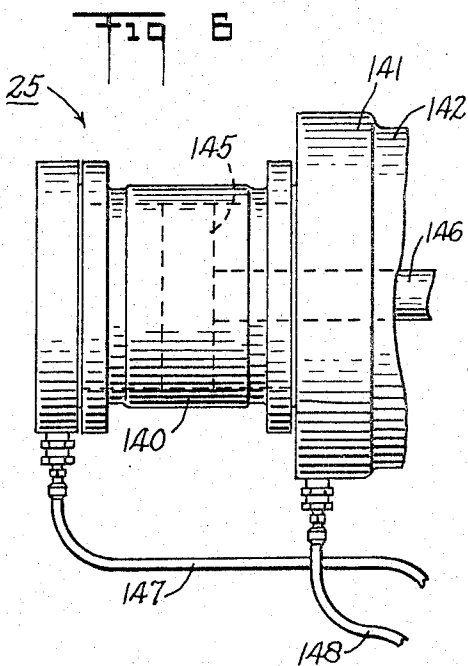
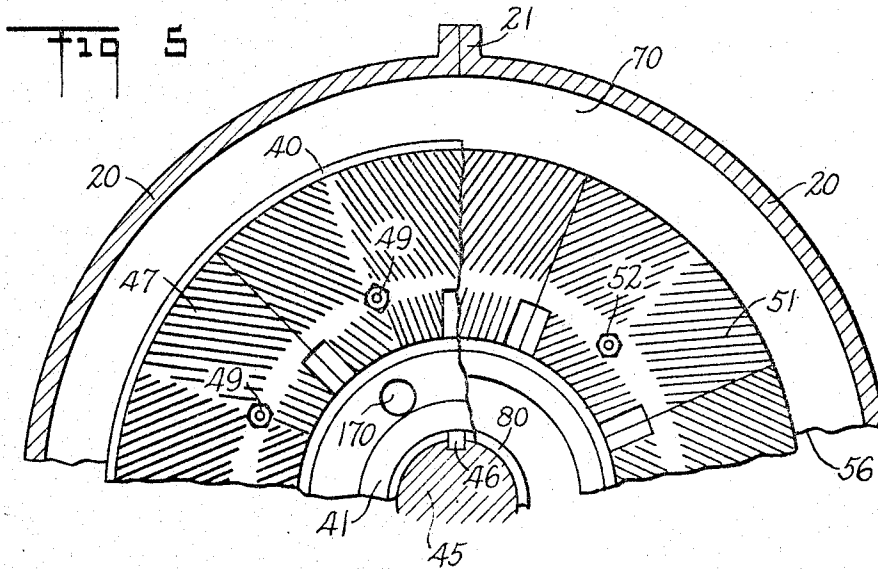
C. D. FISHER

3,276,701

ATTRITION MILL APPARATUS

Original Filed Jan. 15, 1962

7 Sheets-Sheet 4



INVENTOR
C. Donald Fisher
BY
Greer Marechal, Jr.
ATTORNEY

Oct. 4, 1966

C. D. FISHER

3,276,701

ATTRITION MILL APPARATUS

Original Filed Jan. 15, 1962

7 Sheets-Sheet 5

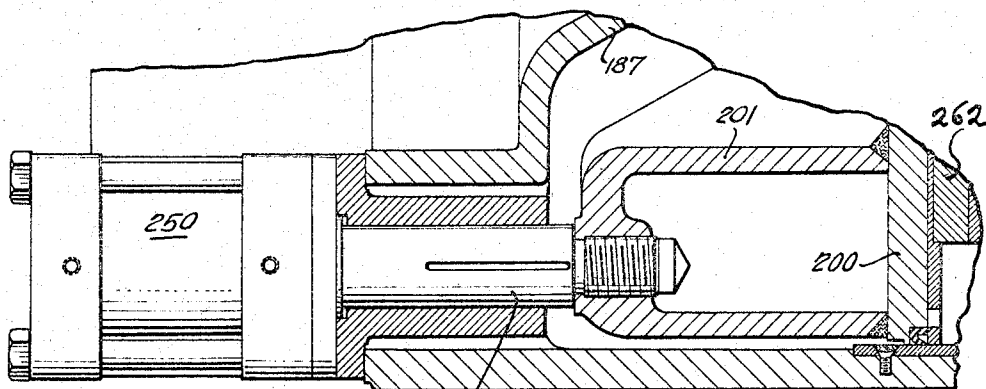
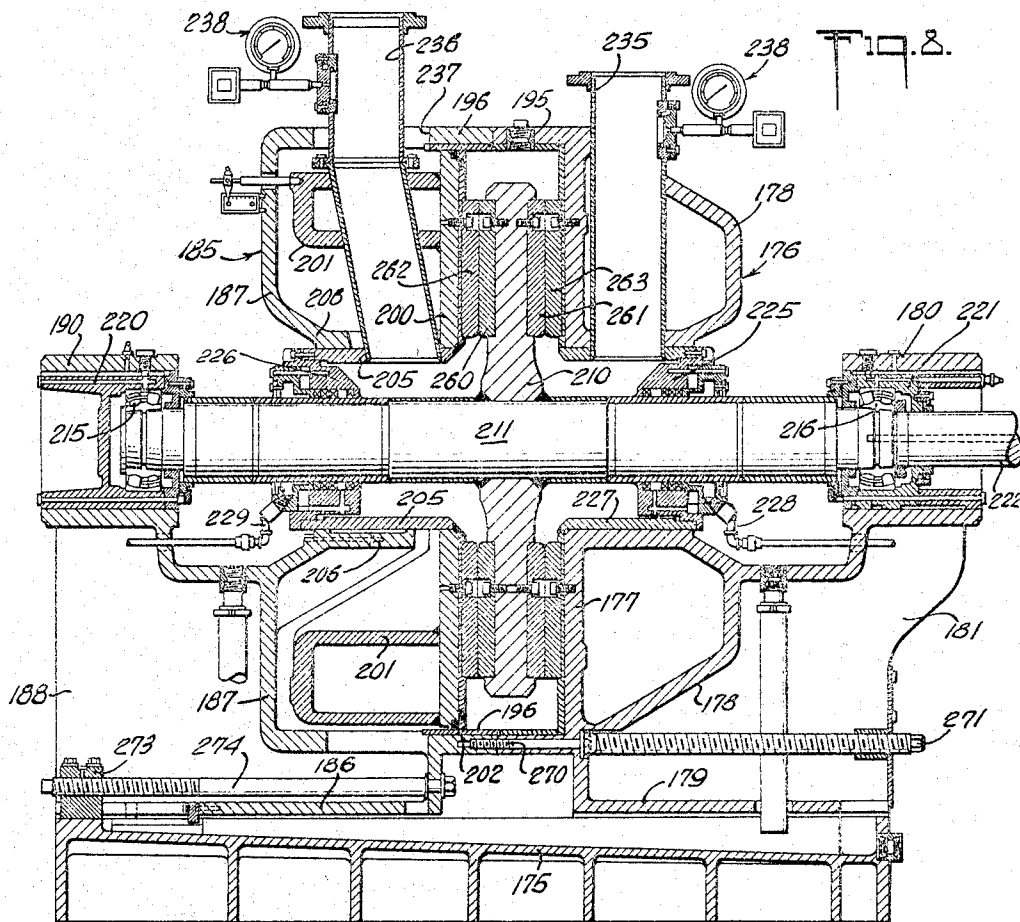


Fig. 14.

INVENTOR
C. DONALD FISHER
BY *Ernest H. Marshall Jr.*
ATTORNEY

Oct. 4, 1966

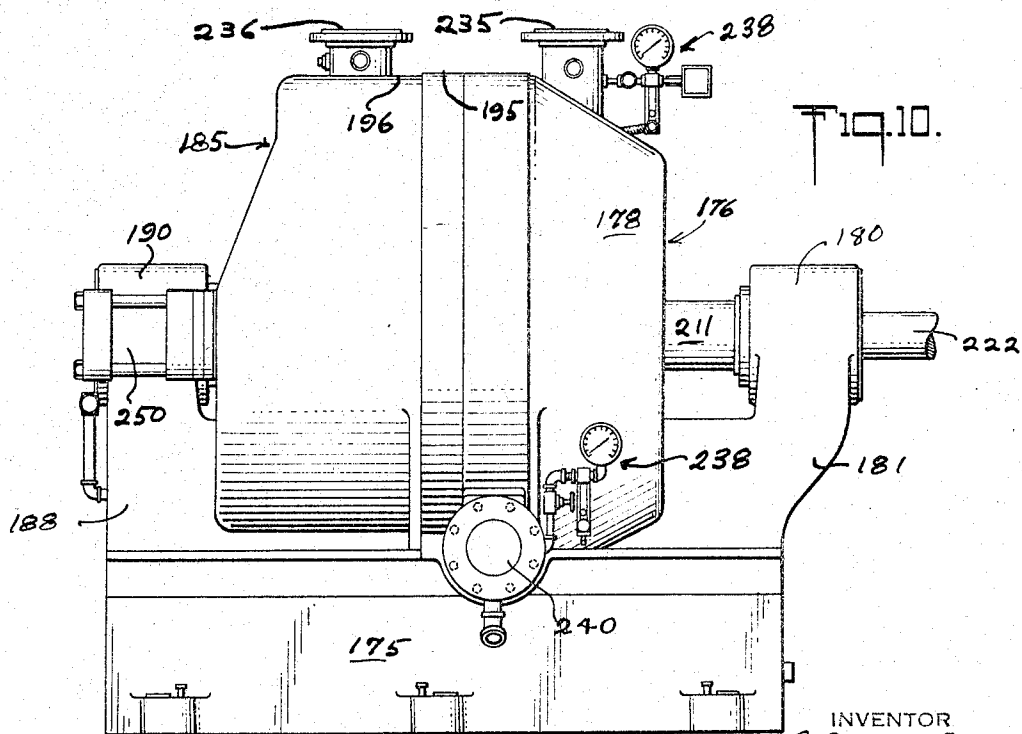
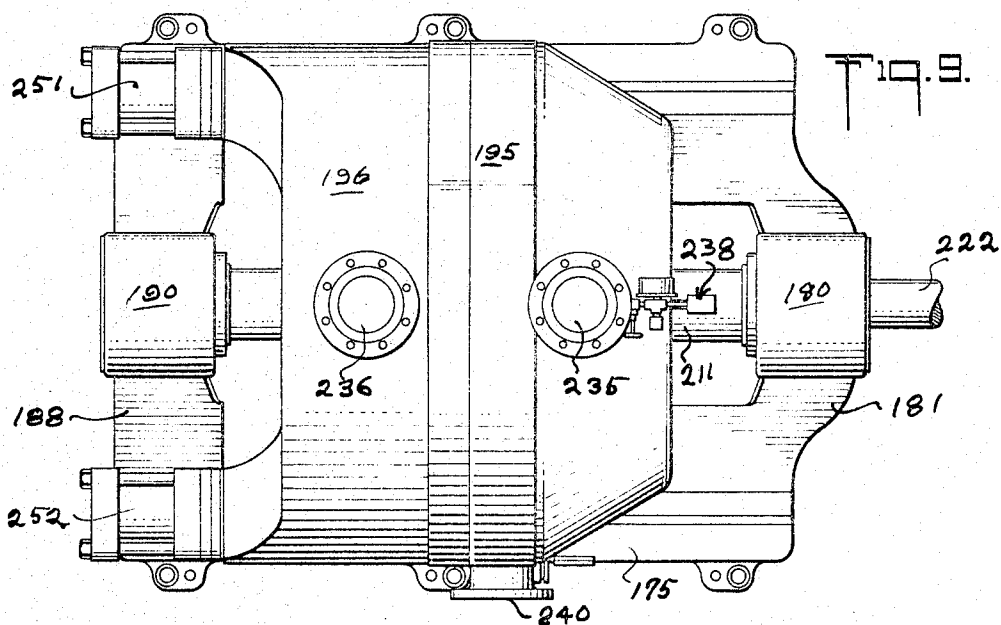
C. D. FISHER

3,276,701

ATTRITION MILL APPARATUS

Original Filed Jan. 15, 1962

7 Sheets-Sheet 6



INVENTOR
C. DONALD FISHER

BY
Green H. Marshall Jr.
ATTORNEY

Oct. 4, 1966

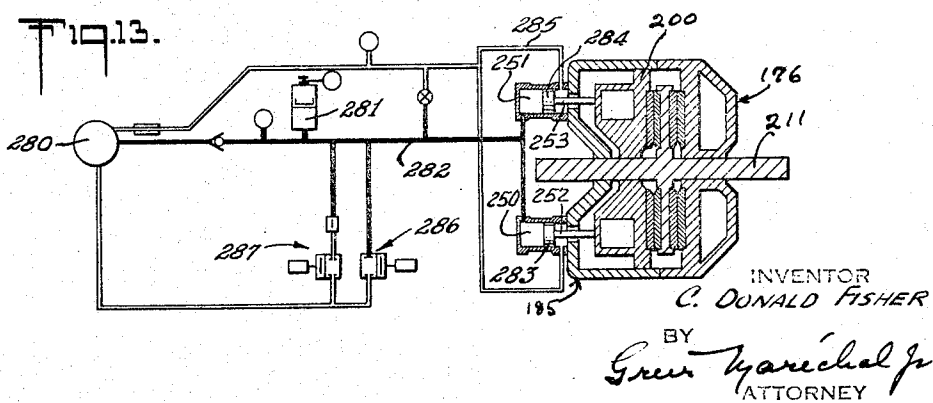
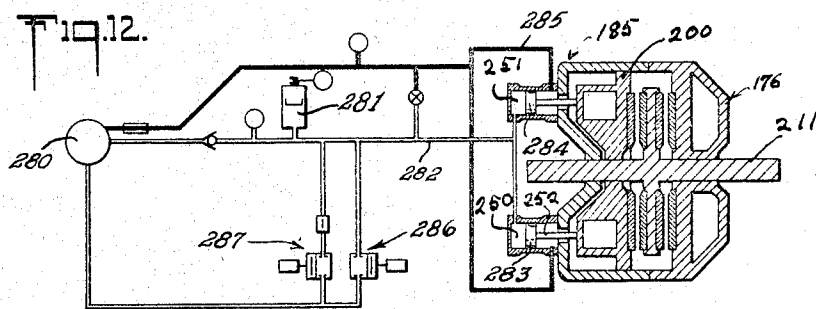
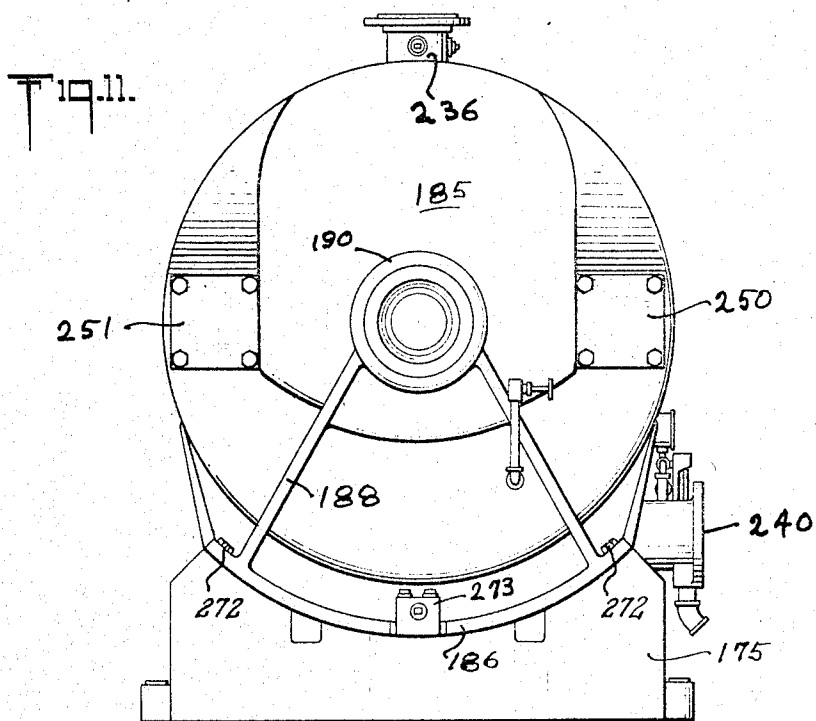
C. D. FISHER

3,276,701

ATTRITION MILL APPARATUS

Original Filed Jan. 15, 1962

7 Sheets-Sheet 7



1

2

3,276,701

ATTRITION MILL APPARATUS

Chester Donald Fisher, Muncy, Pa., assignor to Sprout, Waldron & Company, Inc., Muncy, Pa., a corporation of Pennsylvania

Continuation of application Ser. No. 175,862, Jan. 15, 1962. This application Apr. 15, 1964, Ser. No. 360,143 16 Claims. (Cl. 241-146)

This application is a continuation of application Serial Number 175,862, filed January 15, 1962, now abandoned, which was a continuation-in-part of application Serial Number 46,457, filed August 1, 1960, now abandoned.

This invention relates to attrition mill apparatus and, more particularly, to rotating disc attrition mills for refining paper pulp and like usage and in which the attrition or refining or grinding action, as may be desired, is obtained by passing the material to be treated between the opposed faces of a rotating disc and a cooperating attrition surface, and, further, in which there are grinding or refining or attrition surfaces on both sides of the rotating disc, each of which cooperates with a mating or opposed non-rotating disc or attrition surface.

As will be understood, with rotating disc attrition mills of the character to which this invention relates (whether the attrition action be provided by a single disc rotating in cooperation with an opposed and mating stationary surface or by opposed and mating counter-rotating attrition disc surfaces) the severity or extent of attrition work done on material being passed between the discs is an important function of, among other things, the maintained spacing between the mating or cooperating surfaces of the discs. Such passing of material between the discs, however, produces substantial moments of thrust force axially of the machine opposing whatever mechanism is provided for maintaining the discs axially spaced with the desired small clearance. The resistance of such substantial axial forces (which, as will be understood, increase tremendously as the diameter of the discs increases) may require expensive and complicated mechanism for the maintenance in operation of close tolerance spacing between the attrition surfaces as is desired and required for many uses of such attrition mills or refiners.

Similarly, if it is desired to incorporate such a disc attrition mill in a closed pressure fluid system so that pressure is maintained within the attrition mill on, for example, a liquid slurry being treated thereby, difficulty may be experienced in providing adequate power into the mill and/or a wastage of power may result from fluid friction and hydraulic losses. For example, considering a single disc attrition mill (that is, with a single rotating disc operating against opposed or mating non-rotating attrition surfaces with liquid slurry on both sides of the rotating disc) and having a disc diameter of three or four feet, it will be noted that, if a device is operated as a part of a closed and pressurized system for treating a fluid slurry, in addition to the axial thrust forces involved, enough power must be introduced into the rotating means for the disc not only to drive it for the attrition work desired but also to drive it against the fluid friction or hydraulic drag forces operating on the back (or ineffective) side of the disc, which situation may result in the expenditure of several hundred horsepower to no purpose other than driving the disc and/or the ineffective back side thereof through the pressurized liquid being treated.

As also will be understood, any or all of the above disadvantageous factors may be increased, for any given amount of work to be performed on the material being treated, if it is attempted to control the treating effect only by increasing the diameter of the discs of either a single disc or a double disc attrition mill of this charac-

ter. Conversely, certain important economies may be obtained by utilizing a rotating disc with effective attrition surfaces on both sides thereof and supported in cooperating and mating relation with two opposed and oppositely directed stationary discs to achieve, with regard to two opposite faces of the rotating disc, an effective working area comparable to that which could be obtained only with substantially larger diameter discs if there were but a single pair of cooperating working surfaces.

According to this invention, then, attrition mill apparatus of the character described is provided for obviating or minimizing the foregoing difficulties and having a single rotating disc with effective working attrition surfaces on each opposite face thereof, each of which surface mates or cooperates with a corresponding non-rotating attrition disc, and with the rotating disc being mounted on a "floating" shaft which is free to move axially under the inherent pressure forces acting on the rotating disc, and with one of the stationary discs being axially adjustable, whereby, according to the controlled or maintained axial adjustment thereof, the rotating disc is correctly positioned between the two nonrotating discs to achieve the desired spacing, yet without substantial thrust forces on the bearings of the shaft which carries the rotating disc.

One object of this invention is to provide an attrition mill of the character described having a single rotating disc with attrition surfaces on each side thereof and positioned between two non-rotating attrition surfaces with which the rotating disc cooperates in treating material fed through the mill, and wherein the rotating disc is mounted on a driven shaft in the mill in such manner that substantially no axial thrust forces are imposed upon the shaft or the bearings therefor during operation.

Another object of this invention is to provide an attrition mill of the character described and having a rotating disc mounted between and for cooperation with two non-rotating discs with the rotating disc being carried by an axially "floating" shaft for free axial movement with respect to the non-rotating discs, and with means being provided for adjusting the axial positioning of at least one of the non-rotating discs whereby a particular spacing is maintained between each side of the rotating disc and the respective non-rotating disc adjacent thereto.

A further object of this invention is to provide an attrition mill of the character described having a rotating disc mounted on an axially "floating" and substantially thrust-free shaft between two non-rotating attrition discs, and with means for introducing material to be treated in the mill to each side of the rotating disc simultaneously whereby the axial positioning of the rotating disc with respect to the two stationary discs is controlled and maintained in accordance with the respective fluid pressures on either side of the rotating disc.

Other objects and advantages of this invention will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawings:

FIG. 1 is a side elevation of attrition mill apparatus embodying and for practicing this invention;

FIG. 2 is a vertical axial section through the apparatus in FIG. 1;

FIG. 3 is a partial vertical axial section showing part of the bearing structure at the right-hand end of the shaft in the apparatus of FIG. 2 on a somewhat larger scale;

FIG. 4 is a view similar to FIG. 3 showing the structure at the left-hand end of the shaft in the apparatus of FIG. 2;

FIG. 5 is a partial vertical transverse section partly broken away, on the line 5-5 of FIG. 2;

FIG. 6 is a vertical axial section partly broken away of the axial adjustment means in the apparatus of FIG. 1; FIG. 7 is a detailed view on a somewhat larger scale and partly broken away of the driving coupling between the driven shaft and the drive motor in the apparatus of FIG. 1;

FIG. 8 is a vertical axial section through another embodiment of attrition mill apparatus in accordance herewith;

FIGS. 9 and 10 are top and side elevations, respectively, of the apparatus of FIG. 8;

FIG. 11 is an end elevation of the apparatus of FIGS. 9 and 10 viewed from the left-hand end thereof;

FIGS. 12 and 13 are somewhat diagrammatic showings of the hydraulic system of the apparatus of FIGS. 8-11 indicating the attrition plates in backed-off and refining positions, respectively; and

FIG. 14 is a detailed view partly in horizontal section and partly broken away of one of the hydraulic plate-positioning cylinders of the apparatus of FIGS. 8-13.

Referring to the drawings, in which like reference characters refer to like parts throughout the several views thereof, apparatus embodying and for practicing this invention is illustrated, in FIGS. 1-7, as having a base 10 for the support of the attrition mill apparatus, on which are mounted two generally upright hollow frame members 11 and 12 for supporting opposite ends of the apparatus. Mounted between uprights 11 and 12 is a generally circular housing for enclosing the attrition discs and including circular or annular or frusto-conical portions 13 and 14, mounted on uprights 11 and 12, respectively, as by bolted flanges 15 and 16, and a generally cylindrical central housing 20, which is removable for access to the attrition discs within the machine and is preferably formed of two arcuate portions externally joined at the top and bottom of the machine as by bolted flanges 21 and 22 for the ready removal and opening of the housing as desired.

As indicated in FIG. 1, fluid pressure means 25 (described below) are provided on vertical support 11 for adjusting the axial spacing within the machine, and the rotating disc, described below, is provided with a drive shaft 26 coupled through a drive coupling 27 to a drive motor 28. Inlet conduits for the material being treated are indicated at 30 and 31 and a discharge for the material is indicated at 32.

As noted more particularly in FIGS. 2-5, the illustrated apparatus includes a rotating disc 40 mounted by the hub 41 thereof on shaft 45 and keyed thereto at 46. Rotating disc 40 carries a set of attrition surfaces or plates, of known design, 47 and 48 fixed to opposite faces of disc 40 as by bolts 49. Mating and cooperating attrition plates 50 and 51 are mounted, as by bolts 52 respectively, on non-rotating discs or heads 55 and 56, the latter of which is axially fixed and, preferably, integrally fabricated with and carried by housing member 14 so as to be both non-rotating and axially stationary. Non-rotating head 55 is mounted within the housing 13-20 as by an annular rim 60 (part of 55) supported within an outer rim including elements 61 and 62 carried by, respectively, housing members 13 and 20 so that stationary disc 55 and rim 60 thereof are free to move axially with respect to stationary disc 56 as rim 60 on disc 55 slides axially within the stationary outer rim 61-62. Packing 63 is preferably provided between rim 60 and outer rim 61, to facilitate such axial movement and prevent slurry from passing between 63-60, and rim 60 is preferably keyed to casing 13 to prevent rotation of disc 55.

Each of the non-rotating discs 55 and 56 carries a generally cylindrical axially extending portion 65 and 66, respectively, defining with packing sleeve 68 and 69 around shaft 45 a central chamber for receiving material to be treated and confining such material away from the various bearing and drive members of the device herein-

after described. Radially outwardly of the rotating disc 40 and the various attrition plates 47, 48, 50 and 51, the material being treated is confined within the portion 20 of the outer housing by an arcuate extension 70 on stationary disc 56 and the arcuate face 71 of outer rim member 62. It is through the upper portion of cylindrical extension 65 and 66 that inlet conduits 30 and 31 communicate for flow of material into the central chamber, such communication being effected through collars 73 and 74, respectively. As will be noted from the foregoing, since cylindrical wall 65 is carried by disc 55 and, consequently, moves axially therewith, inlet conduit 30 also moves axially with disc 55, and an opening 75 in housing member 13 is provided to accommodate such axial movement of the inlet conduit 30 with respect to the stationary housing.

As noted above, rotating disc 40 is mounted on shaft 45, which is supported at either end thereof by bearing structures mounted in the upright frame members 11 and 12, detailed illustration of such structures being omitted for clarity in FIG. 2, but being illustrated in FIGS. 3 and 4. Thus, shaft 45 is provided with an outer wear sleeve 80. Considering the right-hand end of the shaft in FIG. 2 (illustrated in more detail in FIG. 3) a somewhat reduced diameter portion 81 is provided on shaft 45 for accommodating and cooperating with the packing within packing sleeve 69. Thus sleeve 80 extends approximately to reduced diameter portion 81 on shaft 45 and another sleeve 82 is there provided. Conventional liquid-resistant packing, indicated generally at 83, is provided within packing sleeve 69 for cooperation with sleeves 80 and 82 on shaft 45, and a retaining ring 84 is threadably engaged at the end of reduced diameter portion 81 for retaining sleeves 80 and 82 in position on shaft 45.

A bearing block 90, carrying anti-friction bearings indicated at 91, supports shaft 45 at a reduced diameter bearing portion 92 thereof, and is axially positioned on the shaft by a retaining ring 93 threadably engaged with the shaft. Bearing block 90 is carried within a generally cylindrical housing portion 95 supported on vertical frame 12, and bearing block 90, as well as packing sleeve 69, are mounted within housing 95 for axial sliding movement with respect thereto, such axial movement, as will be understood, also causing axial movement of shaft 45 by virtue of the positive positioning axially on shaft 45 of bearings 91 by retaining rings 84 and 93. A threaded collar 100 is threaded into the end of cylindrical housing 95 as indicated at 99 and engages end plate 101 of bearing block 90 through springs 102. Thus, shaft 45 and its appertaining bearing structure is resiliently urged axially to the left in FIG. 3 by springs 102, and the extent or force of such axial urging being adjusted and controlled by adjusting the axial positioning of collar 100 through its threaded engagement with housing 95 at 99.

Regarding the opposite end of shaft 45 and its bearing support (illustrated in FIG. 4), a reduced diameter portion 110 is also provided at this end of shaft 45, as with portion 81 at the other end, for cooperating with packing means carried by packing sleeve 68. As with the other end, sleeve 80 extends along shaft 45 within packing sleeve 68, and another sleeve 111 is provided over the reduced diameter portion 110 for cooperating with conventional packing indicated at 112 within packing sleeve 68, both these sleeves 111 and 80 being retained axially in position by threaded retaining rings 113, which also, as with the corresponding ring 84, provides for the axial positioning of shaft 45 within its supporting bearings.

A generally cylindrical housing 115 is provided in the upper portion of vertical support 11, and within housing 115 is mounted an extension of the cylindrical wall 65 associated with disc 55, such element 65 being, as previously noted, free to slide axially with respect to housing 115 and support 11. Within cylindrical wall 65 is

mounted bearing block 120 carrying anti-friction bearings indicated at 121 engaging a bearing portion 122 at the end of shaft 45, with the shaft being axially positioned and maintained with respect to bearing block 120 by retaining ring 123 threadably engaged to the end of the shaft.

The end opening of sliding member 65 is closed by plate 130, having a threaded flange 131 thereon onto which is threaded an adjustable collar 132. Springs 135 are positioned in end plate 130 to act between collar 132 and the end closure 136 of bearing block 120, thus resiliently urging bearing block 120 and, consequently, shaft 45 to the right in FIG. 4 by a force adjustable according to the axial positioning of collar 132 as it bears against springs 135. As will be apparent from the foregoing, if springs 102 at the right end of the shaft are chosen to be substantially stronger than springs 135 at the left end and/or if adjusting bolts 103 are adjusted between collar 100 and plate 101 to maintain sufficient compression on springs 102 so that they are substantially a rigid member, then the axial positioning of shaft 45 and axial spacing between attrition plates 48 and 51 is readily adjusted to maintain a desired clearance between the plates by adjustment of collar 100 (at least in the absence of thrust forces in the opposite direction arising from the passage of material being treated through the apparatus, as discussed below) and some clearance is resiliently maintained (or, at least, actual contact resiliently avoided) between the other pair of attrition plates 47 and 50 by control of the force on springs 135 as by adjustment of collar 132 at the left end of the shaft for controlling the axial positioning of shaft 45 with respect to end plate 130 and, consequently, the axial positioning of attrition plate 47 with respect to axially movable attrition plate 50.

Thus, initial clearance spacing between plates 48 and 51 is adjusted or pre-set by adjustment of collar 100, while springs 135 assure that shaft 45 will be urged to the right in the drawing to the extent limited by the adjustment of collar 100 and substantially independently of the particular positioning of sliding extension 65 and axially slidable disc 55, it being understood, however, that the foregoing adjustments are primarily for maintaining clearance between the various plates under idling conditions and the like since the actual thrust forces imposed when the apparatus is in operation with material being forced between the pairs of plates, substantially exceed and override the axial forces provided by springs 102 and/or 135.

As previously noted, a fluid pressure device indicated at 25 and shown in more detail in FIG. 6 is provided for the adjustment and maintaining of the axial positioning of disc 55 with respect to stationary disc 56 and, consequently, rotating disc 40 therebetween, such device being illustrated as comprising a fluid pressure cylinder 140 mounted in known manner on a flange 141 at the end of an extension 142 of housing 115 on vertical support 11. A piston 145 is provided in cylinder 140 and acts through piston rod 146 axially and positively to move and position plate 130 (and, consequently, axially slidable member 65 and disc 55 and the other axially movable elements appertaining thereto) as hydraulic pressure is introduced to or withdrawn from either side of piston 145, in known manner, as through fluid pressure connections 147 and 148. Such movement, it will be understood, of disc 55 and its appertaining structure positively varies the axial spacing between the opposed surfaces of discs 55 and 56, but without positively controlling the intermediate position therebetween of rotating disc 40, which, by virtue of the bearing structure hereinbefore described for supporting shaft 45, axially "floats" between non-rotating discs 55 and 56 with the spacing or clearance with respect thereto being determined by the oppositely directed interaction of springs 102 and 135

and/or the axial thrust components arising from material being treated in the apparatus, whichever is greater.

As will be understood from the foregoing, then, as material to be treated (usually in the form of a liquid slurry) is introduced through inlet conduit 30 into the apparatus, it is forced radially outwardly between attrition plates 50 and 47 by the centrifugal force action arising from the rotation of rotating disc 40 as discussed more in detail below and additional material to be treated is introduced through conduit 31 and passes between attrition discs 48 and 51. With material being treated (i.e., having work done on it) on both sides of rotating head 40, certain axial thrust components are engendered on the faces of rotating disc 40. If, then, fluid pressure is applied to piston 145 to urge head 55 to the right in FIG. 2, substantial thrust is brought to bear on rotating disc 40, which may be substantially in excess of the axial forces from springs 102 or 135. Thus, rotating disc 40 automatically positions itself axially or "floats" between the opposed faces 50 and 51 of the non-rotating discs according to the thrust or fluid pressure effective on the two sides of rotating disc 40, so that for any degree of pressure or thrust which it may be desired to impose upon the material being treated by forcing disc 55 closer to disc 56, still rotating disc 40 locates itself between discs 55 and 56 according to the thrust imposed upon it and without the requirement of thrust-resisting bearings or other means in the bearing supports for shaft 45 carrying disc 40, thereby eliminating, according to this invention, the need for expensive thrust bearings or other thrust-resisting or adjusting mechanisms for maintaining the desired axial spacing between rotating disc 40 and either of the non-rotating discs. Because, as is well known in this art, it is frequently desired to maintain the clearances between the co-acting attrition surfaces or plates with close tolerance limits of the order of thousandths of an inch, slight deflections, particularly with regard to discs several feet in diameter, are magnified from the center of the drive shaft outwardly, and particularly when the thrust-resisting mechanism for maintaining the desired clearance between the discs operates solely through the shaft. As will be noted from the foregoing, such difficulties are also avoided according to this invention because, with the shaft floating axially, the spacing or clearances between either face of rotating disc 40 and either one of the non-rotating discs 55 or 56 are maintained by the thrust forces actually effective on the faces of disc 40 through the material being treated.

In order to maintain a positive rotating drive of shaft 45 and disc 40 notwithstanding the axial movements thereof with respect to the apparatus, and, particularly, drive motor 28, a coupling 27 is provided to accommodate such axial movement. This coupling, as indicated in FIG. 7, includes a sleeve 150 keyed at 151 to the drive end portion 26 of shaft 45, which sleeve has a projecting flange 152 thereon. A corresponding sleeve 153 is provided for mounting on motor shaft 154 of motor 28 and keyed thereto at 155 and is also provided with a projecting flange 156. An outer coupling sleeve for each of the foregoing are also provided and indicated at 160 and 161, respectively, and are connected together for positive rotary driving as by a bolted flange 162. The inner surface of both sleeves 160 and 161 is provided with axial splines, as are the peripherally outer surfaces of flanges 152 and 156, such splines being generally indicated by 163 and 164, whereby, as will be understood, a positive rotary drive is obtained from motor shaft 154 through drive sleeve 153, splines 164 meshing with sleeve 161, driving sleeve 160, the splines of which drive sleeve 150 through flange 152 and, in turn, drive end 26 of shaft 45—and all notwithstanding the fact that shaft 45 and flange 152 on sleeve 150 move axially with respect to the inner splined surface of coupling sleeve 160. Springs 165 are also preferably provided in known manner for resilient axial cushioning between the separate sleeves 150 and 153.

Material to be treated is simultaneously introduced into the apparatus through both conduits 30 and 31 for simultaneous outward radial passage between plates 47, 50, and plates 48, 51, for collection in the space radially outwardly of the attrition plates and defined by housing 20 and surfaces 70 and 71, from which space the treated material is discharged through discharge opening 32 communicating with the interior of the machine through housing 20.

It should also be noted that, if desired, the entire apparatus may be fully pressurized and the material to be treated fed thereto under pressure and discharged therefrom against pressure without substantially affecting the thrust or other power considerations involved. Also, it may be desired to provide a series of openings 170 through the face of rotating disc 40 communicating between opposite sides thereof for the equilization of pressure on opposite sides thereof. Since conduit 30 must experience some axial movement in the operation of the machine, it is preferred to insert a flexible section 171 of piping in conduit 30 to accommodate this axial movement. It should also be noted that the central cylindrical housing section 20 may be readily removed to expose and give access to the rotating disc 40 and stationary discs 55 and 56, as for cleaning and/or replacement of the attrition plates, and that this can be accomplished, according to this invention, without the necessity of disconnecting or disassembling the drives or bearings, or even the piping to and from the apparatus, thereby increasing the economy of operation thereof.

Although the lubrication and maintenance of the various bearings, packings, etc., will be understood, in conventional manner, from the foregoing, it may be noted that lubricating connections or conduits 172 and 173 are provided for such purpose, to extend through openings in the housing 115 and 95 for access thereto, and the various packing elements and means will also be understood in known manner and, of course, may be somewhat altered depending upon the type and severity of work the device is designed to produce and the particular characteristics of the material being treated.

Referring now more particularly to FIGS. 8-14, a further embodiment or modification of attrition mill apparatus in accordance herewith is illustrated as comprising a base 175, in which is mounted a stationary and somewhat toroidal casing and support indicated generally at 176 and including an upright annular disc 177 and hollow annular casing portions 178, all supported on base 175 as by a footing 179. Also carried by footing 179 and as a part of stationary casing 176 is a bearing housing 180 supported as by web members 181 etc.

At the other end of base 175 is provided another mating annular or toroidal casing portion indicated at 185 and supported on a footing 186 of generally circular curved transverse configuration and including annular hollow casing members 187. Also supported on footing 186, as by webs 188, is another bearing housing 190, axially aligned with bearing housing 180. The entire left hand casing portion 185 is axially slidable on base 175, as will be apparent from the following description, to permit opening of the machine and access to the interior of the apparatus. Right hand casing 176 includes an annular circumferential member 195 for mating engagement with a similar annular member 196 on the left hand casing 185 to form, in the position shown in FIG. 8, a completely enclosing casing for the working portions of the apparatus.

Within the left hand casing portion 185 is positioned a generally circular disc 200, including an annular or toroidal backing member 201, mounted for axial sliding movement within casing 185 as by outer circumferential bearing edges indicated at 202 cooperating with the inner surface or lining of circumferential casing portion 196, and an annular sleeve 205, slidably cooperating with sleeve portion 206 on annular member 187.

A rotating refining or attrition disc 210 is carried by

main shaft 211, the opposite ends of which are mounted for rotation in bearing assemblies 215 and 216, which are in turn carried by bearing blocks 220 and 221, respectively. Bearing blocks 220 and 221 are, respectively, mounted for axial sliding movement in bearing housings 190 and 180, whereby free but limited axial movement of shaft 211 is permitted without interference with the rotating mounting thereof and without the need for thrust bearing mountings. The right hand end 222 of main shaft 211 is adapted (with a coupling as previously explained or otherwise) for driving connection with a motor, not shown.

Packing glands 225 and 226 are provided to complete the enclosing casing around rotating shaft 211, with gland 226 being mounted in or carried by sleeve 205, for axial movement therewith, while gland 225 is mounted on sleeve portion 227 of annular casing member 178. Both glands 225 and 226 include conventional labyrinth and other packing around shaft 211, in known manner, as well as the appertaining water supplies 228 and 229 etc., to complete water-tight closures around shaft 211 during both rotating and axial movements thereof.

A stationary stock inlet pipe 235 is provided in the right hand or stationary casing 176 for introducing material to be refined into the interior of the casing and adjacent the central portion of rotating disc 210. An additional stock inlet pipe 236 communicates with the interior of casing 185 on the other side of disc 210 and is carried by annular portion 201 of axially slidable disc 200, with an enlarged opening 237 being provided in the upper portion of casing 185 to accommodate axial movements of inlet 236. As with the embodiment previously described, a flexible connection, not shown, connects inlet pipe 236 with the stock supply system leading to the apparatus. Preferably, a diaphragm-type purge meter and switch and gauge assembly (indicated at 238) is provided in each of the stock inlet pipes 235 and 236 in known manner. A tangential stock discharge 240 is provided at a desired point on the circumference of the apparatus (here illustrated as being at the bottom thereof) and is carried by the right hand or stationary casing 176, which stock discharge may also be provided with a diaphragm meter 238.

A pair of hydraulic cylinder-and-piston assemblies 250 and 251, preferably diametrically oppositely positioned at the horizontal axial plane of the apparatus, are carried by the left-hand casing portion 185. As indicated in somewhat more detail in FIGS. 12-14, the pistons 263 and 264 of such hydraulic assemblies 250 and 251 are connected, as by rods 252 and 253, to annular portions 201 of axially slidable disc 200, whereby movement of the pistons in hydraulic cylinders 250 and 251 effects axial sliding movements of disc 200 within the left hand portion 185 of the outer casing and as disc 200 slides on peripheral edge portions 202 thereof.

Rotating attrition or refining plates 260 and 261 are affixed, as by bolts, to the opposite faces of rotating disc 210, while similar refining plates 262 and 263 are mounted, respectively, on axially movable disc 200 and stationary disc 177. In this manner, as previously explained with regard to the apparatus illustrated in FIGS. 1-7, axial movement of disc 200 with respect to stationary disc 177 controls the spacing between the cooperating working faces of plates 260 and 261 on rotating disc 210 and non-rotating plates 262 and 263, respectively, while the axially floating nature of main shaft 211 as carried in sliding bearings 220 and 221 effects automatic and uniform adjustment of rotating plates 260 and 261 with the non-rotating plates for any given axial positioning of disc 200 and non-rotating plates 262 thereon.

As illustrative of the foregoing, one may note the diagrams of FIGS. 12 and 13, illustrating respectively axial disc 200 withdrawn or backed off toward the left (FIG. 12) and in refining or working position moved toward the right (FIG. 13) under the action of hydraulic cylinders 250 and 251, depending upon whether hydraulic fluid

from pump and reservoir 280 is provided, through accumulator 281 and line 282, behind pistons 283 and 284 (as in FIG. 13) or is provided on the opposite side of the pistons through lines 285, as will be understood from the diagrams. Preferably a separate valving and control for either fast or slow operation of the pistons are provided in known manner and as indicated generally by 286 and 287, respectively.

In order to gain access to the inside of the apparatus for the purpose of, for example, replacing the attrition plates 260-263, etc., a plurality of bolts 270 around casings 185 and 176 are loosened (as by wrench extension 271 where needed), and the entire left hand side 185 of the casing is slid back to the left in the drawing, because of the sliding relation of footing 186 on base 175, and also with suitable regard to additional bolts such as 272 and a bronze draw block 273 cooperating with rod 274, all in well understood manner. In this way, the two halves of the casing 185 and 176 are separated, at the mating edges 195 and 196 thereof, sufficiently to permit access to rotating disc 210 for changing plates or other operations, as may be required, yet completely within the limits of axial sliding movements provided by bearing blocks 220 and 221 in bearing housings 190 and 180 and without interfering with (or even without needing to change) the axial hydraulic adjustment of non-rotating disc 200 with respect to the left hand casing 185.

Since stock discharge 240 is preferably carried on the right hand or stationary casing 176 and since inlet pipe 236 is connected to the stock inlet system through a flexible conduit (not shown), there is no need to disconnect or break any of the piping to or from the apparatus for the purpose of opening the casing as explained; nor, provided the motor coupling to main shaft 211 will accommodate the axial movement, need the motor coupling be disconnected. As illustrative of this feature of the invention, for example, satisfactory results have been achieved, on a machine wherein the diameter of the attrition plates was about 42", if the left hand casing 185 is arranged to be retracted by about 7". Although a stroke of only about 2½" in cylinders 250 and 251 has been found satisfactory to accommodate the maximum desired range of axial adjustment of non-rotating disc 200 during operation, some manual axial displacement of rotating disc 210 is readily available when the casing is in open position to provide as much as 7" of access space on opposite sides of disc 210, although not simultaneously.

A principal advantage of the use of hydraulic piston and cylinder assemblies for controlling the spacing of the attrition surfaces is that a uniform stock quality is obtained regardless of variations of the flow of the stock as controlled by a discharge throttle valve. This advantage results from the cushioning effect of the hydraulic system and specifically that provided by the accumulator 281 which serves to absorb pressure increases within the casing which are transmitted to the hydraulic system through the piston and cylinder assemblies. Other means of releasing or absorbing pressure increases, for example a pressure regulating valve, could be employed for this purpose.

A decrease in the stock discharge flow increases the stock pressure within the refining zone, which increased pressure acts against the set hydraulic pressure of the hydraulic piston and cylinder assemblies and the accumulator resulting in a small but significant increase in the spacing between attrition surfaces. Since the attrition work done is a function of the spacing and pressure between the surfaces, less work is done on the stock when the flow is decreased. This lesser amount of work is directly proportional to the reduced flow of stock so that the unit work done on the stock is approximately constant.

Conversely, should flow be increased, a diminished pressure in the refining zone causes the accumulator pressure to act on the piston and cylinder assemblies to decrease the attrition surface spacing, increase the pressure

between the surfaces and maintain unit work done on the stock. By means of this hydraulic disc spacing control system, the work done on the stock and hence the quality of the stock is maintained automatically without adjusting the disc spacing despite changes in the stock flow.

Particularly with regard to the embodiment just described, the advantages of completely pressurized flow are readily obtained and, with double stock inlet on both sides of rotating disc 210, a substantial increase in production is realized with but a single piece of apparatus as the material to be refined or worked enters both inlets 235 and 236, passes radially outwardly between the mating and cooperating working surfaces of plates 260-262 and 261-263 to be discharged adjacent the circumference of the machine through discharge 240. Also, as with the embodiment of FIGS. 1-7, the only non-working surfaces of rotating disc 210 operating in contact with the material being worked is the single peripheral edge thereof, as compared to the situation with single-disc attrition mills where the entire back surface of the rotating disc is operating in and subject to whatever hydraulic pressures are implicit in operation of the machine filled with a quantity of liquid slurry material to be worked.

Similarly, the free floating axial positioning of rotating disc 210 (provided by sliding bearing blocks 220 and 221, etc.) automatically permits even spacing on each opposite working face of disc 210, yet without the necessity for thrust bearings on shaft 211 and without the necessary provision of hydraulic or other adjusting pressures to maintain a particular working spacing or association of the working faces of disc 210 with the respective cooperating non-rotating discs 200 and 177. Although the axial positioning of non-rotating disc 200 is completely and uniformly adjusted and maintained by cylinders 250 and 251, none of the mechanisms associated therewith need interfere with either the assembling or maintaining complete co-axial alignment of the various rotating and axially movable parts, which alignment is maintained by the single series of cylindrical sleeves 205, 206, 227, and bearing housings 180 and 190, and in an economical and simply constructed manner with a minimum of close tolerance interfitting moving parts and a maximum of simplicity in packing glands and bearing arrangements. All of the foregoing also aid in the maximum utilization of driving horsepower for performing the attrition work desired, and minimize any wasting thereof merely for combating hydraulic drag and pressure forces of the slurry material being treated on the moving parts of the apparatus, while opening the casing for access to the interior of the machine and like operations are readily performed without disconnecting permanent piping arrangements to or from the apparatus.

While the forms of apparatus herein described constitute a preferred embodiment of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

I claim:

1. In disc-type rotating attrition mill apparatus having an essentially horizontal axis and a rotor mounted thereon for cooperating attrition work with respect to both of two opposed non-rotating attrition discs between which said rotor rotates, the combination which comprises a horizontal shaft for said rotor, bearing means for mounting said shaft in said apparatus for rotation of said rotor between said opposed non-rotating discs, said bearing means including means for free axial floating displacement of said shaft and rotor with respect to said non-rotating discs with respect to the other and with through said shaft, and means for axially displacing and adjusting the axial positioning of at least one of said non-rotating discs with respect to the other and with respect to said rotor, said axial displacing and adjusting means being mounted in said apparatus for axial move-

ment substantially independently of said axial movement of said floating rotor and said shaft.

2. In disc-type rotating attrition mill apparatus having an essentially horizontal axis and a rotor mounted thereon for cooperating attrition work with respect to both of two opposed non-rotating attrition discs between which said rotor rotates, the combination which comprises a horizontal shaft for said rotor, bearing means for mounting said shaft in said apparatus for rotation of said rotor between said opposed non-rotating discs, said bearing means including means for free axial floating displacement of said shaft and said rotor with respect to said non-rotating discs, drive means for rotating said rotor through said shaft, means for axially displacing and adjusting the axial positioning of at least one of said non-rotating discs with respect to the other and with respect to said rotor, said axial displacing and adjusting means being mounted in said apparatus for axial movement substantially independently of said axial movement of said floating rotor and said shaft, and means for introducing material to be treated into said apparatus at opposite sides of said rotor and for withdrawing the material therefrom after treatment therein.

3. Attrition mill apparatus comprising a casing defining a chamber therein and having axially spaced bearing supports coaxially of the chamber, a first non-rotating attrition disc in said chamber fixedly mounted in the casing coaxially of the bearing supports, a second non-rotating attrition disc movably mounted in said casing for coaxial adjustment relative thereto and to the first non-rotating disc, a shaft extending coaxially of the casing chamber and said bearing supports, a rotatable attrition disc on said shaft disposed between the first and second non-rotating discs for cooperation therewith, bearings rotationally mounting the shaft in said bearing supports providing free axial floating displacement of said shaft and rotatable attrition disc with respect to the casing and non-rotating discs operable to cause the rotating disc automatically to assume a balanced position axially between said non-rotating discs in response to the pressures generated at respectively opposite sides of the rotating disc during operation of the mill, and means operable at will to effect coaxial adjustment of said second non-rotating disc relative to the casing and first non-rotating disc independently of said free axial floating displacement of said shaft.

4. Attrition mill apparatus as claimed in claim 3 wherein the means to effect coaxial adjustment of the second non-rotating disc relative to the casing and first non-rotating disc comprises a pair of pressure fluid operated cylinder and piston means mounted on the casing in laterally spaced relation at diametrically opposite sides of the adjacent bearing support and operatively connected to the second non-rotating disc at corresponding diametrically opposed positions thereon.

5. Attrition mill apparatus comprising a base, a casing on said base comprising normally closed complementary casing sections defining a chamber therein, axially aligned bearing supports exteriorly of the chamber and coaxially thereof, one of said casing sections being stationary and fixedly mounted on the base and the other of said sections being movable relative to the stationary section for access to said chamber, means to actuate said movable casing section relative to the stationary casing section, a first non-rotating attrition disc in said chamber fixedly mounted in the stationary casing section coaxially of the bearing support, a second non-rotating attrition disc movably mounted in said movable casing section for coaxial adjustment relative thereto and to the first non-rotating disc, a shaft extending coaxially of the casing chamber and said bearing supports, a rotatable attrition disc on said shaft disposed between the first and second non-rotating discs for cooperation therewith, bearings rotationally mounting the shaft in said bearing supports, and means to effect coaxial adjustment of said second non-

rotating disc relative to the movable casing section and the first non-rotating disc independently of the actuating means for said movable casing section.

6. Attrition mill apparatus comprising a base, a casing on said base comprising normally closed complementary casing sections defining a chamber therein and having axially aligned bearing supports coaxially of the chamber, one of said casing sections being stationary and fixedly mounted on the base and the other of said sections being slidably supported on the base for axial movement relative to the stationary section for access to said chamber, a first non-rotating attrition disc in said chamber fixedly mounted in the stationary casing section coaxially of the bearing supports, a second non-rotating attrition disc movably mounted in said slidable casing section for coaxial adjustment relative thereto and to the first non-rotating disc, a shaft extending coaxially of the casing chamber and said bearing supports, a rotatable attrition disc on said shaft disposed between the first and second non-rotating discs for cooperation therewith, bearings rotationally mounting the shaft in said bearing supports, and means carried by the slidable casing section operable at will to effect coaxial adjustment of said second non-rotating disc relative to the said slidable casing section and the first non-rotating disc independently of the actuating means for the slidable casing section.

7. Attrition mill apparatus as claimed in claim 6 wherein the means to effect coaxial adjustment of the second non-rotating disc relative to the casing and first non-rotating disc comprises a pair of pressure fluid operated cylinder and piston means carried by the slidable casing section in laterally spaced relation at diametrically opposite sides of the adjacent bearing support and operatively connected to the second non-rotating disc at correspondingly diametrically opposed positions thereon.

8. Attrition mill apparatus as described in claim 6 wherein the base is provided with an upwardly facing longitudinally extending transversely arcuate slide surface for the slidable casing section and the latter is provided at its underside with a correspondingly configured surface for complementary sliding engagement on the slide surface of the base.

9. Attrition mill apparatus as claimed in claim 8 wherein the transversely arcuate complementary slide surfaces on the base and slidable casing section extend parallel to and concentrically of the rotational axis of the apparatus.

10. Attrition mill apparatus comprising a base, a casing on said base comprising normally closed complementary casing sections defining a chamber therein and having axially aligned bearing supports coaxially of the chamber, one of said casing sections being stationary and fixedly mounted on the base and the other of said sections being movable relative to the stationary section for access to said chamber, means to actuate said movable casing section relative to the stationary casing section, a first non-rotating attrition disc in said chamber fixedly mounted in the stationary casing section coaxially of the bearing support, a second non-rotating attrition disc movably mounted in said movable casing section for adjustment relative thereto and to the first non-rotating disc, a shaft extending coaxially of the casing chamber and said bearing supports, a rotatable attrition disc on said shaft disposed between the first and second non-rotating discs for cooperation therewith, bearings rotationally mounting the shaft in said bearing supports providing free axial floating displacement of said shaft and rotatable attrition disc with respect to the casing and non-rotating discs operable to cause the rotating disc automatically to assume a balanced position axially between said non-rotating discs in response to the pressure generated at respectively opposite sides of the rotating disc during operation of the mill, and means to effect coaxial adjustment of said second non-rotating disc relative to said movable casing section and the first non-rotating disc independently of the actuating means for the mov-

able casing section and independently of said free axial floating displacement of said shaft.

11. Attrition mill apparatus comprising a base, a casing on said base comprising normally closed complementary casing sections defining a chamber therein and having axially aligned bearing supports coaxially of the chamber, one of said casing sections being stationary and fixedly mounted on the base and the other of said sections being slidably supported on the base for axial movement relative to the stationary section to give access to said chamber, means to actuate said slidable casing section relative to the stationary casing section, a first non-rotating attrition disc in said chamber fixedly mounted in the stationary casing section coaxially of the bearing support, a second non-rotating attrition disc movably mounted in said slidable casing section for coaxial adjustment relative thereto and to the first non-rotating disc, a shaft extending coaxially of the casing chamber and said bearing supports, a rotatable attrition disc on said shaft disposed between the first and second non-rotating discs for cooperation therewith, bearings rotationally mounting the shaft in said bearing supports providing free axial floating displacement of said shaft and rotatable attrition disc with respect to the casing and non-rotating discs operable to cause the rotating disc automatically to assume a balanced position axially between said non-rotating discs in response to the pressures generated at respectively opposite sides of the rotating disc during operation of the mill, and means carried by the slidable casing section operable at will to effect coaxial adjustment of said second non-rotating disc relative to the said slidable casing section and the first non-rotating disc independently of the actuating means for the slidable casing section and independently of said free axial floating displacement of said shaft.

12. Attrition mill apparatus as claimed in claim 11 wherein the means to effect coaxial adjustment of the second non-rotating disc relative to the casing and first non-rotating disc comprises a pair of pressure fluid operated cylinder and piston means carried by the slidable casing section in laterally spaced relation at diametrically opposite sides of the adjacent bearing support and operatively connected to the second non-rotating disc at correspondingly diametrically opposed positions thereon.

13. Attrition mill apparatus as described in claim 11 wherein the base is provided with an upwardly facing longitudinally extending transversely arcuate slide surface for the slidable casing section and the latter is provided at its underside with a correspondingly configured

surface for complementary sliding engagement on the slide surface of the base.

14. Attrition mill apparatus as claimed in claim 13 wherein the transversely arcuate complementary slide surfaces on the base and slidable casing section extend parallel to and concentrically of the rotational axis of the apparatus.

15. In disc-type rotating attrition mill apparatus having an essentially horizontal axis and a rotor mounted thereon for cooperating attrition work with respect to both of two opposed non-rotating attrition discs between which said rotor rotates, the combination which comprises a horizontal shaft for said rotor, bearing means for mounting said shaft in said apparatus for rotation of said rotor between said opposed non-rotating discs, means for supporting said bearing means on said apparatus adjacent opposite ends thereof, said bearing means including means for free axial floating displacement of said shaft and said rotor with respect to said non-rotating discs, drive means for rotating said rotor through said shaft, means for axially displacing and adjusting the axial positioning of at least one of said non-rotating discs with respect to the other and with respect to said rotor substantially independently of said axial floating displacement of said rotor and said shaft, a casing on said apparatus for enclosing said rotor and said non-rotating discs, packing gland means on said casing and around said shaft for maintaining said casing substantially tight to hydraulic pressure notwithstanding said rotating and axial floating movements of said shaft.

16. Attrition mill apparatus as claimed in claim 2 wherein said means for axially displacing and adjusting the axial positioning of at least one of said non-rotating discs with respect to the other and with respect to said rotor comprises pressure fluid operated means including cylinder and piston means operable automatically to control the spacing of the non-rotating discs and maintain a constant attrition effect on the material regardless of fluctuations in the flow of said material.

References Cited by the Examiner

UNITED STATES PATENTS

323,561	8/1885	Cadwgan	241—146
1,835,984	12/1931	Haskell	241—256 X
2,690,098	9/1954	Jones	241—297 X
2,930,534	3/1960	Baxter	241—163

ROBERT C. RIORDON, *Primary Examiner.*

D. KELLY, *Assistant Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,276,701

October 4, 1966

Chester Donald Fisher

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 55, after "if" insert -- such --; column 4, line 51, for "is", first occurrence, read -- its --; column 7, line 52, after "another" insert -- and --; column 8, line 26, for "potrion" read -- portion --; column 10, line 69, after "and" insert -- said --; line 70, strike out "with respect to the other and with" and insert instead --, drive means for rotating said rotor --.

Signed and sealed this 22nd day of August 1967.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents