

May 10, 1927.

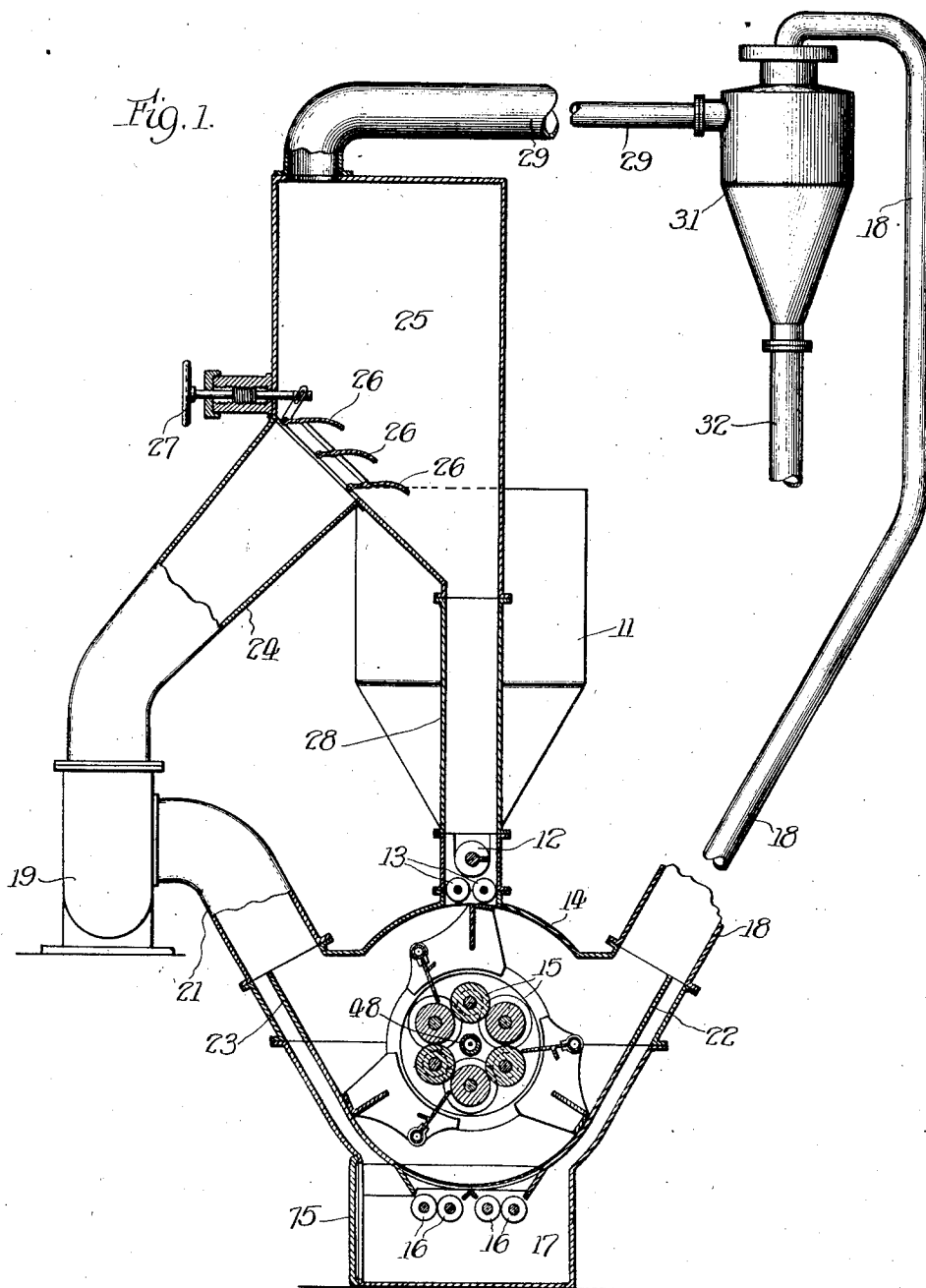
M. W. ARROWOOD

1,628,099

COAL GRINDING MILL

Filed Jan. 20, 1923

6 Sheets-Sheet 1



Witness:
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Inventor:
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By Ira J. Wilson Atty.

May 10, 1927.

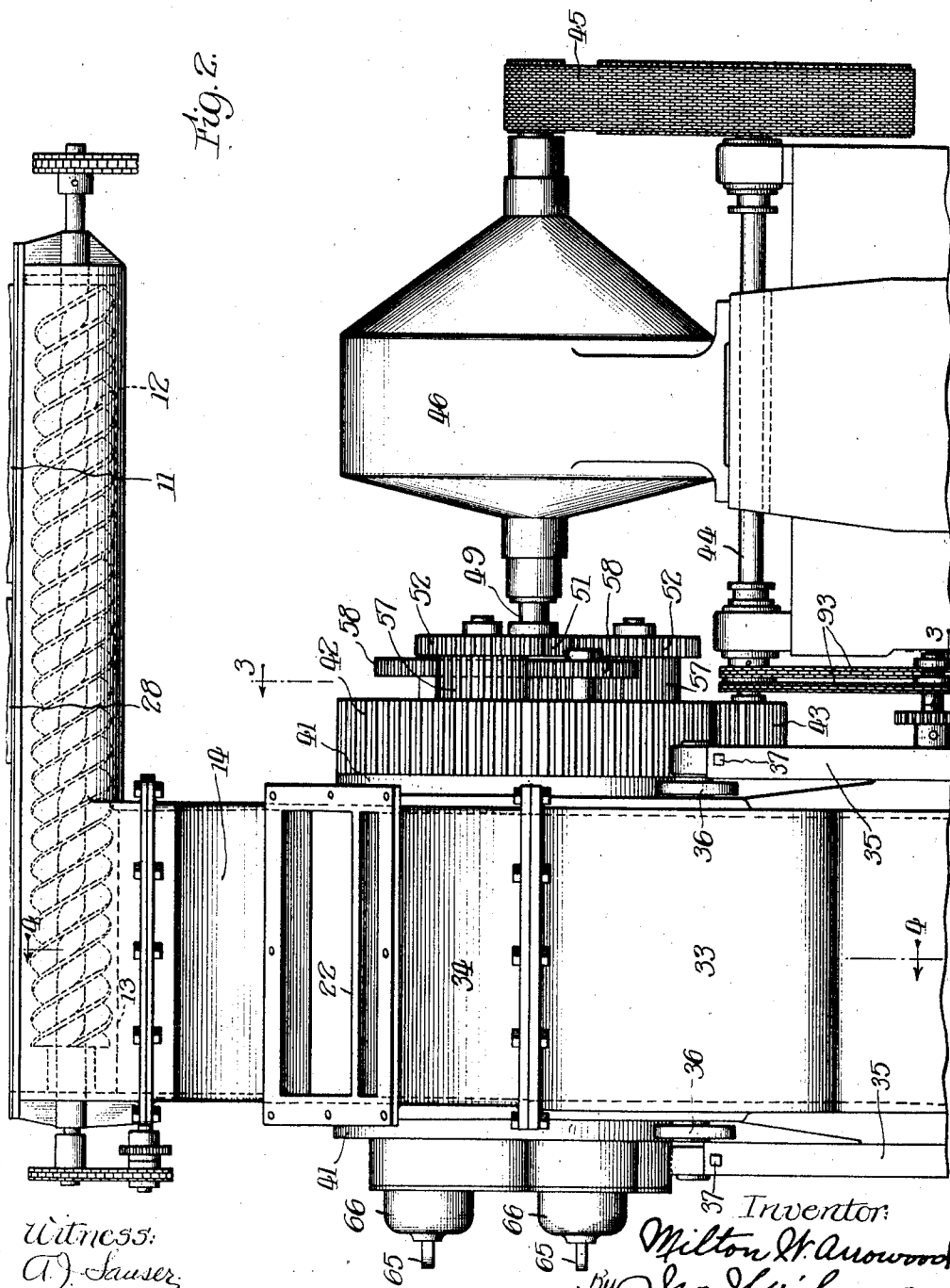
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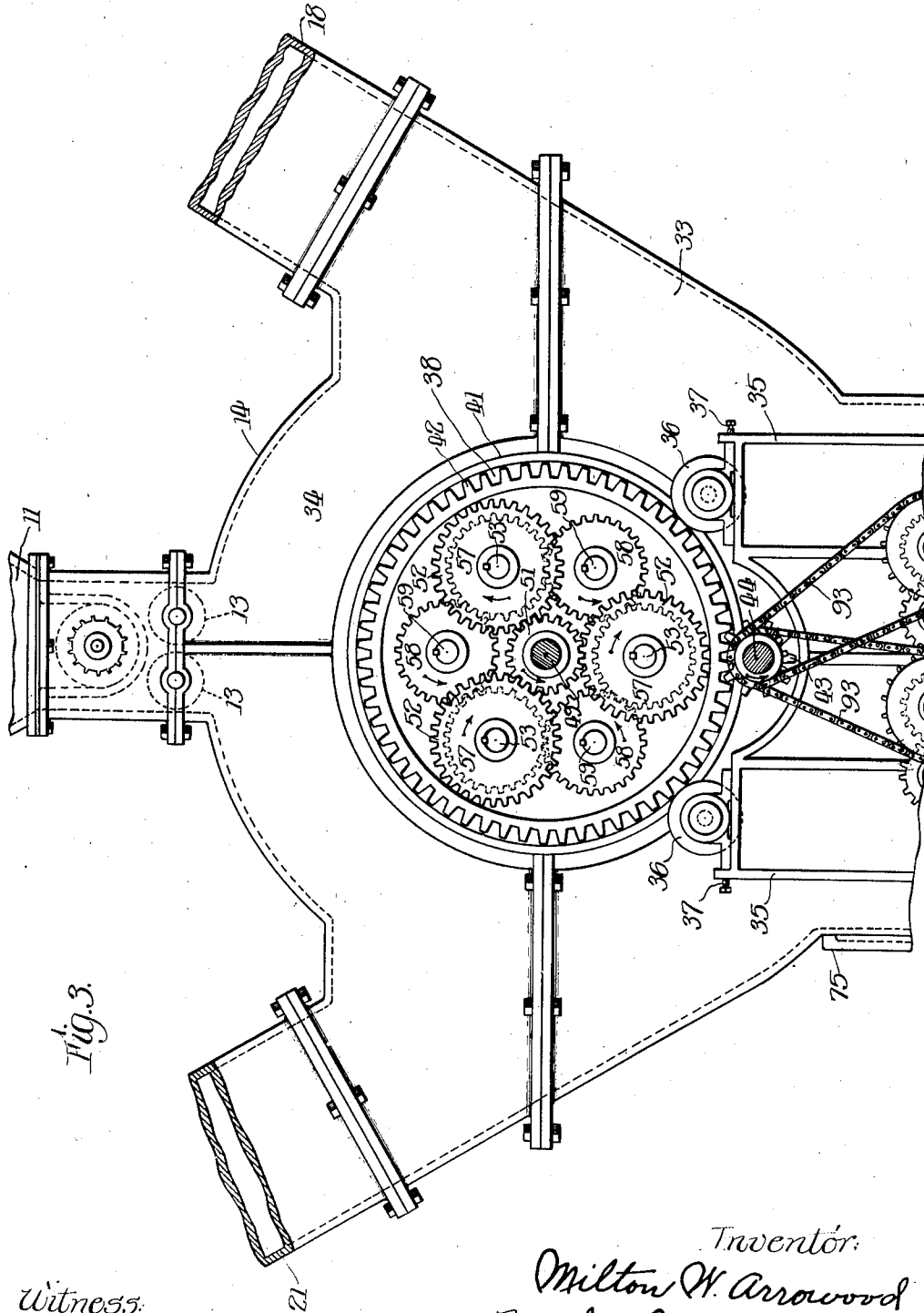


Fig. 3.

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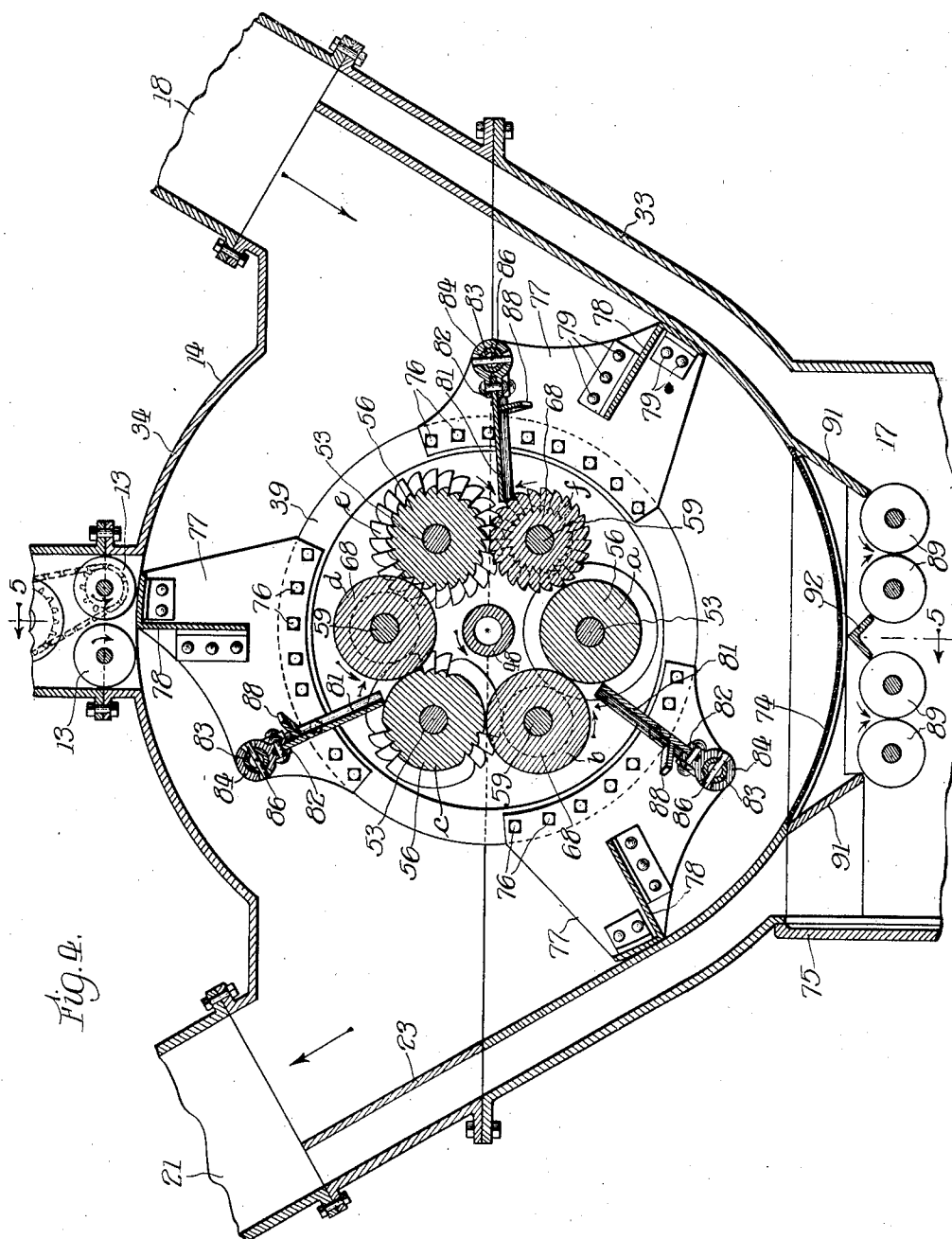
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COAL GRINDING MILL

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6 Sheets-Sheet 4



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COAL GRINDING MILL

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6 Sheets-Sheet 5

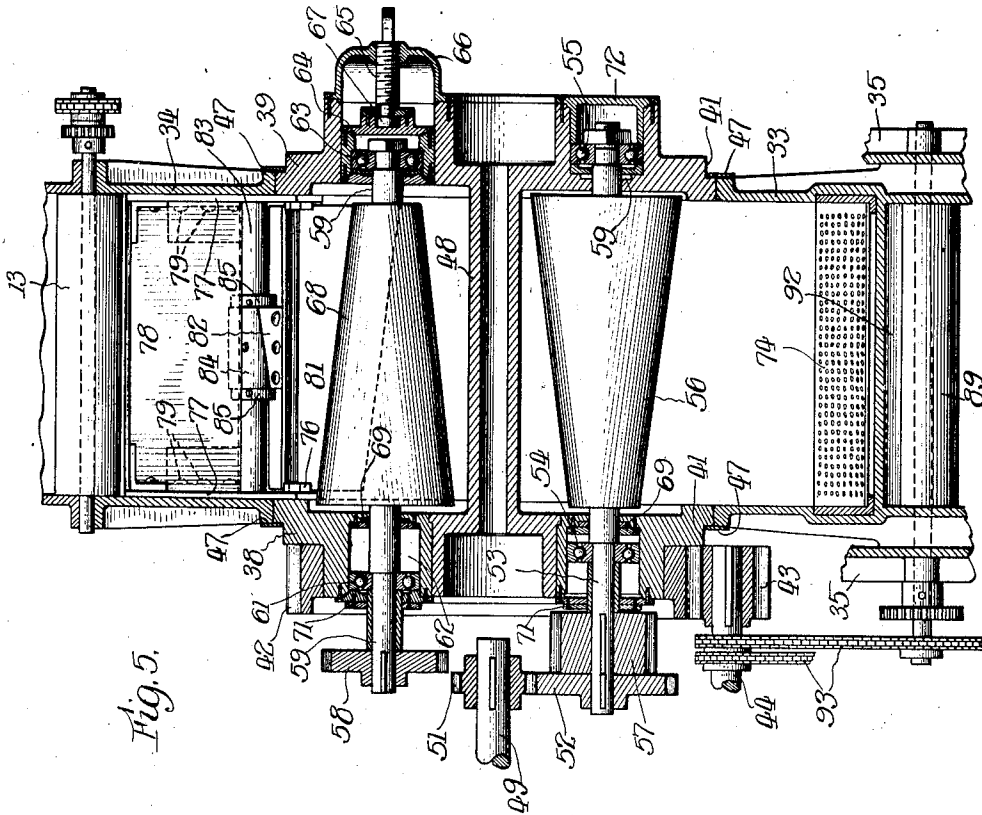


Fig. 5.

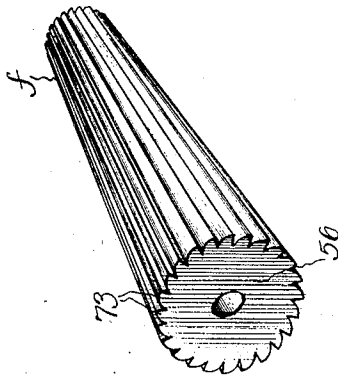


Fig. 6.

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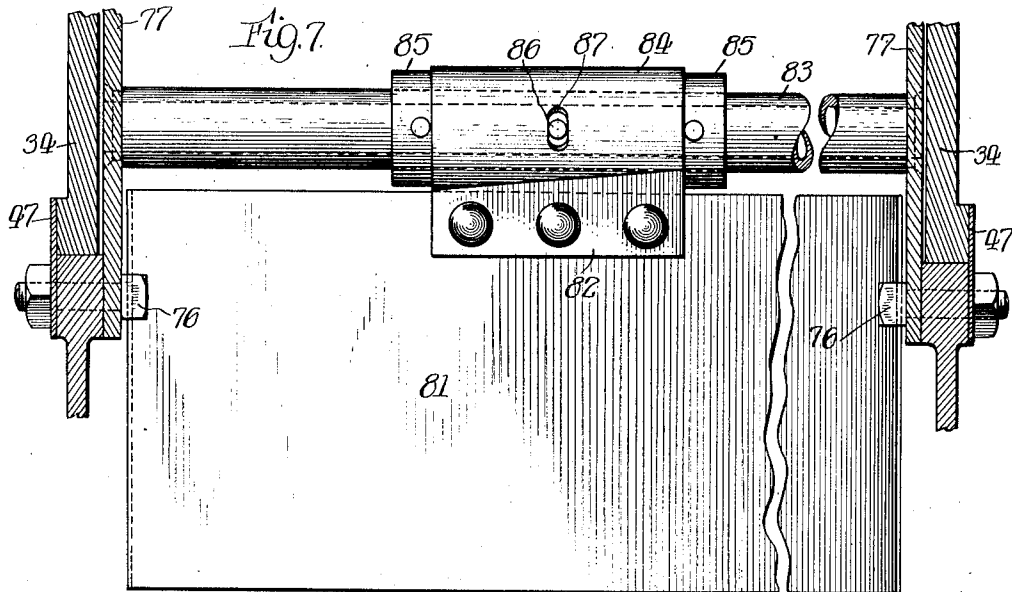
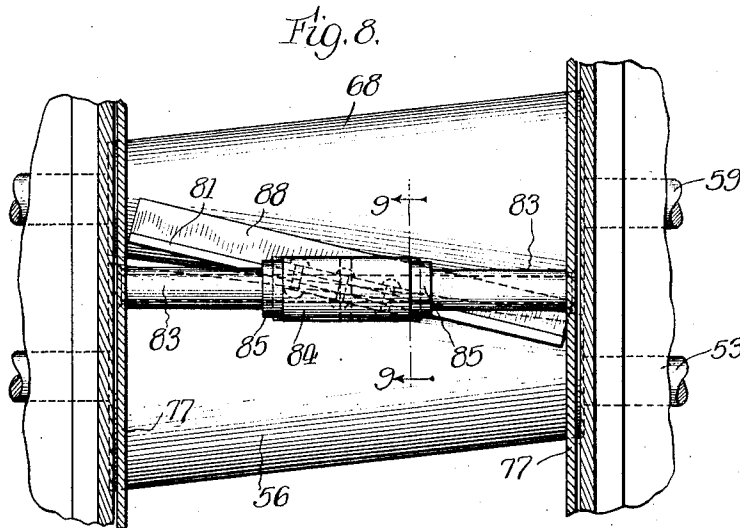
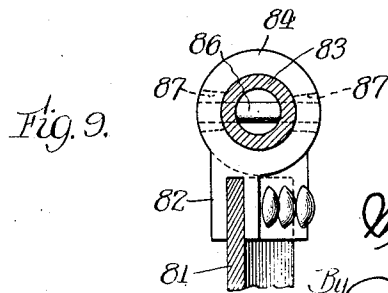
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COAL GRINDING MILL

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6 Sheets-Sheet 6



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Patented May 10, 1927.

1,628,099

UNITED STATES PATENT OFFICE.

MILTON W. ARROWOOD, OF WILMETTE, ILLINOIS.

COAL-GRINDING MILL.

Application filed January 20, 1923. Serial No. 613,867.

This invention pertains in general to the art of grinding or pulverizing, and while the principles of the invention are applicable to mills for grinding various substances and products, I have shown the invention herein, for illustrative purposes, as embodied in a mill adapted for reducing coal to powdered form, suitable for burning, when properly mixed with air, in furnaces and other combustion chambers.

One of the primary purposes of this invention is to provide a mill which will be small in size, so as to occupy but little space and be capable of being economically manufactured, and which at the same time will have a large grinding capacity, enabling it to handle and satisfactorily grind large quantities of material and with minimum expenditure of power.

Another object is to provide a mill in which the powdered material will be removed therefrom as fast as it is produced, and should any of the removed particles be larger than is desirable in the finished product, such particles will be automatically returned to the grinding mechanism, where they will be further reduced to the requisite size.

Another object is to provide in conjunction with the grinding mill a closed circuit transport system by which the powdered product is removed from the mill and transported to a suitable place of storage, the closed circuit being adapted to permit the same air to be repeatedly used, thereby obviating losses which would result from the inevitable loss of a certain amount of the ground material with the air which in some systems is permitted to escape to the atmosphere.

Another object is to provide, in addition to the main grinding mechanism of the mill, a preliminary crushing or grinding mechanism through which the material passes enroute to the main grinding mechanism, and also a final grinding mechanism through which the material delivered from the main grinding mechanism passes and is subjected to a final pulverizing operation.

My invention also contemplates a novel arrangement of the grinding rolls, together with novel mechanism for operating the same; also an improved method of mounting and adjusting the rolls, and in addition a novel construction of the rolls themselves which novel features, in conjunction with

novel means for feeding material to the grinding rolls, and other novel features of construction associated in the machine, result in a mill of high efficiency and large capacity, and possessing many other features of advantage, which will be apparent as the invention becomes better understood by reference to the following description, when considered in connection with the accompanying drawings.

Referring to the drawings:

Fig. 1 is an end elevation, partially in section, of a coal grinding apparatus including the grinding mill per se, and associated parts, embodying my invention;

Fig. 2 is a side elevation, on an enlarged scale, of the grinding mill;

Fig. 3 is a sectional view on the line 3—3 of Fig. 2;

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

Fig. 5 is a sectional view on the line 5—5 of Fig. 4;

Fig. 6 is a detail perspective view of one of the grinding rolls;

Fig. 7 is an enlarged detail view showing one of the oscillatable deflecting plates and its mounting;

Fig. 8 is a plan view of the construction shown in Fig. 7; and

Fig. 9 is a fragmentary sectional view on the line 9—9 of Fig. 8.

Referring now to Fig. 1, reference character 11 indicates the hopper in which the coal or other material to be ground is stored, and from which it is fed in regulated quantities by a screw-conveyor 12 to a pair of preliminary crushing or grinding rolls 13, between which it passes into the grinding mill, designated generally by reference character 14. After being subjected to the action of the grinding rolls 15 of the mill, the construction of which will later be described more in detail, the material is subjected to the action of final grinding rolls 16, and drops into the hopper or chamber 17. Air is drawn from the pipe 18 through the mill and through the chamber 17 by a fan 19 connected to the discharge side of the mill by a pipe 21. The air supply and discharge pipes 18 and 19 are divided by partitions 22 and 23, respectively, so that some of the air is caused to flow through the chamber 17 and pick up the pulverized material therein while the remainder of the air is drawn directly through the mill. carry-

ing the fine particles of material therefrom into the fan 19. From the fan the air carrying the finely ground material is delivered through a discharge pipe 24 into a separating chamber 25, and at the entrance of this pipe into the chamber there is provided a plurality of deflector plates 26, angularly adjustable by means of a hand wheel 27, and adapted to deflect the material so that the heavier particles drop to the bottom of the chamber 25 and are returned through the pipe 28 to the mill for regrinding. The finer and lighter particles are carried upwardly with the air through the chamber 25, from whence they are conducted by pipe 29 to the cyclone separator 31, the construction of which is well known in the art. In this separator the coal is separated from the air and discharged through pipe 32 into a tank or other means of storage, while the separated air is withdrawn from the cyclone through pipe 18 and returned to the mill. A closed circuit is therefore provided so that such dust as escapes from the cyclone with the air, instead of being discharged to atmosphere and lost, is returned to the mill and retained in the circuit, thus obviating the fuel losses which customarily occur at the cyclone discharge.

The general layout and plan of operation having been explained, the construction of the grinding mill itself will now be taken up more in detail. Referring more particularly to Figs. 1 to 5, inclusive, it will be apparent that the casing to which the pipes 18 and 21 are connected comprises a lower section 33 and an upper section 34, forming together a housing in which the various operating mechanisms of my improved mill are mounted. The lower portion 33 is provided at each side with standards 35, each carrying at its upper end a supporting roller 36, these rollers being adjustable by means of adjusting screws 37. Heavy metal end rings or members 38 and 39 are each provided with an annular supporting track 41 resting upon the rollers 36, whereby the operating mechanisms of the mill are rotatably supported. The end member 38 is also equipped with a large gear 42, which meshes with and is driven by a pinion 43 mounted on a counter-shaft 44, which, in turn, is driven through a link belt 45, or other form of transmission, from a driving motor 46. By this mechanism the member 38 and its associated parts are revolved in a clockwise direction, viewing Fig. 3. Sealing plates 49, overlapping the joint between the rotatable members 38 and 39 and the surrounding walls of the housing, as shown in Fig. 5, are provided, so that leakage of dust from the housing between these relatively moving parts is prevented. Rigidity is added to the revolvable structure by a central hollow shaft 48 formed integrally

with one of the end pieces and securely connected with the other, as is best shown in Fig. 5. If desirable, this shaft may form a portion of a water circulating system by which the various parts of the mill are cooled, so as to obviate any danger of igniting the finely pulverized fuel therein.

The end of the motor shaft 49, remote from the drive belt 45, is provided with a driving pinion 51 which meshes with and drives three gears 52, arranged concentrically about the shaft 49, as shown in Fig. 3. Each of these gears 52 is fixed upon its respective roll shaft 53, which extends between and is journaled in the end members 38 and 39, preferably in ball bearings 54 and 55 mounted in these respective members. Each shaft 53 carries between the members 38 and 39 a frusto conically shaped grinding roll 56. Upon each shaft 53, in addition to the gear 52, there is fixedly mounted an elongated gear 57, which gears mesh with intervening gears 58 fixed on shafts 59, also arranged concentrically around the axis of the main drive shaft 49, and spaced intermediate the shafts 53. It will be apparent, therefore, that the three shafts 53 are driven directly from the main shaft 49, all in the same direction, while the shafts 59 are all driven from the shafts 53, and in the opposite direction to the direction of rotation of the shafts 53.

Each shaft 59 extends transversely between the end members 38 and 39 and is carried in the member 38 by a ball bearing 61 slidable longitudinally in a bearing socket 62, while the other end of each of said shafts is carried in a ball bearing 63 mounted in a slidable guide 64, which may be adjusted longitudinally by means of an adjusting screw 65 threaded through a cap 66 and shaped at its outer end to receive a wrench by which the adjustment may be effected. This screw 65 is rotatably connected with the guide 64 at 67 as best shown in Fig. 5, and by manipulation of the respective adjusting screws, the shafts may be adjusted longitudinally to dispose the frusto conically shaped grinding rolls 68 carried thereby in proper relation with respect to their opposed grinding rolls 56.

In order to prevent leakage of dust and ground coal from the casing around the shafts 53 and 59, a packing ring 69 is disposed around each shaft adjacent the end of the roll, as shown in Fig. 5. The driving end of each shaft 59 is also surrounded by a sealing cap 71, and the opposite end of the shafts 53 are covered by sealing caps 72, while the corresponding ends of shafts 59 are covered by the caps 66.

The peripheries of the various grinding rolls may be smooth, fluted, corrugated, or otherwise roughened, if preferred, and for illustrative purposes I have shown in Fig. 4

of the drawings three different types of rolls, which may be arranged as shown, or any type may be used exclusively or substituted for any of the others shown. The six grinding rolls illustrated comprise two co-operating smooth rolls *a* and *b*, an intermittently fluted roll *c*, cooperating with a smooth roll *d*, and a pair of cooperating rolls *e* and *f* longitudinally fluted throughout their entire peripheries. The roll *f* is shown in perspective in Fig. 6, from which it will be observed that this roll is provided upon its periphery with longitudinally extending flutes or grinding teeth 73 tapering from the large to the small end of the roll in conformity with the taper of the roll itself. In operation, this roll will revolve on its axis in a clockwise direction, viewing Figs. 4 and 6, so that the radially disposed front faces of the teeth will force the pieces of coal between the rolls, whereby such pieces will be broken, ground, and pulverized.

The direction of rotation of the various grinding rolls is indicated by the arrows in Fig. 4, and each roll, cooperating with a companion roll thereof, will feed the coal delivered above the rolls downwardly between the rolls into the center of the machine, and similarly when, as the result of the rotation of the rolls as a unit about the axis of the shaft 49, each roll is disposed below the axis of this shaft, it will cooperate with the roll at the other side thereof to feed the material outwardly from the center of the machine. The material to be ground is therefore subjected during its travel from the top to the bottom of the machine casing to two grinding actions; namely, it is first fed inwardly by the upper rolls and is subjected to the action of these rolls, and it is then fed outwardly by the lower rolls and again subjected to the action of these rolls. The tapered shape of the rolls also contributes toward the effectiveness of their grinding action since the linear peripheral speed of each roll is greater at one end than at the other, and the differences in size of the cooperating parts of adjacent rolls results in a speed differential between their grinding surfaces, which greatly facilitates their grinding and crushing action.

In the lower portion of the casing, beneath the grinding rolls 56, there is disposed a screen 74, which is slidably removable from the machine for cleaning purposes at one side thereof through a door 75 adapted to be opened, and this screen is of segmental shape, conforming to and forming a portion of the arcuately shaped lower portion of the casing beneath the grinding rolls. Such material as is too large to pass through this screen is removed therefrom and returned to the upper portion of the

machine, where it is redelivered to the grinding rolls 56 for further grinding action, and this operation is repeated until the material is fine enough to be withdrawn through the pipe 21 by the air passing through the casing, or falls by gravity through the screen 74 into the chamber 17 beneath the screen, from whence it is drawn out by the air delivered from this chamber beneath the partition wall 23.

The mechanism for removing the pieces of material tending to collect on the screen 74 and returning them to the grinding rolls for further grinding action, will now be described. Upon the rotatable end members 38 and 39 of the casing there is fixedly secured by bolts 76 a plurality of, in the present instance three, brackets 77, which project radially outwardly beyond the perimeters of the members 38 and 39. A scoop or collector 78 extends transversely of the machine between the opposed brackets 77 on the end members 38 and 39, these scoops being fastened at each end by rivets 79, or otherwise, to the brackets between which they extend thereby adding to the rigidity of the revolving carrier as well as forming collecting scoops which travel in proximity to the arcuate lower portion of the casing, including the screen 74, so as to pick up and carry with them the material tending to collect upon the screen. As the scoops revolve in a clockwise direction, viewing Fig. 4, the picked-up material will be carried upwardly by the scoops until it is elevated above the central axis of the machine, whereupon the material will be delivered by the scoops to the grinding rolls for further grinding action.

For the purpose of preventing the material which leaves the scoops from dropping to the bottom of the casing outside the grinding rolls, instead of being fed through between the rolls, I have provided a plurality of deflectors, one for each scoop, which deflect such material toward the rolls and insure its passage between the rolls. Each deflector comprises, as will be apparent from Figs. 4, and 7 to 9 inclusive, a deflecting plate 81 suspended by a hanger 82 from a shaft 83, extending between opposed brackets 77 and rigidly secured at its ends thereto. Each shaft extends straight across the casing parallel with the axes of the grinding rolls, but its hanger 82, which is carried by a sleeve 84 oscillatably supported by the shaft 83, is twisted or turned at an angle with respect to the axis of the shaft, so that the deflector plate extends in the general direction of the contour of the tapered rolls between which its free edge is disposed. Collars 85 fixed to the shafts 83 hold the sleeves 84 against longitudinal displacement, and the oscillating movement of each sleeve on its shaft is limited by a pin or stud 86, extending from the shaft into

slots 87 formed in the sleeve. Each deflector plate is, by reason of the mounting just described, permitted a limited degree of oscillating movement, which enables its free or inner edge to at all times assume a position contiguous or adjacent to the lower roll of the pair between which this edge is disposed. For instance, viewing Fig. 4, as a deflector plate travels upwardly at the left of the machine, its free edge will be disposed in proximity to the lower roll of the pair, and the material delivered by the scoop, mounted somewhat in advance of the plate, is deflected by the plate and delivered to and between the rolls. Any material being fed to the machine from above, and which might fall outside the grinding wheels instead of being fed between them, is also caught and diverted by these plates into the grinding zone of the rolls. As each deflector plate passes the vertical center of the machine, it will tilt by gravity so as to dispose its inner edge in proximity to the other roll of the pair, as shown at the right in Fig. 4, thus serving to divert the material at this side of the machine also into the grinding zone of the rolls. It may be desirable in some instances to provide each plate with a flange 88, as shown in Fig. 4, which will prevent any material dropping onto this plate from sliding off at the outer end during the upward travel of the plate. or, in other words, from the time that the plate is in the lower left-hand position shown in Fig. 4 until it reaches a point above the center line of the machine.

The material which passes through the screen 74 is subjected to the further grinding action of final grinding rolls 89, two pairs of which are shown in Fig. 4 of the drawings. These rolls may be roughened or fluted if desired, but preferably they are plain, and the material passing through the screen is deflected into the grinding zone of these rolls by inclined side deflectors 91 and a central inverted V-shaped deflector 92. These rolls may be driven in any desired manner, but are shown, for illustrative purposes as being driven by belts 93 from the counter-shaft 44, the rolls of each pair being geared together to insure their cooperative action. The finely ground and pulverized material delivered by these rolls into the chamber 17 is withdrawn therefrom by the current of air entering from the pipe 18 beneath the partition 22, and discharged beneath the partition 23 into the pipe 21, and this finely powdered material, together with that withdrawn by the air directly from and around the grinding rolls 56, is discharged by the fan 19 into the separating chamber 25, as previously explained.

The operation of the system as a whole has been previously set forth; but the operation of the grinding mill itself will be taken up

a little more in detail. The material to be ground is delivered from the hopper 11 and from the separating chamber 25 by the screw 12 to the preliminary grinding and crushing rolls 13, from which it is delivered into the casing of the grinding mill. The material falls therein directly upon the uppermost grinding rolls 56, and any which may fall on either side of these sets of rolls is diverted by the deflecting plates 81 into the grinding zone of the rolls. The material is first fed inwardly and operated upon during its passage between the rolls, and it is then fed outwardly at the bottom of the revolving set and again operated upon by the rolls during its outward passage. The material then falls upon the screen 74, and such as is fine enough to fall therethrough is subjected to the final grinding action of the rolls 89. The larger particles collecting on the screen are picked up by the revolving scoops and carried upwardly to be again delivered by the scoops and deflecting plates to the grinding rolls at the upper portion of the machine, where these particles are subjected to further grinding action of the rolls, passing inwardly between the upper rolls and outwardly between the lower rolls, as in the initial grinding. During the operation of the mill, air is continually drawn through the casing, both above and beneath the screen 74, and the dust or finely powdered material is removed by this current of air from the mill and delivered by the fan 19 into the separating chamber, from whence the heavier particles are returned again to the mill, while the lighter particles travel on to the cyclone. A continuous closed circuit is therefore provided, which insures successive grinding and regrinding of the particles until they are sufficiently reduced in size to pass on into the cyclone, thus insuring a finely powdered product, and also preventing any losses by escape of the finely powdered product with air to the atmosphere. The apparatus is compact, efficient, and durable; it occupies a relatively small amount of space, and can be manufactured and installed at a relatively low cost. The details of construction shown and described are, however, merely illustrative, and the principles of the invention may be embodied in structures differing materially from those illustrated without departing from the essence of the invention, as defined in the following claims.

I claim:

1. In a grinding mill the combination of a rotatable carrier, a housing surrounding said carrier, a plurality of grinding rolls mounted on said carrier, the axes of said rolls and carrier being parallel said rolls being cylindrically arranged in said carrier, the peripheries of said rolls being arranged sufficiently close to grind material therebe-

tween means for revolving the carrier, means for simultaneously rotating said rolls, and means for feeding the material to be ground between the peripheries of said rolls outwardly again between said peripheries to effect the grinding of such material between said peripheries.

2. In a grinding mill the combination of a housing, a carrier rotatably mounted therein and forming a portion of the housing walls, a plurality of grinding rolls rotatably mounted on said carrier within said housing, means for supplying material to the housing above said rolls, means for revolving the carrier and rolls as a unit means for simultaneously rotating said rolls, and pneumatic means for removing the ground material from said housing.

3. In a grinding mill the combination of a stationary housing, a plurality of grinding rolls mounted within said housing, means for rotating said rolls, alternate rolls being rotated in opposite directions, means for revolving all of said rolls as a unit about a common axis, and pneumatic means for removing the ground material from the housing.

4. In a grinding mill the combination of a stationary casing, a carrier rotatably mounted therein, a series of grinding rolls arranged in cooperative relation cylindrically about the axis of and carried by said carrier, means for revolving said carrier and rolls as a unit and simultaneously rotating said rolls, and means for feeding material to be ground between the upper rolls of said carrier, said material being fed inwardly toward the center of the carrier between said upper rolls, and outwardly from said carrier between the lower rolls said rolls being arranged sufficiently close together to effect the grinding of said material therebetween.

5. In a grinding mill the combination of a housing, a plurality of grinding rolls arranged in said housing cylindrically about a central axis, and in substantially contiguous relation, means for delivering material to be ground above and between certain of said rolls, and means for rotating said rolls so that adjacent surfaces travel in the same direction and simultaneously revolving the rolls as a unit about said central axis to thereby cause the material to be fed inwardly by the upper rolls and outwardly by the lower rolls.

6. In a grinding mill the combination of a housing, a series of frusto conically shaped grinding rolls mounted in said housing cylindrically about and parallel with a central transversely extending axis, the rolls being arranged in alternation so that the large end of each roll is opposed to the small ends of adjacent rolls, means for rotating all of said rolls, alternate rolls being rotated in opposite directions, means for revolving

all of the rolls as a unit about said central axis means for delivering material to be ground to the upper rolls, and means for returning partially ground material to said rolls for regrinding purposes.

7. In a grinding mill the combination of a rotatable carrier, a plurality of frusto conically shaped rolls carried by the carrier and arranged cylindrically about the axis of rotation of said carrier, the large and small ends of said rolls being arranged in alternation, means for revolving said carrier and rolls mounted therein, and means for rotating each of said rolls about its axis.

8. In a grinding mill the combination of a casing provided at one side with an air supply pipe and at its other side with an air delivery pipe, a carrier comprising end members rotatably mounted in the side walls of said casing, a series of tapered rolls rotatably mounted in said carrier, means for revolving the carrier and the rolls about the axis of the carrier, and means for simultaneously rotating each of said rolls about its own axis.

9. In a grinding mill the combination of a casing, a carrier therein, a series of grinding rolls arranged in a circle within said casing and carried by said carrier, one or more of said rolls being longitudinally fluted, means for revolving said carrier and rolls as a unit about a common center, and means for rotating each of said rolls about its own axis.

10. In a grinding mill the combination of a casing, a carrier rotatably mounted therein and comprising end members forming portions of the end walls of said casing, said end members having leak proof joints with said casing, a plurality of grinding rolls mounted on said carrier cylindrically about the axis of rotation of the carrier, means for revolving the rolls about said axis, means for rotating the individual rolls, and means for effecting a relative longitudinal adjustment between adjacent rolls.

11. In a grinding mill the combination of a casing, a carrier comprising a pair of end members rotatably mounted in the casing and rigidly connected together, a series of grinding rolls mounted on said carrier, means for revolving said carrier and the rolls mounted therein, means for driving alternate ones of said rolls in the same direction, and a gear connection between said rolls and the intervening rolls, whereby said intervening rolls are driven in the opposite direction.

12. In a grinding mill the combination of a casing, a rotatable carrier mounted therein, a plurality of tapered rolls mounted on said carrier with their large ends disposed toward one side of the casing, a gear connected with each of said rolls outside the casing, a driving gear meshing with all of

said roll gears, a plurality of tapered rolls mounted on said carrier between said first mounted rolls with their large ends disposed at the other side of the casing, and geared connections between all of said rolls, whereby alternate rolls are driven in opposite directions.

13. In a grinding mill the combination of a rotatable carrier, a series of grinding rolls mounted thereon cylindrically about the axis of said carrier, means for revolving the carrier and simultaneously rotating the rolls, means for feeding material to be ground to the upper rolls on said carrier, and means carried by the carrier for returning partially ground material from beneath the carrier to the upper rolls for regrinding.

14. In a grinding mill the combination of a rotatable carrier, a series of grinding rolls mounted thereon, a plurality of scoops carried by the carrier outside the path of travel of said rolls, and means for deflecting the material delivered by said scoops into the grinding zone of said rolls.

15. In a grinding mill the combination of a rotatable carrier, a plurality of grinding rolls mounted thereon and rotatable therewith, scoops attached to said carrier outside the path of travel of the rolls, and deflecting plates disposed between and in proximity to adjacent rolls and movable with said carrier.

16. In a grinding mill the combination of a rotatable carrier, a plurality of grinding rolls arranged in a circle on said carrier, and oscillatable deflecting plates suspended from the carrier outside the path of travel of the rolls, the free edges of said plates being disposed between and in proximity to adjacent rolls.

17. In a grinding mill the combination of a rotatable carrier, a series of grinding rolls mounted thereon, a plurality of deflecting plates having their inner edges disposed in proximity to the rolls of a pair, and means on the carrier for supporting said plates.

18. In a grinding mill the combination of a rotatable carrier, a series of tapered grinding rolls mounted thereon with their large and small ends arranged in alternation, shafts mounted on the carrier parallel with the axis of rotation thereof, and deflector plates carried by said shafts and disposed at an angle thereto, so that said plates may conform in position to the inclination of said rolls.

19. In a grinding mill the combination of a casing, a carrier rotatably mounted therein, a series of tapered grinding rolls arranged in alternation with respect to their large and small ends and disposed cylindrically about the axis of said carrier, means

for revolving the carrier, means for rotating the individual rolls, scoops mounted on the carrier outside the path of travel of the rolls, and deflector plates oscillatably mounted on the carrier rearwardly of the scoops, said deflector plates being disposed at an angle with respect to the axis of said carrier and having their inner edges positioned between and in proximity to adjacent rolls of a pair.

20. In a grinding mill the combination of a casing, a carrier rotatably mounted therein, the lower portion of said casing being concentric with said carrier, a screen forming a part of said lower portion, grinding rolls mounted on the carrier, scoops carried by the carrier and adapted to travel in proximity to said screen, means for feeding material to the casing above said carrier, final grinding rolls beneath said screen to which material ground by the carrier rolls is delivered through said screen, and means for removing the ground material from said casing.

21. In a grinding mill the combination of a casing, a carrier rotatably mounted therein, a series of grinding rolls rotatably mounted on the carrier, a screen beneath said carrier, and additional grinding rolls beneath said screen.

22. The combination of a casing, a rotatable carrier therein, grinding rolls rotatably mounted on said carrier, a screen beneath the carrier, final grinding rolls beneath the screen, preliminary grinding rolls above the carrier between which the material is delivered to the casing, means for returning partially ground material to the carrier grinding rolls, and pneumatic means for removing the completely pulverized material from the casing.

23. The combination of a casing, including a main portion and a bottom chamber and air inlet and exit ducts to and from said chamber and casing, a rotatable carrier mounted in the main portion of said casing, grinding rolls mounted on said carrier, preliminary grinding rolls above the carrier, final grinding rolls in said chamber beneath the carrier, and a screen interposed between said final grinding rolls and said carrier.

24. The combination of a casing, a carrier rotatably mounted therein, said carrier comprising a pair of end members rigidly connected together, a series of tapered rolls mounted on said carrier, means for longitudinally adjusting one or more of said rolls, means for driving alternate rolls of said series, and gears connecting all of said rolls whereby all the rolls are driven, alternate rolls being driven in opposite directions.

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