July 15, 1941. C. F. OSGOOD 2,249,364

METHOD AND APPARATUS FOR SIZE REDUCTION

Filed Aug. 29, 1936 3 Sheets-Sheet 1

Fig. 1.

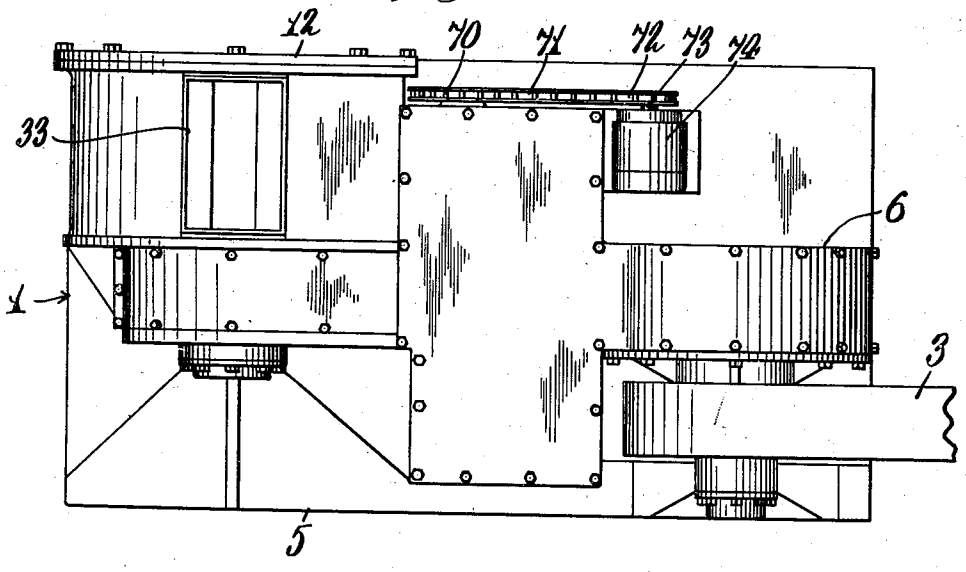
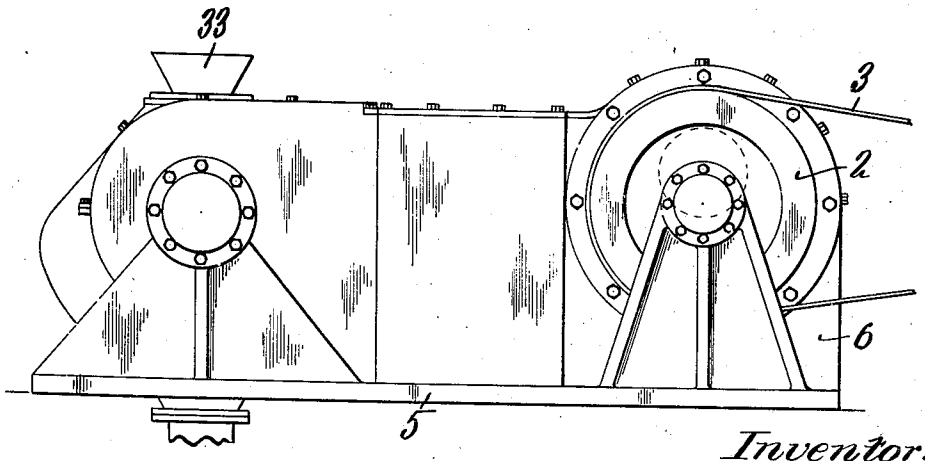


Fig. 2.



Inventor:
Charles F. Osgood.
by
Louis A. Maxson.
Atty.

July 15, 1941. C. F. OSGOOD 2,249,364

METHOD AND APPARATUS FOR SIZE REDUCTION

Filed Aug. 29, 1936 3 Sheets-Sheet 2

Fig. 3.

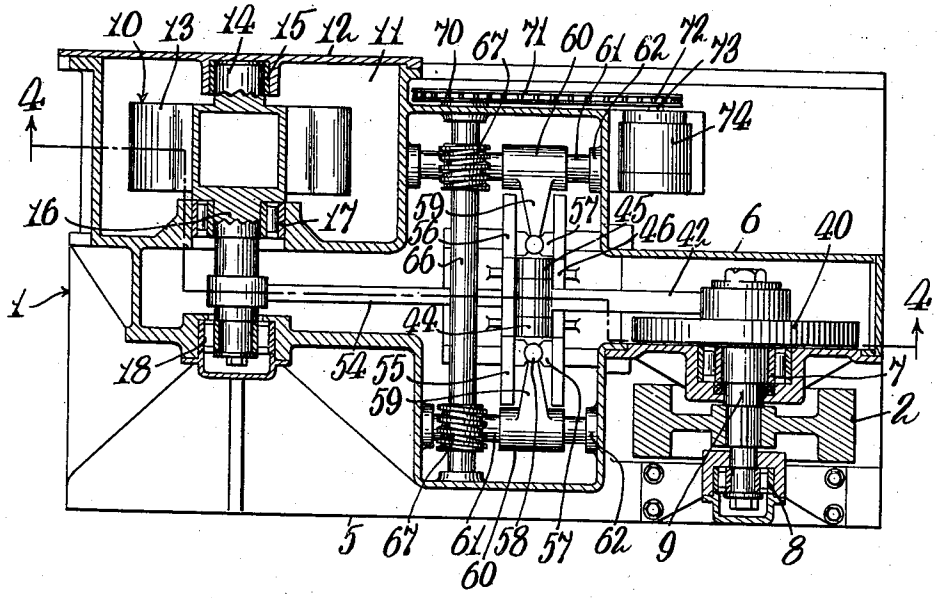


Fig. 4.

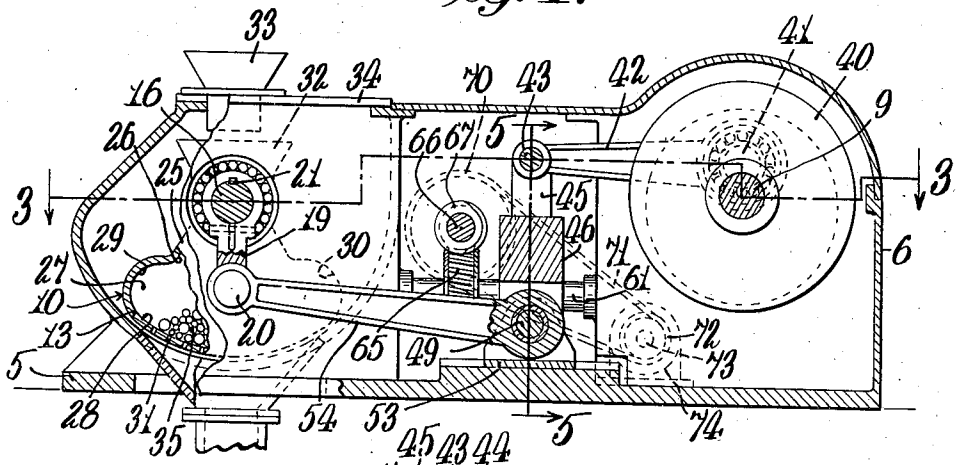
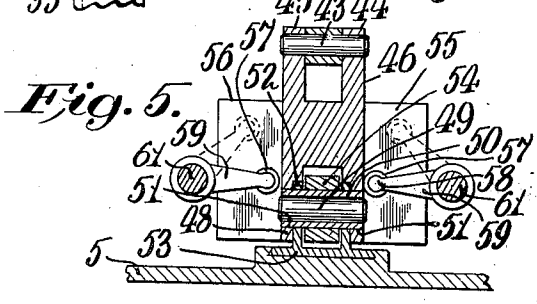


Fig. 5.



Inventor:
Charles F. Osgood.
by
Louis A. Uhlman.
Atty.

July 15, 1941. C. F. OSGOOD 2,249,364

METHOD AND APPARATUS FOR SIZE REDUCTION

Filed Aug. 29, 1936 3 Sheets-Sheet 3

Fig. 6.

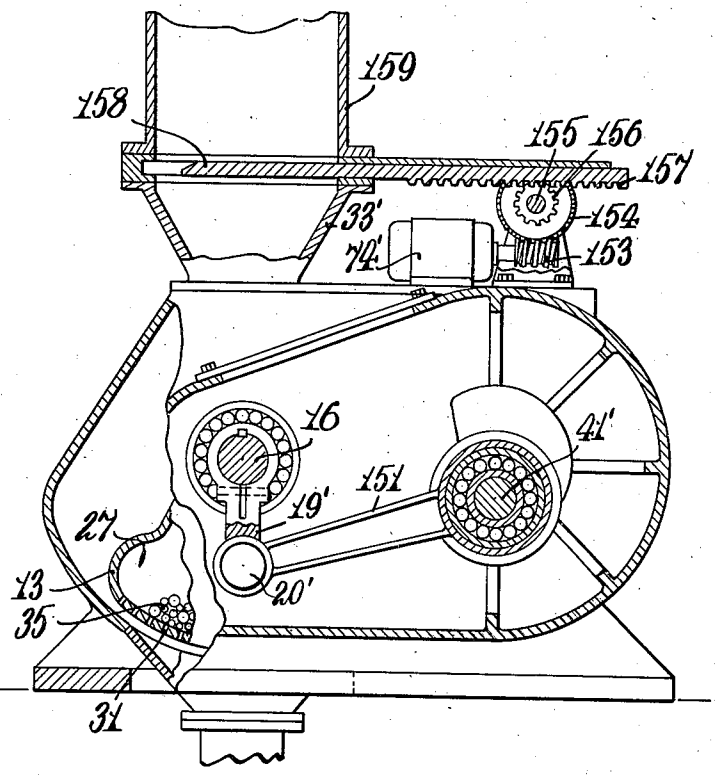
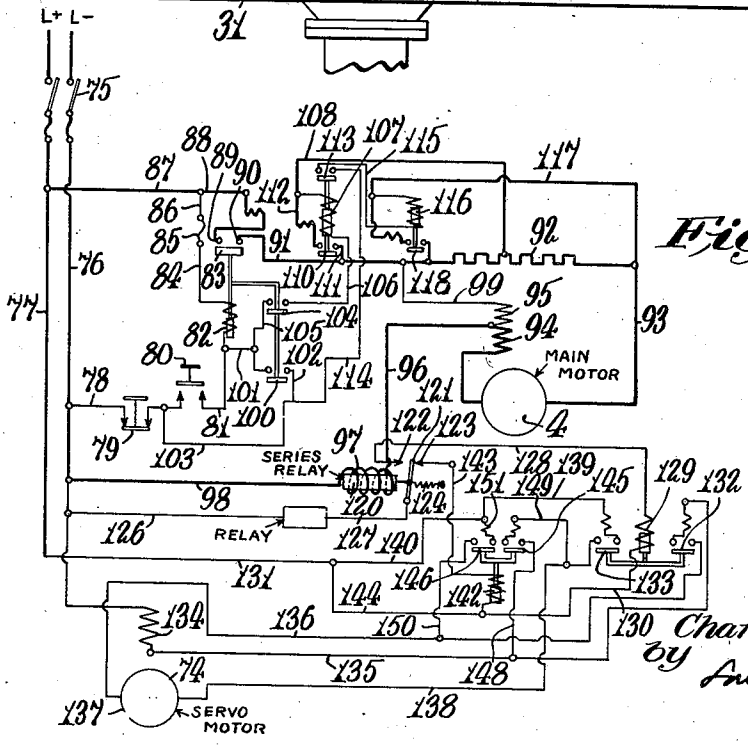


Fig. 7.



Inventor:
Charles F. Osgood.
by
Louis A. Mixon.
Atty.

Patented July 15, 1941

2,249,364

UNITED STATES PATENT OFFICE

2,249,364

METHOD AND APPARATUS FOR SIZE REDUCTION

Charles F. Osgood, Claremont, N. H., assignor to Sullivan Machinery Company, a corporation of Massachusetts

Application August 29, 1936, Serial No. 98,549

20 Claims. (Cl. 83—9)

My invention relates to mills and more particularly to mills having controlling apparatus associated therewith for preventing choking thereof.

Certain forms of size-reducing apparatus provide, when fed under close control, quite efficient size reduction, but, unless the rate of feed is rigorously regulated, the mills will either tend to clear themselves of material undergoing the process of reduction and occasion excessive wear on the size-reducing media and the mill chamber, or, on the other hand, tend to choke and first lose efficiency and then entirely cease to function if this process is too long continued. It is an object of my invention to avoid both the difficulties mentioned. This can be accomplished, as demonstrated in the different embodiments of my invention hereinafter disclosed, described and claimed, in different ways. The intensity of the size-reducing action may be speeded up for the purpose of offsetting a tendency to choke, due to the ingress of material at a rate in excess of the previous grinding or size-reducing rate at which the mill was operated. This involves either an increase in speed of operation of the mill, or an increase in the speed of relative movement between the material in the mill and the mill chamber, variously produced by means other than means for merely increasing the rate at which the mill is driven. When feed rate decreases, a reduction in mill speed or grinding rate will be called for. Another mode of possible procedure is to throttle variably, as it were, the rate of material ingress into the size-reducing chamber, and to control the effective area of the material ingress passage automatically in accordance with the load within the mill, cutting down the ingress area when the load within the mill chamber tends to become too great, and increasing such area when the load within the mill chamber falls below a desired minimum. It is another object of my invention to provide an improved milling apparatus having controlling means regulating its rate of milling in accordance with the quantity of material therein. It is still another object of my invention to provide an improved apparatus for regulating the intensity of the size-reducing action in a mill, while maintaining the number in cycles of operation per time unit constant, and thereby to control the output of the mill to prevent material deviations from optimum size-reducing conditions therein. It is still another object of my invention to provide an improved size-reducing apparatus having a driving motor and provided with means for regulating the quantity of material within the mill in accordance with the load upon the driving motor. It is still a further object of my invention to provide an improved method of regulating the operation of a milling apparatus by varying the intensity thereof automatically in accordance with the quantity of material within the mill. Other objects and advantages of my invention, from both its method and apparatus aspects, will hereinafter more fully appear in the course of the present specification and the appended claims.

In the accompanying drawings, in which two illustrative embodiments which my invention may assume from its apparatus aspects are shown for purposes of illustration,

Fig. 1 is a top plan view of a milling apparatus in which one of the illustrative embodiments of the invention is incorporated and designed to operate in accordance with certain method phases of my invention;

Fig. 2 is a side elevation of the mill shown in Fig. 1;

Fig. 3 is a section through the mill approximately on the planes of the section line 3—3 of Fig. 4, with some parts shown in elevation;

Fig. 4 is a vertical sectional view on the planes of the section line 4—4 of Fig. 3;

Fig. 5 is a fragmentary section on the vertical plane of the line 5—5 of Fig. 4;

Fig. 6 is a vertical sectional view showing a modified embodiment of the invention; and

Fig. 7 is a wiring diagram showing a system applicable to either the apparatus of Figs. 1 to 5 or the apparatus of Fig. 6.

Referring first to the form of the invention illustrated in Figs. 1 to 5, and of which a diagrammatic representation of the circuits is contained in Fig. 7, it will be noted that a size-reducing apparatus, generally designated 1, has a primary drive pulley 2 suitably connected by power transmission means, herein in the form of a belt 3, with a main driving motor 4, which is shown only in the diagrammatic view of Fig. 7. The mill 1 comprises a base 5 upon which a suitable frame structure 6 is supported; and, in bearing means 7 and 8, carried by portions of the frame structure 6, is a drive shaft 9 to which there is suitably fixed the drive pulley 2, which is preferably made of heavy construction, so that it may also perform a flywheel function. The other end of the frame 5 herein provides a mounting for a size-reducing mechanism proper which is generally designated 10. Within a chamber 11 formed by a portion of the frame 6 and suitably closed by a cover plate 12, there is supported

for oscillatory movement a size-reducing-chamber-providing element 13 supported by suitable pivoting means, herein in the form of a stub shaft 14 journaled in a bearing 15 in the cover plate 12 and a rock shaft 16 journaled at 17 in the frame 6 and having an outboard bearing 18 in another portion of the frame 6. A depending arm 19, forked at its lower end to provide a mounting for a pin 20, is secured at 21 to the rock shaft 16, and is adapted, upon the transmission of swinging movement thereto, to rock the rock shaft 16 and the supported chamber-forming element 13.

The chamber-forming element 13 is merely representative, and indeed this is true of the entire size-reducing apparatus, as a very wide variety of mill structures could be employed within the spirit and scope of my invention. Herein the chamber-providing element 13 comprises a depending portion 25 providing a passage 26 through which material may be introduced to the size-reducing chamber proper 27 formed in the lower part of the member 13. The size-reducing chamber 27 is provided with an arcuate bottom 28, and herein with approximately semi-cylindrical opposite end portions 29 and 30; and the chamber is formed with suitable discharge openings, herein shown as arranged in the bottom wall 28 and designated 31 and obviously adapted to be formed in any suitable wall of the member 13. At the upper end of the supporting and feed passage forming-portion 25, and above the pivot axis of the stub shaft 14 and drive shaft 16, is an upwardly expanding material-receiving device 32 adapted to receive material fed through a suitable feed element 33 supported upon a top cover 34, and to deliver it, irrespective of the oscillation of the member 13, at all times into the connection 25. Preferably, although not necessarily, there is arranged within the size-reducing chamber 27, a portion of size-reducing media 35 which may be graduated in size, as illustrated in Fig. 4, to good advantage.

It will be appreciated that, upon rocking of the member 13 through an appropriate arc, material fed into said chamber, and the intermingled charge of size-reducing media 35 within the chamber 27, will constitute a load which will be reciprocated within the chamber, the load moving in each complete cycle of oscillation of the chamber element 13, twice with the chamber element and twice relative to the chamber element. For example, to describe briefly a part of a cycle, and beginning with the chamber element 13 in a laterally swung position and with the load in contact with the higher end of the chamber at that time, the chamber will rock downward through its mid-position and over to its opposite extreme position accelerating perhaps during early portions of its movement and decelerating through the latter portion of such movement. The load within the chamber will accelerate with the chamber, and, as it will not be positively decelerated, as will the chamber, through the latter's power-oscillating connections, which will shortly be described, the load will continue to move in the same direction with relatively undiminished velocity during the period of deceleration of the chamber though of course friction on the chamber walls does exert a decelerating effect. By appropriately controlling the quantity of material within the chamber, any result between an overtaking by the charge of the end of the chamber, which is ahead of it, as the chamber comes to rest, and an impact between the charge and a reversely moving end of the chamber, when both are at maximum velocity, will be possible. Accordingly, the size-reducing action may involve little or no impact, slight impact, moderate impact, considerable impact and very great impact, depending upon the velocity of the chamber, the load it contains, and its amplitude of movement. Accordingly, by appropriately varying the velocity and amplitude of movement of the chamber, the contents of the chamber may be subjected to a more or less violent size-reducing action, and, in the event of a tendency of the chamber to fill up, due to an unduly rapid feed, or any other cause, the rate of material reduction and discharge can be accelerated, if suitable means to do this be provided, and thereby overcome the choking tendency mentioned.

Now to take care of the desired acceleration or deceleration of the size reducing rate, various means may be provided which will utilize the essence of my invention and control the size-reducing rate in accordance with the load which the mill imposes upon its driving motor, such being one of the simplest modes of regulation falling within the scope of my invention.

The method of controlling the rate of size reduction for a substantially constant speed drive of the primary drive pulley 2, illustrated in Figs. 3, 4 and 5, comprises broadly means for altering the angular range of oscillation of the rocker arm 19, operating on a principle of varying the fulcrum point in an oscillating lever. It will be obvious that shaft 9 is provided with a crank disc 40 having a crank pin 41 projecting therefrom and connected by a connecting rod 42 with a pin 43 mounted between arms 44 and 45 of a substantially upright oscillating rocking arm or lever 46. The lower end of the lever 46 is forked, and, between its arms 48, supports a pin 49 and surrounding sleeve 50, said sleeve 50 secured, at its ends, in bores 51 formed in the arms 48, being surrounded by upstanding brackets 52 carried upon a sliding shoe or crosshead 53, and, midway between its ends, supporting one end of connecting rod 54 whose other end is operatively connected with the pin 20 mounted at the lower end of the arm 19. It will be evident that, with no more structure present than has so far been described, rotation of the shaft 9 would merely rock the upper end of the lever 46 about the sleeve 50 and there would be no longitudinal movement of the slide 53 nor transmission of motion to the rocker arm 19. To provide for the transmission of motion, by the lever 46, to the rocker arm 19, an adjustable pivot or fulcrum mechanism is arranged to cooperate with the lever 46 at different points between the ends of the latter. From the opposite sides of the lever 46 project pairs of spaced wings 55, 56; and, between these spaced wings, sliding blocks 57, cooperating with spherical heads 58 on pivotally mounted arms 59, are arranged for upward and downward pivotal movement, movement of the spherical heads 58 moving the blocks 57 up and down between the spaced wings 55, 56 and, accordingly, varying the fulcrum point about which the arm 46 oscillates, since movement of the spherical heads 58 at right angles to the planes in which they are swingably movable is prevented by securing the arm mountings 60 on shafts 61 journaled for oscillation, but fixed against longitudinal movements in bearings 62 carried by the frame 6. Means for simultaneously rotating the shafts 61 at a slow rate is provided, and herein the shafts 61 each support, adjacent one end

thereof, a worm wheel 65, and a cross shaft 66 carries worms 67, 67 which mesh with the worm wheels 65. Rotation of the shaft 66 through the worms 67 rotates the worm wheels 65, and thereby causes upward or downward swinging of the fulcrum devices 57, 58 between the plate portions 55, 56. The worm and worm wheel associated with each shaft 61 are so made that the shafts 61 will turn at the same angular rates, and the arms 59 are so arranged on the shaft 61 that, in all positions of adjustment of said arms through rotation of the shaft 66, the centers of the spherical heads 58 will, at all times, remain together in a common horizontal line, the elevation of such line of course changing as the arms are adjusted.

The teeth of the worms and worm wheels are preferably made self-locking. The shaft 66 is provided with a sprocket wheel 70, herein connected with a sprocket chain 71 connected with a driving sprocket 72 mounted upon the drive shaft 73 of a servo motor 74, this mechanism merely being illustrative of a wide variety of power actuating connections for adjustment of the shaft 66. Further reduction may of course be provided between motor shaft and shafts 61.

To vary the position of the fulcrum for the oscillating arm 46 between a position in which the motion transmitted to the rocking arm 19 may be zero (as is the case when the centers of the heads 58 lie in the same horizontal plane with the axes of the sleeve 50) and a maximum (when the spherical heads 58 are in their uppermost position), appropriate means automatically controlled by the load on the driving motor 4 is provided, and the load variation on the driving motor is caused to control the direction and the time of operation of the motor 74. To accomplish this result, various means may be, of course, employed; and, in Fig. 7, there is diagrammatically illustrated one means suited to this purpose. It will be observed in this figure that the power lines L— and L+ are connectible, through a suitable main line switch 75, with main conductors 76 and 77. A conductor 78 leads from the conductor 76, through a stop switch 79, to a manually operable starting switch 80, from which a conductor 81 leads to the operating coil 82 for a main line contactor 83, and the solenoid 82 is connected, at its other end, by a conductor 84, a fuse 85 and conductors 86 and 87, back to the power line 77. Closure of the main line contactor 83 establishes a circuit through the conductor 87, a conductor 88, the stationary contacts 89 and 90 of the main line contactor, a conductor 91, a multiple step resistance 92, a conductor 93, the motor 4, having a series field 94 and a shunt field 95, a conductor 96, a series relay coil 97, later described, and a conductor 98 to the line 76. A conductor 99 connects the shunt field 95 to conductor 91. The main line contactor 83 has associated with it a pair of interlocking switch elements, one numbered 100 establishing a hold-in circuit for the solenoid 82, through a circuit including conductor 87, conductor 86, fuse 85, conductor 84, solenoid 82, a portion of conductor 81, conductor 101, switch 100, conductor 102, conductor 103, switch 79 and conductor 76. Another switch element 104 moving with the main line contactor 83 establishes a circuit from the conductor 101, through a conductor 105, a conductor 106, an operating solenoid 107 and a conductor 108 to the resistance 92 and thence back through conductor 91, the main line switch, conductors 88 and 87 to the line 77. The solenoid 107 closes a resistance cut-out contactor 110 and shunts the first step of the resistance 92 by way of a conductor 111, the switch 110, conductor 112 and conductor 108. The contactor 110 also has moved with it a further switch element 113 which closes an operating circuit including a conductor 114 connected to the conductor 103, a further conductor 115 and the operating coil 116 of the second resistance cut-out contactor, and a conductor 117 connected to the conductor 93. Accordingly, on closure of the switch 113, the second resistance cut-out contactor 118 is closed by the solenoid 116, and the motor is then on the line with the resistance 92 completely cut out. From the description so far given, it will be evident that the main driving motor of the mill may be started by closing the manual starting switch 80, and may be stopped by opening the manual stop switch 79. The motor will operate as long as current is supplied to it, and the current taken by the motor will pass through the coil 97 which is arranged in series with the motor.

The motor 74 is a reversible motor and may be run in either direction or remain idle, depending upon the amount of current taken by the motor 4. The motor 4 will take an increased amount of current as the quantity of material within the chamber 27 builds up above a median value, and will take a smaller amount of current as the quantity within the chamber 27 is reduced. This fact is made use of to control the direction of rotation of the motor 74, and thereby the direction of adjustment of the fulcrum elements 57, and so the intensity of the size-reducing action of the mill 10, when more current is taken by the motor 4, will be increased, and it may be noted that this very thing in itself will cause a further increase in the amount of current drawn by the motor 4. In other words, the adjustment to speed up the mill will not cause a reduction in the quantity of motor current until after the quantity of material in the chamber has been substantially reduced.

The solenoid or series coil 97 is equipped with a plunger 120 whose position controls the position of a switch 121. Contacts 122 and 123 are arranged at opposite sides of the switch 121 and, when the motor current increases, switch 121 contacts the stationary switch element 122, while when the motor current decreases, a spring 124 causes contact between arm 121 and stationary contact 123. In its opposite positions the arm 121 causes operation in opposite directions of the servo motor 74. Operation in one direction of the servo motor 74, the direction to cause an increase in the intensity of the milling operation, may first be described. It will be noted that a conductor 126 leads from the line 76 through a relay device, Relay, whose function it is to cause only intermittent current transmission therethrough, and whose mode of operation will be further explained hereinafter, through a conductor 127 to the switch arm 121, through the stationary contact 122, a conductor 128, a switch operating coil 129, a conductor 130 and further conductors 131 and 144 back to the line 77. The operating coil 129, upon energization, closes a pair of switch elements 132 and 133 and establishes then a circuit as follows: from the line 76 through the field 134 of the motor 74 through a conductor 135, switch 132, a conductor 136, armature 137 of the motor 74, a conductor 138, switch element 133, conductor 139, conductor 140 and conductor 131 back to the line 77. Motor 74 will then operate the adjustable fulcrum devices to

increase the oscillation of arm 19, raising the pivot blocks 57, 57. If, due to the reduction of current taken in the motor 4, the arm 121 moves into contact with stationary contact 123, an operating solenoid 142 for the other of the two reverse switches is energized through the conductor 126, the Relay, conductor 127, arm 121, stationary contact 123, conductor 143, solenoid 142, conductor 144 and conductor 131 to line 77. This closes the switch elements 145 and 146 and causes the motor 74 to operate in the opposite direction through a circuit as follows: starting with line 75, field 134, conductor 135, conductor 148, switch 145, conductor 149, conductor 138, in the other direction through the armature 137, through a portion of conductor 136, a conductor 150, switch element 146, conductor 151 and conductors 140 and 131 back to line 77. This will lower the fulcra 57, 58.

Now one more word about the relay Relay, and the mode of operation of this form of the invention may be briefly summarized. This relay is of well known commercial construction and is operative to permit current flow therethrough, say for five or any other small number of seconds, and then to interrupt current flow therethrough for a period of, say, twenty seconds. After such period, which is adjustable, a renewed current flow takes place. This relay is shown in the same circuit with the switch arm 121 and so causes, even though such energization of series coil 97 may exist as to maintain the switch arm 121 in contact with the contact 122, for, let us say, a minute, only very brief periods of operation of the motor 74. As a result, there is prevented the harmful phenomenon of a more or less continuous hunting of the motor 4 due to the lag in the rate of the load change within the chamber 27 behind the adjustments which would otherwise be made by the motor 74. Of course, the relay Relay, save for the fact that larger currents would have to be controlled thereby, might be arranged directly in the operating circuit of the motor 74. This is not impossible, but merely less desirable.

Now the mode of operation of this form of the invention will be clearly apparent from what has been described. Feeding arrangements, as through a belt conveyor, having been made available for the supply chute 33, the operator will close the starting switch 80, and through the circuits which have been described, the motor 4 will be started. This will cause the mill-chamber-forming member 13 to be rapidly and powerfully oscillated, though with short stroke, and the load therein which may initially be only size-reducing media, will be moved, as soon as some material begins to come in, in the manner heretofore described. As feed to the chute 33 continues, the load on the motor 4 will build up; and as a result, the original short stroke of the mill will be increased as soon as the quantity of material in the chamber 27 gets more than is desirable, as this will cause the motor 4 to draw more current and so move the switch arm 121 into contact with the stationary contact 122. This will, as above explained, cause the motor 74 to operate in a direction to move the fulcrum elements 58 upwardly and increase the range of oscillation of the arm 19, and so the chamber 27 will increase the rate of size reduction in the chamber, and excessive increase will be avoided by reason of the fact that the adjustment will not be carried on continuously by the apparatus illustrated throughout the time that the quantity of material within the chamber is being reduced. Should the rate of feed fall off, the current taken by the motor 4 will be reduced as the chamber tends to empty itself, and the contact arm 121 will then move into contact with the stationary contact 123 and the motor 74 will be reversed and the stroke of the mill chamber shortened with a reduced rate of size reduction and a refilling of the chamber to optimum load conditions. The relay Relay may be omitted if a mill of very rapid size-reducing capacity is being employed, or the time delay between the duration of periods of current supply through the relay may be varied to fit different mills. If feed is interrupted, and the quantity of size-reducing media be properly determined, impingement of the chamber ends upon the chamber load may be entirely discontinued automatically.

In Fig. 6 a different arrangement is shown. In this case, instead of varying the amplitude of movement of the size-reducing chamber, a substantially constant rate and amplitude of chamber oscillation is maintained, the crank pin 41' being directly connected by connecting rod 151 with the pin 20' on rock arm 19'. In this form of the invention, the motor 74', through a suitable worm 153, worm wheel 154, shaft 155, spur pinion 156 and rack 157, is adapted to adjust in opposite directions a gate 158 arranged transversely of a feed supply connection 159 mounted upon the top of the feed chute 33'. Here similar circuit connections for controlling the motor 74' may be used, and, if the chamber tends to get too full, the motor 74' will be operated in a direction to move the gate 158 to reduce the area of the feed supply passage, while, should the chamber load become too light, opposite movement of the motor will be effected. The general control of size reduction to maintain optimum conditions will, however, be present in this device as in the other.

From the foregoing description, it will be evident that I have provided an improved milling apparatus in which automatic control is provided, whereby optimum size-reducing conditions may be maintained. Different forms have been illustrated in which the grinding rate is increased or diminished while the feed rate is maintained constant, and in which the feed rate is increased or diminished while the operating conditions of the mill remain substantially uniform. In each case, the arrangements are simple, positive, reliable and substantially effective to produce the desired results. It is obvious moreover that I have provided an improved method of milling, in which the rate of size reduction is varied in proportion to the load on the driving motor.

While I have in this application specifically described two forms which the invention may assume in practice, it will be understood that these forms are shown for purposes of illustration and that the invention may be further modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In combination, a milling chamber, means for effecting movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means for automatically increasing chamber movement upon

increase in the quantity of material therein and decreasing the chamber movement upon decrease in the quantity of material therein to effect a restoration of the material load in said chamber to a predetermined quantity upon deviation therefrom.

2. In combination, a milling chamber, means for effecting movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means including means for altering the movement of said chamber for regulating the intensity of the milling operation in said chamber automatically in direct accordance with the quantity of material therein.

3. In combination, a milling chamber, means for effecting movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means for automatically increasing chamber movement upon increase in the quantity of material therein and decreasing the chamber movement upon decrease in quantity of material therein to effect a restoration of the material load in said chamber to a predetermined quantity upon deviation therefrom, said automatic means including means for varying the linear speed of chamber movement.

4. In combination, a milling chamber, means for effecting translatory movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means for regulating the intensity of the milling operation in said chamber automatically in direct accordance with the quantity of material therein including means for varying the travel of the chamber.

5. In combination, a milling chamber, means for effecting reciprocating movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means for regulating the intensity of the milling operation in said chamber automatically in direct accordance with the quantity of material therein including means for varying the range of reciprocation of said chamber.

6. In combination, a milling chamber, means for effecting oscillatory movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means for regulating the intensity of the milling operation in said chamber automatically in direct accordance with the quantity of material therein including means for varying the range of oscillation of said chamber.

7. In combination, a milling chamber, means for effecting movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means for regulating the intensity of the milling operation in said chamber automatically in accordance with the quantity of material therein including a variable lever mechanism for transmitting different ranges of movement to said milling chamber.

8. In combination, a milling chamber, a motor for effecting movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means for regulating the intensity of the milling operation in said chamber automatically in accordance with the quantity of material therein including a variable lever mechanism for transmitting different ranges of movement to said milling chamber and a motor for adjusting said lever mechanism whose operation is regulated by the power input to said first mentioned motor.

9. In combination, a milling chamber, a motor for effecting movement of said milling chamber to effect a milling operation therein, said milling chamber having means for supplying material thereto and means for discharging milled material therefrom as a substantially continuous process during operation, and means for regulating the intensity of the milling operation in said chamber automatically in accordance with the quantity of material therein including a variable lever mechanism for transmitting different ranges of movement to said milling chamber and a motor for adjusting said lever mechanism whose direction of operation is controlled by the power input to said first mentioned motor.

10. In combination, a size-reducing mill comprising a movable milling chamber, a driving motor therefor, driving connections between said motor and said milling chamber including mill-speed varying mechanism, and means governed by the load in said mill for automatically adjusting said speed varying mechanism to increase the speed of the chamber with increased load.

11. In combination, a size-reducing mill, a driving motor therefor, driving connections between said motor and said mill including mill-speed varying mechanism including adjustable-fulcrum lever means through which the drive is transmitted to said mill, and means governed by the load in said mill for adjusting said speed varying connections by varying the lever fulcrum.

12. In combination, a material-size-reducing mill, a driving motor therefor, driving connections between said motor and said mill including adjustable connections for varying the speed of actuation of said mill and means including a servo-motor governed by the load in said mill for adjusting said speed varying connections.

13. In combination, a material-size-reducing mill, an electric driving motor therefor, driving connections between said motor and said mill including adjustable connections for varying the speed of actuation of said mill, and means including an electric servo-motor governed by the load on said driving motor for adjusting said speed varying connections.

14. In combination, a material-size-reducing mill, an electric driving motor therefor, driving connections between said motor and said mill including adjustable connections for varying the speed of actuation of said mill, and means governed by the load in said mill for adjusting said speed varying connections including a servo-mo-

tor for adjusting said connections and having controlling means governed by a series relay in said driving motor circuit.

15. The method of controlling the output of an oscillating mill automatically which comprises automatically varying the range of oscillation of said mill directly with the quantity of material fed thereto to increase such range with the rate of feed.

16. The method of precluding the choking of the movable size-reducing chamber of a continuously operating mill which comprises varying the linear rate of movement of such chamber automatically directly in accordance with variations in the quantity of material in said chamber.

17. The method of precluding the choking of an oscillating mill which comprises varying the amplitude of oscillation of said mill in step and in direct accordance with variations in quantity of material in said mill.

18. The method of precluding the choking of an oscillating mill which comprises varying the amplitude of oscillation of said mill in step and in direct accordance with variations in quantity of material in said mill while maintaining the time rate of oscillation substantially constant.

19. In combination, a material-size-reducing mill having a size-reducing chamber and provision for the supply to and discharge from said chamber of material during chamber movement, and having means including a motor for driving said mill at a substantially uniform rate, and automatic means governed by the mass of the material in said chamber for varying the amplitude of milling movement responsive to and in direct accordance with variations in the load in said chamber.

20. In combination, a material-size-reducing mill having an oscillatory size-reducing chamber and provision for the supply to and discharge from said chamber of material during chamber movement, and having means including a motor for driving said mill to effect chamber oscillation at a substantially uniform rate, and automatic means for varying the milling rate responsive to variations in the load in said chamber including means the adjustment of whose position controls the ratio between material supply and discharge rates and means governed by the power required by said motor for adjusting said last named means.

CHARLES F. OSGOOD.