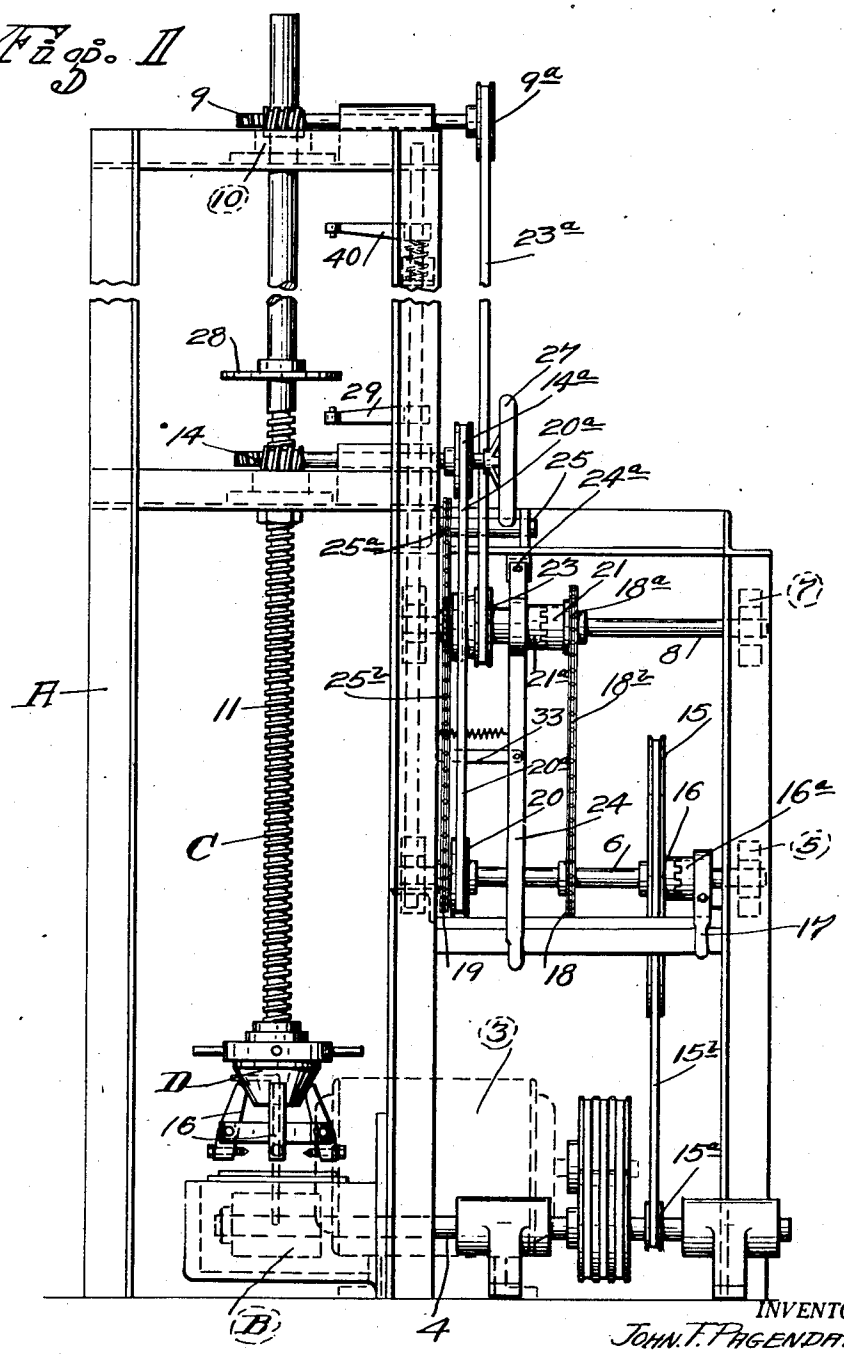
Feb. 6, 1945. J. F. PAGENDARM 2,368,870

COMMINUTING APPARATUS

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Fig. 1

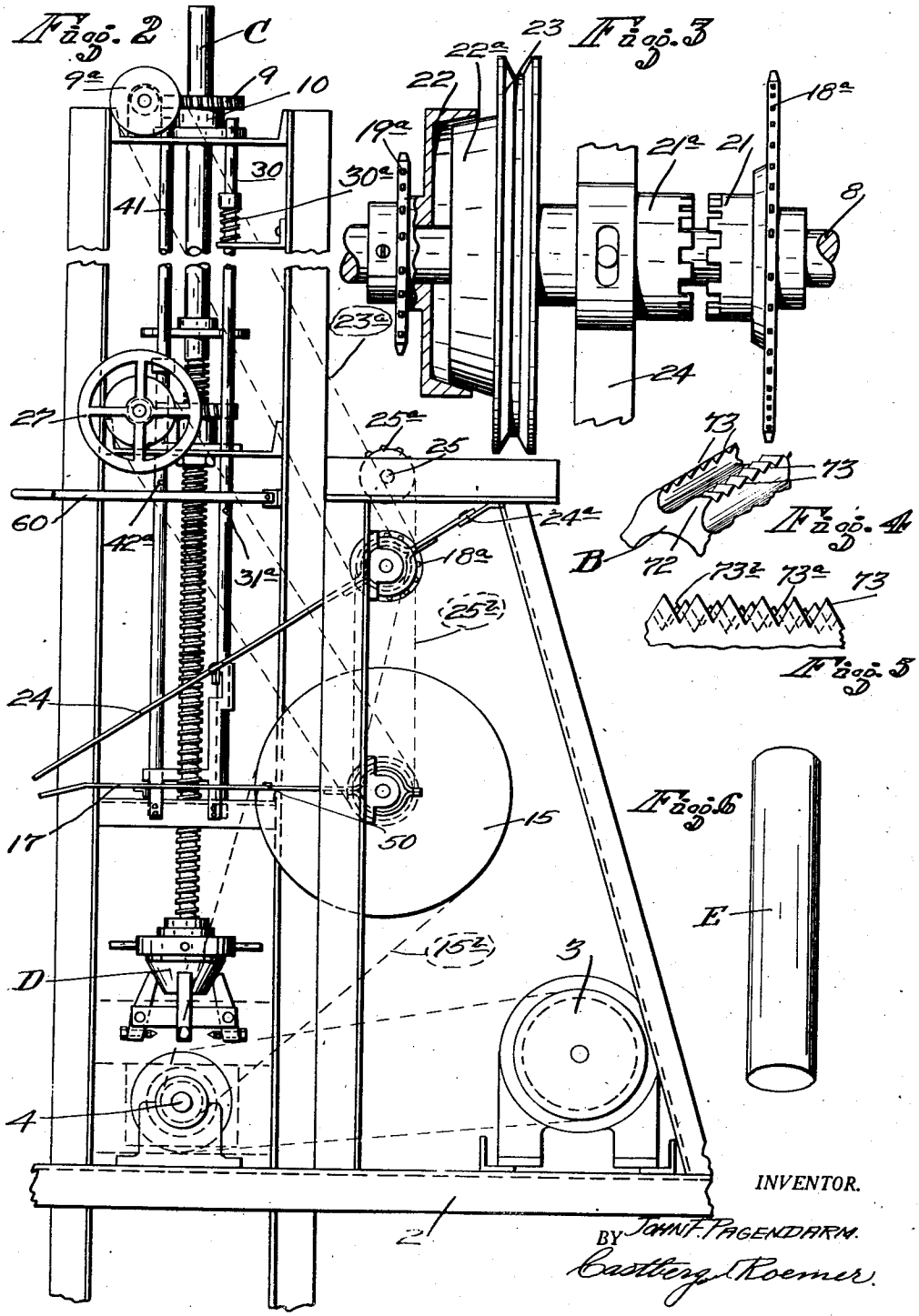


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Fig. 7

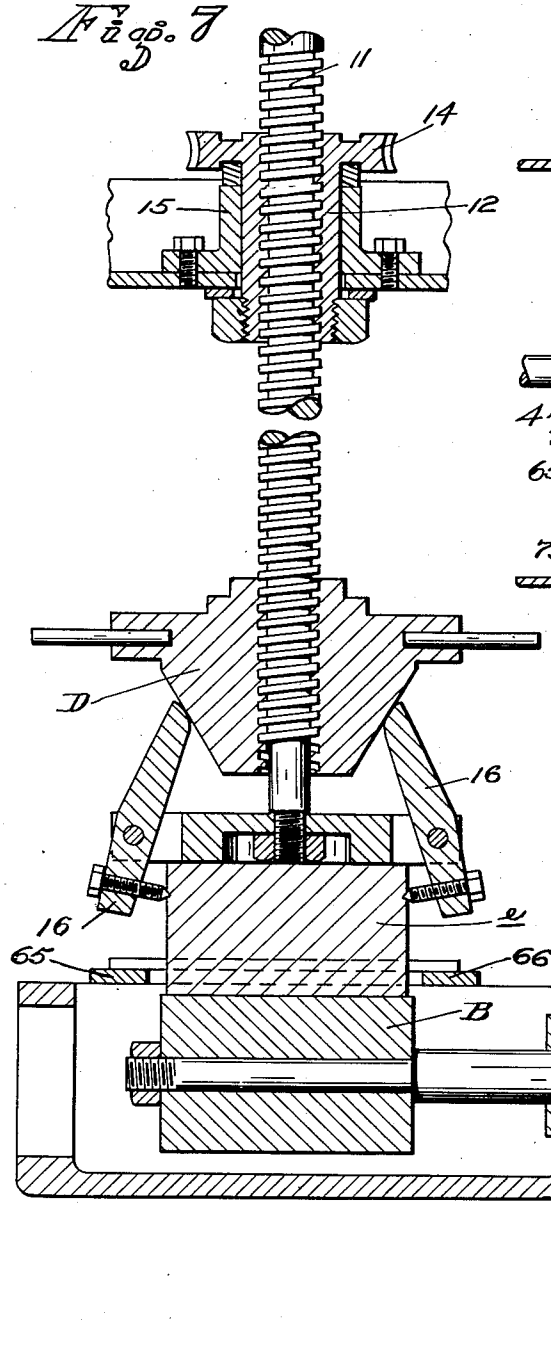
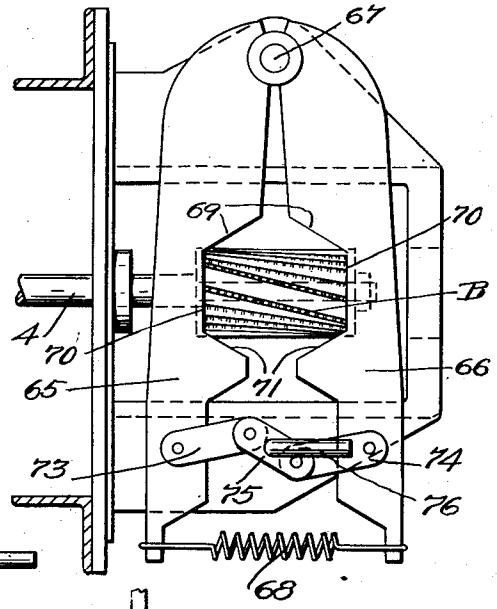


Fig. 8



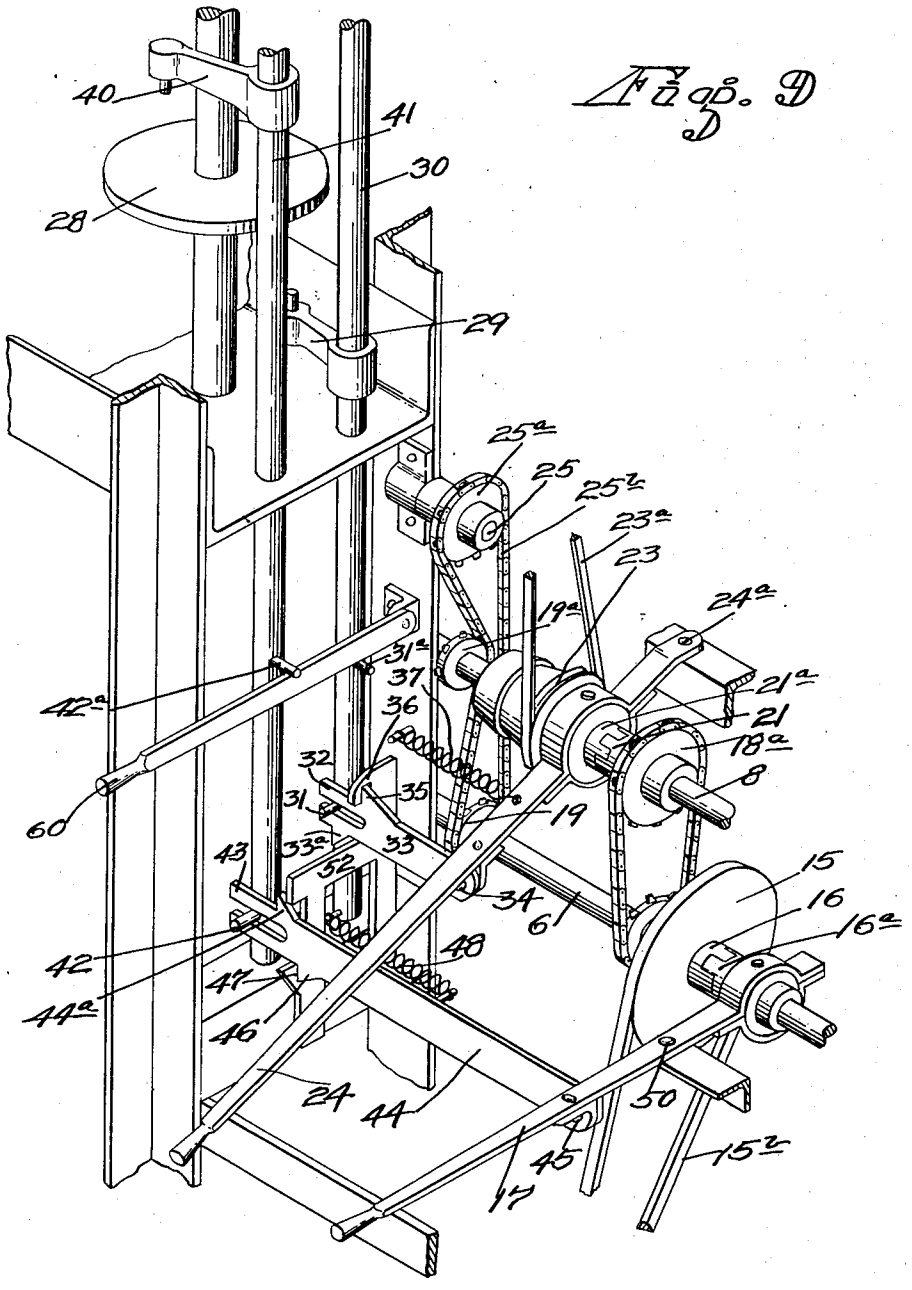
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Fig. 9



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2,368,870

COMMINUTING APPARATUS

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Application February 1, 1943, Serial No. 474,281

4 Claims. (Cl. 29—4.5)

This invention relates to a machine or apparatus comminuting or reducing metals such as magnesium, aluminium and the like into minute particles preparatory to further reduction by grinding, attrition, or otherwise to powder form.

It is well known that magnesium in powder form is at the present time extensively employed in the manufacturing of incendiary bombs, flash bombs, flares, tracer bullets and the like. Several methods are employed but most of them depend upon extensive grinding operations to reduce the metal to the degree of fineness required. The reduction of magnesium metal from ingot or other solid form to powder is extremely hazardous, and the hazard increases as the size of the metal particles decrease as the tendency to oxidize and ignite increases with degrees and particle size due to greater surface exposure, hence, if grinding can be reduced to a minimum, the hazard is proportionately decreased.

The object of the present invention is generally to improve and simplify the operation of reducing metals of the character described to powder form, and especially to provide an efficient cutting operation whereby metal in ingot form is rapidly cut to such minute particles that the final grinding operation is reduced to a minimum.

A form of cutting machine that may be employed is shown by way of illustration in the accompanying drawings, in which:

Fig. 1 is the side elevation of the machine;

Fig. 2 is a front view of the machine;

Fig. 3 is an enlarged detail view partially in section of two cooperating clutches and the driving mechanism used in conjunction therewith;

Fig. 4 is a perspective view of a portion of the rotary cutter;

Fig. 5 is a diagrammatic view showing the staggering of the cutting points;

Fig. 6 is a perspective view of the metal ingot to be cut;

Fig. 7 is an enlarged detailed view of the lower end of the feed shaft showing the chuck carried thereby and the feed nut whereby the feed of the shaft is controlled;

Fig. 8 is a plan view of a pair of steady rest arms which engage the lower end of the metal ingot when it is brought into engagement with the rotary cutter; and

Fig. 9 is a perspective diagrammatic view of the clutch controlling mechanism.

Referring to the drawings in detail and particularly to Figs. 1 and 2, A indicates a frame constructed of angle and channel shaped structural members. Supported on cross members 2 of said frame is an electric motor 3 and driven thereby is a shaft 4 on one end of which is secured a rotary cutter B, the detail of construction of which will later appear. Journalled in bearings 5 secured to the frame is a jack shaft 6 and similarly journalled in bearings 7 is a secondary jack shaft 8. Disposed in a vertical position within the frame directly above and in alignment with a rotary cutter B is a feed shaft C on the lower end of which is secured a chuck D. The upper end of the feed shaft extends through a worm gear 9 journalled in a bearing 10. The shaft is vertically movable through the worm gear as it is splined thereto, and as such the worm gear serves to rotate the feed shaft, but at the same time permits vertical movement of the feed shaft as it is fed in an upward or downward direction. Approximately one-half of the length of the feed shaft carries the spline and cooperates with the driving worm gear 9. The remaining or lower half of the shaft is threaded as indicated at 11 and cooperates with a nut 12 which forms a portion of the hub of a worm gear 14 (see Fig. 7). This worm gear and the hub are journalled in a bearing 15 and controls the speed with which the shaft moves either downwardly or upwardly, as will later be described.

The material to be cut or reduced to powder form, for instance magnesium metal, is for the sake of convenience preferably supplied in long bars such as indicated at E (see Fig. 6). The bars are circular in cross section, and when placed in the machine, are secured at the upper end by the jaws 16 of chuck D, and when secured are fed downwardly into engagement with a rotary cutter B and once in engagement therewith, the feed is automatically regulated to insure chips which are minute in size, and furthermore chips which have a tendency to break laterally into still smaller particles.

The automatic feed is constructed and operated as follows:

The feed shaft, as previously stated, is rotated by the worm gear 9. This, in turn is rotated by a worm pinion and pulley 9a driven by a belt 23a which in turn is driven by a pulley 23 which is mounted on a secondary jack shaft 8. This drive serves a main function, to wit, that of rotating the feed shaft C together with the chuck D and the ingot E held thereby. It also serves one other function, to wit, that of rapidly retracting or elevating the feed shaft C and the chuck

D when the cutting operation of an ingot is complete.

The worm gear 14 together with the nut 12 forming a part thereof is driven by a worm pinion and an adjustable pulley 14a which in turn is driven by a belt 20a and an adjustable pulley 20 mounted on the main jack shaft 6. If the pulley 14a is driven at the same speed as the pulley 9a, feed shaft C will rotate, but it will not feed either upwardly or downwardly. Hence, if a predetermined rate of downward feed is required, pulley 14a must be driven at a slightly slower speed with the result that the feed shaft is fed downwardly at a speed which insures the cutting away of the lower end of the ingot at a rate which determines the size of the chips being cut. This predetermined rate of feed continues until a mere stump of the ingot bar remains in the chuck. At this time the direction or rotation of the worm gear 9 and the feed shaft is automatically reversed causing the feed shaft and chuck to be rapidly elevated until a predetermined raised position is reached, and when this position is reached, the drives through the belts 23a and 20a are automatically disconnected and the feed shaft comes to rest so that the stub of ingot metal remaining in the chuck may be removed and a new ingot or bar is inserted. This is accomplished as follows:

The jack shaft 6 carries a pulley 15 which is freely rotatable thereon. Forming a part of the pulley or secured thereto is one-half of a jaw clutch 16. The other half of the clutch is indicated at 16a. This latter half of the clutch is splined to the shaft 6 and may accordingly be moved longitudinally on the shaft by means of a clutch actuating lever 17 into or on engagement with a clutch section 16. Thus when the clutch sections 16 and 16a are engaged, the jack shaft will be driven and when the clutch sections are disengaged, the jack shaft will remain at rest. Pulley 15 is driven continuously from shaft 4 by a pulley 15a and a belt 15b but the jack shaft 6 rotates only when the clutch sections 16 and 16a are engaged. The shaft 6 has keyed or otherwise secured thereto two sprocket gears 18 and 19 and the pulley 20 which through belt 20a drives the pulley 14a. The secondary jack shaft 8 carries a sprocket gear 18a which is driven from the sprocket 18 by a chain 18b. The sprocket gear 18a (see Fig. 3) carries one-half of a jaw clutch 21 which is adapted to be engaged by a complementary clutch section 21a. Sprocket gear 18a and the clutch section 21 carried thereby are freely rotatable on the shaft 8 and only transmit power to the complementary clutch section 21a when this is moved longitudinally on the shaft into engagement. Keyed or otherwise secured on shaft 8 is a sprocket gear 19a which carries, or has secured thereto, one-half of a cone clutch 22. Freely rotatable on the shaft 8 is a complementary cone clutch section 22a, and carried or secured thereto is the pulley 23 which, through belt 23a, transmits power to the pulley 9a. Pulley 23 is also secured to the jaw clutch section 21a and this together with the pulley 23 and the cone clutch section 22a are longitudinally movable and freely rotatable on shaft 8. A clutch actuating lever 24 pivoted at its end to the frame as indicated at 24a serves the function of moving the clutch sections 21a and 22a into or out of engagement with their complementary clutches. An idler shaft 25 is journalled in the frame above the secondary jack shaft 8 and carries a sprocket gear 25a. A sprocket chain 25b passes over the sprocket gears 19 and 25a and behind the sprocket gear 19a so as to drive this sprocket together with the cone clutch section 22 and the shaft 8 to which they are keyed in a direction reverse to the other shafts. The operation of the several belts and sprocket chain drives and the cooperating clutches is as follows:

If the feed shaft C has been elevated to its upper-most position and a new ingot or bar inserted in the chuck, a hand wheel 27 secured on the pulley shaft 14a is grasped and rotated so as to feed the shaft C and chuck D downwardly until the lower end of the ingot just contacts the rotary cutter B. The clutch actuating lever 24 is next grasped and swung about its pivot 24a in a right hand direction, thus engaging the jaw clutch sections 21 and 21a, and finally the clutch actuating lever 17 is grasped and swung to engage the jaw clutch sections 16 and 16a. Power will thus be transmitted from shaft 4 through pulley 15a, belt 15b and pulley 15 to drive the main jack shaft 6. This will in turn drive the pulley 20, the belt 20a and the pulley 14a which drives the worm gear 14. Power is at the same time transmitted through sprocket gears 18 and 18a and the chain 18b to drive the clutch sections 21 and 21a and the pulley 23 in the same direction as jack shaft 6 and as the pulley 23 is driven it will transmit power through the belt 23a to the pulley 9a and the worm gear 9, thus transmitting a rotor motion to the feed shaft, and, as the nut carried by the worm gear 14 is also rotating, but at a slightly slower speed than the feed shaft C, this shaft will gradually feed in a downward direction causing the lower end of the ingot to be cut away by the rotary cutter at a given rate.

The cutting operation will continue until a small stub is left in the chuck D as indicated at e in Fig. 7. At this time a disc 28 (see Figs. 1 and 9) which is secured in the feed shaft C will engage an arm 29 which is secured on a vertically disposed rod 30 which is slidably mounted and guided in the frame. This rod carries a pin 31 adjacent its lower end which extends through the forked end 32 of a lever 33 which is pivotally attached as at 34 to the clutch actuating lever 24. When the disc 28 engages the arm 29 carried by the rod 30, the rod will be forced in a downward direction, and as the pin 31 carried by the rod engages the forked end of lever 33, it will swing the forked end downwardly about the pivot 34 and cause a latch 35 formed on the upper side of the lever to move out of engagement with a retainer 36 which is stationary and secured to the frame. The moment the downward movement of the rod 30 is sufficient to clear the latch 35 with relation to the retainer 36, a spring indicated at 37 which is connected with the clutch actuating lever 24 and the frame will pull the lever towards the frame or in a left hand direction. The jaw clutch sections 21 and 21a will thus be disengaged and at the same time, the cone clutch sections 22 and 22a will become engaged and as the cone clutch section 22 is driven by the sprocket 19a in a reverse direction due to the arrangement of the chain 25b which passes over the sprockets 19 and 25a and behind the sprocket 19a; the direction of rotation of the pulley 23 will be reversed and so will the direction of rotation of pulley 9a and the worm gear 9. This reversal causes the feed shaft to rapidly become elevated and as it moves upwardly, the disc 28 will engage an arm 40 which is secured on a rod 41, which is also vertically

disposed and slidably guided in the frame. This rod has a pin 42 secured adjacent its lower end which engages the end 43 of a lever 44 which is pivotally attached as at 45 to the clutch actuating lever 17. The lever 44 also carries a latch member 46 which normally engages a stationary keeper 47 secured to the frame. Now as the rod 41 is moving in an upward direction, the pin 42 carried thereby will raise the forked end of the lever 44 or swing it about the pivot 45 and a point will finally be reached where latch 46 rides out of engagement with the keeper 47. At that moment, a spring 48 secured to the frame at one end and to the lever 44 at the opposite end will exert a pull on the lever 44 and the clutch actuating lever 17 and pull it towards the frame or in a left hand direction, and as the lever 17 is pivoted to the frame as at 50, the jaw clutch sections 16 and 16a will be disengaged and the jack shafts 6 and 8, and all mechanism driven thereby, will come to rest. The only part of the machine which will continue operation will be the electric motor, the shaft 4 driven thereby, the cutter B carried by said shaft, and the pulleys 15 and 15a. At this time the jaws 16 of clutch D may be opened (see the detailed construction of the jaw clutch in Fig. 7), the stub e removed and a new ingot inserted and secured. The hand wheel 27 is then rotated to bring the lower end of the ingot into engagement with the rotary cutter B. Clutch actuating lever 24 is then grasped and swung to the right causing the jaw clutch sections 21 and 21a to engage and clutch actuating lever 17 is finally swung to the right causing the jaw clutch sections 16 and 16a to engage, thereby setting the jack shafts 6 and 8 in motion and the parts driven and connected therewith. The feed shaft will accordingly rotate and at the same time feed in a downward direction at a given rate, and this will continue until a mere stub of ingot metal is left in the chuck at which time the disc 28 on the feed shaft will engage the arm 29 to cause downward movement of the rod 30 so as to cause automatic disengagement of the jaw clutch sections 21 and 21a and simultaneously engagement of the cone clutch sections 22 and 22a thus reversing the direction of rotation of the worm gear 9 to cause rapid retraction or elevation of the feed shaft and the chuck. When it reaches a predetermined raised position, disc 28 will again engage the arm 40 and raise the rod 41 so as to automatically disengage the jaw clutch sections 16 and 16a thereby bringing the machine to rest so that the ingot stub may be removed and a new ingot inserted.

If for any reason one or another of the clutches should tend to stick or one or the other of the springs 37 and 48 should break or weaken, the automatic functioning or release of the clutches would not be dependable. Means have accordingly been provided whereby positive functioning may be insured. This is accomplished by placing a cam 33a on the under side of the lever 33 and a similar cam 44a on the upper side of the lever 44. The faces of these cams present an angle of 45° or more and they are so positioned that they will engage a stationary bar 52 when the latches 35 and 46 are released with relation to their respective keepers. Normally when either latch moves out of engagement with its keeper, the cooperating spring will function and the cooperating clutch actuating lever will be pulled or swung to the left but if the spring should be broken or weakened or the associated clutch should stick, the release of the latch would be of no avail but as one or another of the cams 33a or 44a is now in contact with the bar 52 and either downward or upward movement of the rods continues, the cams will react with the bar 52 and pull on the levers 33 and 44 with a sufficient force to insure operation of the clutch actuating levers.

It should be noted that the rod 30 is provided with a lift spring 30a (see Fig. 2). This spring is a compression spring and has sufficient lifting force to overcome the weight of the rod and to normally maintain it in a raised position where latch 35 is maintained in engagement with its keeper 36. No spring is required in connection with rod 41 as latch 46 assumes a reversed position with relation to latch 35; hence the weight of rod 41 may be and is utilized to retain latch 46 in engagement with its keeper 47. It should be also noted that while the rods 30 and 41 are normally intended to be automatically actuated by the disc 28 carried by the feeding shaft C that it is also possible to actuate them manually as by the lever indicated at 60. This lever engages one or an other of a pair of pin 31a and 42a secured on the respective rods; thus by raising or lifting lever 60, clutch actuating lever 17 is operated and clutch sections 16 and 16a are released and conversely by pushing down on the lever 60, the clutch actuating lever 24 is operated and the feed shaft C is thrown into reverse. The manually actuated lever 60 is important as it may be necessary from time to time to raise the ingot bar from the cutter or to stop the feed for one reason or another.

The rotary cutter B may for all practical purposes be termed a milling cutter but it distinguishes from the ordinary milling cutter in that the teeth 72 (see Fig. 4) are ground along the cutting edge to form a serrated edge or a series of V shaped cutting points such as indicated at 73. Not only that, but it should be noted that the points 73 are staggered; for instance, see Fig. 5, the points 73 of a tooth are shown in full lines, the points in the next tooth are indicated in dotted lines at 73a and in the next or following tooth at 73b. By this staggering arrangement minute chips may be cut from the ingot bar; for instance, if the spacing between the cutting points 73 is $1/50$ of an inch then by staggering the teeth as indicated in Fig. 5, the spacing between the successive cuts will be $1/150$ of an inch, hence very materially reducing the size of the chips.

In actual practice inasmuch as the cutting points are V shaped, a cross-section of the chip cut from the ingot bar would be triangular in shape and the area or size of the triangle would be largest at the center of the chip and would decrease in area towards the ends as the chip is elongated; furthermore the chips would be of varying length, the shortest chips being cut adjacent the center of the ingot and the longest adjacent the outer peripheral edge and due to the fact that the cutter rotates in one plane, and the ingot rotates in a plane at right angles to the cutter the chips are curled or substantially crescent shaped with minute cracks extending crosswise of the chips so that each chip tends to break laterally into tiny, almost powder-size particles, a large percentage of which are actually powder-size particles which may and are screened out before the remainder is subjected to grinding or attrition for further reduction.

To prevent oxidation of the magnesium metal, or danger of fire during the cutting operation,

the lower end of the ingot and the rotary cutter is maintained submerged in a substantially non-volatile liquid free from oxygen. A satisfactory liquid is kerosene. This liquid is maintained in constant circulation through a tank, not shown, which surrounds the cutter and lower end of the ingot and through a filter or the like and as such reduces fire danger to a minimum and at the same time serves to carry the cut metal to the filter for removal, grading, grinding, etc.

It was previously stated that the feed shaft was fed downwardly at a predetermined rate and that this rate to a large extent is one of the factors that control the size of the chips cut away from the lower end of the ingot bar by the cutter B. For instance, if the rate of feed is increased, the chip will be larger as the amount of metal feed towards the cutter is greater and conversely with decrease in the rate of feed the chips will be smaller as the ingot bar is fed toward the cutter at a slower rate and the amount of metal to be cut away is less. Hence, a rate of feed is selected which produces chips or particles of the most desirable size. Even so it is obvious that the cutting points 72 on the cutter will in time gradually become dull and in fact so dull that if the feeding rate is constant there would be a tendency to jam the end of the ingot bar against the cutter as the dull cutting points would not be able to cut the metal away as fast as the predetermined feeding rate demands. It is for this reason that a belt drive is employed in connection with the pulleys 9*a* and 14*a*. Belt 23*a* driving the pulley 9*a* in particular will tend to slip and squeal when the cutter becomes too dull thus slowing down the rate of revolution of the feed shaft to a point where downward feeding of the feed shaft is substantially stopped thereby not only preventing jamming or excessive pressure of the ingot bar against the cutter, but also warning the operator as the sound or squeal produced by the slipping belt is sufficiently audible to give the operator a timely warning of the fact that the cutter is becoming too dull to efficiently perform the work or at least that it is time to change cutters as the feeding rate will become so slow that the output of the machine will be substantially diminished.

Another factor that should be considered in the production of small chips is the fact that the cutter is not operated at ordinary slow milling machine speeds; conversely its revolutions are up around two thousand R. P. M. while the ingot revolves at about sixty R. P. M. Inasmuch as the ingot bar E may be two and three feet or more in length and is secured when placed in the machine at the upper end only, it has been found advisable to guide the end of the ingot bar which engages the rotary cutter as there is otherwise a tendency towards excess vibration and chatter. A form of guide which may be likened with a steady-rest is shown in Figs. 7 and 8. It consists of a pair of arms 65 and 66 pivotally secured at one end as at 67 and connected by a spring 68 at their opposite ends. On the inner edge of each of said arms approximately midway of their length is a recess presenting three surfaces 69, 70 and 71. These faces engage the exterior surface of the ingot adjacent its lower end and as the engagement is yielding due to the tension of the spring 68 any variation in exterior diameter of the ingot or roughness of surface is automatically taken care of and vibration and chatter is reduced to a minimum. Links such as indicated at 73, 74 and 75 also connect the arms. The link 75 is provided with a handle 76 and by grasping this and rotating it together with link 75 in the proper direction arms 65 and 66 are spread apart when a new ingot is being inserted. While these and other features of the machine have been more or less specifically described and illustrated, I nevertheless wish it understood that changes may be resorted to within the scope of the appended claims, and that the materials and finish of the various parts employed may be changed as the experience of the manufacturer may dictate and as varying conditions or use may demand.

Having thus described and illustrated my invention, what I claim and wish to secure by Letters Patent is:

1. In a machine of the character described, a rotary cutter, a chuck to secure an ingot, said chuck and ingot being disposed at right angles to the cutter, means for rotating the chuck and ingot, means for gradually advancing the chuck and ingot toward the cutter, and means for automatically stopping the advance when the chuck reaches a predetermined position adjacent the cutter.

2. In a machine of the character described, a rotary cutter, a chuck to secure an ingot, said chuck and ingot being disposed at right angles to the cutter, means for rotating the chuck and ingot, means for gradually advancing the chuck and ingot toward the cutter, means for automatically stopping the advance when the chuck reaches a predetermined position adjacent the cutter, and means for maintaining the ingot in contact with the cutter and under a predetermined pressure as the chuck and ingot are being advanced against the cutter.

3. In a machine of the character described, a rotary cutter, a chuck to secure an ingot, said chuck and ingot being disposed at right angles to the cutter, means for rotating the chuck and ingot, means for gradually advancing the chuck and ingot toward the cutter, means for automatically stopping the advance when the chuck reaches a predetermined position adjacent the cutter, and means for automatically retracting the chuck to a loading position to permit insertion of another ingot to be cut.

4. In a machine of the character described, a rotary cutter, a chuck to secure an ingot, said chuck and ingot being disposed at right angles to the cutter, means for rotating the chuck and ingot, means for gradually advancing the chuck and ingot toward the cutter, means for automatically stopping the advance when the chuck reaches a predetermined position adjacent the cutter, means for automatically retracting the chuck to a loading position, and means for automatically stopping rotation of the chuck when it reaches the loading position to permit removal of what is left of a previous ingot and insertion of another ingot to be cut.

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