

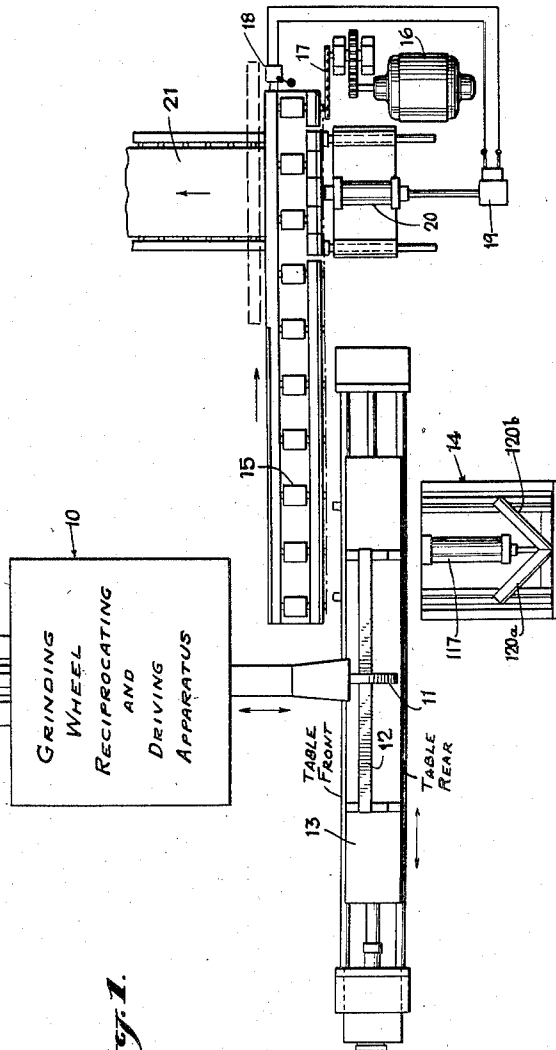
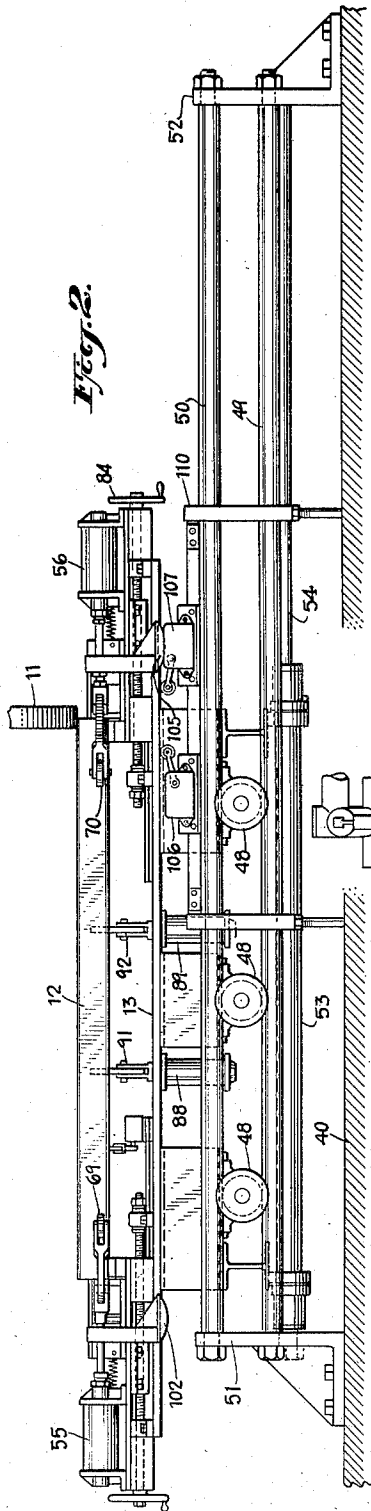
Jan. 14, 1958

W. K. LOWE  
BILLET GRINDER

2,819,563

Filed Dec. 7, 1953

10 Sheets-Sheet 1



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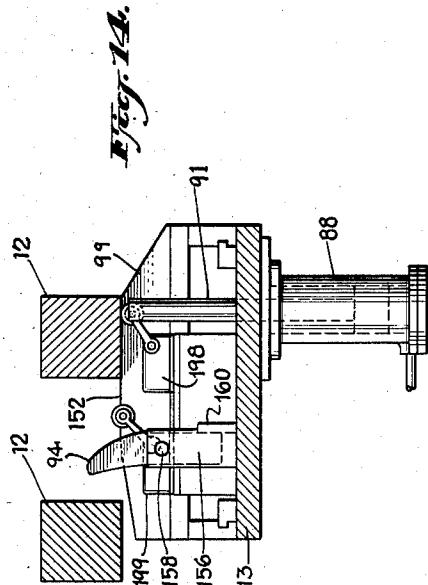
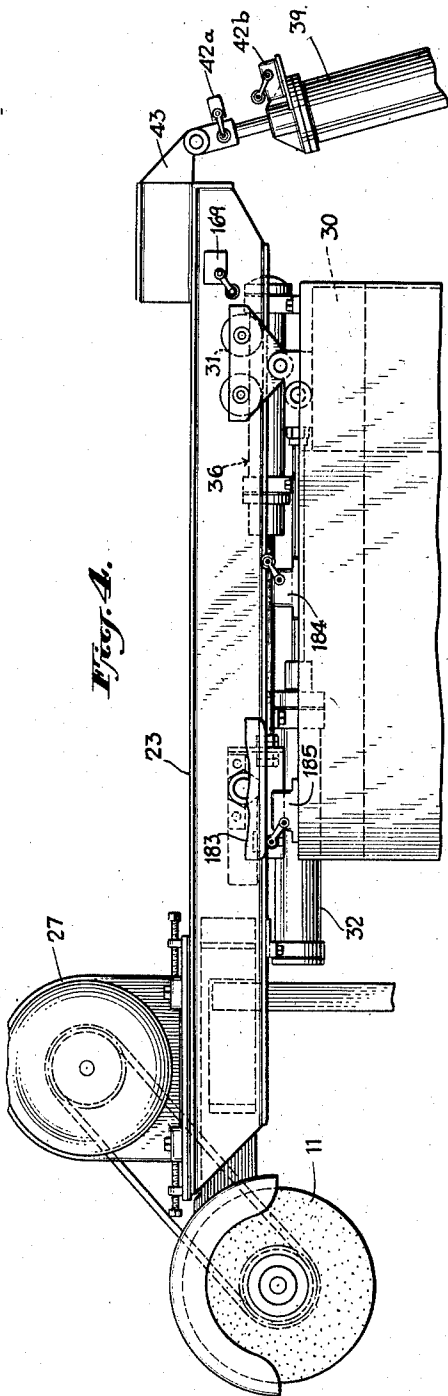
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10 Sheets-Sheet 3



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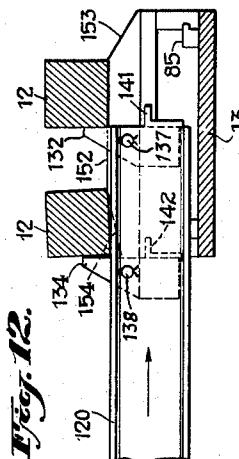
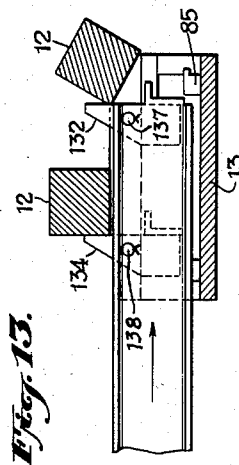
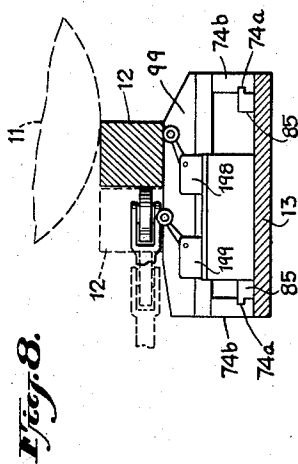
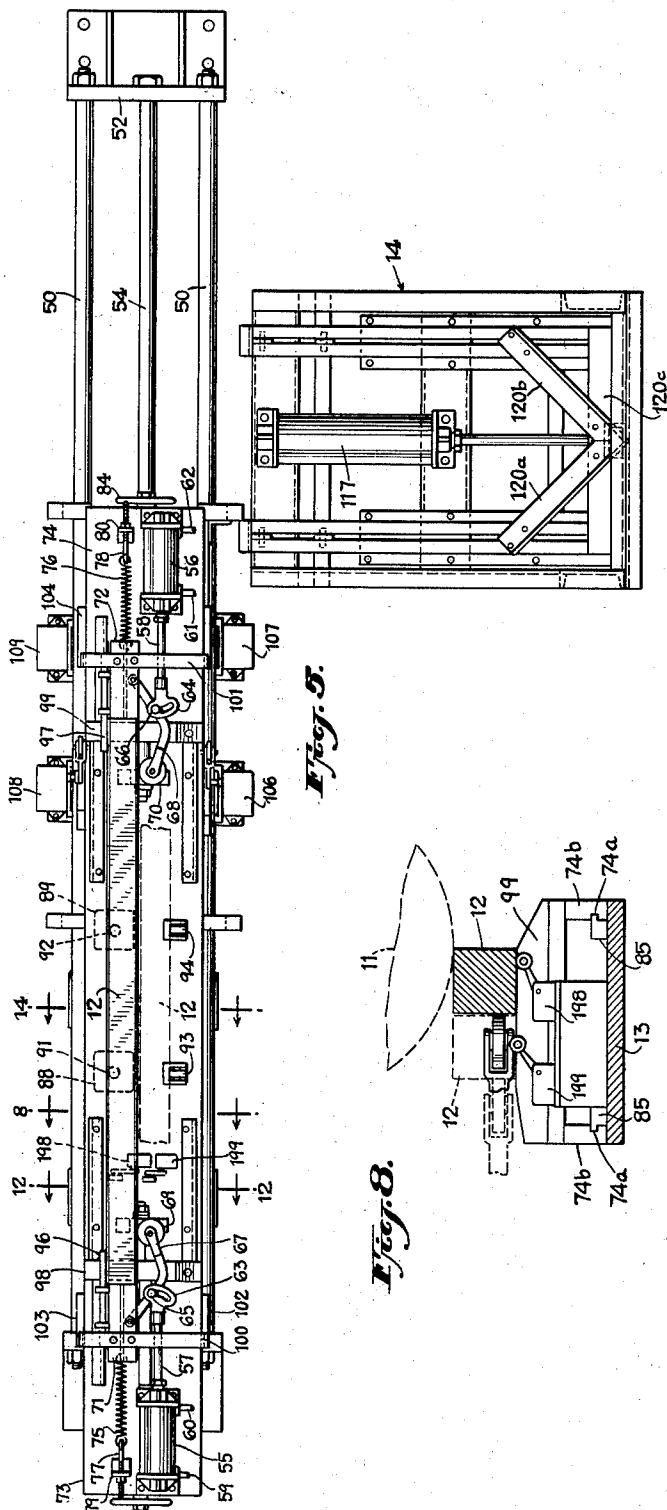
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10 Sheets-Sheet 4



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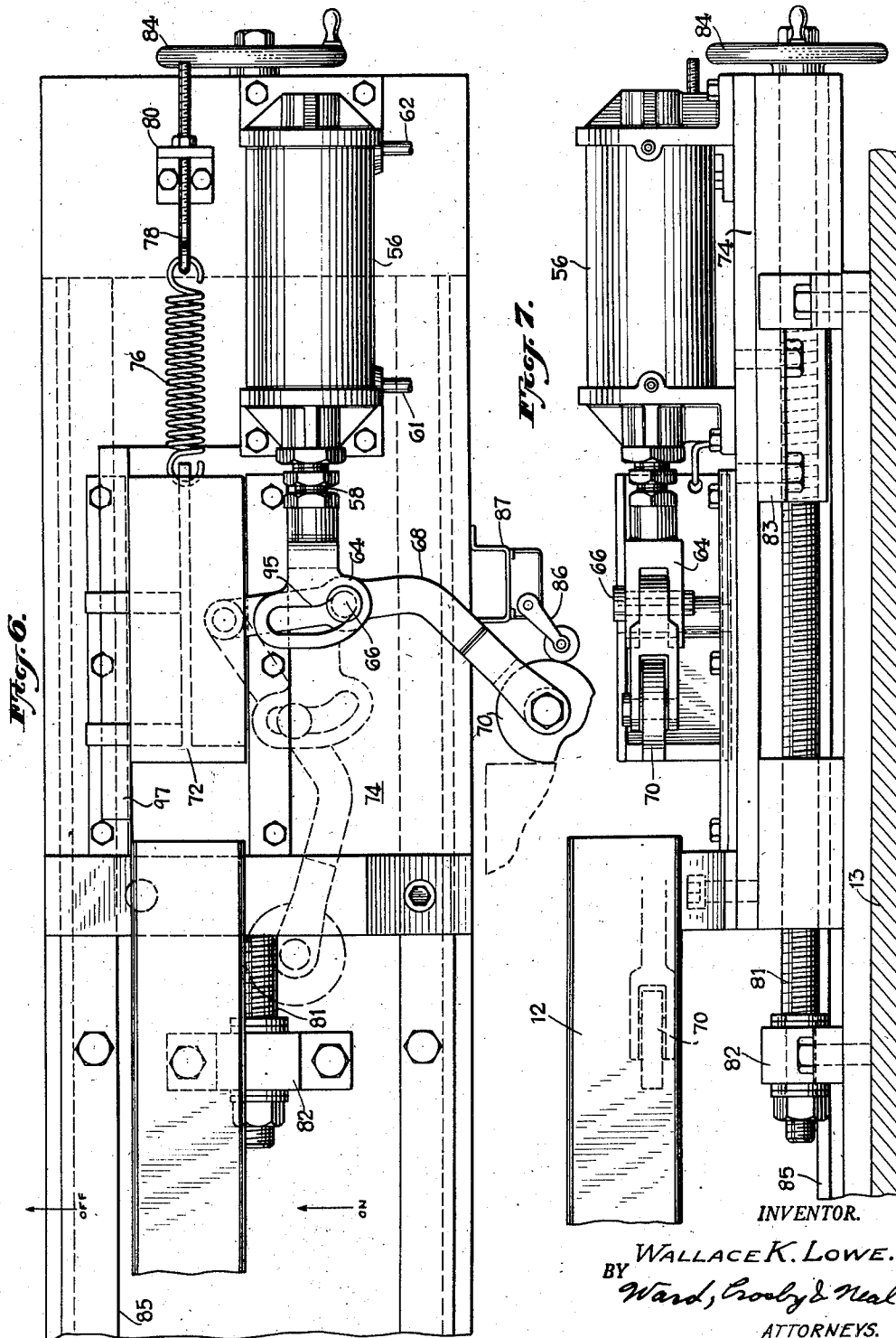
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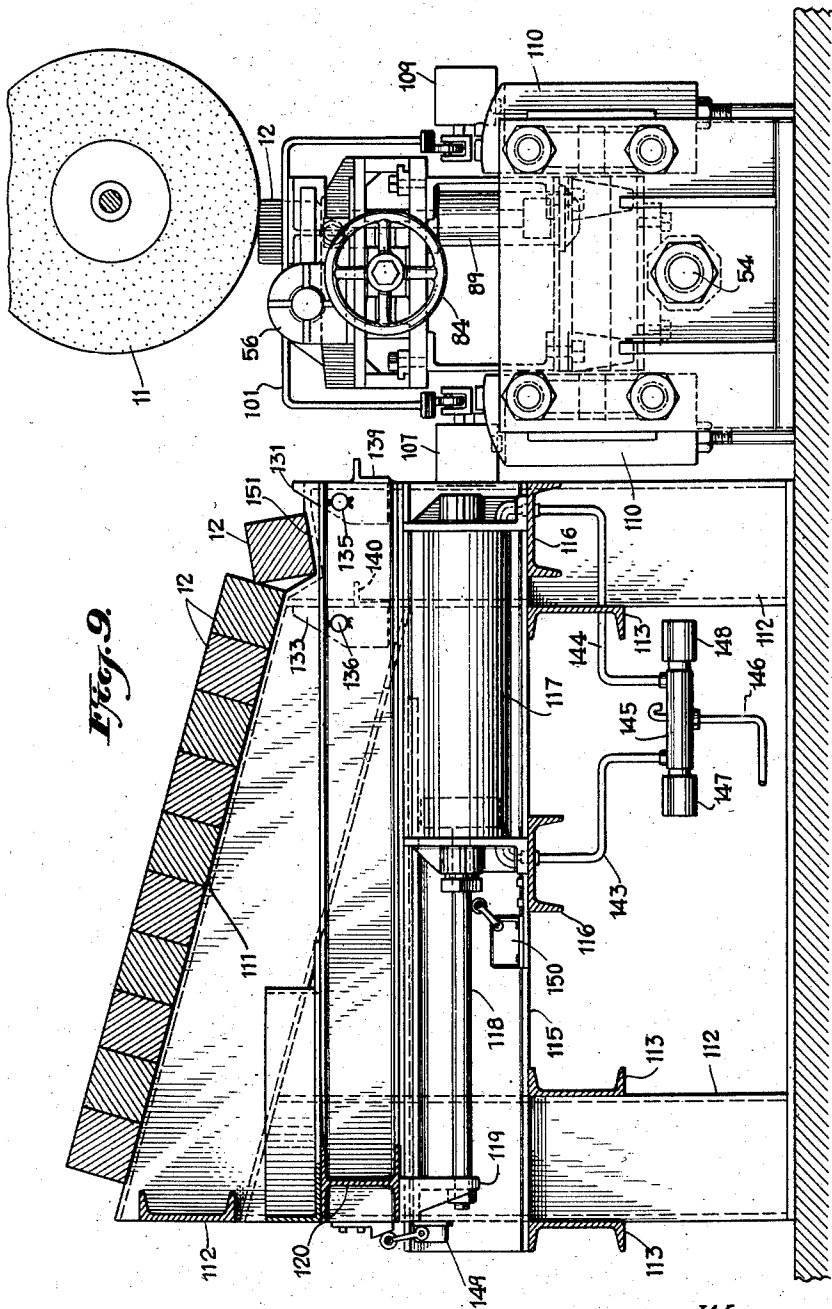
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Filed Dec. 7, 1953

10 Sheets-Sheet 6



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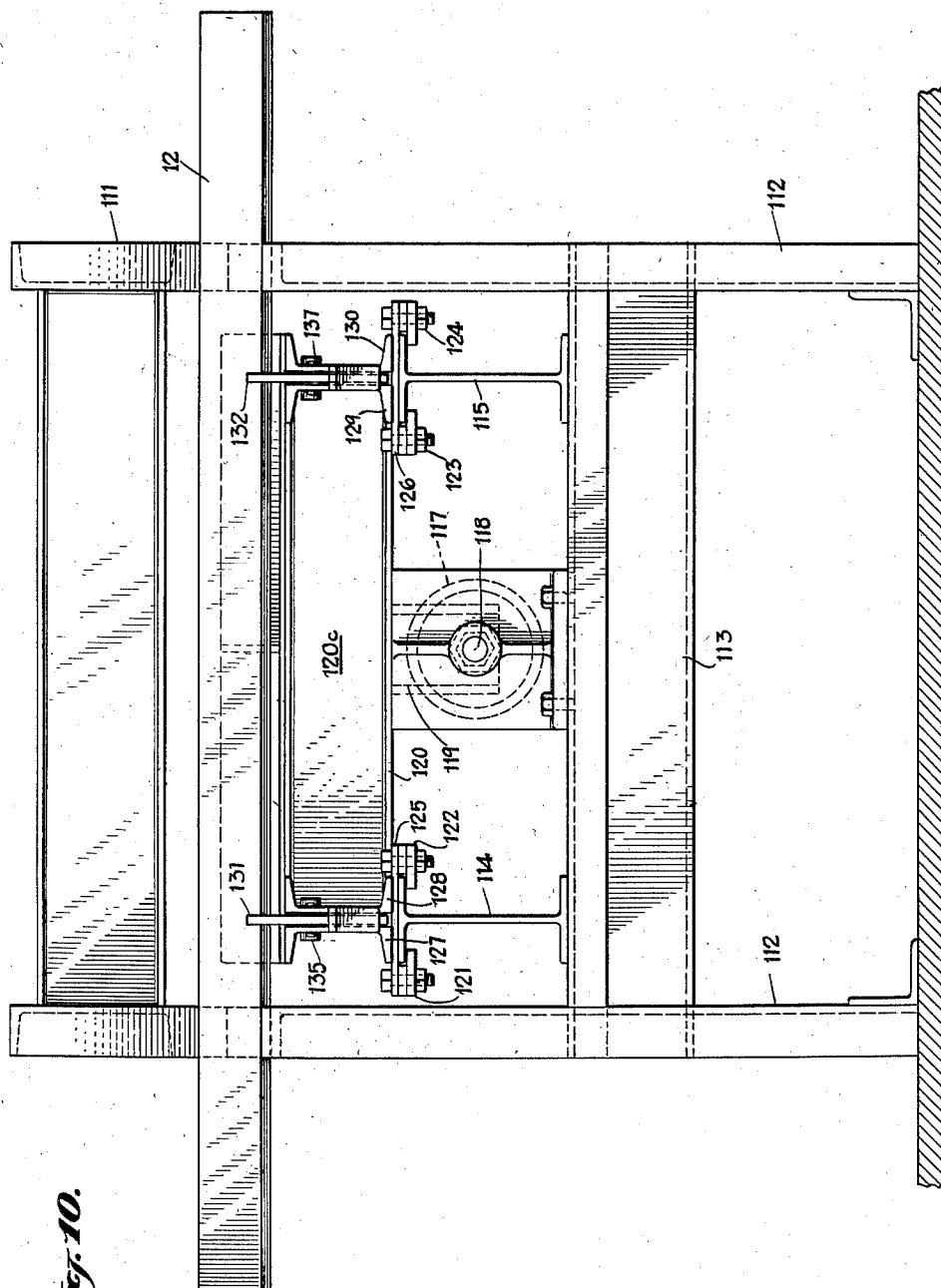


*Fig. 10.*

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10 Sheets-Sheet 8

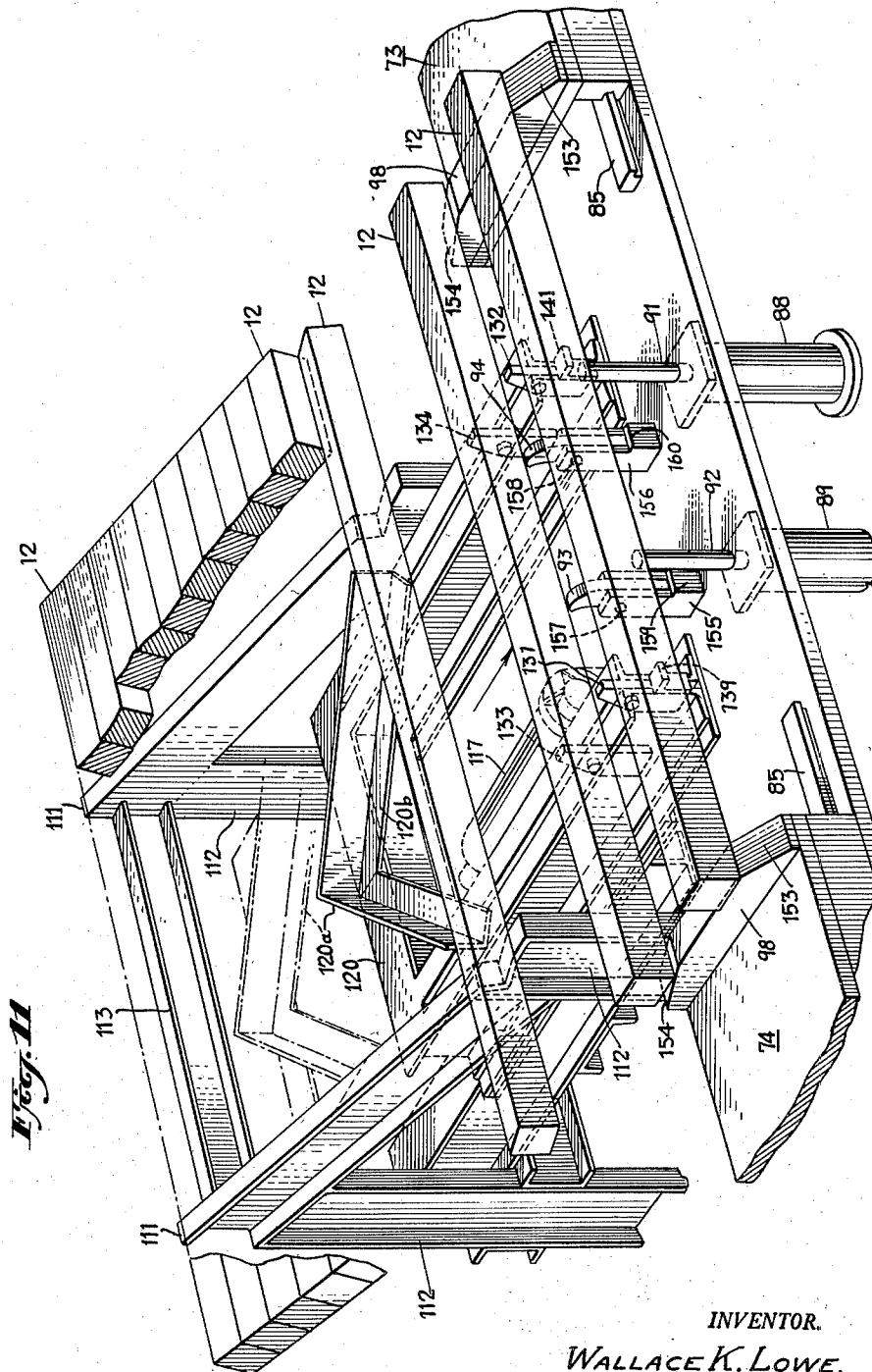


*Fig. 11*

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Fig. 15.

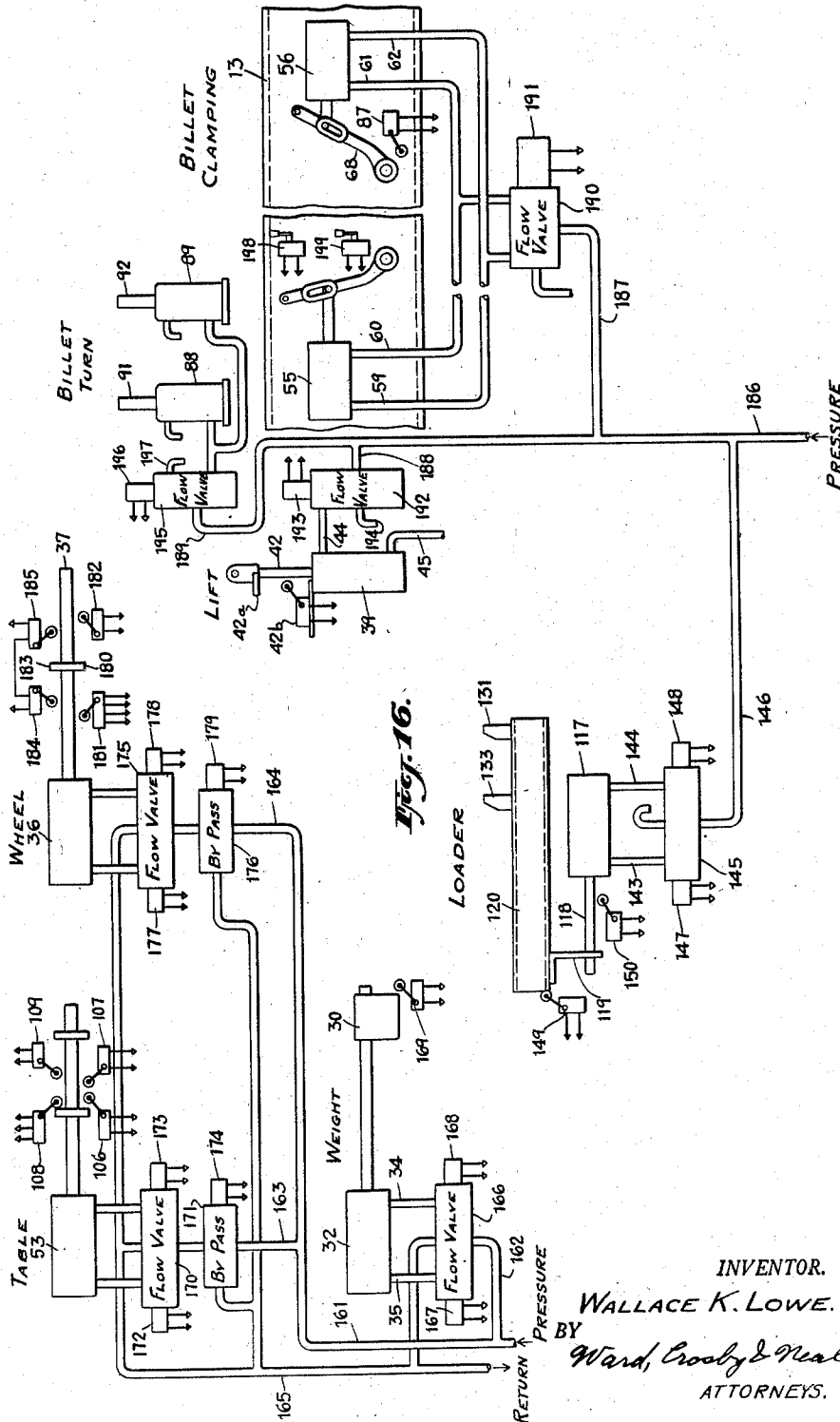


Fig. 16.

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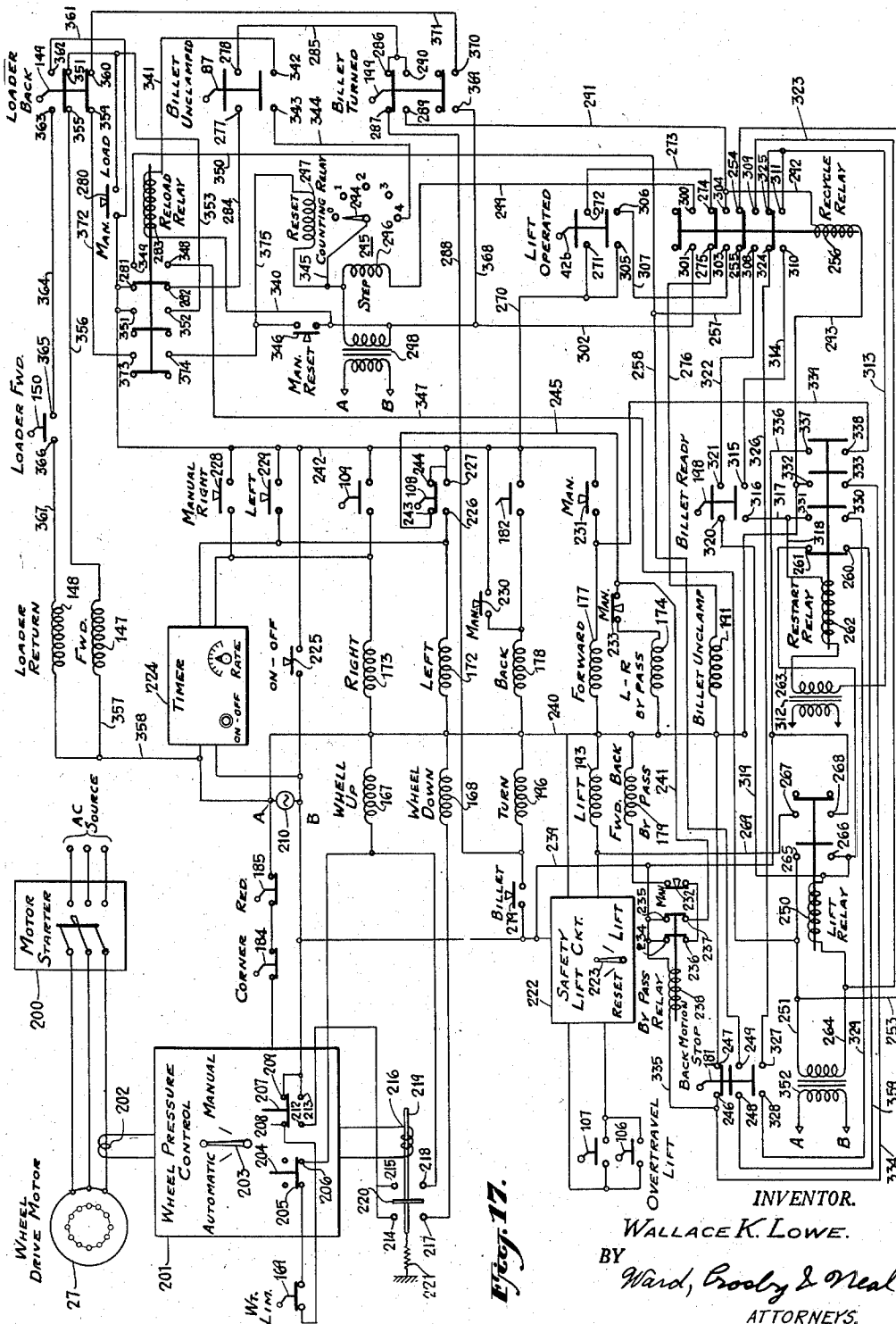
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2,819,563

## BILLET GRINDER

Wallace K. Lowe, Syracuse, N. Y., assignor to Crucible Steel Company of America, Pittsburgh, Pa., a corporation of New Jersey

Application December 7, 1953, Serial No. 396,439

16 Claims. (Cl. 51—45)

This invention relates to grinding apparatus and particularly to such apparatus for automatically grinding the surfaces of metal billets, for example, rolled or forged steel billets.

As described in my copending applications Serial Nos. 253,242 filed October 26, 1951, now abandoned, and 279,789 filed April 1, 1952, which issued as Patent No. 2,726,490 on December 13, 1955, both entitled, "Billet Grinder," the present application being a continuation-in-part of said applications, rolled or forged steel billets have, in an intermediate stage in their manufacture, relatively rough and uneven surfaces which are made acceptable and surface imperfections which are removed by grinding the surfaces. The grinding apparatus described in the aforesaid pending applications provides means whereby such grinding could be accomplished in a semi-automatic manner, some of the operations being performed without intervention of an operator and other operations required the operation of switches or other devices by an operator.

Although the present invention is useful for grinding material other than billets of steel, it is primarily intended for the automatic grinding of the four surfaces of metal billets which are square in cross-section, such billets being successively loaded and ground as long as an automatic loader associated with the grinding apparatus is supplied with billets and the loading, grinding of the four surfaces and the discharge of a billet after grinding all taking place without the assistance of an operator.

In the grinding apparatus of the present invention as in the apparatus described in the aforesaid copending applications, the grinding wheel which is motor driven is mounted on a pivotally mounted beam. The beam is reciprocated by fluid-operated cylinder and piston means, and the pressure of the wheel on the billet to be ground is controlled by the position of a movable weight also mounted on the beam, the position of the weight being determined by the current drawn by the wheel driving motor. When desired, the wheel is lifted free from the billet by a further cylinder and piston means. The billet to be ground is mounted on a movable table which is reciprocated at a relatively high rate with respect to the rate of reciprocation of the wheel, the table making several excursions to one excursion of the wheel and being reciprocated along a path extending transversely to the path of reciprocation of the wheel. The billet is clamped on the table by fluid-actuated clamping means and is turned by fluid-actuated turning means so as to present a new face to be ground.

In accordance with the present invention, the operation of the aforesaid apparatus is co-ordinated by electrical control apparatus and novel billet loading and discharging apparatus is provided so that, after a billet is loaded on the table by an operator who merely pushes a button to cause such loading, the subsequent operations are automatic. Thus, the billet is clamped in position for grinding, the grinding wheel contacts the first face of the

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billet, the reciprocation of the wheel and the table is initiated and the first face is ground a predetermined number of times. When the grinding of the first face is completed, the reciprocation of the wheel and the table is stopped, the wheel is raised from the face of the billet, the billet is unclamped, turned, and re-clamped and the next face of the billet is ground. This cycle is repeated until all of the faces of the billet are ground, at which time the billet is unclamped, the loading and discharging apparatus automatically removes the ground billet from the table and deposits an unground billet on the table. The cycle of operation described above is then automatically initiated so that all the faces of the newly deposited billet are ground. As long as the loading apparatus has a billet thereon, the process continues, but after the last billet on the loading apparatus is deposited and ground, the process is stopped until further billets are supplied and/or an operator intervenes.

By omission of certain features of the invention, the aforesaid process may be interrupted at any desired time. Thus, the process may be stopped each time a billet face is ground or after each billet is ground on all its faces so that further operation of the apparatus is initiated by an operator, but it is to be understood that the preferred form of the invention is as described above.

The various objects and advantages of the invention will more fully appear from the following detailed description setting forth the manner in which I now prefer to practice the invention and from the accompanying drawings, in which:

Fig. 1 is a partly diagrammatic plan view of the grinding apparatus of the invention;

Fig. 2 is a front elevation view of a portion of the apparatus shown in Fig. 1 and illustrating said portion in greater detail;

Fig. 3 is a side elevation view of a portion of the grinding apparatus of the invention;

Fig. 4 is a fragmentary, side elevation view of a portion of the grinding apparatus of the invention and is taken from the side of the apparatus opposite from that of Fig. 3;

Fig. 5 is a plan view of a portion of the apparatus shown in Fig. 1 and the apparatus of Fig. 2;

Fig. 6 is an enlarged, fragmentary, plan view of the apparatus shown in Fig. 5;

Fig. 7 is an enlarged, fragmentary, front elevation view of the apparatus shown in Fig. 5;

Fig. 8 is a fragmentary, cross-sectional view of the apparatus shown in Fig. 5 and is taken along the line 8—8 indicated in Fig. 5;

Fig. 9 is an enlarged, side elevation view of a portion of the apparatus shown in Fig. 1;

Fig. 10 is an enlarged, front elevation view of the loading rack shown in Fig. 9;

Fig. 11 is a fragmentary, enlarged perspective view of the loading rack shown in Figs. 9 and 10 and a portion of the grinding table shown in Fig. 9;

Figs. 12 and 13 are fragmentary, cross-sectional views of a portion of the loading rack and the grinding table and are taken along the line 12—12 indicated in Fig. 5;

Fig. 14 is an enlarged, fragmentary cross-sectional view of a portion of the grinding table and is taken along the line 14—14 indicated in Fig. 5;

Fig. 15 is a schematic diagram illustrating the system employed in the preferred embodiment of the invention for reciprocating the grinding table and the grinding wheel and for controlling the load on the grinding wheel;

Fig. 16 is a schematic diagram illustrating the system employed in the preferred embodiment of the invention for clamping and turning a billet, for loading and discharging billets and for lifting the grinding wheel; and

Fig. 17 is an electrical circuit diagram showing the circuits which are employed for automatically and manually controlling the grinding apparatus of the invention.

### GENERAL DESCRIPTION

In Fig. 1, which is a partly schematic plan view of a billet grinding installation incorporating the apparatus of the invention, the rectangle designated by the numeral 10 represents that portion of the apparatus employed to reciprocate and drive the grinding wheel 11, such portion of the apparatus being described in detail in my aforesaid copending applications and being described in greater detail hereinafter. The portion of the apparatus within the rectangle 10 not only causes the grinding wheel 11 to rotate, but also reciprocates the wheel 11 along a path extending perpendicular to the axis of rotation of the wheel 11 and raises and lowers the wheel 11 with respect to a billet 12 mounted on a reciprocable table 13. The table 13 is reciprocated along a path extending transversely to the path of reciprocation of the wheel 11 by apparatus described in further detail in said copending applications and hereinafter.

Billets are loaded on the table 13 by loading apparatus 14 which also discharges a ground billet from the table 13 to a conveyor 15 which is driven by a motor 16 with its associated drive apparatus 17. A billet deposited on the conveyor 15 is moved in a direction away from the grinding wheel 11 and when it reaches the end of the conveyor 15 the billet operates a switch 18 which operates a hydraulic valve 19 causing the cylinder and piston means 20 to push the billet from the conveyor 15 to a conveyor 21 which conveys the ground billet to storage or to further processing equipment.

### Grinding wheel operation

By reference to Figs. 2-4, it will be seen that the grinding wheel 11 is mounted on a rotatable shaft 22 which is mounted on a pair of bearings supported on the end of a beam 23. The grinding wheel 11 is rotated with the shaft 22 by a pulley 24 which is drivingly connected by means of belts 25 and a pulley 26 to an electric motor 27.

The beam 23 is pivotally mounted on a frame 28 by means of a shaft 29 which is rotatable in bearings slidably mounted on shafts secured to the frame 28, the details of such mounting not being shown in the drawings of the present application but being shown in detail in the aforesaid copending applications. The motor 27 is secured to the beam 23 at a point thereon spaced from the pivot shaft 29, and hence the pivot point of the beam 23, and is on the same side of the shaft 29 as the grinding wheel 11.

Due to the fact that the grinding wheel 11 and its associated driving motor 27 are both mounted on the same side of the pivot shaft 29, the weight of these components tends to press the beam 23 downward on this side of the shaft 29. A movable counterweight 30 is mounted on the beam 23 on the opposite side of the shaft 29 from the wheel 11 and the motor 27. The weight 30 is suspended from the beam 23 by brackets 31 having wheels associated therewith and riding on the beam 23 in the manner described in the aforesaid copending applications.

Counterweight 30 is adjusted along the beam 23 by fluid-actuated cylinder and piston means 32 which is fixedly mounted on the underside of beam 23. The piston rod 33 of the cylinder and piston means 32 is connected to the counterweight 30 and fluid, such as hydraulic fluid, is admitted into the cylinder and piston means 32 by the lines 34 and 35 causing the counterweight 30 to move toward and away from the shaft 29.

The beam 23 is reciprocated with respect to the frame 28 by fluid-actuated cylinder and piston means 36 which is fixedly secured to the frame 28, the piston rod 37 of the cylinder and piston means 36 being connected to a bracket 38 secured to the beam 23.

A quick-operating, air-actuated cylinder and piston means 39 is connected between the end of the beam 23 and the foundation 40. One end of the means 39 is

pivotally connected to a bracket 41 secured to the foundation 40 and the piston rod 42 of the cylinder and piston means 39 is pivotally connected to a bracket 43 mounted on the end of the beam 23. Air under pressure is supplied to the means 39 through a line 44 and is exhausted from the means 39 through a line 45. When the grinding apparatus is in operation the cylinder and piston means 39 is inoperative in that it exerts substantially no force on the beam 23 and, hence, the pressure applied to the billet 12 by the grinding wheel 11 is determined substantially by the position of the counterweight 30. However, in the event that it is desired to lift the grinding wheel 11 either from the billet which is being ground on the table or because the wheel has overrun the billet, then air under pressure is supplied to the means 39 through the line 44 causing the wheel 11 to lift irrespective of the position of the counterweight 30.

Particles removed from the billet being ground or from the grinding wheel 11 during the grinding process are drawn away from the machine through an exhaust hood 46 connected to an exhaust conduit 47.

### Table operation

A billet which is to be ground, such as the billet 12, is mounted on the table 13 which is supported on grooved wheels 48 which travel on rails 49, the wheels also being guided by guide rods 50 mounted above the rails 49 and extending parallel thereto. The rails 49 and guide rods 50 are mounted on frames 51 and 52 secured to the foundation 40. Fluid-actuated cylinder and piston means 53 is fixedly secured to the underside of the table 13 and, when fluid is admitted to the opposite ends thereof, the cylinder portion of the cylinder and piston means 53 travel along the piston rod 54 secured at its ends to the frames 51 and 52 and carries the table 13 with it. Thus, if fluid such as hydraulic fluid is supplied to the cylinder and piston means 53, the table 13 can be caused to reciprocate along the rails 49.

### Billet mounting and clamping

The billet 12 is clamped in grinding position on the top of table 13 by a power-operated clamping arrangement best shown in Figs. 2 and 5-8. As shown in these figures, the clamping arrangement comprises a pair of double-acting cylinder and piston means 55 and 56 having piston rods 57 and 58 extending therefrom. Fluid under pressure and preferably air is admitted to the cylinder and piston means 55 and 56 through the lines 59-62 causing the piston rods to move in directions determined by the line to which the fluid is supplied. Arcuately slotted members 63 and 64 are attached to the ends of the rods 57 and 58 and engage pins 65 and 66 secured to billet-engaging members 67 and 68 having rollers 69 and 70 at their ends. The billet-engaging members 67 and 68 are pivotally mounted at opposite ends to slidable end clamps 71 and 72.

The means 55 and 56 are mounted on plates 73 and 74 and the end clamps 71 and 72 are guided by the walls of slots provided in the plates 73 and 74. The end clamps 71 and 72 are also urged away from the billet 12 by springs 75 and 76 which are connected to the plates 73 and 74 by the threaded bolts 77 and 78 and the brackets 79 and 80.

The mounting plates 73 and 74 are adjustable along the top of the table 13. The adjusting apparatus for the plate 74 only is shown in detail in Figs. 6 and 7, but it will be understood that similar apparatus is provided for the other mounting plate 73. In Figs. 6 and 7 the plate 74 is adjustable by the screw 81 rotatable in the bearing 82 secured to the top of table 13 and in threaded engagement with a sleeve 83 secured to the bottom of the plate 74. The screw 81 is rotatable by a hand wheel 84 at the end of the table. The mounting plate 74 is held down on the top of the table 13 by ways 85 engageable with the walls of grooves 74a in the slides 74b (Fig. 8) for the mounting plate.

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When the piston rods 57 and 58 are retracted by the cylinder and piston means 55 and 56, the end clamps 71 and 72 move away from the billet 12 because of the action of springs 75 and 76 and in addition the rollers 69 and 70 of the billet-engaging members 67 and 68 move away from the side of the billet 12 and pivot to the position shown in solid lines in Fig. 6. In this position the roller 70 engages the arm 86 of a switch 87 whose function will be described hereinafter. With the end clamps 71 and 72 and the billet-engaging members 67 and 68 in the position shown in Fig. 6, the billet 12 is completely free and may be rotated to expose another surface for grinding or may be removed from the table 13.

#### *Billet turning*

The grinding apparatus is also provided with power-operated, billet-turning equipment which is best shown in Figs. 2, 5 and 14. This equipment comprises a pair of fluid-actuated cylinder and piston means 88 and 89 mounted on the underside of the table 13 and having turning fingers 91 and 92 extending above the top of the table 13. When fluid such as air under pressure is introduced into the appropriate ends of the means 88 and 89, the fingers 91 and 92 move upwardly engaging the billet 12 on the underside thereof at a point to the front of its center of gravity. As the fingers move upwardly they tilt the billet 12 rearwardly until finally the billet falls on the side which was previously engaged by the rollers 69 and 70, thus producing a 90-degree rotation of the billet 12. When the air pressure is reduced, the fingers 91 and 92 retract.

Movement of the billet 12 away from the front of the table is limited by the stop members 93 and 94 and, after it has been rotated 90 degrees as described, the billet 12 will rest in the position indicated in dotted lines in Figs. 5 and 8.

After the billet has been turned, fluid is again supplied to the cylinder and piston means 55 and 56 through the lines thereof which causes the rods 57 and 58 to move outwardly. Due to the arcuate configuration of the slots in the members 63 and 64, the end clamps 71 and 72 will not, during initial movement of the rods 57 and 58, move toward the ends of the billet 12 or will move only a small amount. As the rods 57 and 58 move outwardly, the members 67 and 68 pivot about their points of connection with the clamps 71 and 72 and the rollers 69 and 70 engage the side of the billet 12 which previously was under the grinding wheel and force the billet 12 forward on the table 13 and toward grinding position. As soon as the rotation of the members 67 and 68 proceeds to a point where the pins 65 and 66 pass the point 95 at the edge of the slot in the members 63 and 64, the end clamps 71 and 72 move closer to the ends of the billet 12 so that the fingers 96 and 97 on the clamps 71 and 72 move in front of the billet 12 and provide a forward stop therefor. At the end of the movement of the rods 57 and 58 the clamps 71 and 72 press tightly against the end of the billet 12 and the rollers 69 and 70 press tightly against the side of the billet 12 holding the billet 12 securely in grinding position.

The mounting plates 73 and 74 are also provided with a pair of rails 98 and 99 for receiving and supporting the billet 12 thereon and with arms 100 and 101 each having a pair of shoes 102—105 for operating the arms of switches 106—109 mounted on a fixed frame 110 supported from the foundation 40. The switches 106—109 are employed for controlling movement of the table 13 in the manner hereinafter described and the switches 106 and 108 are operated respectively by the shoes 102 and 103 and the switches 107 and 109 are operated respectively by the shoes 105 and 104.

#### *Billet storage and loading*

Referring to Figs. 5 and 9—13, the billet loader apparatus employed to deposit a billet on the table 13 and,

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if a ground billet is on the table 13, for removing the ground billet from the table 13 comprises an inclined billet storage rack 111 supported by a frame having vertical legs 112 and having horizontal cross braces 113.

A pair of longitudinally extending I-beams 114 and 115 are mounted on the cross braces 113 and are held in spaced relationship by a pair of cross pieces 116. The cross pieces 116 support a fluid-actuated cylinder and piston means 117 having a piston rod 118 extending therefrom and connected to a bracket 119 on the underside of a pusher ram 120. The pusher ram 120 is U-shaped, as is best shown in Fig. 11, and is arranged to slide back and forth on I-beams 114 and 115, the ram 120 being guided on the tops of I-beams 114 and 115 by guides 121—124. Each side member of the ram 120 includes a longitudinally extending plate 125 and 126 to which is secured, such as by welding, pairs of channels 127 and 128 and 129 and 130, the channels 127—130 being spaced apart so as to receive therebetween billet-discharging links 131 and 132 and billet-feeding links 133 and 134. These links are pivotally supported on cross pins 135—138 which are secured to the channel members 127—130. The channels 127—130 are braced by a pair of angle members 120a and 120b fastened thereto and to the rear member 120c of the ram 120.

The links 131—134 are constructed so as to stand normally in the upright positions shown in Figs. 8—13 and immediately in front of the links 131—134 below their pivot pins are angle brackets 139—142 which are secured to the channels 127—130 so as to prevent the links 131—134 from tilting in a counter-clockwise direction as viewed in Fig. 9 but still permitting them to tilt in a clockwise direction as viewed in this figure.

The cylinder and piston means preferably is operated by air and has a pair of fluid lines 143 and 144 connected thereto for the purpose of admitting such air thereto and thereby moving the piston rod 118 and with it ram 120 either toward or away from the table 13. The supply of air to the lines 143 and 144 is controlled by the three-way valve 145 having an air line 146 connected thereto and controlled by the solenoids 147 and 148. Switch 149 operated by the pusher ram 120 and switch 150 operated by the bracket 119 are mounted on the members 112 and 115 respectively for controlling the operation of the apparatus in the manner hereinafter described.

The storage rack 111 is adapted to support a plurality of the billets 12 at such an angle that gravity tends to force them one by one onto a billet land or waiting area 151, the surface of the billet land 151 being inclined rearwardly of the loading apparatus so as to hold the bottom-most billet in the position shown in Fig. 9, thereby retaining the remainder of the billets on the surface of the rack 111.

As is best shown in Figs. 11—14, the rails 98 and 99 have intermediate surfaces 152 and sloping end surfaces 153 and 154. The intermediate surfaces 152 are raised above the top of the table 13 a distance greater than the upper surface of the pusher ram 120 when it is moved forward for the purpose of loading a billet 12 on the rails and the rails 98 and 99 are spaced apart a distance sufficient to permit the forward end of pusher ram 120 to pass therebetween.

When it is desired to place a new billet on the table 13 for grinding, the loading apparatus is in the rest position shown in Fig. 9. The grinding wheel 11 is raised from the grinding position shown in Fig. 9 and the billet whose grinding has been completed is unclamped so that the clamping members 67 and 68 are in the position indicated in solid lines in Fig. 6. An unground billet 12 which has fallen by gravity on to the billet land 151 is ready to be engaged by the links 133 and 134. The valve 145 is operated by one of the solenoids 147 and 148 so that air under pressure is admitted into the cylinder and piston means 117 through the line 143 causing the piston rod 118, and hence the pusher ram 120, to

move forward toward the table 13. It will be understood, of course, that prior to operation of the cylinder and piston means 117 the table 113 will have been moved to its right-hand position as viewed in Fig. 5 so as to permit the pusher ram 120 to enter the space between the rails 98 and 99.

As the ram moves forward the feeder links 133 and 134 engage the unground billet on the land 151 and push it onto the rails 98 and 99 in the manner indicated in Figs. 12 and 13. As soon as the billet on the land 151 is removed, the next billet on the rack 111 drops down on the land 151 and hence is in position for the next loading of the table 13. When the billet which is being loaded on the rails 98 and 99 reaches the inclined surfaces 154 on the rails, it will be guided up the inclined surfaces 154 to the middle surfaces 152. As the billet being loaded reaches the beginning of the surfaces 152, as shown in Fig. 12, the discharge links 131 and 132 engage the ground billet which is on the surfaces 152 and push it forward to the inclined surface 153 as shown in Fig. 13. The slope of the inclined surfaces 154 is sufficient to cause the discharged billet 12 to fall down on the continuously running conveyor 15 shown in Fig. 1.

It will be noted that the unground billet is pushed to a position on the middle surfaces 152, which is the same as the position at which a billet is located after it has been turned by the fingers 91 and 92 and at which a turned billet is engaged by the clamping members 67 and 68. After reversal of the movement of the ram 120, such reversal being accomplished by another operation of the valve 145 and admission of air into the cylinder and piston means 117 through the line 144, and moving the ram 120 to its fully withdrawn position shown in Fig. 9 the cylinder and piston means 55 and 56 may be operated causing the unground billet to move from the rear portion of the surfaces 152 to the forward portion of the surfaces 152 where it is ready for grinding in the manner set forth above.

As the ram 120 is withdrawn, the discharge links 131 and 132 strike the unground billet on the rear portion of the surfaces 152, but due to the fact that they are permitted to rotate in the clockwise direction as viewed in Figs. 9, 12 and 13 the links 131 and 132 do not disturb the unground billet but instead merely slide under the billet. Similarly, as the ram 120 is further withdrawn, the feed links 133 and 134 engage the unground billet on the land 151 but due to their ability to rotate as mentioned above they merely pass under the unground billet on the land 151.

Upon reference to Figs. 11 and 14, it will be seen that the stop members 93 and 94 also are in the form of rotatable links. Thus, the stop members 93 and 94 are mounted on U-shaped brackets 155 and 156 which are secured to the top of the table 13. The stop members 93 and 94 are rotatably mounted on the brackets 155 and 156 by a pair of pins 157 and 158 and are rotatable in the clockwise direction as viewed in Fig. 14, rotation in the counter-clockwise direction being prevented by engagement of the lower end of the members 93 and 94 with upwardly extending portions 159 and 160 of the brackets 155 and 156. Thus, the stop members 93 and 94 rotate during loading of the unground billet and movement of the unground billet to the grinding position and thereby slide under the unground billet as it is moved. However, when the billet is turned so as to present a new face to the grinding wheel, the members 93 and 94 are in the vertical position indicated in Fig. 14 and prevent the billet as it is turned from moving backward beyond the desired position upon the rails 98 and 99.

#### *Fluid actuating systems*

As mentioned above, the various fluid-actuated cylinder and piston means may be actuated by air or by a liquid, such as oil, under pressure. In the preferred form of the invention, the cylinder and piston means employed

for the reciprocation of the table 13, the beam 23 and the weight 30 are actuated by oil under pressure and the cylinder and piston means employed for lifting the grinding wheel 11, turning of the billet 12, clamping of the billet 12 and reciprocation of the loader 120 are actuated by air, air being preferred for the operation of the latter cylinder and piston means because of the speed and cushioning effect obtainable.

Figure 15 shows schematically the oil-operated cylinder and piston means and their connections with the valves controlling the operation thereof and show the electrical controls which are operated either directly or indirectly by the cylinder and piston means. Referring to Fig. 15, oil is supplied under pressure to the line 161 and is conveyed to the various cylinder and piston means through the control valves by lines 162-164, the various lines being equipped with conventional shut-off and pressure-relief valves which have not been shown in the drawings for purposes of simplicity. Oil which is by-passed from the system or which is returned to the source by the various cylinders when the direction of movement is changed is returned to the source through the line 165.

The supply of oil to the weight-operating cylinder and piston means 32 is controlled by a two-way valve 166 which is controllable electrically by the solenoids 167 and 168. Counterweight 30 in its rearmost position, i. e., the position in which the grinding wheel 11 is lifted by the weight 30 from the billet 12, strikes the arm of a limit switch 169 whose function will hereinafter be explained.

The supply of oil to the cylinder and piston means 53 which reciprocates the table 13 is controlled by a two-way valve 170 and a by-pass valve 171. Valve 170 is electrically controllable by solenoids 172 and 173 and by-pass valve 171 is electrically controllable by solenoid 174. Valve 170 permits fluid to flow into one end or the other of the cylinder and piston means 53 and hence causes reciprocation of the table 13, and by-pass valve 171 when de-energized cuts off the flow of fluid to both the valve 170 and to the cylinder and piston means 53 stopping the table 13. As previously explained, shoes 102-105 mounted on arms 100 and 101, which in turn are movable with the table 13, operate the arms of reciprocation control switches 108 and 109 and, when the grinding wheel 11 overruns the billet 12, operate the limit switches 106 and 107, the function of these switches being explained in further detail hereinafter.

The supply of oil to the cylinder and piston means 36 for reciprocating the beam 23 on which the grinding wheel 11 is mounted is controlled by the valve 175 and the by-pass valve 176, these valves being electrically controllable by solenoids 177-179 connected as shown by Fig. 15. Valve 175 permits oil to enter one end or the other of the cylinder of cylinder and piston means 36 causing beam 23 to reciprocate, whereas when by-pass valve 176 is de-energized the supply of oil to the valve 175 and the cylinder and piston means 36 is cut off causing the beam 23 on which the grinding wheel 11 is mounted to stop.

A shoe or cam 180 is mounted on the beam 23 as shown in Fig. 3 and, therefore, is movable with the piston rod 37 of the cylinder and piston means 36. This cam or shoe 180 engages the arms of a pair of reciprocation control switches 181 and 182, also shown in Fig. 1, and these switches control the reciprocation of the beam 23 in the manner described hereinafter.

As shown in Fig. 4, a further cam or shoe 183 is mounted on the opposite side of the beam 23 and, therefore, is also movable with the piston rod 37 of the cylinder and piston means 36. This cam or shoe 183 engages the arms of a pair of switches 184 and 185 which reduce the pressure applied to the grinding wheel 11 at the corners of a billet being ground in the manner described in further detail hereinafter.

Figure 16 illustrates schematically the controls for the

air-actuated cylinder and piston means. In Fig. 16 it will be seen that air under pressure is supplied to the system through a line 186 connected to branch line 146 supplying air to the loader cylinder and piston means 117, branch line 187 supplying air to the clamping cylinder and piston means 55 and 56, branch line 188 supplying air to the beam-lift cylinder and piston means 39 and branch line 189 supplying air to the billet-turning cylinder and piston means 88 and 89. These lines are equipped with conventional pressure regulators and shut off the valves which have not been shown for the sake of simplicity.

The supply of air to the double-acting cylinder and piston means 117 is controlled by the two-way valve 145 which in turn is electrically controllable by the solenoids 147 and 148. In its normal or rest position the loader 120 engages the arm of switch 149, and in its forward position the bracket 119 of the loader 120 engages the arm of switch 150, the functions of these switches being described hereinafter.

The supply of air to the double-acting cylinder and piston means 56 is controlled by the valve 190 which in turn is electrically controllable by the solenoid 191. When the solenoid 191 is energized, the valve 190 admits air to the cylinder and piston means 55 and 56 at the end thereof which causes the clamping members 67 and 68 to pull away from the billet on the table 13. On the other hand, when the solenoid 191 is de-energized, valve 190 supplies air to the opposite ends of the cylinder and piston means 55 and 56 causing the clamping members 57 and 58 to engage and clamp a billet on the table 13. When a billet is in its grinding position on the table 13, it engages and operates the arm of a switch 198 and, when the billet is in its turned position or has just been loaded on the table 13, it engages and operates the arm of a switch 199, the function of these switches being described hereinafter.

The supply of air to the cylinder and piston means 39 is controlled by a valve 192 which in turn is electrically controllable by a solenoid 193. When the solenoid 193 is energized, the valve 192 admits air to the end of cylinder and piston means 39 which causes the piston rod 42 to pull the end of the beam 23 to which it is attached in the downward direction, whereas when the solenoid 193 is de-energized the supply of air to the cylinder and piston means 39 is cut off and the air in the cylinder and piston means is exhausted through vent 194. When the rod 42 has moved in the downward direction sufficiently to lift the grinding wheel 11 from the face of the billet, the arm 42a engages and operates the arm of switch 42b whose function is described hereinafter.

The supply of air to the billet-turning cylinder and piston means 88 and 89 is controlled by a valve 195 which is electrically controllable by a solenoid 196. When the solenoid 196 is energized, the valve 195 permits air to flow into the end of cylinder and piston means 88 and 89 which causes the fingers 91 and 92 to raise. When the solenoid 196 is de-energized, the supply of air to the cylinder and piston means 88 and 89 is cut off and the air in these means 88 and 89 is exhausted through a vent 197.

#### Wheel pressure control

Fig. 17 is an electrical circuit diagram of the electrical system employed for controlling the grinding apparatus of my invention, and as shown in Fig. 17 the motor 27 which may, for example, be a three-phase motor is connected to a suitable source of electrical power through conventional motor-starting apparatus 200. As described in the aforesaid copending applications, the force applied to the grinding wheel 11 to hold it against the face of a billet is automatically adjusted in accordance with the load on the grinding wheel 11. To accomplish this result a pressure control circuit illustrated diagrammatically by the rectangle 201 is coupled to the input circuit of the motor 27 by a transformer 202 which may, for example,

be a current transformer. The pressure control circuit 201 is described in detail in my aforesaid copending application Serial No. 279,789 and, briefly, the circuit when set for automatic operation decreases the downward pressure on the grinding wheel when the current drawn by the motor 27 increases and vice versa. By setting of the automatic control to the correct position the pressure will adjust itself so that the input current to the motor 27 has a predetermined value. Such automatic control is desirable not only because it produces an even grinding of the surface of a billet but also because the undesired material on the surface of the billet is removed at a constant rate.

When the control handle 203 of the pressure control circuit 201 is set in the position marked "Manual," the contactor 204 is moved in the downward direction interconnecting the contacts 205 and 206 and the contactor 207 is permitted to move upwardly and to interconnect the contacts 208 and 209. In this position of the control handle 203 a circuit for energization of the solenoid 167 of the weight control valve 166 is established from terminal B to terminal A of the power source 210 through contacts 208 and 209, the contacts of limit switch 169, contacts 205 and 206 and solenoid 167. Energization of the solenoid 167 causes the weight 30 to move rearwardly of the beam 23 lifting the wheel 11 from a billet on the table 13. When the weight 30 reaches the end of its rearward movement, it operates limit switch 169 breaking the energizing circuit for the solenoid 167 and stopping the further supply of fluid to the cylinder and piston means 32. In this position of the control handle 203 the grinding wheel may be pressed against a billet and reciprocated manually by an operator who may grasp and manipulate the handle 211 (Fig. 3) adjacent the grinding wheel 11.

When automatic control of the downward force on the grinding wheel 11 is desired, the control handle 203 is moved from the position shown and toward the position marked "Automatic." Such movement releases contactor 204 disconnecting contacts 205 and 206 and moves contactor 207 in the downward direction interconnecting contacts 212 and 213. Interconnection of the contacts 212 and 213 connects the contacts 214 and 215 of the relay 216 to terminal B of the power source 210. Contacts 217 and 218 of relay 216 are connected respectively to the ends of solenoids 168 and 167 which control the operation of valve 166. The armature 219 of the relay 216 having a contactor 220 thereon is urged by spring 221 toward a position such that it interconnects contacts 214 and 217. Energization of the coil of relay 216 moves the armature 219 in such a direction that it interconnects contacts 215 and 218 and in an intermediate position the contacts are not interconnected. The control circuit 201 supplies a current to the coil of relay 216 which is proportional to the current drawn by the motor 27 and the control handle 203 adjusts the magnitude of this current.

Assuming that the control handle 203 is moved from the manual toward the automatic position, there will at first be substantially no current in the coil of the relay 216 because, due to the fact that the weight 30 is at the rear-most position, the current drawn by the motor 27 is relatively small. Thus, the contactor 220 will interconnect contacts 214 and 217 energizing solenoid 168 through a circuit extending from terminals B to A of source 210 through contacts 212, 213, 214 and 217 and solenoid 168. This will cause the cylinder and piston means 32 to move the weight 30 in a forward direction and in turn cause the grinding wheel 11 to lower to the face of a billet on the table 13. As the weight 30 continues to move forward the pressure exerted by the grinding wheel 11 on the face of the billet will increase causing the current drawn by the motor 27 to increase. An increase in the current drawn by the motor 27 will cause an increase in the current in the coil of relay 216 and will, after a predetermined current is reached, move the armature 219 to the right as shown in Fig. 17 and will, therefore, disconnect

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contacts 214 and 217 breaking the energization circuit for the solenoid 168.

As long as the current in the coil of relay 216 does not exceed a predetermined value, the contactor 220 will remain in an intermediate position between the contacts 214 and 217 and contacts 215 and 218. If, however, for some reason, such as a change in the surface characteristics of the billet or the grinding wheel, the current in the coil of relay 216 increases a sufficient amount the contactor 220 will interconnect contacts 215 and 218 establishing a circuit from terminal A to terminal B through contacts 212, 213, 215, 218 and solenoid 167. Accordingly, the cylinder and piston means 32 will move the weight 30 rearwardly reducing the downward force on the wheel 11 and hence the current drawn by the motor 27. This in turn will reduce the current in the coil of relay 216 and will permit the armature 219 to move to the left as viewed in Fig. 17 and will break the energization circuit for the solenoid 167. In this manner the downward force on the grinding wheel 11 is automatically controlled in accordance with the amount of energy supplied to the motor 27. Further details of the automatic control circuit 201 are set forth in the aforesaid copending application Serial No. 279,789.

If when the grinding wheel 11 is at the corners of a billet the value of the downward force is maintained the same as its value when the grinding wheel is in engagement with a portion of the face spaced from the corners of the billet, the grinding wheel will have a tendency to round such corners. Accordingly, switches 184 and 185 are provided for the purpose of reducing the downward force by a predetermined amount as the grinding wheel approaches such corners. These switches control the circuit 201 in the manner described in the aforesaid copending application Serial No. 279,789 and their function need not be described in further detail herein.

#### *Safety lift and timing control*

A safety lift circuit 222 of the type described in the aforesaid copending application Serial No. 279,789 is also provided for the purpose of energizing the lift solenoid 193 and hence lifting the grinding wheel 11 rapidly and independently of the control circuit 201. In the position of control handle 223 marked "Lift" the grinding wheel 11 is lifted and the handle 223 must be moved to the position marked "Reset" after the wheel 11 has been lifted by movement of the handle 223 to the "Lift" position by an operator or by actuation of one of the over-travel switches 106 and 107. The over-travel switches 106 and 107 (Figs. 2 and 5) are positioned so that, if the table 13 moves the billet 12 out from under the grinding wheel 11, switch 107 is actuated by shoe 105 or switch 106 is actuated by shoe 102 causing the wheel 11 to lift and preventing damage to the table or the equipment mounted thereon.

A timer 224 of the type disclosed in the aforesaid application Serial No. 279,789 is provided for the purpose of reciprocating the table 13 along a short path when it is desired to provide additional grinding for a portion of the surface of the billet being ground. Timer 224 when connected into the circuit alternately energizes solenoids 172 and 173 and produces a short reciprocatory movement of the table 13.

#### *Single face grinding controls*

For purposes of explanation, assume that the mounting plates 73 and 74 have been adjusted so as to receive a billet 12 thereon in the manner shown in Figs. 2 and 5, a billet 12 is clamped in grinding position as shown in these figures, table 13 is being reciprocated, grinding wheel 11 has commenced its reciprocation beginning at the edge of the billet 12 nearest the grinding wheel mounting frame 28 and hence the forward edge of table 13, the automatic control circuit 201 has been set to give the desired grinding pressure, the motor 27 being in operation, the control

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handle 223 is set so that the lift solenoid 193 is de-energized, on-off switch 225 has been manually actuated and the timer 224 is out of operation. As the table 13 reciprocates the shoes 103 and 104 strike respectively the arms of switches 108 and 109 (Figs. 5 and 17) causing the direction of movement of the table 13 to be reversed as the grinding wheel 11 reaches each end of the billet 12. As shown in Fig. 17 switch 108 when moved in the downward direction completes a circuit from terminal B to terminal A of the power source 210 through the contacts of on-off switch 225, contacts 226 and 227 of switch 108 and solenoid 172. When switch 109 is actuated and hence switch 108 is released, switch 109 completes a circuit from terminals B to A through switch 225, contacts of switch 109, and solenoid 173. It will be noted that momentary energization of either solenoid 172 or 173 reverses valve 170 and the valve remains in the position to which it has been moved until the other of the solenoids 172 and 173 is energized. Solenoids 172 and 173 may also be energized by means of manual switches 228 and 229 for reciprocating the table 13 under manual control.

When the grinding wheel 11 reaches the rear edge of the billet 12, the rear edge being the one most remote from the forward edge of the table 13, the shoe or cam 180 actuates the switch 182 (Figs. 3 and 17) and completes an obvious circuit for energization of the solenoid 178. Energization of the solenoid 178 reverses the direction of fluid flow to the cylinder and piston means 36 causing the direction of movement of the wheel 11 to reverse. The valve 175 remains in the position to which it is operated by the solenoid 178 until the solenoid 177 is operated. Solenoid 177 may be energized in the manner hereinafter described and both solenoids 177 and 178 may also be energized by manual operation of the switches 231 and 230 respectively.

As pointed out above, when solenoids 174 and 179 are energized, fluid under pressure is supplied to the valves 170 and 175 which control the reciprocation of the table 13 and the grinding wheel 11. However, when the solenoids 174 and 179 are de-energized, as they may be by manual operation of the switches 232 and 233 and by release of by-pass relay 238 as well as actuation of switch 108, the supply of fluid to the valves 170 and 175 is cut off so that both the table and the wheel stop. Normally, the switches 232 and 233 are unoperated so that both solenoids 174 and 179 are energized by circuits completed through the contacts 234-237 of normally energized relay 238. Thus, the energizing circuit for solenoid 179 may be traced from lead 239 which is connected to terminal B of source 210 to lead 240 which is connected to terminal A of source 210 through contacts 234 and 236, contacts of switch 232 and solenoid 179. The energizing circuit for solenoid 174 may be traced from lead 239 to lead 240 through contacts 235 and 237, lead 241, contacts of switch 233 and solenoid 174. Solenoid 174 is also separately energized, when switch 108 is unactuated, by a circuit which may be traced from lead 242 connected to terminal B to lead 240 through contacts 243 and 244 of switch 108, lead 245, contacts of switch 233 and solenoid 174. Thus, both operation of switch 108 and release of relay 238 is required to de-energize solenoid 174 as long as the manual switches 232 and 233 are unoperated.

Switch 181 is provided with a pair of normally connected contacts 246 and 247, contact 247 being connected to lead 240 and contact 246 being connected to one end of the coil of relay 238. These contacts 246 and 247 complete a circuit for the coil of relay 238 extending from lead 239 to 240 and, therefore, relay 238 is maintained in an energized condition until the switch 181 is operated. As viewed in Fig. 3, switch 181 is operated when the beam 23 on which the grinding wheel 11 is mounted is in a position to the left of the position shown and the position of the switch 181 with respect to the

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shoe or cam 180 is adjusted so that the switch 181 is operated when the billet-engaging portion of the face of the wheel 11 is at the forward edge of the billet 12. Thus, when the grinding wheel 11 reaches this position, the switch 181 is operated disconnecting contacts 246 and 247 and de-energizing relay 238. De-energization of relay 238 disconnects contacts 234 and 236 and de-energizes solenoid 179 stopping the movement of the beam 23 which carries the grinding wheel 11. At the same time, relay 238 disconnects contacts 235 and 237.

Operation of switch 181 also interconnects contacts 248 and 249 completing a circuit for energization of lift relay 250. The energization circuit for relay 250 may be traced from lead 251 connected to one end of transformer 352 to lead 264 connected to the opposite end of transformer 352, through lead 253, contacts 254 and 255 of normally de-energized recycle relay 256, lead 257, lead 258, contacts 248 and 249, lead 359, contacts 260 and 261 of normally de-energized restart relay 262, lead 263, and the coil of relay 250. When relay 250 is operated it interconnects its contacts 265 and 266 establishing a locking circuit for its coil and it interconnects its contacts 267 and 268 completing an energizing circuit for the lift solenoid 193 extending from lead 239 to lead 240 through contacts 267 and 268, lead 269 and solenoid 193.

Shortly after switch 181 is actuated, switch 108 is actuated by shoe 103 and, although the delays may be such that switch 108 is operated after lift solenoid 193 has been energized, the delay before solenoid 193 is energized also may be arranged in a well-known manner so that switch 108 is actuated before movement of the lift piston rod 42. Switch 108 preferably is of the break-before-make type so that contacts 243 and 244 are disconnected before contacts 226 and 227 are connected. Thus, although switch 108 completes the energizing circuit for the solenoid 172 which would normally cause the table 13 to move to the left as viewed in Figs. 1, 2 and 5, the solenoid 174 has previously been de-energized because contacts 243 and 244 have been disconnected. As pointed out above, when solenoid 174 is de-energized the table 13 is brought to rest and, because the table 13 is brought to rest immediately after actuation of the switch 108, the table stops in its extreme right-hand position as viewed in Figs. 1, 2 and 5.

Energization of the lift solenoid 193 by the previously described circuit causes operation of the cylinder and piston means 39 and, when the wheel 11 is lifted from the face of the billet by a predetermined amount, the arm 42a actuates the switch 42b. Actuation of switch 42b completes an energizing circuit for the billet unclamping solenoid 191 which may be traced from lead 242 to lead 240 through lead 270, contacts 271 and 272, lead 273, contacts 274 and 275 of relay 256, lead 276 and solenoid 191. Energization of the solenoid 191 causes the clamping members 67 and 68 as well as the end clamps 71 and 72 to move away from the billet 12, thereby releasing the billet.

If desired, the cycle of operations may be interrupted at this point by omission of contacts 277 and 278 of clamp operated switch 87 so that before further operations take place it is necessary for an operator to energize billet-turning solenoid 196 by actuation of manual switch 279 or to discharge the ground billet and load a new billet by actuation of manual loading switch 280. However, in the preferred form of the invention, the operations are continued automatically so that the billet which has been ground on one face is automatically turned, reclamped and ground on the next face.

#### Multiple face grinding controls

When clamping member 68 reaches the full release position as shown in Fig. 6, it strikes the arm 86 of switch 87 interconnecting contacts 277 and 278 which complete an energizing circuit for billet-turning solenoid 196, which circuit may be traced from lead 242 to lead 240

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through contacts 281 and 282 or normally de-energized reload relay 283, lead 284, contacts 277 and 278, lead 285, contacts 286 and 287 of switch 199, lead 288 and solenoid 196. Energization of solenoid 196 causes operation of cylinder and piston means 88 and 89 and rotation of the billet 12 which is square in cross section through 90 degrees as well as movement of the billet 12 from the position shown in solid lines in Fig. 5 to the position indicated in dotted lines in Fig. 5.

When the billet 12 is in the position shown in dotted lines in Fig. 5, it actuates the "billet-turned" switch 199 disconnecting contacts 286 and 287 and de-energizing solenoid 196 causing the turning fingers 91 and 92 to return to their normal positions. Actuation of switch 199 also interconnects contacts 289 and 290 completing a circuit for energization of recycle relay 256 which may be traced from lead 242 to lead 240 through contacts 281 and 282 of reload relay 283, lead 284, contacts 277 and 278, lead 285, contacts 289 and 290, lead 291, lead 292 and the coil of relay 256, the opposite end of the coil of relay 256 being connected to lead 240 by lead 293.

As will be explained in further detail hereinafter, the arm 294 of stepping relay 295 having the stepping coil 296 and resetting coil 297 is in engagement with the contact numbered 1 during the grinding of the first face of the billet 12. When relay 256 is operated it completes an energizing circuit for the stepping coil 296 which may be traced from one terminal of transformer 298 to the other terminal of transformer 298 through coil 296, lead 299, contacts 300 and 301 of relay 256 and lead 302. The arm 294 of relay 295 does not move upon energization of coil 296 but instead moves to the next contact when the coil 296 is subsequently de-energized.

At its contacts 303 and 304 relay 256 completes a locking circuit for its coil extending from lead 242 to 240 through lead 270, contacts 305 and 306 of lift-operated switch 42b, lead 307, contacts 303 and 304, lead 292, the coil of relay 256 and lead 293. At its contacts 308 and 309 relay 256 prepares part of a circuit for subsequent release of relay 250 and at its contacts 310 and 311 relay 256 completes part of a circuit for subsequent operation of restart relay 262.

When relay 256 is operated it disconnects contacts 274 and 275 and hence breaks the energization circuit for billet unclamping solenoid 191 causing the clamping members 67 and 68 and end clamps 71 and 72 to engage the billet 12 and move it from the position shown in dotted lines in Fig. 5 to the position shown in solid lines in Fig. 5 in the manner previously described, the position of the billet shown in solid lines in Fig. 5 being the grinding position of the billet. As the billet is moved from its turned position to the grinding position the switches 87 and 199 are released and in the grinding position the switch 198 is actuated by the billet or, if desired, by the clamping mechanism.

The switches 87 and 199 are arranged so that the contacts 277 and 278 of switch 87 are disconnected before the contacts 286 and 287 of switch 199 are connected. Release of switch 87 at first has no effect because, although it breaks the initial energizing circuit for relay 256, relay 256 is held by the locking circuit previously described. However, when contacts 286 and 287 are again connected by the switch 199 the circuit previously established by contacts 277 and 278 for energizing billet-turning solenoid 196 is open thus preventing turning of the billet when it is returned to the grinding position.

Operation of switch 198 which indicates that the billet is ready for grinding completes an energizing circuit for restart relay 262 which may be traced from one terminal to the other terminal of transformer 312 through lead 313, contacts 310 and 311 of relay 256, lead 314, contacts 315 and 316 of switch 198, leads 317 and 318 and the coil of relay 262. Switch 198 also completes a circuit for short-

circuiting the coil of lift relay 250 and hence for releasing this relay, the circuit being traced from one end to the other of the coil of relay 250 through leads 319, contacts 320 and 321 of switch 198, lead 322, contacts 308 and 309 of relay 256 and lead 323 which is connected to one end of the coil of relay 250. Operation of relay 256 breaks the previously established energizing circuit for lift relay 250 at its contacts 254 and 255 and operation of relay 262 adds a further discontinuity in the energizing circuit for relay 250 for purposes hereinafter explained. Release of relay 250 breaks its locking circuit at contacts 265 and 266 and breaks the energizing circuit for lift solenoid 193 at its contacts 267 and 268. De-energization of lift solenoid 193 permits the grinding wheel to lower to the surface of the billet in the grinding position and lowering of the grinding wheel 11 releases switch 42b. Release of switch 42b disconnects contacts 271 and 272 and thereby prevents re-energization of the billet unclamping solenoid 191 when the relay 256 is subsequently released. The release of switch 42b also disconnects contacts 305 and 306 breaking the locking circuit for relay 256 and releasing relay 256.

Although release of relay 256 interconnects contacts 254 and 255 which form part of the energization circuit for lift relay 250, the circuit is interrupted at the contacts 260 and 261 of restart relay 262. Release of relay 256 also interconnects contacts 324 and 325 which completes a hold circuit for the relay 262, either the delay in release of relay 262 being sufficient to hold the relay 262 until the contacts 324 and 325 are interconnected or the contacts 324 and 325 being interconnected before the contacts 310 and 311 are disconnected. The circuit just established for holding relay 262 may be traced from one terminal to the other terminal of transformer 312 through lead 313, contacts 324 and 325, lead 326, contacts 327 and 328, lead 329, contacts 330 and 331, leads 317 and 318 and the coil of relay 262. Release of relay 256 also causes coil 296 to become de-energized and hence causes arm 294 to step forward to contact numbered 2.

Operation of restart relay 262 also completes an energizing circuit for by-pass relay 238 and forward solenoid 177, by-pass relay 238 energizing the forward-back by-pass solenoid 179 and the left-right by-pass solenoid 174 permitting fluid to be supplied to the valves 170 and 175 and causing the table 13 and the wheel 11 to reciprocate in the manner previously described. Energization of the forward solenoid 177 determines the initial direction of movement of the grinding wheel 11. The circuit for energization of by-pass relay 238 may be traced from lead 240 to lead 239 through lead 293, contacts 332 and 333 of relay 262, lead 334, lead 335 and the coil of relay 238. The energization circuit for solenoid 177 may be traced from lead 239 to lead 240 through lead 336, contacts 337 and 338 of relay 262, lead 339 and solenoid 177.

It will be noted that until the grinding wheel 11 moves forward by a predetermined amount the switch 181 is actuated and, therefore, no energizing circuit for the relay 238 is established through the switch 181. Accordingly, one of the functions of the restart relay 262 is to energize by-pass relay 238 and hold it in energized condition until the switch 181 is released and as soon as switch 181 is released the restart relay 262 is also released. Thus, either by suitable provision of a slow release time for the relay 262 or by interconnection of contacts 246 and 247 of switch 181 before disconnection of contacts 327 and 328 of switch 181, the contacts 246 and 247 are interconnected before the energizing circuit for by-pass relay 238 extending through the contacts 332 and 333 of relay 262 is broken. When contacts 327 and 328 are disconnected by release of switch 181 the previously described holding circuit for the restart relay 262 is broken. Also, by release of switch 181 a second discontinuity in the energizing circuit for relay 250 is provided at the contacts 248 and 249 so that, even though both relays 256 and

262 are released, the lift relay 250 does not again become energized.

After switch 181 and restart relay 262 are released as aforesaid, the grinding operation continues in the manner previously described so that the newly presented face of the billet 12 is traversed by the grinding wheel 11, the grinding wheel 11 moving forward to the rear edge of the billet 12 and returning to the forward edge of the billet 12. When the grinding wheel 11 again reaches the forward edge of the billet 12 the switching operations just described repeat, the only difference being that stepping relay 295 steps from contact 2 to contact 3. In this manner all four faces of the billet are ground, it being understood that if the billet has a number of faces other than four the stepping relay 295 would be provided with a corresponding number of contacts.

During grinding of the fourth and last face of the billet 12 the arm 294 is on contact No. 4. However, during this portion of the grinding, the arm 294 does not complete a circuit because when arm 294 reaches contact No. 4 the switch 87 is released. However, when the switch 87 is actuated by the clamping mechanism after the fourth face has been ground, switch 87 completes a circuit for energization of reload relay 283. This circuit may be traced from one terminal to the other terminal of transformer 298 through lead 340, the coil of reload relay 283, lead 341, contacts 342 and 343 of switch 87, lead 344, contact No. 4, arm 294 of relay 295 and lead 345. Switch 87 is of the type in which contacts 342 and 343 are connected before contacts 277 and 278 are connected so that relay 283 disconnects its contacts 281 and 282 before contacts 277 and 278 are connected. Thus, relay 283 interrupts the previously described energizing circuit for turning solenoid 196 so that after the fourth face is ground and the billet is unclamped the turning apparatus does not operate to turn the billet. The automatic cycle of operations may be discontinued at this point so that it is necessary for an operator to intervene before grinding will be resumed. Thus, if the circuits hereinafter described are omitted, resumption of the grinding cycle can be initiated by operation of manual loading switch 280 to load a billet on the table 13 and then by operation of manual resetting switch 346, the switch 346 returning the arm 294 of stepping relay 295 to contact numbered 0 and releasing relay 283 to initiate the clamping, grinding and turning operations previously described. It will be noted that when a billet is loaded on the table 13 it will at first be in the position shown in dotted lines in Fig. 5 and, therefore, the switch 199 is actuated preventing energization of turn solenoid 196 when the relay 283 is manually released by operation of switch 346.

#### *Automatic reloading and recycling controls*

In the preferred embodiment of the invention a billet from the loader is automatically transferred to the table of the grinding apparatus and the ground billet is discharged. Also, the cycle of operations is automatically reinitiated. Of course, provision is also made to prevent reinitiation of the grinding operations when there is no billet on the loading rack and the last billet on the table has been ground.

In the preferred embodiment of the invention operation of the reload relay 283 completes a holding circuit for the lift relay 250 so that the grinding wheel 11 will not be lowered as long as the reload relay 283 is energized. This circuit may be traced from lead 251 to lead 264 through lead 347 which is connected to lead 251, contacts 348 and 349 of reload relay 283, leads 350 and 258, contacts 248 and 249 of switch 181, lead 359, contacts 260 and 261 of restart relay 262, lead 263 and the coil of lift relay 250.

In the normal or rest position of the loader ram 120 the switch 149 is actuated and, therefore, when reload relay 283 is operated it completes a circuit for energiza-

tion of the solenoid 147 which causes the ram 120 to move forward. This circuit may be traced between terminals B and A of power source 210 through switch 225, lead 242, contacts 351 and 352 of reload relay 283, lead 353, contacts 351 and 355 of switch 149, lead 356, solenoid 147 and leads 357 and 358. After solenoid 147 is energized, ram 120 moves forward carrying a billet from the land 151 on the loader rack to the rails 98 and 99 and discharging the ground billet to the conveyor 15 in the manner previously described. Although the switch 149 opens when the ram 120 moves forward, de-energization of the solenoid 147 does not stop the ram or cause it to reverse its direction, the valve 145 remaining in the position to which it was actuated by solenoid 147. However, release of the switch 149 prevents at its contacts 359 and 360 resetting of the stepping relay 295 when the new billet is loaded on the table 13 and delays resetting of the relay 295 until the loader has returned to its rest position.

When the ram 120 reaches its forward position and hence places the new billet in the position shown in dotted lines in Fig. 5, the switch 150 is actuated. The loader return solenoid 148 is energized by a circuit extending from lead 242 to lead 358 through lead 361, contacts 362 and 363 of switch 149, lead 364, contacts 365 and 366 of switch 150, lead 367 and solenoid 148. Energization of solenoid 148 causes the ram 120 to return to its rest position and hence causes reactivation of switch 149.

When switch 149 is again actuated it completes the circuit for energizing resetting coil 297 of relay 295. This circuit may be traced from one terminal to the other terminal of transformer 298 through lead 368, contacts 369 and 370 of switch 199 which has been actuated by the billet which was deposited on the table by the loading apparatus, lead 371, contacts 359 and 360 of switch 149, lead 372, contacts 373 and 374 of reload relay 283, lead 375 and resetting coil 297. Energization of resetting coil 297 causes the arm 294 to return to contact No. 0 in the manner previously described. Movement of arm 294 from contact No. 4 opens the energizing circuit for relay 283 and connects contacts 281 and 282 establishing the previously described energizing circuit for the recycle relay 256 and causing the switching and grinding cycles previously described to be reinitiated. The newly deposited billet will then be ground on four sides in the manner previously described and the cycle of operations will continue as long as there is a billet on the loader rack. It will be noted that, after a new billet is placed on the table 13 and the cycle of operations is resumed causing relay 256 to release after its function has been performed, the arm 294 of relay 295 moves to contact No. 1 where it remains during the grinding of the first face of the new billet.

In the event that the loader rack is empty when the ram 120 moves forward, the ram 120 will not deposit a billet on the rails 98 and 99 and hence will not cause operation of switch 199. The ram 120 will, however, discharge the ground billet on the conveyor 15. When switch 199 fails to operate after the ram 120 moves forward, reactivation of switch 149 will not complete a circuit for energization of resetting coil 297 because contacts 369 and 370 are not connected. Accordingly, after the ram 120 returns to its normal or rest position the entire apparatus will remain at rest. Thus, although the grinding wheel will be rotating, neither the table nor the reciprocable beam on which the grinding wheel is mounted will move and the clamping apparatus will remain in the open position. Therefore, when the supply of billets on the loading rack is exhausted, the grinding apparatus will remain at rest until further billets are placed on the loading rack and the manual loading switch 280 is actuated. When the switch 280 is actuated a new billet from the loading rack will be deposited on the table 13 causing the cycle of operations previously described as taking

place after a billet is loaded to be repeated. The cycle of operations will then continue as described above until the new supply of billets is exhausted.

It will be apparent from the above that the particular switches and relays disclosed are not required for providing the operation of the grinding apparatus as aforesaid, since it will be obvious to those skilled in the art that certain of the functions may be accomplished by other well-known substitutes for such switches and relays. For example, in some cases the functions of certain relays may be accomplished by switches and other well-known types of counting apparatus may be substituted for the specific counting apparatus disclosed. Also, it is possible to change the positions of certain of the switches as long as they are operated at the times indicated.

Having thus described my invention with particular reference to the preferred form thereof, it will be obvious to those skilled in the art to which the invention pertains, after understanding my invention, that various changes and other modifications may be made therein without departing from the spirit and scope of my invention, as defined by the claims appended hereto.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. Apparatus for grinding the surface of billets comprising means for reciprocating a billet in a first direction starting from a first position, a grinding wheel, means for reciprocating said grinding wheel in a second direction transverse to said first direction and starting from a second position and automatic control means operable by said reciprocating means for first causing each of said reciprocating means to execute a cycle of reciprocation and for then stopping both said reciprocating means in said positions thereof.

2. Grinding apparatus comprising a grinding wheel means having a starting position, supporting means for supporting a piece to be ground and having a starting position, means for moving both said wheel means and said supporting means for thereby producing relative movement between said wheel means and said supporting means, and automatic control means operable by at least one of said first-mentioned two means for first causing said moving means to move said grinding wheel means and said supporting means away from and back to said positions and for then stopping said movement when said grinding wheel means and said supporting means have returned to their starting positions.

3. Grinding apparatus comprising a grinding wheel means, supporting means for supporting a piece to be ground, means for producing relative movement between said wheel means and said supporting means, first control means operable by at least one of said first-mentioned two means for stopping said movement when a surface of said piece has been traversed by said wheel means, turning means operable by said control means for turning said piece a predetermined amount to expose an unground surface to said wheel, second control means controlled by said turning means for reinitiating said relative movement after said piece is turned, third control means controlled by one of said turning means and said control means and loading means operable by said third control means for discharging said piece after a predetermined number of the surfaces thereof have been ground and for loading a further piece to be ground on said supporting means, and fourth control means controlled by said loading means for reinitiating said relative movement after said further piece has been loaded on said supporting means.

4. Grinding apparatus comprising a grinding wheel means, supporting means for supporting a piece to be ground, means for producing relative movement between said wheel means and said supporting means, first control means operable by at least one of said first-mentioned two means for stopping said movement when a surface of said piece has been traversed by said wheel means,

turning means operable by said control means for turning said piece a predetermined amount to expose an unground surface to said wheel, second control means operable by said piece for reinitiating said relative movement after said piece is turned, and third control means operable by one of said control means for preventing further operation of said second control means after a predetermined number of the surfaces of said piece have been ground.

5. Grinding apparatus comprising a grinding wheel means, supporting means for supporting a piece to be ground, means for producing relative movement between said wheel means and said supporting means, first control means operable by at least one of said first-mentioned two means for stopping said movement when a surface of said piece has been traversed by said wheel means, turning means operable by said control means for turning said piece a predetermined amount to expose an unground surface to said wheel, second control means operable by said piece for reinitiating said relative movement after said piece is turned, third control means operable by one of said control means for discharging said piece after a predetermined number of the surfaces thereof have been ground and for loading a further piece to be ground on said supporting means, and fourth control means operable by at least one of said second and third control means for reinitiating said relative movement after said further piece has been loaded on said supporting means.

6. Apparatus for grinding the surface of billets comprising a reciprocable table for holding a billet and having thereon means for clamping said billet in grinding position, said clamping means including means for driving said clamping means into and out of engagement with said billet, means for reciprocating said table in a path extending in a predetermined direction, a grinding wheel mounted adjacent said table and engageable with said billet, means for reciprocating said wheel in a path extending transversely of the path of said table, first control means for permitting said wheel to engage a face of said billet and for alternatively lifting said wheel from said face of said billet, second control means operable by said wheel reciprocating means in a predetermined position thereof for stopping said wheel reciprocating means, third control means operable by said table reciprocating means in a predetermined position thereof for stopping said table, means operable by one of said reciprocating means for operating said wheel control means to its lift position, and means operable by one of said control means for operating said driving means and thereby driving said clamping means out of engagement with said billet.

7. Apparatus for grinding the surface of billets comprising a reciprocable table for holding a billet and having thereon means for turning said billet and means for clamping said billet in grinding position, means for reciprocating said table in a path extending in a predetermined direction, a grinding wheel mounted adjacent said table and engageable with said billet, means for reciprocating said wheel in a path extending transversely of the path of said table, first control means for permitting said wheel to engage a face of said billet and for alternatively lifting said wheel from said face of said billet, second control means operable by said wheel reciprocating means in a predetermined position thereof for stopping said wheel reciprocating means, third control means operable by said table reciprocating means in a predetermined position thereof for stopping said table, means operable by one of said reciprocating means for operating said wheel control means to its lift position, means operable by one of said control means for releasing said clamping means, fourth control means operable by said clamping means in the release position thereof for operating said billet turning means, fifth control means operable by said billet in its turned position for operating said clamping means and thereby reclamping said billet, and sixth

control means operable by said clamping means when said billet is in said grinding position and after it has been reclamped for restarting said table and said wheel reciprocating means and for releasing said wheel control means and thereby permitting said wheel to engage a face of said billet.

8. Apparatus for grinding the surface of billets comprising a reciprocable table for holding a billet and having thereon means for turning said billet and means for clamping said billet in grinding position, means for reciprocating said table in a path extending in a predetermined direction, a grinding wheel mounted adjacent said table and engageable with said billet, means for reciprocating said wheel in a path extending transversely of the path of said table, first control means for permitting said wheel to engage a face of said billet and for alternatively lifting said wheel from said face of said billet, second control means operable by said wheel reciprocating means in a predetermined position thereof for stopping said wheel reciprocating means, third control means operable by said table reciprocating means in a predetermined position thereof for stopping said table, means operable by one of said reciprocating means for operating said wheel control means to its lift position, means operable by one of said control means for releasing said clamping means, fourth control means operable by said clamping means in the release position thereof for operating said billet turning means, fifth control means operable by said billet in its turned position for operating said clamping means and thereby reclamping said billet, sixth control means operable by one of said billet and said clamping means after said billet has been reclamped for restarting said table and said wheel reciprocating means and for releasing said first control means and thereby permitting said wheel to engage a face of said billet, counting means operable by one of said control means for counting the number of times said last-mentioned control means is operated, seventh control means operable by said counting means after a predetermined number of operations of said latter means for temporarily suspending further operation of said control and said reciprocating means.

9. Apparatus for grinding the surface of billets comprising a reciprocable table for holding a billet and having thereon means for turning said billet and means for clamping said billet in grinding position, means for reciprocating said table in a path extending in a predetermined direction, a grinding wheel mounted adjacent said table and engageable with said billet, means for reciprocating said wheel in a path extending transversely of the path of said table, first control means for permitting said wheel to engage a face of said billet and for alternatively lifting said wheel from said face of said billet, second control means operable by said wheel reciprocating means in a predetermined position thereof for stopping said wheel reciprocating means, third control means operable by said table reciprocating means in a predetermined position thereof for stopping said table, means operable by one of said reciprocating means for operating said wheel control means to its lift position, means operable by one of said control means for releasing said clamping means, fourth control means operable by said clamping means in the release position thereof for operating said billet turning means, fifth control means operable by said billet in its turned position for operating said clamping means and thereby reclamping said billet, sixth control means operable by said billet in said grinding position and after it has been reclamped for restarting said table and said wheel reciprocating means and for releasing said first control means and thereby permitting said wheel to engage a face of said billet, counting means operable by one of said control means for counting the number of times said last-mentioned control means is operated, seventh control means operable by said counting means after a predetermined

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number of operations of said latter means for maintaining said clamping means in its release position, and means for reoperating said clamping means.

10. Apparatus for grinding the surface of billets comprising a reciprocable table for holding a billet and having thereon means for turning said billet and means for clamping said billet in grinding position, means for reciprocating said table in a path extending in a predetermined direction, a grinding wheel mounted adjacent said table and engageable with said billet, means for reciprocating said wheel in a path extending transversely of the path of said table, wheel control means for permitting said wheel to engage a face of said billet and for alternatively lifting said wheel from said face of said billet, means operable by said wheel reciprocating means in a predetermined position thereof for stopping said wheel reciprocating means and for operating said wheel control means to its lift position, means operable by said table reciprocating means in a predetermined position thereof and by said wheel reciprocating means in said predetermined position thereof for stopping said table, means operable by said wheel control means in said lift position for releasing said clamping means, means operable by said clamping means in the release position thereof for operating said billet turning means, recycle means operable by said billet in its turned position for operating said clamping means and thereby reclamping said billet, further means operable by said billet in said grinding position after it has been reclamped for restarting said table and said wheel reciprocating means and for releasing said wheel control means and thereby permitting said wheel to engage a face of said billet, counting means operable by said further means for counting the number of times said further means is operable, control means operable by said counting means after a predetermined number of operations of said latter means for preventing operation of said turning means and maintaining said clamping means in its release position, and means for resetting said counting means and for reoperating said clamping means.

11. Apparatus for grinding the surface of billets comprising a reciprocable table for holding a billet and having thereon means for turning said billet and means for clamping said billet in grinding position, means for reciprocating said table in a path extending in a predetermined direction, a grinding wheel mounted adjacent said table and engageable with said billet, means for reciprocating said wheel in a path extending transversely of the path of said table, pressure control means for regulating the pressure applied to a billet in accordance with the load on said wheel, wheel control means for permitting said wheel to engage a face of said billet and for alternatively lifting said wheel from said face of said billet, means operable by said wheel reciprocating means in a predetermined position thereof for stopping said wheel reciprocating means and for operating said wheel control means to its lift position, means operable by said table reciprocating means in a predetermined position thereof and by said wheel reciprocating means in said predetermined position thereof for stopping said table, means operable by said wheel control means in said lift position for releasing said clamping means, means operable by said clamping means in the release position thereof for operating said billet turning means, recycle means operable by said billet in its turned position for operating said clamping means and thereby reclamping said billet, further means operable by said billet in said grinding position after it has been reclamped for restarting said table and said wheel reciprocating means and for releasing said wheel control means and thereby permitting said wheel to engage a face of said billet, counting means operable by said further means for counting the number of times said further means is operated, billet loading and discharging means for discharging a ground billet from said table and for loading an unground billet

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on said table, control means operable by said counting means after a predetermined number of operations of said latter means for operating said loading and discharging means and for preventing operation of said turning means and maintaining said clamping means in its release position, and means operable jointly by said loading means in a predetermined position thereof and by said recycle means for resetting said counting means and for reoperating said clamping means whereby said unground billet is placed in grinding position and ground, said recycle means also being operable by said ground billet when loaded on said table, and means controlled by said recycle means for preventing operation of said clamping means when said recycle means is unoperated.

12. Apparatus for grinding the surface of billets comprising a reciprocable table for holding a billet and having thereon electrically controllable means for turning said billet and electrically controllable means for clamping said billet in grinding position, electrically controllable means for reciprocating said table in a path extending in a predetermined direction, a grinding wheel mounted adjacent said table and engageable with said billet, electrically controllable means for reciprocating said wheel in a path extending transversely of the path of said table, pressure control means for regulating the pressure applied to a billet in accordance with the load on said wheel, electrically controllable wheel control means for permitting said wheel to engage a face of said billet and for alternatively lifting said wheel from said face of said billet, first switch means connected to said wheel reciprocating means and operable by said wheel reciprocating means in a predetermined position thereof for stopping said wheel reciprocating means and connected to said wheel control means for operating said wheel control means to its lift position, second switch means operable by said table reciprocating means in a predetermined position thereof and electrically interconnected with said first switch means for stopping said table when both said first and said second switch means are operated, third switch means operable by said wheel control means in said lift position and connected to said clamping means for releasing said clamping means, fourth switch means operable by said clamping means in the release position thereof and connected to said billet turning means for operating said billet turning means, recycle means including fifth switch means operable by said billet in its turned position and connected to said clamping means for operating said clamping means and thereby reclamping said billet, sixth switch means operable by said billet in said grinding position after it has been reclamped and connected to said table and said wheel reciprocating means and to said wheel control means for restarting said table and said wheel reciprocating means for releasing said wheel control means and thereby permitting said wheel to engage a face of said billet, electrical counting means operable by said fourth and sixth switch means for counting the number of times said fourth switch means is operated, billet loading and discharging means for discharging a ground billet from said table and for loading an unground billet on said table, switching means operable by said counting means after a predetermined number of operations of said latter means for operating said loading and discharging means and connected to said turning and said clamping means for preventing operation of said turning means and maintaining said clamping means in its release position, and seventh switch means operable by said loading means in a predetermined position thereof and interconnected with said recycle means, said counting means and said clamping means for resetting said counting means and for reoperating said clamping means whereby said unground billet is placed in grinding position and ground, said fifth switch means also being operable by said ground billet when loaded on said table, and said clamping means being jointly controlled by said seventh switch means and said recycle means whereby

operation of both said fifth and seventh switch means is required for operation of said clamping means after said loading means is operated.

13. In apparatus for surface grinding billets of the class having a billet holding table, the combination therewith of a billet loading device positioned adjacent one longitudinal side of said table, said loading device comprising a billet storage rack for holding a series of billets one behind another in generally parallel relation to said table, said rack having a forwardly and downwardly inclined portion for gravity feed of said billets and a land portion at the forward lower end of said incline for arresting the foremost of said billets, a reciprocable pusher ram movable in a direction transverse said table and provided with a rotatable link for successively engaging the foremost billet of said series disposed on said land portion and feeding it onto said table upon the forward movement of said ram, said ram also being provided with a further rotatable link for successively engaging a billet which has been ground and discharging it from said table simultaneously with the feeding of a billet onto said table, and means for reciprocating said ram forwardly on its feed stroke and rearwardly into position for a succeeding cycle of operation, and said table having stop means thereon permitting forward movement of a billet thereon but preventing rearward movement thereof.

14. Loading and discharging apparatus comprising a rack having an inclined upper surface, a material receiving land mounted adjacent the lower end of said rack, a ram reciprocable forwardly away from said rack and rearwardly toward said rack, said ram having a portion for receiving and carrying said material which portion is movable with said ram to a position adjacent said land, said ram having a pair of links mounted thereon in positions spaced apart in the direction of reciprocation of said ram with one link of said pair mounted on one side of one said portion and with the other link of said pair mounted on the other side of said portion, said links normally extending upwardly from said portions and the upper ends thereof being rotatable forwardly with respect to the forward direction of movement of said ram, and means connected to said ram for reciprocating said ram.

15. Billet loading and discharging apparatus comprising a rack having an inclined upper surface, a billet land mounted adjacent the lower end of said rack and having its upper surface spaced downwardly from said lower end, a ram mounted below said rack, said ram being reciprocable forwardly away from said rack and rearwardly toward said rack, said ram having a pair of spaced portions for receiving and carrying a billet and having two pairs of links mounted thereon, the links of each pair being spaced apart in the direction of reciprocation of said ram and one link of one said pair being mounted on one side of one said portion and the other link of said one pair being mounted on the other side of said one portion and the links of the other pair being similarly

mounted with respect to the other portion, said links normally extending upwardly from said portions and the upper ends thereof being rotatable only forwardly with respect to the forward direction of movement of said ram, and means connected to said ram for reciprocating said ram.

16. Billet loading and discharging apparatus comprising a rack having an inclined upper surface, a billet land mounted adjacent the lower end of said rack and having its upper surface spaced downwardly from said lower end a distance less than the thickness of a billet to be loaded by said apparatus, a ram mounted below said rack, said ram being reciprocable in a horizontal path intersecting the plane of the upper surface of said rack at an acute angle and reciprocable forwardly away from said rack and rearwardly toward said rack, said ram having a pair of spaced portions for receiving and carrying a billet and having two pairs of links mounted thereon, the links of each pair being spaced apart in the direction of reciprocation of said ram and one link of one said pair being mounted on one side of one said portion and the other link of said one pair being mounted on the other side of said one portion and the links of the other pair being similarly mounted with respect to the other portion, said links normally extending upwardly from said portions and the upper ends thereof being rotatable only forwardly with respect to the forward direction of movement of said ram and downwardly below said portions, said ram having a rest position in which said portions are adjacent said land and two of said links are forwardly of said land and two of said links are rearwardly of said land, and fluid-actuated cylinder and piston means connected to said ram for reciprocating said ram.

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