July 2, 1957 W. K. LOWE 2,797,532

BILLET GRINDER

Original Filed April 1, 1952 3 Sheets-Sheet 1

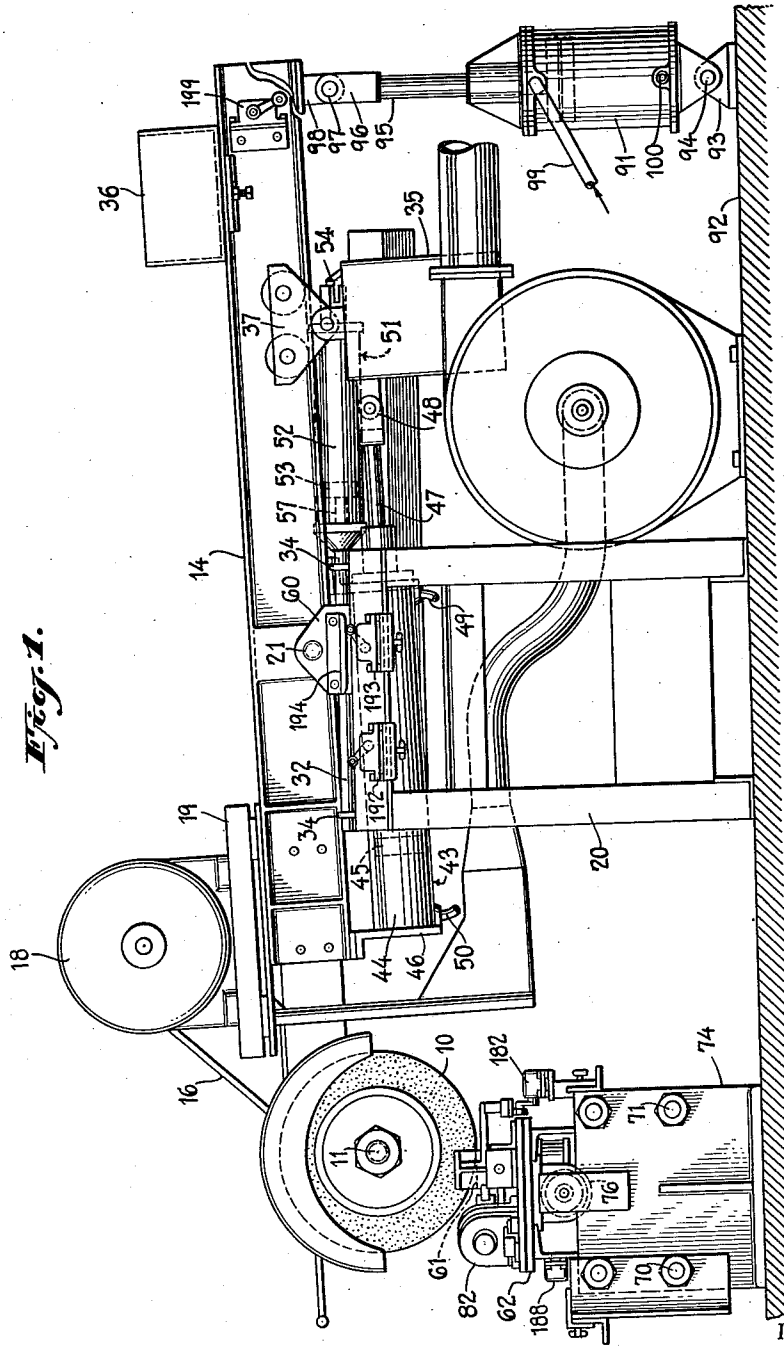

Fig. 1.

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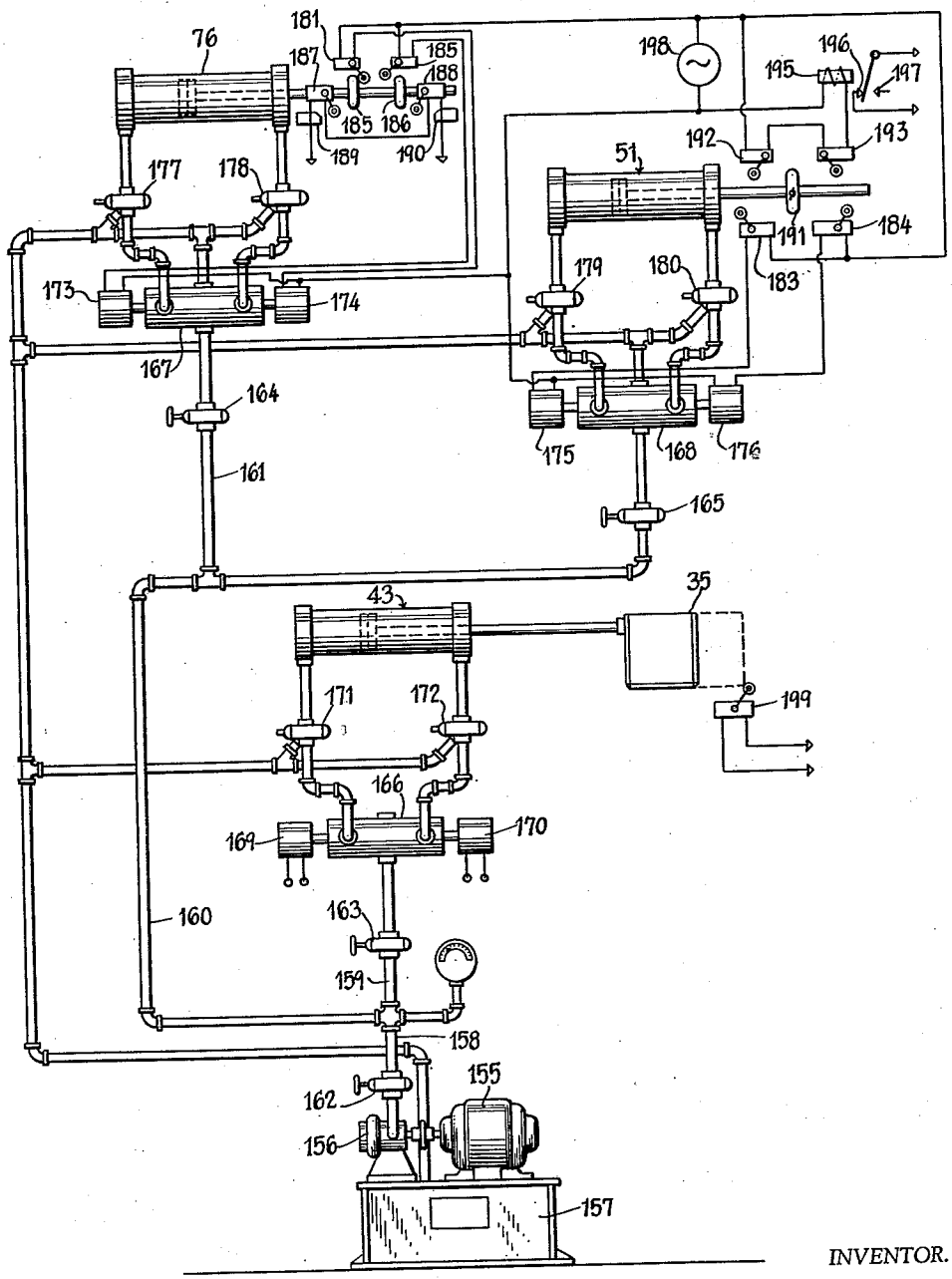
Fig. 2.



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BILLET GRINDER

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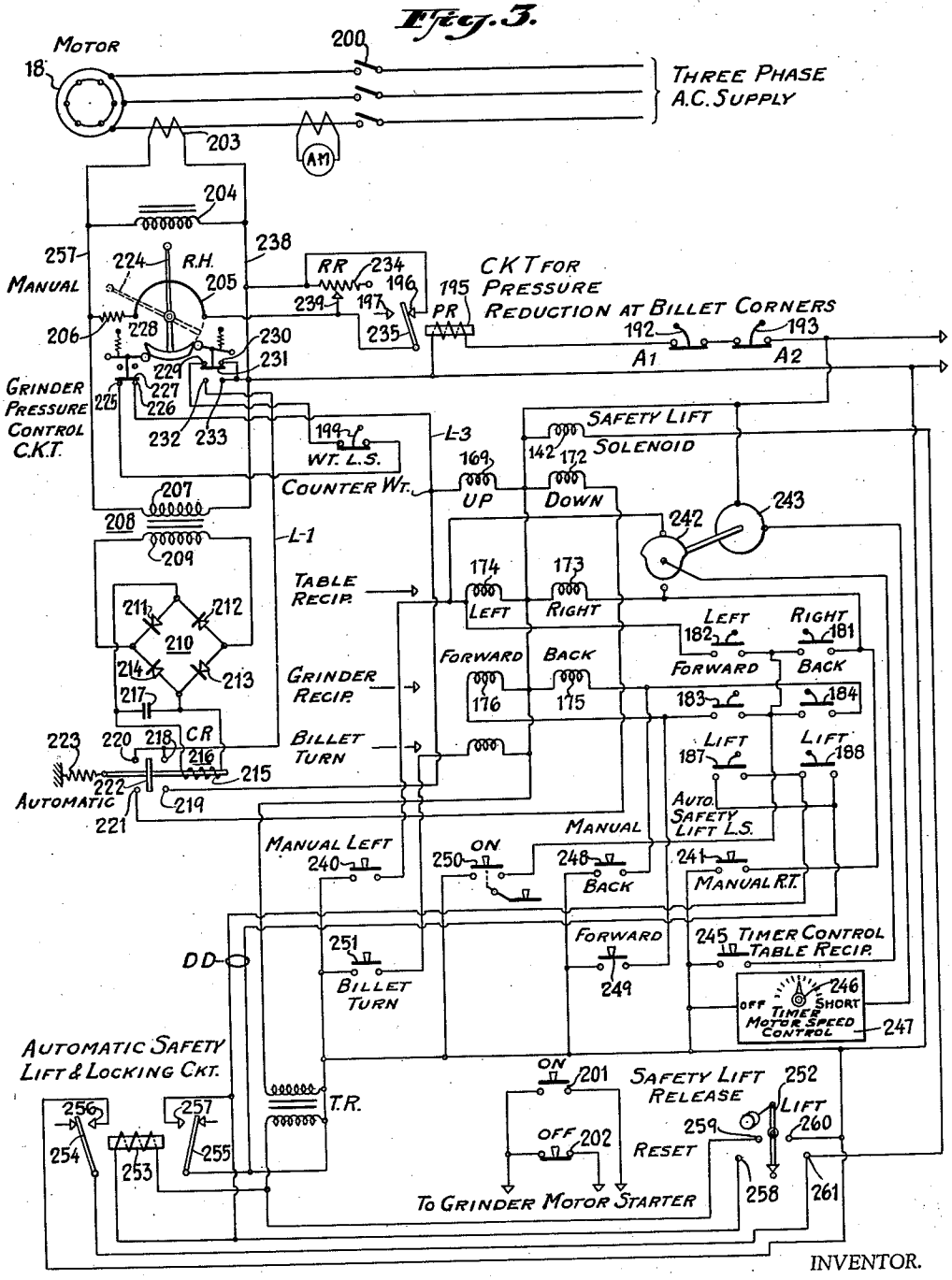
Fig. 3.



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United States Patent Office

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Patented July 2, 1957

2,797,532

BILLET GRINDER

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Original application April 1, 1952, Serial No. 279,789, now Patent No. 2,726,490. Divided and this application March 23, 1955, Serial No. 496,255

6 Claims. (Cl. 51—45)

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

This application is a division of my application Ser. No. 279,789, filed April 1, 1952, and now Patent No. 2,726,490, and relates to the billet grinding apparatus disclosed therein and particularly to controls for such apparatus for reducing the pressure of the grinding wheel on the billet as it approaches the corners thereof to prevent thereby undesirable rounding of the corners.

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

Fig. 1 is a side elevation view of the preferred embodiment of the invention and corresponds to Fig. 4 of my United States Patent No. 2,726,490;

Fig. 2 is a schematic diagram illustrating the system employed in the preferred embodiment of the invention for reciprocating a billet and the grinding wheel and for controlling the load on the grinding wheel; and

Fig. 3 is an electric circuit diagram showing the electrical circuits which may be employed for controlling the grinding apparatus of the invention.

Referring to Fig. 1 which shows a side elevation view of billet grinding apparatus incorporating the invention and which is described in detail in my patent above-mentioned, it will be seen that a grinding wheel **10** is mounted on a rotatable shaft **11** which is mounted on a pair of bearings which are supported on the end of a beam **14**. The grinding wheel **10** is drivingly connected by means of belts **16** to an electric motor **18**.

The motor **18** is secured to a platform **19** which is fastened to the beam **14** at a point thereon spaced from the pivot point of the beam **14**. The beam **14** is pivotally mounted on a frame **20** by means of a shaft **21**.

The shaft **21** is rotatably mounted on a pair of plates **60** which are slidably mounted on a pair of shafts whose axes are parallel to each other and one of which is shown in Fig. 1 and is identified by the numeral **32**. The shafts are secured to the frame **20** by bolts **34**.

It will be noted from the drawings that the grinding wheel **10** and its associated driving motor **18** are both mounted on the same side of the pivot shaft **21** and therefore their weight tends to press the beam **14** downward at the side of the pivot shaft **21** on which the wheel and motor are mounted. A movable counter-weight **35** and a fixed counter-weight **36** are provided on the opposite side of the shaft **21** so as to counter-balance the weight of the wheel **10** and the motor **18**. The counter-weight **35** is suspended from the beam **14** as described in the above-mentioned patent.

The counter-weight **35** is adjustable along the beam **14** by fluid actuated cylinder and piston means **43** which comprises a cylinder **44** and a piston **45** and which is mounted on the underside of the beam **14**. The cylinder **44** is secured to the beam **14** in any suitable manner, such as by a bracket **46**, and the piston rod **47** is connected to the counter-weight **35** by a pivotal coupling **48**. The cylinder has a pair of flexible fluid lines **49** and **50** for the purpose of admitting fluid to the cylinder and thereby moving the piston rod **47** in either of two directions.

The beam **14** is reciprocated by fluid actuated cylinder and piston means **51** comprising a cylinder **52** and a piston **53**. The cylinder **52** is secured to the frame **20** by means of a bracket **54**. The piston **53** is connected to a piston rod **57** which is secured to the plate **60** as described in the above-mentioned patent.

A billet to be ground such as billet **61** is mounted on a table **62** which is movably supported on rails **70** and **71** which are mounted on a frame **74**. Fluid actuated cylinder and piston means **76** is provided to move the table **62** back and forth in a direction parallel to the longitudinal axis of the billet **61**. The cylinder and piston means **76** has a pair of flexible fluid lines (not shown) connected thereto for supplying fluid thereto and for thereby causing the table **62** to move in either of two directions along the rails **70** and **71**.

The billet **61** preferably is clamped on top of the table **62** by air actuated cylinder and piston means described in Patent No. 2,726,490, one portion of which, cylinder and piston means **82**, is shown in Fig. 1.

A quick-operating, air actuated cylinder and piston means **91** is connected between the end of beam **14** and the foundation **92**. One end of the means **91** is pivotally connected to a bracket **93** secured to the foundation **92** by a pin **94**, and the piston rod **95** is connected to the end of the beam **14** by a yoke **96**, a pin **97** and a bracket **98**. Air under pressure is supplied to the means **91** through a hose **99** and is exhausted from the means **91** through the port **100**. When the grinding apparatus is in operation the cylinder and piston means **91** is inoperative; that is, it exerts substantially no force on the beam **14** and hence the pressure on the grinding wheel **10** is determined substantially by the position of the counterweight **35**. However, in the event that it is desired to lift the grinding wheel **10** quickly either from the billet **61** or because the wheel has overrun the billet, then air under pressure is supplied to the means **91** through the hose **99**, and the end of the beam **14** to which the rod **95** is attached is moved downwardly.

In Fig. 2 there is shown schematically the oil operated cylinder and piston means and their connections both with the valves which produce operation thereof and the electrical controls which are operated thereby. Referring to Fig. 2, oil is supplied under pressure by a motor **155** and a pump **156** from a reservoir **157**. The oil is conveyed to the cylinder and piston means over the lines **158**, **159**, **160** and **161**, line **158** being provided with a pressure relief valve **162** and lines **159**, **160** and **161** being provided with shut-off valves **163**, **164** and **165**. The supply of fluid to the cylinder and piston means **43**, **76** and **51** is controlled respectively by electrically operable valves **166**, **167** and **168**. The valve **166** is provided with a pair of solenoids **169** and **170** which operate the valve, and pressure relief valves **171** and **172** are connected between valve **166** and cylinder and piston means **43**. The valves **167** and **168** are also equipped with pairs of solenoids **173**—**174** and **175**—**176**, and pressure relief valves **177**, **178**, **179** and **180** are connected in the lines between the valves **167** and **168** and the cylinders **51** and **76**.

The solenoids **169** and **170** of valve **166** are controlled by the circuit shown in Fig. 3 and described in connection therewith, and the valves **167** and **168** are controlled respectively by the limit switches **181**—**182**

mounted on the frame **74** to the rear of table **62** (see Fig. 1 and Patent No. 2,726,490) and switches **183**—**184** mounted on the frame **20** as described in Patent No. 2,726,490. Limit switches **181** and **182** are actuated by a pair of stops **185** and **186** movable with the table **62** and safety lift switches **187** and **188** carried by the table **62** are controlled by a pair of stationary but adjustable stops **189** and **190** as described in Patent No. 2,726,490.

Limit switches **183** and **184** are operated by a stop **191** carried by the beam **14** as described in Patent No. 2,726,490. Switches **192** and **193** are also mounted on the frame **20** to the right of the beam **14**, as indicated in Fig. 1 and are operated by a cam **194** also shown in Fig. 1. These switches **192** and **193** are employed in connection with relay **195** to reduce the pressure on the grinding wheel **10** before the wheel reaches the corners of the billet **61** and their operation will be described in greater detail in connection with Fig. 3. Relay **195** has contacts **196** and **197** and is connected in series with the switches **192** and **193** and the source **198**.

A limit switch **199** is mounted on the end of beam **14**, as is best shown in Fig. 1, and is engageable with the bracket **37** which supports the counter-weight **35** so as to deenergize the solenoid **169** when the counter-weight **35** is at its rearmost position.

Referring to Fig. 3, which is an electrical circuit diagram of the electrical system employed for controlling the grinding apparatus of the invention, it will be seen that the motor **18** is connected to a three-phase source through contacts **200** which are controlled by the manually operable switches **201** and **202**. The force applied to the grinding wheel **10** to hold it against the billet **61** is automatically adjusted in accordance with the load on the grinding wheel **10**. To accomplish this, I employ the circuit shown in the upper left-hand side of Fig. 3. A transformer **203**, which may be, for example, a current transformer, is coupled to the input circuit of the motor **18** and when the motor **18** is in operation a voltage is produced across the secondary of the transformer **203** which is shunted by a reactance **204**, a manually variable resistor **205** in series with a fixed resistor **206** and the primary **207** of the transformer **208**. The secondary **209** of the transformer **208** is connected to diagonally opposite points on a bridge rectifier **210** which comprises dry rectifiers **211**, **212**, **213** and **214**, which may, for example, be selenium or copper oxide rectifiers. The output of the bridge rectifier **210** is connected to the energizing coil **215** of a three-position relay **216** which may be shunted by a filter condenser **217**. The relay **216** has two pairs of contacts **218**—**219** and **220**—**221** and an armature **222**. The armature **222** is connected to an adjustable spring **223** which causes the armature **222** to connect the contacts **20** and **221** unless the coil **215** is energized to at least a predetermined extent by the rectifier **210**. Thus, when only a small current is flowing through the coil **215**, the contacts **220** and **221** are connected together by the armature **222**, but when the current exceeds a predetermined level, determined by the sensitivity of the relay **216** and the tension on the spring **223**, contacts **220** and **221** are disconnected. As the current through coil **215** is further increased, the armature **222** moves toward the contacts **218** and **219** until finally when a second predetermined current level is reached the contacts **218** and **219** are connected together.

When the handle **224** of the variable resistor **205** is in the vertical position shown, the contacts **225** and **226** are connected together by the contactor **227** which is moved into its downward position by the actuator **228** on the end of the handle **224** and the contacts **229** and **230** are connected together by the contactor **231**, but when the handle **224** is moved from the vertical position shown to some position such as the one shown in dotted lines the contacts **225** and **226** are disconnected and the contacts **232** and **233** are connected together by the contactor **231**. In the vertical position of the handle **224** the automatic operation of the grinding apparatus is discontinued and the grinding wheel **10** is completed lifted off the billet **61**, but when automatic operation is desired, the handle **224** is moved to the left from the vertical position shown in solid lines to the position shown in dotted lines and the contacts **218** and **220** are thereby connected to terminal B of the power source.

Contact **219** is connected to one end of the solenoid or coil **169** employed to actuate the valve **166** and the opposite end of solenoid **169** is connected to terminal A. Also, contact **221** is connected to one end of solenoid or coil **170** which operates the valve **166** in the opposite direction and the other end of solenoid **170** is connected to the terminal A. Thus, when contacts **218** and **219** are connected together by the armature **222**, a circuit for the solenoid **169** which actuates the valve **166** in such a direction that the counter-weight **35** is moved rearwardly of the beam **14**, and hence in such a direction that the force on the grinding wheel **10** is decreased, is established from terminal B of the power source through contacts **232** and **233** which have been connected by operation of the handle **224** to the position shown in dotted lines as described above, contactor **231**, contacts **218** and **219**, solenoid **169** and back to terminal A. However, when contacts **220** and **221** are connected together by armature **222**, a circuit is completed for energizing solenoid **170** (which moves the counter-weight **35** toward the grinding wheel **10**) from terminal B through contacts **232** and **233**, contactor **231**, contacts **220** and **221**, solenoid **170** and back to terminal A. When the armature **222** is in a position intermediate the contacts **220**—**221** and **218**—**219**, neither of the pairs of contacts is connected together and hence neither of the solenoids **169** and **170** is energized. When neither solenoid **169** and **170** is energized, the counter-weight **35** remains in a fixed position.

Since the current in coil **215** varies with the current in the input circuit of the motor **18**, the position of the counter-weight **35** is controlled by the current in the input circuit of motor **18** and hence by the energy consumed by the motor **18**. Consequently, when the input current to the motor **18** is increased above a predetermined value because of an increase in the load on the grinding wheel **10**, the valve **166** is operated so that the counter-weight **35** moves away from the grinding wheel **10**. Also, when the input current to the motor **18** decreases below a predetermined value because of a decrease in the load on the grinding wheel **10**, the valve **166** is operated so that the counter-weight moves toward the grinding wheel **10**. In this manner, the load on the motor **18**, and hence the rate at which material is removed from the billet **61**, and the load on the grinding wheel **10** may be maintained at a substantially constant value.

The value of the load on the motor **18** may be adjusted by adjustment of the spring **223** and by adjustment of the position of the handle **224**. Because of the well-known characteristics of a current transformer, variations of the load on the output winding of the transformer **203** will cause corresponding variations in the output voltage of the transformer **203**. Adjustment of the handle **224** changes the value of the resistor **205** in series with the resistor **206** and hence changes the load on the transformer **203** and the voltage of the primary **207** at the transformer **208**. Thus, if the handle **224** is moved to the position shown in dotted lines, the value of the resistor **205** is decreased causing an increase in the load on the transformer **203** and the voltage at the primary winding **207** is correspondingly decreased. When the handle **224** is slightly to the left of the vertical position shown, the resistor **205** has the maximum value that can be attained under automatic operating conditions and hence the voltage at the primary winding **207** is at its maximum value under these conditions. The current

in the coil 215 changes with and in the same direction as the voltage across the primary winding 207.

In accordance with the invention, the downward force on the grinding wheel 10 is reduced as the grinding wheel 10 approaches the forward and rear corners of the billet 61. This feature is desirable not only because it prevents sudden dropping of the grinding wheel if it goes over the front and rear corners of the billet 61, but also because it reduces rounding of these corners of the billet. Adjustable resistor 234, relay 195 and its associated armature 235 and contact 196 and switches 192 and 193 are provided to accomplish this control of the force on the grinding wheel 10.

Referring to Fig. 1, the switches 192 and 193 which are adjustably mounted on the frame 20 are adjusted to such positions that switch 192 is operated by cam 194 when the billet contacting surface of the grinding wheel 10 is close to the forward edge of the billet 61 and the switch 193 is operated by the cam 194 when the billet contacting surface of the grinding wheel 10 is close to the rear corner of the billet 61. As appears in Fig. 3, the relay 195 normally is energized by a circuit which may be traced from terminal A through switches 192 and 193, through the coil of relay 195 and back to terminal B. When the relay 195 is energized, the armature 235 is pulled up against contact 196 and hence the resistor 234 is shorted out. With resistor 234 shorted out, the load on the transformer 203 and therefore the voltage at the primary winding 207 is determined by the setting of handle 224 and resistor 206 and hence the downward force on the grinding wheel 10 is determined by the setting of the handle 224. However, when either of the switches 192 and 193 is operated by the cam 194, the energizing circuit for relay 195 is broken and the armature 235 falls back against contact 197. The resistance then appearing between the leads 237 and 238 is increased by the value of the resistance 234. Because of the increase of resistance between leads 237 and 238 and the consequent decrease of the load on the transformer 203 a larger voltage will appear across the primary 207 than when the resistor 234 is shorted out. A larger voltage across the primary 207 produces a larger current in the coil 215 and pulls armature 222 against contacts 218 and 219 closing the circuit for the solenoid 169 which, as explained previously, moves the counter-weight 35 rearwardly away from the grinding wheel 10 and reduces the downward force on the grinding wheel 10. As soon as the counter-weight 35 has moved rearwardly enough to reduce the downward force on the grinding wheel 10, and hence the input current to the motor 18, an amount sufficient to compensate for the increase in current produced in coil 215 by the insertion of the resistor 234 in series with resistors 205 and 206, the armature 222 will resume its intermediate position and the counter-weight 35 will stop. It is thus apparent that when either of the switches 192 and 193 is operated, the downward force of the grinding wheel 10 is decreased and the amount of decrease is determined by the setting of control 239 for resistor 234.

It will also be apparent from a consideration of the above and from an examination of the circuit diagram in Fig. 3 that the downward force on the grinding wheel 10 may be manually adjusted at any time during the operation of the grinding apparatus by movement of the handle 224. In its position nearest the horizontal in the counter-clockwise direction, the handle will reduce the voltage across the primary 207 to the minimum for a predetermined value of the current supplied to the motor 18. Therefore, in order to separate armature 222 from the contacts 220 and 221, a higher motor current will be required, and the counter-weight 35 will cause the wheel 10 to press with maximum force against the billet 61 and, as the handle 224 is moved toward the vertical position shown in solid lines, the downward force is decreased until in some position just prior to the vertical position the minimum force which it is possible to obtain with an automatic control circuit is applied to the grinding wheel 10. However, the circuit shown is so arranged that by motion of the handle 224 into its vertical position the counter-weight 35 is moved to the rear end of the beam 14. When the counter-weight 35 is at the rear end of the beam 14, the wheel 10 is completely lifted from the billet 61, and normally the grinding wheel is in this position when the grinding apparatus is idle. Therefore, it is desirable that when the counter-weight 35 is in its rearmost position, the solenoid 169 is deenergized. To accomplish this result the arm 228 on the handle 224 moves contactor 227 against contacts 225 and 226, connecting contacts 225 and 226 together, and the arm 228 permits the contactor 231 to connect contacts 229 and 230 together. Thus, a circuit may be traced from terminal B through contacts 229 and 230, contactor 231, switch 199, contacts 225 and 226, contactor 227, solenoid 169 and back to terminal A, and when the handle 224 is first moved to the vertical position, the solenoid 169 is energized causing the counter-weight 35 to move rearwardly along the beam 14. However, when the counter-weight 35 reaches its rearmost position, it operates switch 199 and opens the last-mentioned energizing circuit for solenoid 169. The counter-weight 35 remains in the rearmost position until the handle 224 is again moved from its vertical position and places the counter-weight 35 under the automatic control circuit previously described.

Solenoids 173 and 174 which control the operation of valve 167, and hence the reciprocation of the table 62, may be energized through manually operable switches 240 and 241, through contactor 242 rotatable by motor 243 and through the table controlled switches 181 and 182. Switches 240 and 241 are provided in the event that it is desired to control the reciprocation of the table 62 manually and the switches 181 and 182 are provided for automatic control of the table reciprocation, such switches being operated as described in Patent No. 2,726,490.

If there is a portion of the surface of the billet 61 which requires additional grinding, a relatively short reciprocatory stroke of the table may be provided by operation of the timer control switch 245 and the control 246 on the timer motor speed control apparatus 247, the latter apparatus being connected to the motor 243 and used to control the speed thereof. Operation of the switch 245 supplies electrical energy to the contactor 242 which alternately energizes solenoids 173 and 174 and the speed of the motor 243 as adjusted by the control 246 determines the times at which solenoids 173 and 174 are alternately energized and hence the length of the path of movement of the table 62.

Switches 248 and 249 are provided for manual control of the reciprocation of the beam 14, and switches 183 and 184, as indicated previously, provide automatic control of the reciprocation of the beam 14 in the manner described in Patent No. 2,726,490.

A manually operable switch 250 is provided so that switches 181, 182, 183 and 184 may be disabled when it is desired to stop the automatic reciprocation of the beam 14 and the table 62. With switch 250 in its "off" position the manual switches 240, 241, 248 and 249 may be employed to position the beam 14 or the table 62.

The billet turning solenoid or coil 150 which controls the turning of the billet 61 as described in Patent No. 2,726,490 may be energized by operation of the manually operable switch 251.

The safety lift solenoid or coil 142 which controls the supply of air to cylinder and piston means 91 may be energized by the switches 187 and 188 which are mounted and operated as described in Patent No. 2,726,490 and it may be energized by the manually operable switch 252. If the wheel 10 passes beyond the end of a billet one of the switches 187 and 188 is operated and energizes relay

253 which has armatures 254 and 255 and contacts 256 and 257. When relay 253 is energized it pulls armature 254 against contact 256 and armature 255 against contact 257. Engagement of the armature 255 with the contact 257 closes an energizing circuit for the relay 253 and keeps the relay 253 operated until the relay is reset by the switch 252, as indicated hereinafter. Armature 254, when pulled against the contact 256, closes an energizing circuit for the solenoid 142 and hence causes operation of the air actuated cylinder and piston means 91. As previously described, the air actuated cylinder and piston means 91 pulls the rear of the beam 14 downwardly and lifts the wheel 10 off the billet 61.

If one of the switches 187 and 188 is operated, the cylinder and piston means 91 remains operated as long as the relay 253 is energized. Because of the holding circuit through armature 255 and contact 257, the relay 253 remains energized until switch 252 is operated to its reset position in which the contacts 258 and 259 are connected together. When contacts 258 and 259 are connected together, the relay 253 is short-circuited and the armatures 254 and 255 fall back against their idle contacts.

If at any time it becomes necessary to lift the wheel 10 quickly from the billet 61, the manually operable switch 252 may be operated to its lift position so as to connect contacts 260 and 261 together. Operation of the switch 252 in this manner also energizes the safety lift solenoid 142 and actuates the cylinder and piston means 91. However, as soon as the switch 252 is returned to its intermediate or rest position, the solenoid 142 is de-energized and cylinder and piston means 91 becomes idle.

Transformer 262 is provided for the purpose of supplying the required voltage to the relay 253 and may be ommited if a relay operating at the voltage of the source connected to terminals A—B is employed.

From the above it will be seen that when the appropriate switches are operated the table 62 is reciprocated along a path which is parallel to the axis of the grinding wheel 10 and the grinding wheel 10 is reciprocated crosswise of the table 62. The rate at which the table 62 and the beam 14 are reciprocated may be controlled by control of the pressure of the fluid supplied to the cylinders 76 and 43 and by controlling the rate at which the fluid is supplied to these cylinders. In the preferred form of the invention the grinding wheel 10 and the beam 14 are moved at a relatively slow rate and the table 62 is moved at a relatively rapid rate so that the table 62 is moved back and forth several times during the time it takes the grinding wheel 10 to move from the rear corner of the billet 61 to the front corner of the billet 61.

Once the switches 183, 184, 192, 193, 181 and 182 have been set to the positions described above, the grinding wheel 10 will completely traverse the surface of a billet one or more times without any action on the part of an operator. When the surface of a billet has been ground to the desired extent, the automatic reciprocation of the table 62 and the beam 14 is discontinued, and the billet is unclamped, turned and reclamped so that a new surface of the billet may be ground by a similar operation.

Although we have illustrated and described the load controlling apparatus of the invention in connection with a grinding wheel that is mounted on a pivotally mounted beam, it will be apparent that such controlling apparatus may also be used to control the load on a grinding wheel mounted in other ways. Also, it will be apparent to those skilled in the art that the stops and limit switches for controlling the reciprocation of the beam 14 and the table 62 and for controlling the lifting of the grinding wheel 10 may be differently arranged.

Having thus described the 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 the invention, that various changes and other modifications may be made therein without departing from the spirit and scope of the invention, as defined by the claims appended hereto.

I claim:

1. Grinding apparatus comprising a table for holding a piece to be ground, means for mounting a grinding wheel, means for reciprocating said mounting means in a predetermined path, means for applying a force to said mounting means in the direction of said table and for adjusting the force on said mounting means and means actuatable by said means for reciprocating said mounting means for operating said force applying and adjusting means in a direction which reduces said force from a first predetermined value to a second predetermined value greater than zero.

2. Grinding apparatus comprising a table for holding a piece to be ground, means for reciprocating said table connected to said table, means for mounting a grinding wheel adjacent said table, a grinding wheel on said mounting means, means for reciprocating said mounting means in a predetermined path connected to said mounting means, means for applying a force in the direction of said table and for adjusting the force on said mounting means, whereby the pressure of said grinding wheel against said piece may be controlled, and means for operating said adjusting means in a direction to effect a reduction in the pressure of said wheel against said piece while maintaining said wheel in contact with said piece, said operating means being actuatable by said means for reciprocating said mounting means in at least one predetermined position thereof.

3. Grinding apparatus comprising a table for holding a piece to be ground, a grinding wheel, means mounting said grinding wheel adjacent said table, means for reciprocating said mounting means connected to said mounting means, means for adjusting the pressure of said grinding wheel against said piece connected to said mounting means, control means connected to said adjusting means for varying the pressure of said grinding wheel on said piece in accordance with the load on said grinding wheel and means for reducing said pressure by a predetermined amount connected to said control means, the reduced value of said pressure being greater than zero and said reducing means being actuatable by said reciprocating means in a predetermined position thereof.

4. Grinding apparatus comprising a table for holding a piece to be ground, a grinding wheel, means mounting said grinding wheel adjacent said table, means for reciprocating said mounting means connected to said mounting means, means for adjusting said mounting means with respect to said piece whereby the pressure of said grinding wheel against said piece may be adjusted and means for reducing the pressure of said grinding wheel against said piece while maintaining said wheel in contact with said piece comprising means actuatable by said reciprocating means in a predetermined position thereof and connected to said adjusting means, said means actuatable by said reciprocating means being adapted to operate said adjusting means a predetermined amount on actuation by said reciprocating means.

5. Grinding apparatus comprising a table for holding a piece to be ground, means for reciprocating said table, means for mounting a grinding wheel, means for reciprocating said mounting means in a predetermined path, means for applying force on said mounting means in the direction of said table and for adjusting said force, and means actuatable by said means for reciprocating said mounting means in a predetermined position thereof intermediate the ends of said path for operating said force applying and adjusting means in a direction which reduces said force.

6. Grinding apparatus comprising a table for holding a piece to be ground, means for reciprocating said table, means for mounting a grinding wheel, means for recipro-

cating said mounting means in a predetermined path, means for applying force on said mounting means in the direction of said table and for adjusting said force, and means actuatable by said means for reciprocating said mounting means in two predetermined positions thereof adjacent the ends of said path but spaced from said ends for operating said force applying and adjusting means in a direction which reduces said force.

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