

Sept. 24, 1957

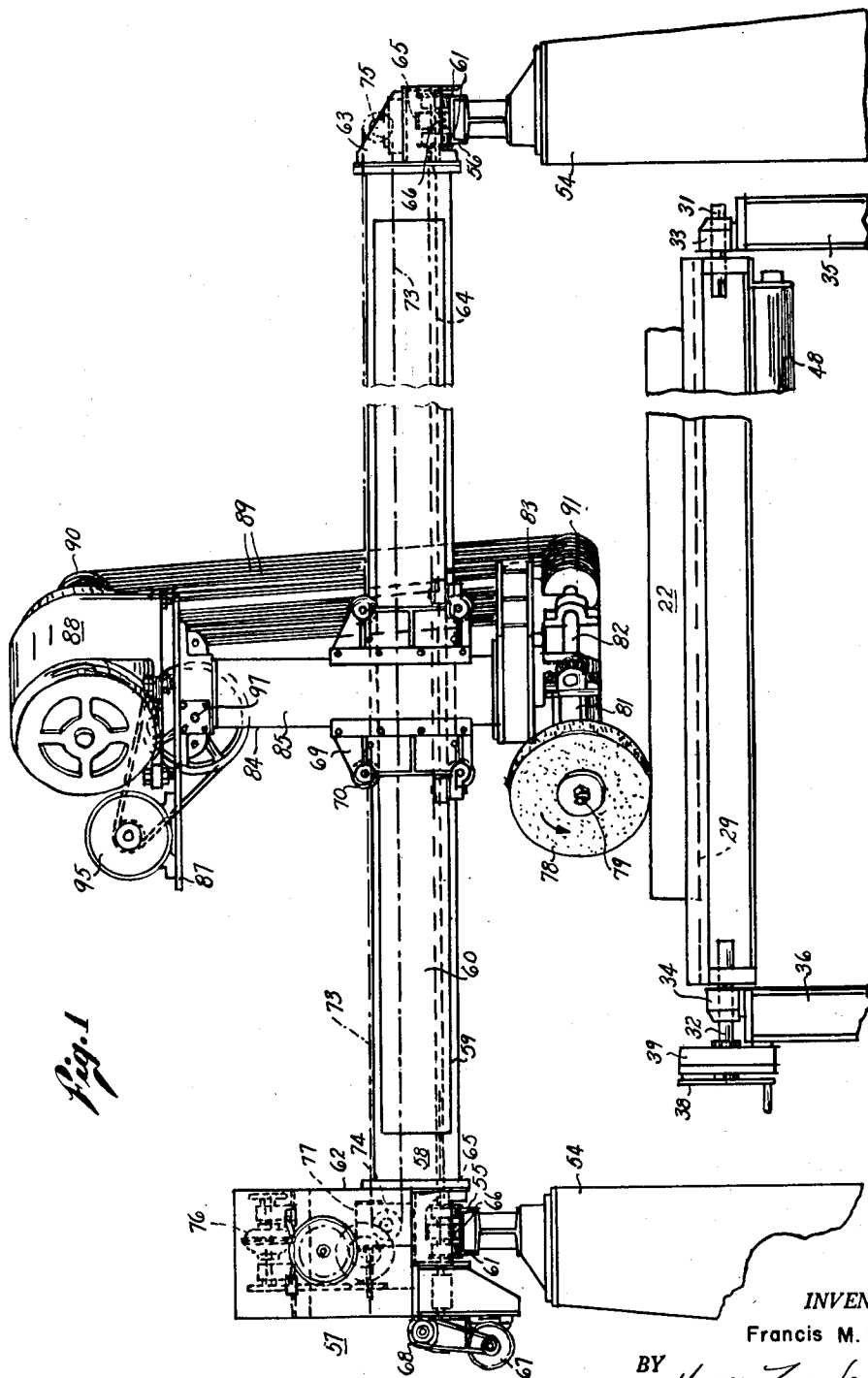
F. M. PALMER

2,807,123

GRINDING MACHINES AND THE LIKE

Filed May 11, 1955

6 Sheets-Sheet 1



INVENTOR.

Francis M. Palmer

BY

James Howard & Buell
his attorneys

Sept. 24, 1957

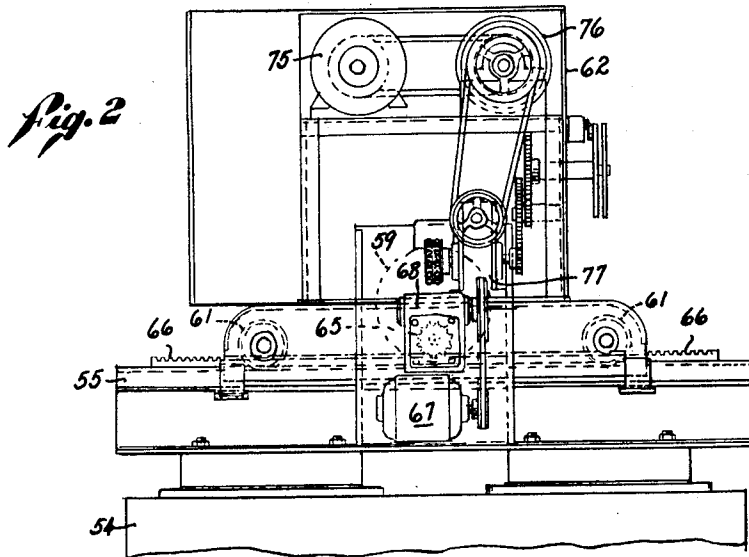
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GRINDING MACHINES AND THE LIKE

Filed May 11, 1955

6 Sheets-Sheet 2



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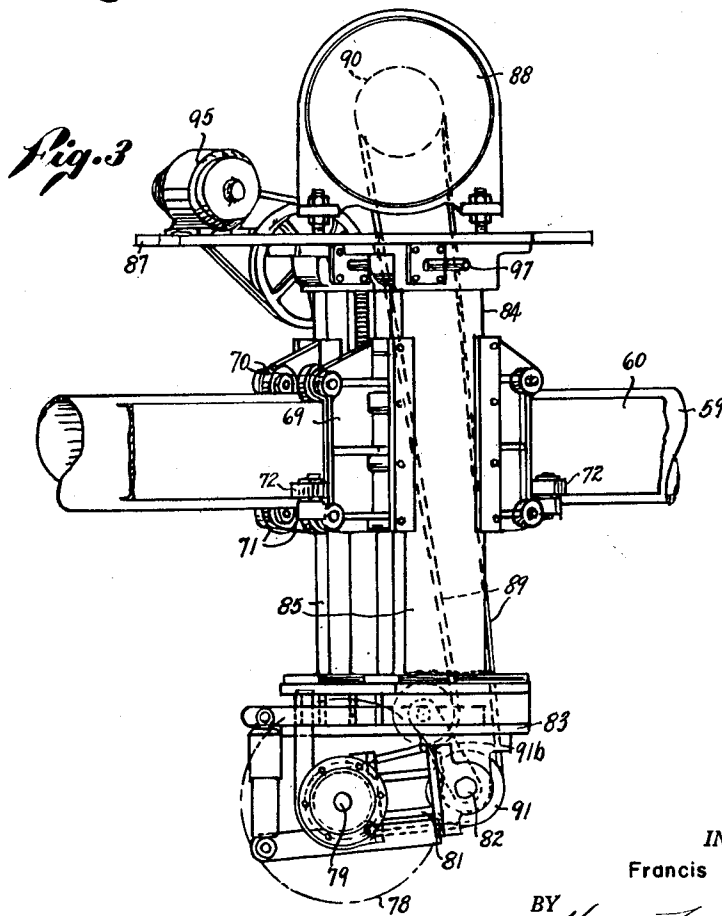
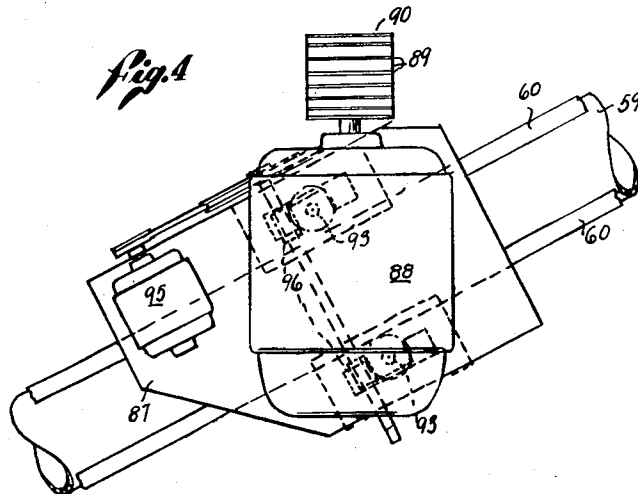
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GRINDING MACHINES AND THE LIKE

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6 Sheets-Sheet 3



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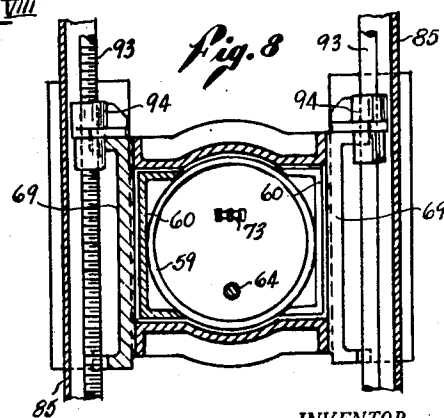
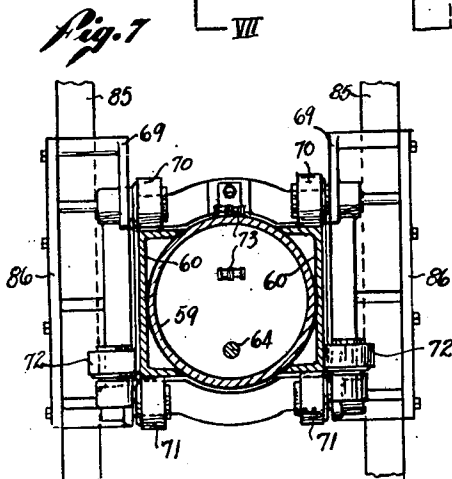
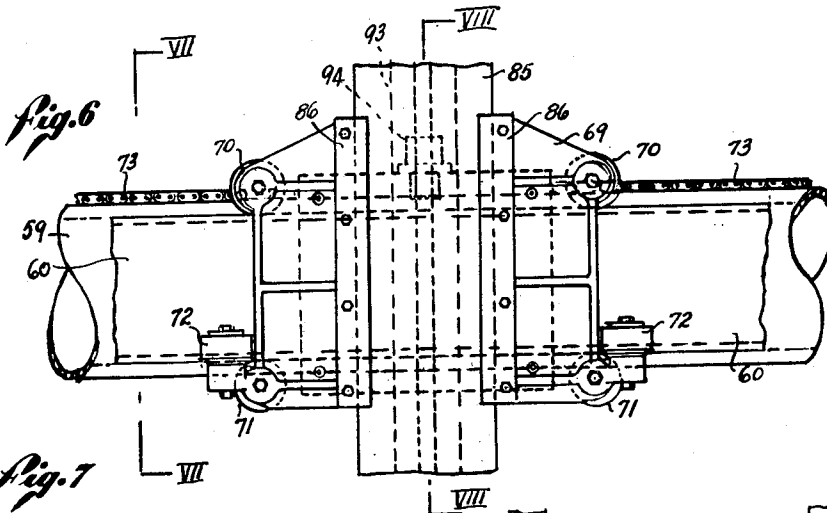
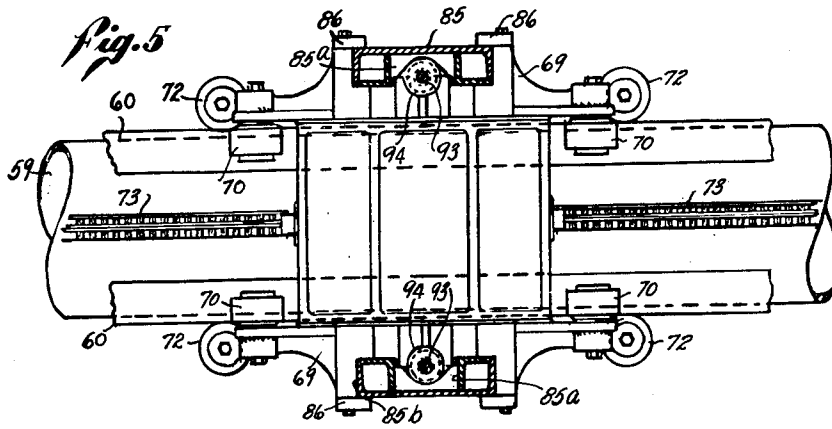
F. M. PALMER

2,807,123

GRINDING MACHINES AND THE LIKE

Filed May 11, 1955

6 Sheets-Sheet 4



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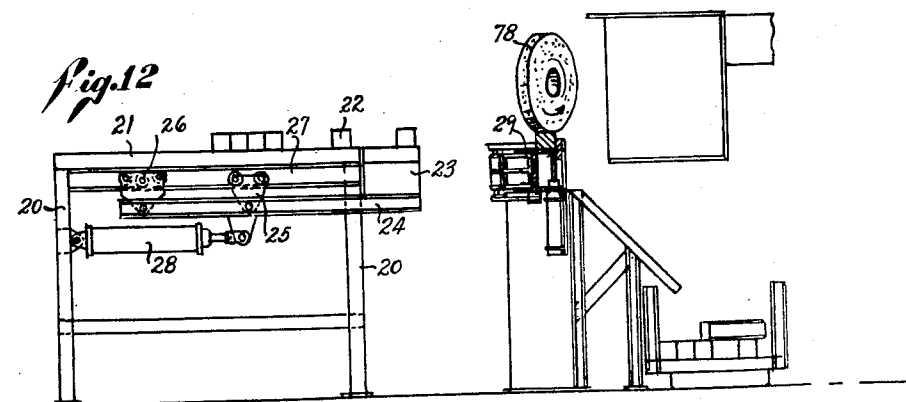
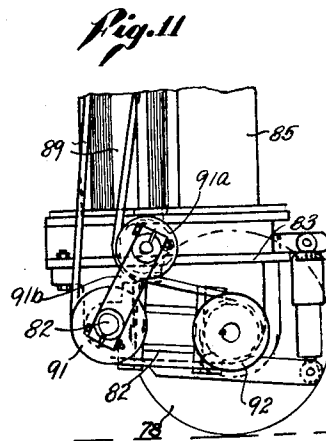
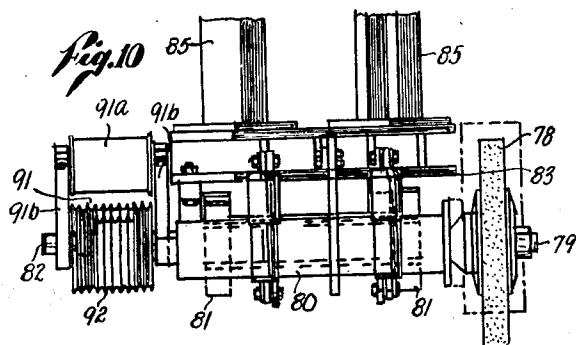
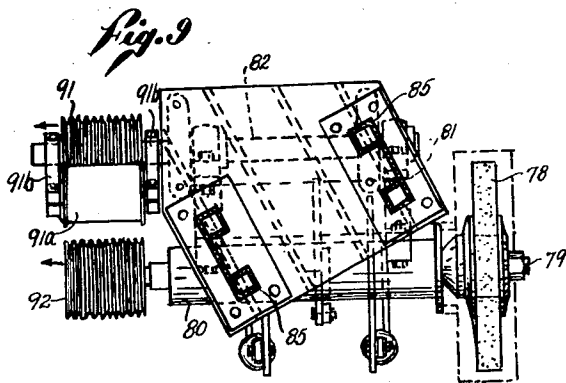
F. M. PALMER

2,807,123

GRINDING MACHINES AND THE LIKE

Filed May 11, 1955

6 Sheets-Sheet 5



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Sept. 24, 1957

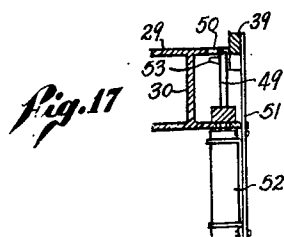
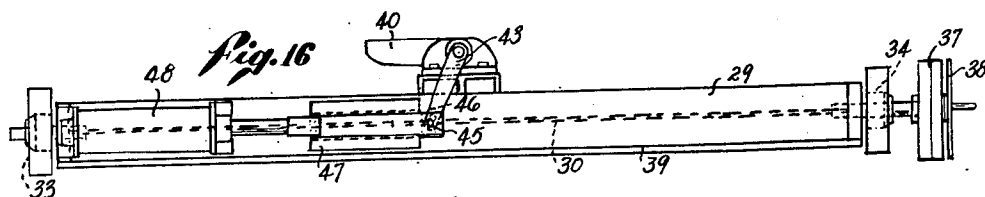
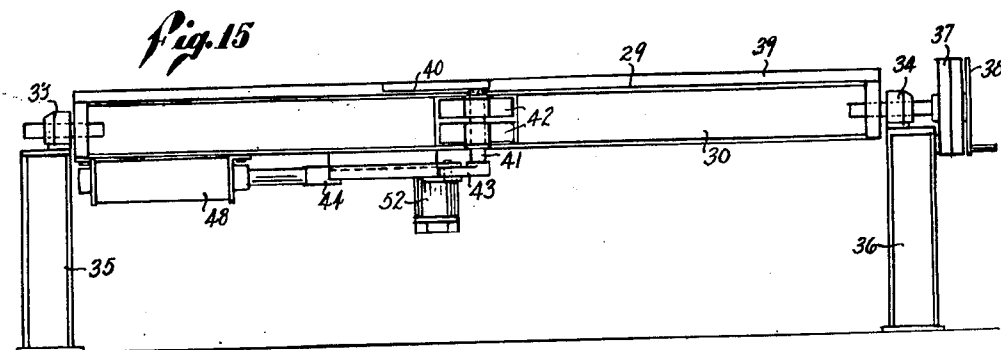
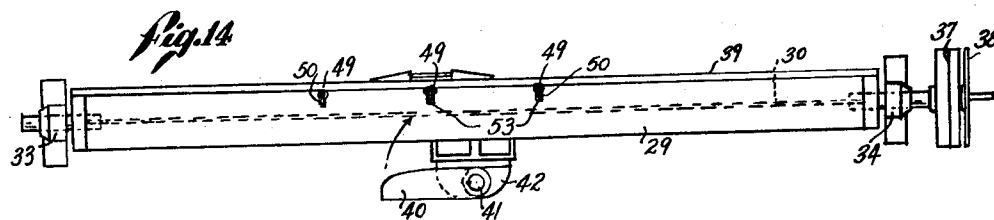
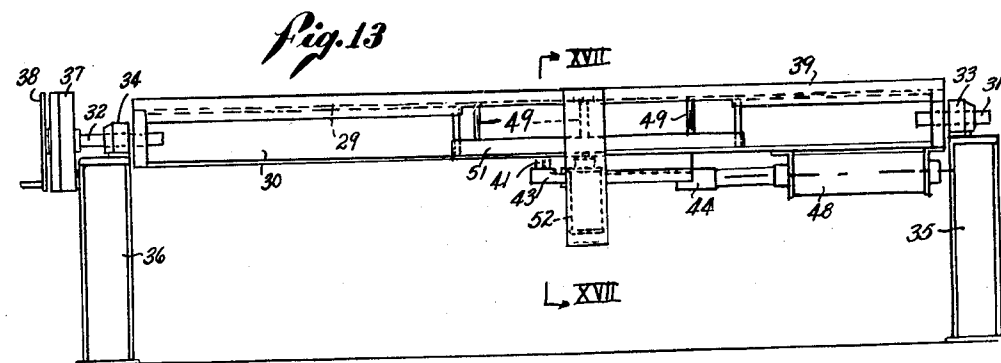
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2,807,123

GRINDING MACHINES AND THE LIKE

Filed May 11, 1955

6 Sheets-Sheet 6



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2,807,123

GRINDING MACHINES AND THE LIKE

Francis M. Palmer, Latrobe, Pa., assignor to Latrobe Steel Company, Latrobe, Pa., a corporation of Pennsylvania

Application May 11, 1955, Serial No. 507,606

14 Claims. (Cl. 51—34)

The present invention relates to grinding machines and the like and comprises numerous features of improvement in apparatus for grinding and otherwise surface treating objects of irregular shape.

I have embodied the invention in a billet grinding machine for removing scale, decarburization and defects from the surface of a steel billet. The following description shall, accordingly, be primarily directed to a machine for surface grinding billets.

In the manufacture of steel and particularly high alloy steel, it is necessary to remove the scale and decarburized surface layer from the billets along with cracks and seams which may be hidden by them. The cracks and seams are usually longitudinal along the billet or concentrated along the corners of the billets and these must be removed before advancement of the billets to the finishing stages of processing. The billets may be the result of rolling operations or forging operations by means of which the ingot has been reduced to a size and shape satisfactory for finishing operations. Billets vary greatly in size and shape as well as surface profile depending upon the ultimate use for which they are intended. As a result, grinding and handling of the billets during the grinding has been a considerable problem.

In the past, billets have been ground by means of hand grinders supported by the workmen or partially supported by an overhead supporting mechanism such as that shown in Leander Patent 1,966,930 (commonly called "swing-grinders"). Such methods of grinding have been slow, tedious and expensive. Various attempts to modify these swing-grinders to make them more effective and less expensive to operate have been attempted as for example the structure of Soderlund Patent 2,704,912.

The aforementioned swing-grinders and modification of them have failed to solve the problems of billet grinding, which has continued to be a serious problem in the industry. In the various grinders which have been suggested, the grinding wheels has been quickly worn out of shape and require frequent dressing in order to maintain their cutting surface in satisfactory condition. With the prior art grinders it is impossible to maintain any uniformity in the amount of material removed. In grinding of billet surfaces of uneven or undulating profile such as are produced by hammer forging, it has been impossible to uniformly remove the scale and decarburization. The result has been that the production in ground billets per man and per machine has been very low.

I have invented a machine for grinding and otherwise surface treating objects which I have embodied for the purposes of this application in a billet grinder which overcomes the difficulties common to the prior art. The machine of my invention makes the grinding wheel self-dressing, maintains a constant pressure between the grinding wheel and the surface being ground and eliminates the necessity for the operator to handle any portion of

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the weight of the grinding wheel mechanism. As a result, a billet grinder according to my invention will grind 15 to 20 times more billets in a given period of time than was possible by the methods heretofore practiced. Moreover, a more satisfactory surface is produced on the billet.

Preferably in a billet grinding machine I provide billet holding means for holding a billet to be ground, abrading means contacting a surface of the billet along a line fixed at an angle materially less than 90° but not less than 15° to the longitudinal axis of the billet, supporting means holding the abrading means articulated and freely rotatable about a pivot spaced from the abrading means in a plane transverse to the longitudinal axis of the billet whereby to maintain said abrading means in contact with the billet under the substantially constant load of its own weight and provide a substantial range of correction between the abrading means and the billet surface above and below the normal grinding plane so that the attack of the wheel upon the billet is substantially uniform regardless of billet profile and means moving one of the billet and abrading means relative to the other selectively longitudinally and transversely of the billet.

Preferably, the abrading means is a grinding wheel mounted to rotate in a vertical plane at an angle of about 27° to the longitudinal axis of the billet so that the line of contact between the grinding wheel and billet is along a line at an angle of about 63° to the longitudinal axis of the billet. It is important that the abrading means contact the surface of the billet along the line materially less than 90° but not less than 15° to the longitudinal axis of the billet. I have found that unless the abrading means is maintained within this angle, it tends to cover up flaws in the billet and therefore to destroy one of the important purposes of billet grinding. I have also found that unless the angle is maintained within these limits, the abrading means will cover only a very small portion of the billet surface to be ground and will tend to "hang up" and gouge the billet when irregularities are met. These difficulties are all overcome by maintaining the abrading means within the angle which I have set out. The means moving one of the billet and abrading means relative to the other is preferably such that both longitudinal and transverse movement of the abrading means can be effected simultaneously if desired. In my preferred embodiment, the abrading means is a grinding wheel mounted on a shaft which is articulated on the traversing means so that the weight of the shaft and the grinding wheel maintain a constant pressure on the surface being ground. In effect, the grinding wheel floats on the surface so that it follows irregularities which result from the rolling or forging operations. Preferably, the means for holding the billet is a table rotatable about a central axis and provided with releasable clamping means to hold the billet while being ground. Preferably, I provide on the table means for turning the billet on the table so that all surfaces of the billet can be made available to the grinding wheel. The table is preferably mounted so that the surface being ground is at about eye level. Preferably the means moving the billet and abrading means relative to one another longitudinally and transversely of the billet is hydraulically controlled through a single control lever.

In the foregoing statement, I have set out certain advantages, objects and structural features which characterize my invention. Other objects, advantages and characteristics will be apparent from a consideration of the following description and the accompanying drawings showing a preferred embodiment of my invention wherein

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Figure 1 is a side elevation, partly in section, showing a billet grinder according to my invention;

Figure 2 is a partial end elevational view of the billet grinder of Figure 1 viewed from the left;

Figure 3 is an enlarged oblique view of the grinder supporting head and carriage of Figure 1;

Figure 4 is a top view of the grinder supporting head and carriage of Figure 1;

Figure 5 is a fragmentary section on the line V—V of Figure 3;

Figure 6 is a fragmentary enlarged elevation of the carriage of Figure 3;

Figure 7 is a section on the line VII—VII of Figure 6;

Figure 8 is a section on the line VIII—VIII of Figure 6;

Figure 9 is a section on the line IX—IX of Figure 3;

Figure 10 is a side elevation of the section shown in Figure 9;

Figure 11 is an end elevation of the section shown in Figure 9 as viewed from the left;

Figure 12 is an end elevation of a feed table and billet holder according to my invention;

Figure 13 is a side elevational view of a billet holder according to my invention viewed from the right of Figure 12;

Figure 14 is a top plan view of the billet holder of Figure 13;

Figure 15 is a side elevational view of the billet holder of Figure 13 viewed from the opposite side;

Figure 16 is a bottom plan view of the billet holder of Figure 13; and

Figure 17 is a section on the line XVII—XVII of Figure 13.

Referring to the drawings, I have illustrated a stock table 20 (Figure 12) provided with a surface 21 upon which billets 22 may be stockpiled. A movable delivery table 23 is provided on the stock table to receive billets therefrom. The delivery table is mounted on arms 24 extending beneath the stock table and mounted on roller carriers 25 and 26 which travel in guideway 27 on the stock table 20. An air cylinder 28 acts to advance and retract the delivery table 23. A billet table 29 is provided spaced from the delivery table 23 to receive billets therefrom. The billet table is preferably an H-beam 30 (Figures 13–17) mounted on stub shafts 31 and 32 journaled in bearings 33 and 34 on supporting end frames 35 and 36. One of the stub shafts 32 is connected through a gear reducer 37 to a handwheel 38 so that the table 29 is rotatable about the axis of the stub shafts 31 and 32. A vertical fence 39 is provided along the top edge of the H-beam 30 remote from the delivery table 23. A clamp 40 is provided on the edge of the H-beam 30 opposite the fence 39. The clamp 40 is mounted on a shaft 41 journaled in bearings 42. An operating crank arm 43 is provided at the end of the shaft 41 opposite the clamp 40. The arm 43 is rotated by a reciprocating slide 44 connected by a pin 45 through an elongated slot 46 in the slide 44 and slidable in guideways 47 on the bottom of the H-beam 30. The slide 44 is connected to an air cylinder 48 which selectively reciprocates it. A billet turning mechanism is mounted in the table 29 made up of pins 49 slidable in openings 50 through the top of the table 29. The pins 49 are mounted on a cross-tie 51 actuated by an air cylinder 52 mounted on the bottom of the table 29. Each of the pins 49 is provided with a projecting latch member 53 which engages the billet to complete its turning on the table 29.

A pair of spaced apart supporting standards 54 (Figure 1) are provided outwardly of the frame members 35 and 36. Tram rails 55 and 56 are mounted on the top of the standards 54. A traveling bridge 57 extends between the tram rails 55 and 56. The bridge 57 comprises a built-up rail 58 made up of a hollow cylindrical central member 59 (Figures 5–7) having welded or otherwise attached thereto a pair of channels 60 on opposite sides

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thereof extending between the tram rails 55 and 56 and carried by flanged wheels 61 (Figure 2) rotatable in end housings 62 and 63. A shaft 64 extends through the rail 58 and is provided with pinions 65 which engage racks 66 on the tram rails 55 and 56. The shaft 64 is driven by an electric motor 67 through a gear reducer 68 of conventional design.

A carriage 69 is movable on the rail 58 on wheels 70 at the top and 71 at the bottom. Wheels 72 are provided on the opposite sides of the rail 58 to prevent side-sway or twisting of the carriage 69. A drive chain 73 is dead-ended at its opposite ends to opposite ends of the carriage 69 and passes over a toothed drive wheel 74 at one end of the rail 58 and a freely rotatable toothed idler wheel 75 at the opposite end of the rail 58. The toothed wheel 74 is driven by an electric motor 75 through a hydraulic coupling 76 and gear reducer 77 both of conventional design.

A grinding wheel 78 is mounted on a shaft 79 journaled in an elongated bearing 80 at an angle of 27° to the axis of the table top 29. The bearing 80 is mounted on arms 81 which are articulated on a shaft 82 mounted on a base plate 83 of a supporting tower 84. The supporting tower is provided with built-up side plates 85 (Figures 5–7) which pass vertically through guideways 86 on the carriage 69. A drive motor mounting plate 87 is fixed on top of built up side plates 85 and carries a drive motor 88. The side plates 85 are built up by welding angles 85a to the flanges 85b of a channel member to form a closed rail at each side. Belts 89 pass over the motor pulley 90 around an idler pulley 91 mounted on shaft 82, an idler pulley 91a rotatably mounted on arms 91b on the shaft 82 and over pulley 92 on shaft 79. Vertical screws 93 are rotatably mounted at one end on the motor plate 87 and pass vertically between the guideways 86 in engagement with nuts 94 fixed on the carriage 69 to raise and lower the supporting tower with respect to the saw rail. The screws 93 are driven by a motor 95 through worm gears 96 on a horizontal shaft 97 journaled beneath the motor plate 87. By operation of the motor 95 vertical screws 93 are threaded through the nuts 94 to raise and lower the supporting tower 84.

The operation of the grinder of this invention is generally as follows: A billet 22 on the stock table 21 is fed onto the feed table top 23. The feed table is extended into a position adjacent the billet holding table 29 and the billet 22 is discharged on the billet table top 29, as by manually tipping the billet onto the top 29. The cylinder 48 is actuated to extend the slide ram 44 and thereby operate the clamp 40 which forces the billet 22 against the fence 39 and locks it in position. The cylinder 48 may be actuated from any conventional source of fluid pressure through conventional valving not shown.

The supporting tower 84 is adjusted by vertical screws 93 to bring the working surface of the grinding wheel 78 below the plane of the profile of the billet 22 to be ground. The carriage 69 is then traversed on the bridge 57 longitudinally of the billet by means of the chain drive 73. Transverse positioning of the grinding wheel with respect to the billet is carried out by actuation of the shaft 64 thereby driving the pinions 65 in racks 66 to carry the entire bridge along the tram rails 55.

The position of the billet with respect to the grinding wheel may be varied by rotation of the table 29 by means of the gear reduction unit 37 so that the billet is moved about the axis of the stub shafts 31 and 32 parallel to the longitudinal axis of the billet itself. This permits the operator to move the billet so that uneven or undulate portions on the profile of the billet can be moved into a plane parallel to the plane of wheel contact to get and maintain the maximum contact between the grinding wheel and the billet regardless of irregularities in the billet and at the same time permits corner cracks and defects to be selectively engaged by the grinder.

When a side of the billet has been ground the operator

may turn the billet to expose a new face to the grinding wheel by releasing clamp 40 and energizing the vertical cylinder 52 through conventional valving from a source of fluid under pressure, not shown, which in turn raises the pins 49 against the edge of the billet, turning the billet over to the next side to be ground.

When the grinding operation has been completed, the operator releases clamp 40, tilts the table 29 by means of handwheel 38 and gear reducer 37 in a clockwise direction viewing Figure 12 and ejects the billet from the fence 39 into skid rails 100 by means of the pins 49 actuated by the cylinder 52 in the same manner as the billet is turned.

While I have illustrated and described a presently preferred embodiment of my invention it will be understood that it may be otherwise embodied within the scope of the following claims.

1. A billet grinding machine comprising billet holding means, abrading means for contacting a surface of a billet held in the holding means along a line fixed at an angle materially less than 90° but not less than about 15° to the longitudinal axis of a billet held in the holding means, supporting means holding the abrading means articulated and freely rotatable about a pivot spaced from the abrading means in a plane transverse to the longitudinal axis of the billet whereby to maintain said abrading means in contact with the billet under the substantially constant load of its own weight and provide a substantial range of correction between the abrading means and a billet surface held in the holding means above and below the normal grinding plane so that the attack of the wheel upon the billet is substantially uniform, regardless of billet profile and means for moving one of the billet holding means and abrading means relative to the other selectively longitudinally and transversely of a billet held in the holding means.

2. A billet grinding machine comprising billet holding means, abrading means for contacting a surface of a billet held in the holding means along a line fixed at an angle materially less than 90° but not less than about 15° to the longitudinal axis of a billet held in the holding means, supporting means including an articulated arm holding the abrading means freely rotatable about a pivot spaced from the abrading means in a plane transverse to the longitudinal axis of the billet whereby to maintain said abrading means in contact with the billet under the substantially constant load of its own weight and the weight of the articulated arm and provide a substantial range of correction between the abrading means and a billet surface held in the holding means above and below the normal grinding plane so that the attack of the wheel upon the billet is substantially uniform regardless of billet profile and means for moving one of the billet holding means and abrading means relative to the other selectively longitudinally and transversely of a billet held in the holding means, while maintaining the substantially constant angle between a billet held in the holding means and abrading means.

3. A billet grinding machine comprising billet holding means for supporting a billet so that the surface to be ground is horizontal, a grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for effecting relative reciprocatory movement of the billet holding means and the grinding wheel unit in a direction parallel to the axis of a billet supported in the holding means, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon a billet held in the holding means with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon a billet held in the holding means is substantially uniform regardless of variations

in billet profile whereby the surface of a ground billet reflects such variations.

4. A billet grinding machine comprising billet holding means for supporting a billet so that the surface to be ground is horizontal, a grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for reciprocating the grinding wheel unit in a direction parallel to the axis of a billet supported in the holding means, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon a billet held in the holding means with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon a billet held in the holding means is substantially uniform regardless of variations in billet profile whereby the surface of a ground billet reflects such variations.

5. A billet grinding machine comprising billet holding means for supporting a billet so that the surface to be ground is horizontal, a grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for reciprocating a billet held in the holding means beneath the grinding wheel unit in a direction parallel to the axis of a billet held in the holding means, the arbor being mounted on the unit at fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon a billet held in the holding means with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon a billet held in the holding means is substantially uniform regardless of variations in billet profile and the surface of the ground billet reflects such variations.

6. A billet grinding machine comprising billet holding means oscillable about a line parallel to the longitudinal axis of a billet held in the holding means, a grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for effecting relative reciprocatory movement of a billet holding means and the grinding wheel unit in a direction parallel to the axis of a billet supported in the holding means, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon a billet held in the holding means with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon a billet held in the holding means is substantially uniform regardless of variations in billet profile whereby the surface of a ground billet reflects such variations.

7. A billet grinding machine comprising billet holding means oscillable about a line parallel to the longitudinal axis of the billet, a grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for reciprocating the grinding wheel unit in a direction parallel to the axis of the supported billet, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon the billet with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon the billet is substantially

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uniform regardless of variations in billet profile and the surface of the ground billet reflects such variations.

8. A billet grinding machine comprising billet holding means for supporting a billet so that the surface to be ground is horizontal, a bridge extending across said billet holding means and traversable thereacross, a grinding wheel unit on said bridge movable transversely, to the direction of movement of the bridge, said grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for effecting relative reciprocatory movement of a billet held in the holding means and the grinding wheel unit in a direction parallel to the axis of the supported billet, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon the billet with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon the billet is substantially uniform regardless of variations in billet profile and the surface of the ground billet reflects such variations.

9. A billet grinding machine comprising billet holding means for supporting a billet with the surface to be ground in a generally horizontal plane, a grinding wheel unit, an arbor for the grinding wheel articulated about a pivot spaced from the arbor in a plane parallel to the horizontal surface to be ground, means for driving the arbor, means for effecting relative reciprocatory movement of a billet held in the holding means and grinding wheel unit in a direction parallel to the axis of the supported billet, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon the billet with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon the billet is substantially uniform regardless of variations in billet profile and the surface of the ground billet reflects such variations.

10. A billet grinding machine comprising billet holding means for supporting a billet so that the surface to be ground is horizontal, a bridge extending across said billet holding means and traversable thereacross, a grinding wheel unit on said bridge movable transversely, to the direction of movement of the bridge, means on the grinding unit for vertically moving said grinding wheel unit relatively to the bridge, said grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for effecting relative reciprocatory movement of a billet held in the holding means and the grinding wheel unit in a direction parallel to the axis of the supported billet, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon the billet with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon the billet is substantially uniform regardless of variations in billet profile and the surface of the ground billet reflects such variations.

11. A billet grinding machine comprising billet holding means for supporting a billet with the surface to be ground in a generally horizontal plane, a grinding wheel unit, an arbor for the grinding wheel articulated about a pivot spaced from the arbor in a plane parallel to the horizontal surface to be ground, means for vertically moving

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said grinding wheel unit relatively to the billet holding means, means for driving the arbor, means for effecting relative reciprocatory movement of a billet held in the holding means and grinding wheel unit in a direction parallel to the axis of the supported billet, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon the billet with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon the billet is substantially uniform regardless of variations in billet profile and the surface of the ground billet reflects such variations.

12. A billet grinding machine comprising billet holding means oscillable about a line parallel to the longitudinal axis of a billet held thereon, a bridge extending across said billet holding means and traversable thereacross, a grinding wheel unit on said bridge movable transversely, to the direction of movement of the bridge, said grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for effecting relative reciprocatory movement of the billet and the grinding wheel unit in a direction parallel to the axis of the supported billet, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon the billet with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon the billet is substantially uniform regardless of variations in billet profile and the surface of the ground billet reflects such variations.

13. A billet grinding machine comprising billet holding means oscillable about a line parallel to the longitudinal axis of a billet held thereon, a bridge extending across said billet holding means and traversable thereacross, a grinding wheel unit on said bridge movable transversely, to the direction of movement of the bridge, means on the grinding unit for vertically moving said grinding wheel unit relatively to the bridge, said grinding wheel unit carrying an arbor for the grinding wheel and means for driving the same, means for effecting relative reciprocatory movement of the billet and the grinding wheel unit in a direction parallel to the axis of the supported billet, the arbor being mounted on the unit at a fixed angle such that the plane of rotation of the grinding wheel is materially less than 90° to the line of reciprocatory movement and a floating connection between the arbor and the unit allowing the wheel to bear upon the billet with substantially constant pressure with a substantial range of vertical movement of the working surface of the grinding wheel both above and below the normal grinding plane whereby the attack of the wheel upon the billet is substantially uniform regardless of variations in billet profile and the surface of the ground billet reflects such variations.

14. A billet grinding machine comprising billet holding means oscillable about a line parallel to the longitudinal axis of a billet held thereon, abrading means contacting a surface of the billet along a line fixed at an angle materially less than 90° but not less than about 15° to the longitudinal axis of the billet, supporting means holding the abrading means articulated and freely rotatable about a pivot spaced from the abrading means in a plane transverse to the longitudinal axis of the billet whereby to maintain said abrading means in contact with the billet under the substantially constant load of its own weight and provide a substantial range of correction between the abrading means and the billet surface above and below

the normal grinding plane so that the attack of the wheel upon the billet is substantially uniform, regardless of billet profile and means moving one of the billet and abrading means relative to the other selectively longitudinally and transversely of the billet.

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