United States Patent

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[45] Patented **Aug. 10, 1971**

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[54] **GRINDER FOR GRINDING THE FACES OF EDGE-SUPPORTED WORKPIECES**
31 Claims, 22 Drawing Figs.

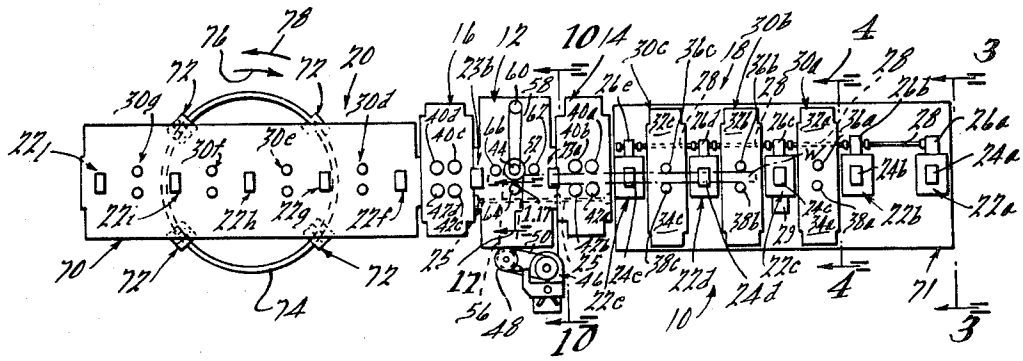
[52] **U.S. Cl.** **51/135,**
51/39, 51/66, 51/78, 51/215
[51] **Int. Cl.** **B24b 21/04,**
B24b 47/00
[50] **Field of Search** 51/135,
139, 66, 78, 74, 215, 118, 87, 39

[56] **References Cited**
UNITED STATES PATENTS

1,602,597	10/1926	Staude	51/78 UX
1,689,703	10/1928	Vidaver	51/78
1,958,001	5/1934	Heim	51/74

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ABSTRACT: An apparatus for grinding the faces of edge-supported workpieces such as metal slabs, billets, coil, strip and the like by means of a vertically disposed grinding head which can include an abrasive belt, with the apparatus including guide apparatus whereby the workpiece can be presented to the abrasive belt, and if desired, can be presented a plurality of times in reverse directions to the abrasive belt surface whereby several cuts can be made on the same surface, with the guide apparatus including a turntable whereby the workpiece can be turned 180° for grinding both sides.



Patented Aug. 10, 1971 3,597,881

12 Sheets-Sheet 1

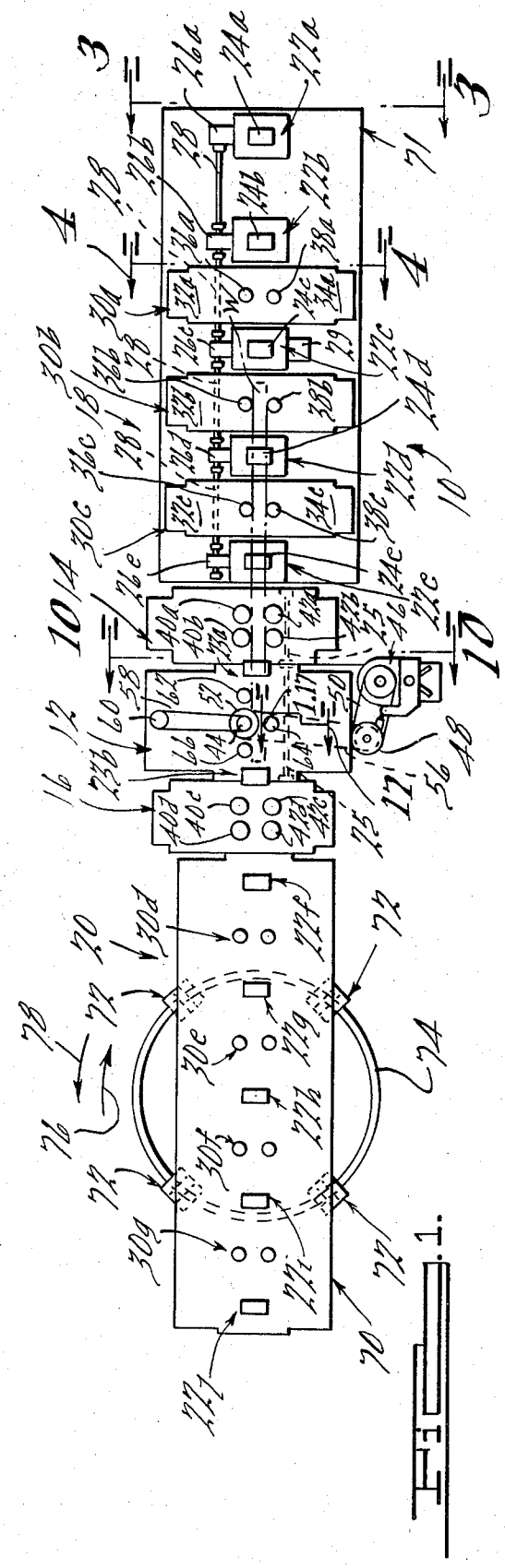


FIG. 1.

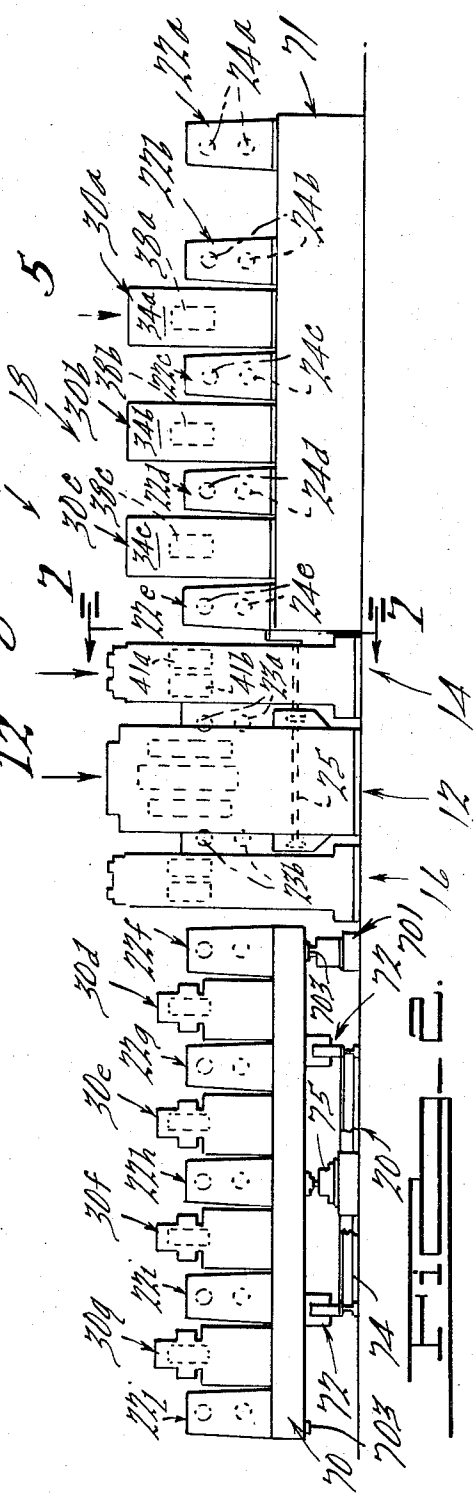


FIG. 2.

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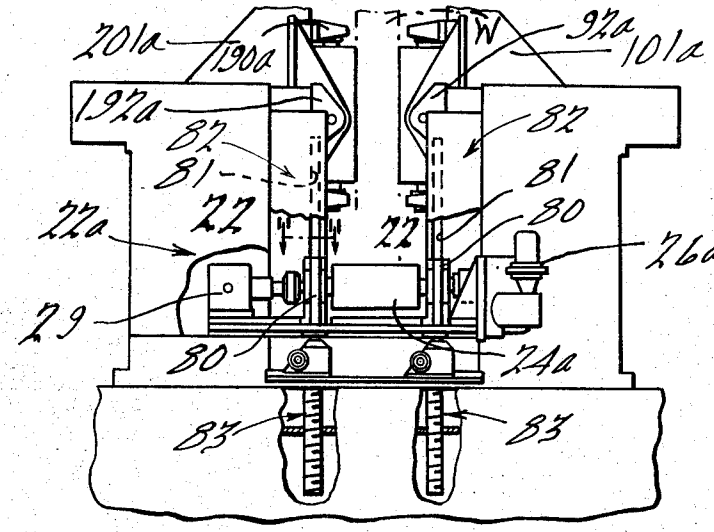


FIG. 3.

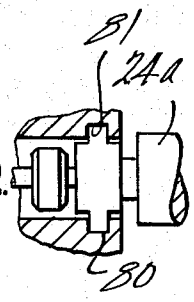


FIG. 22.

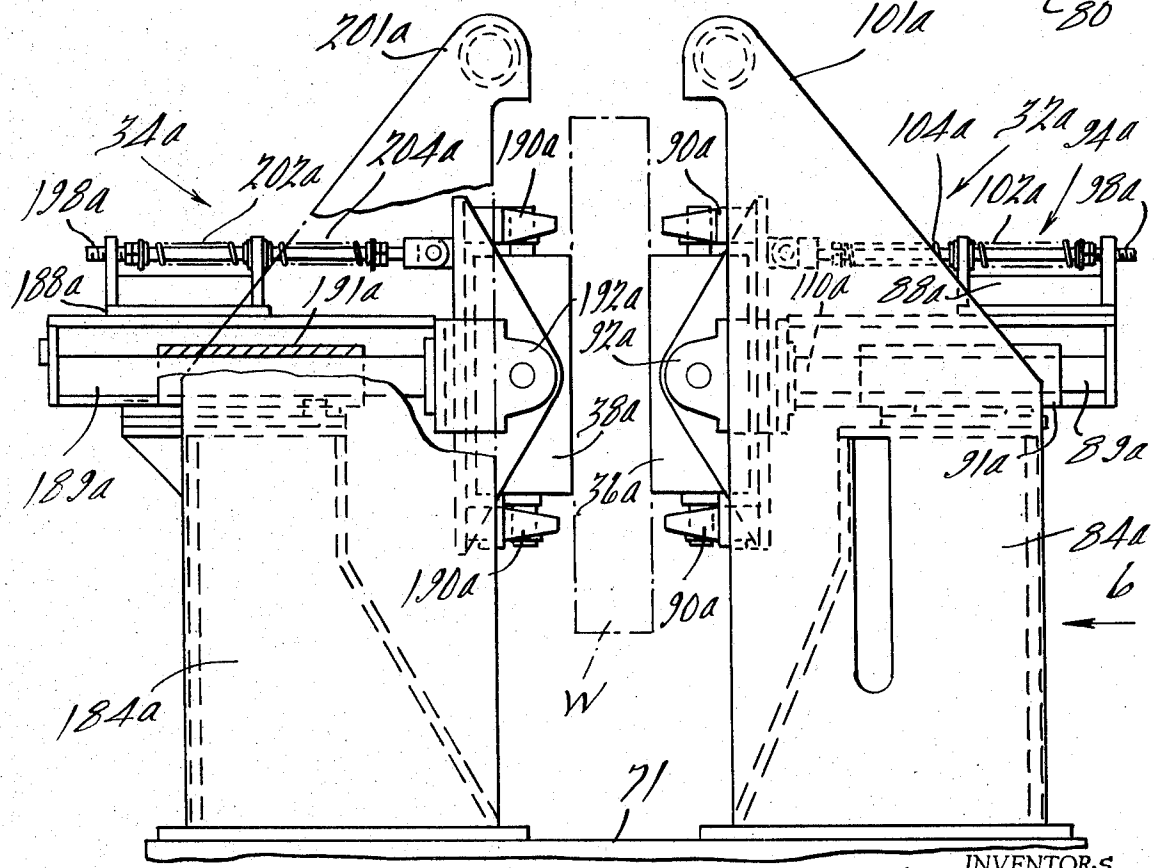
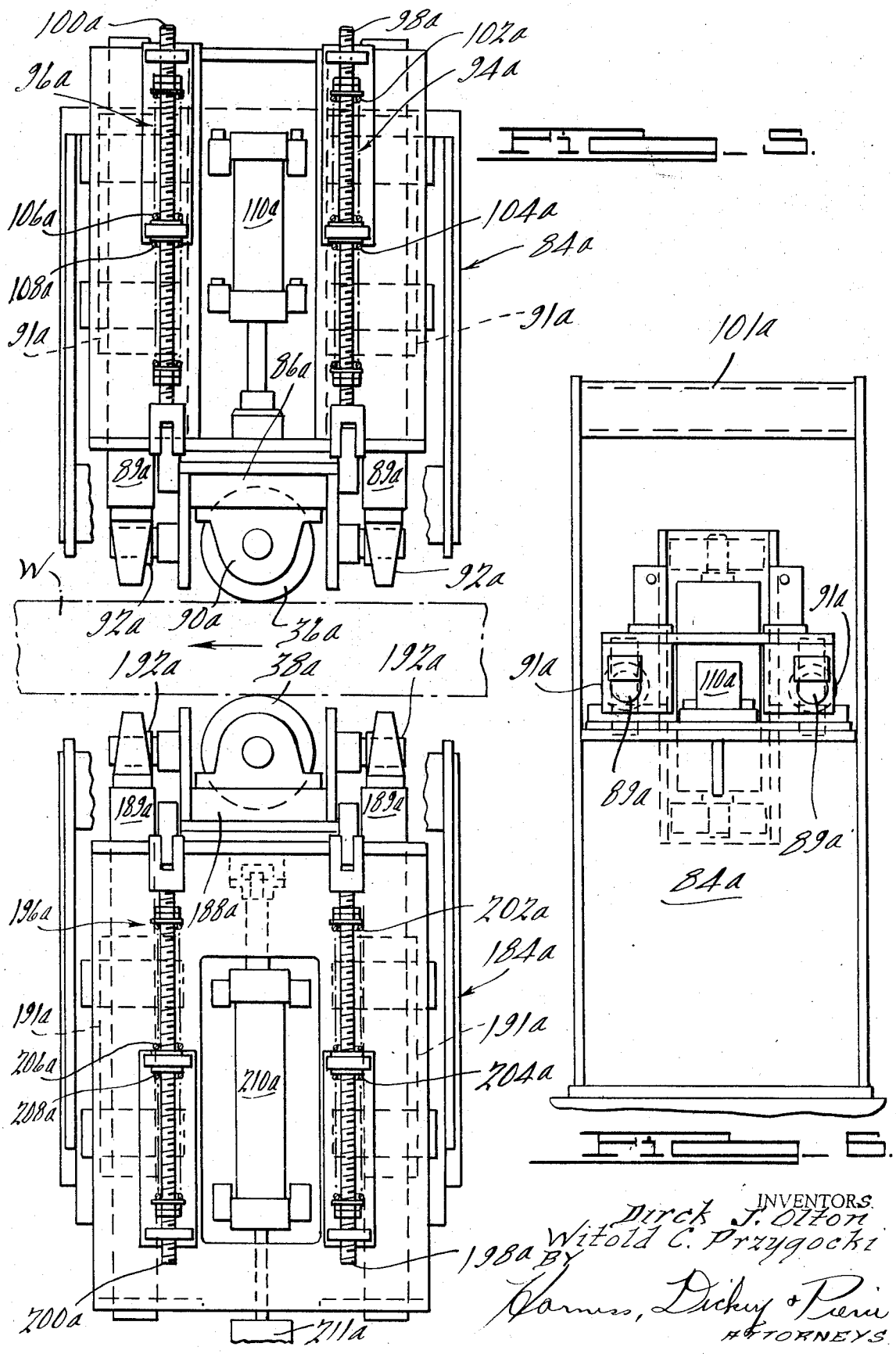


FIG. 4.

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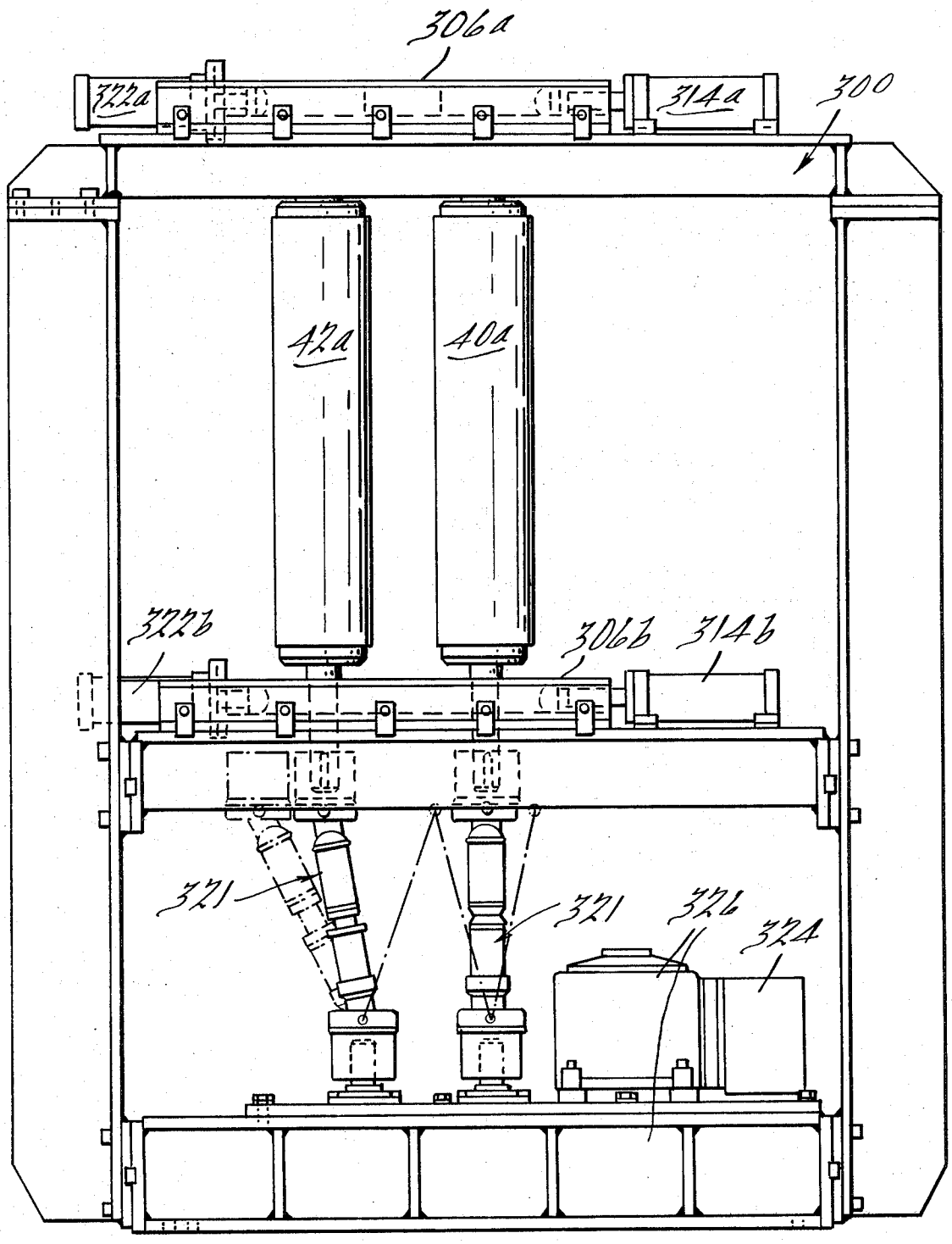
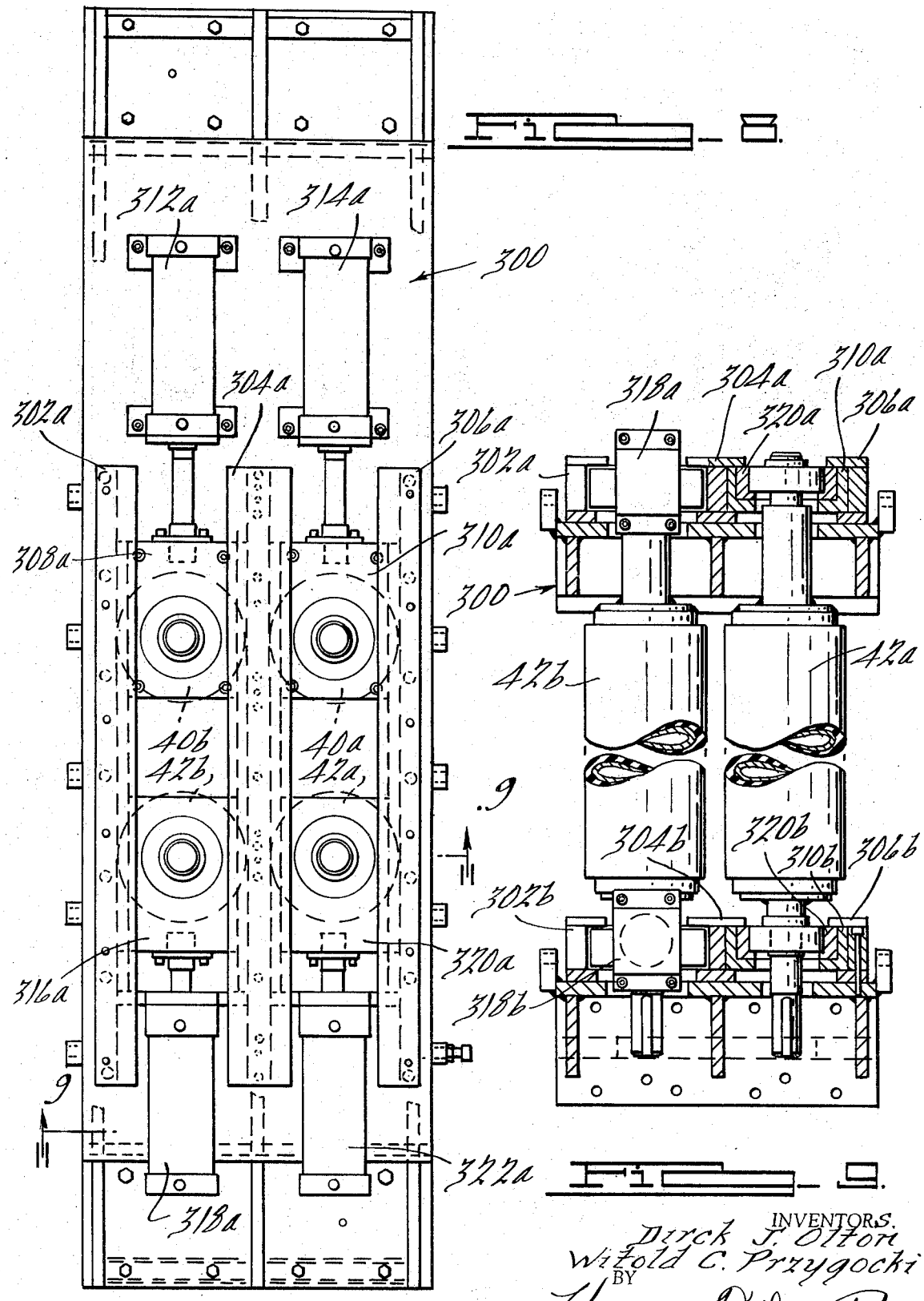
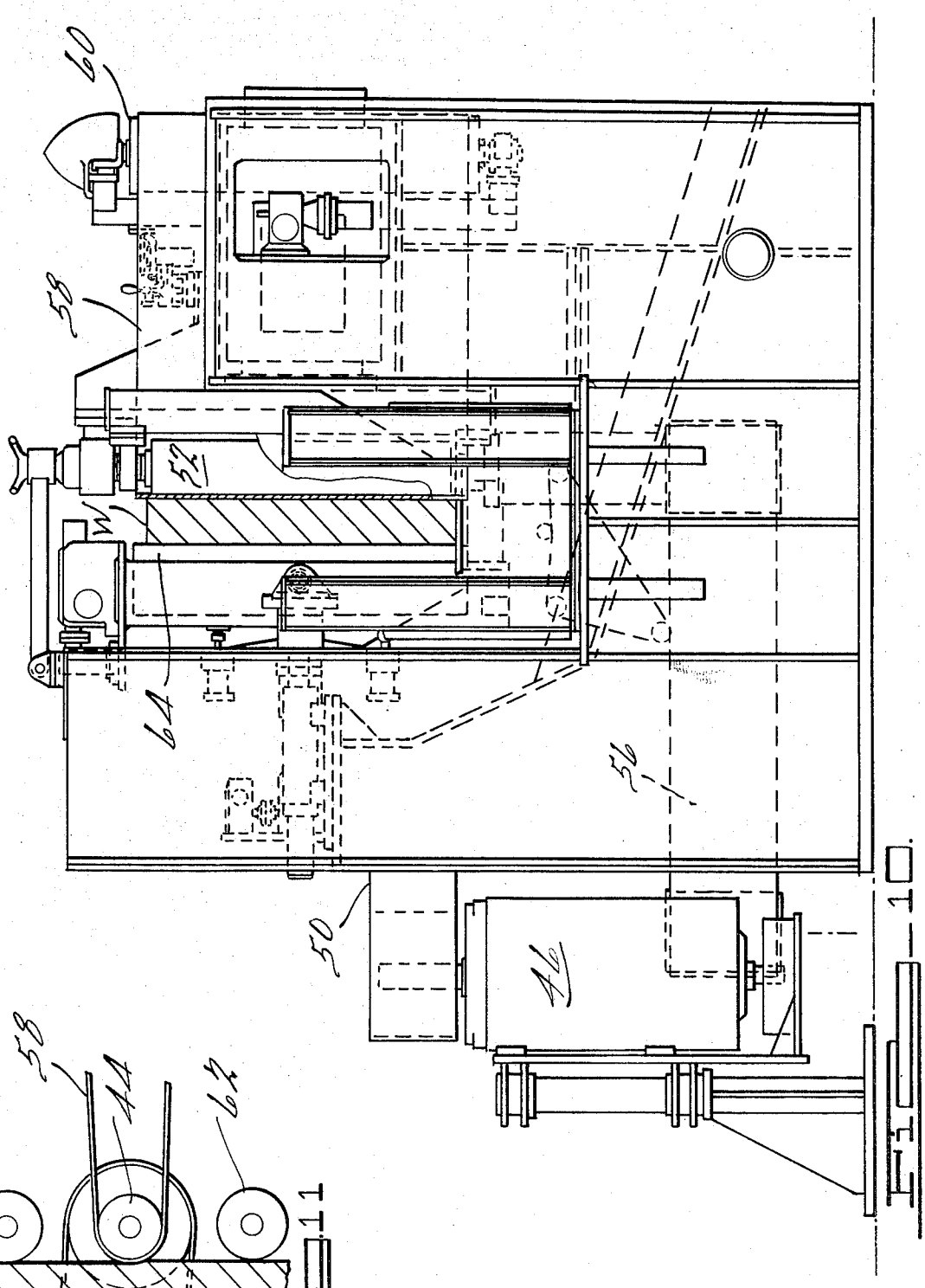


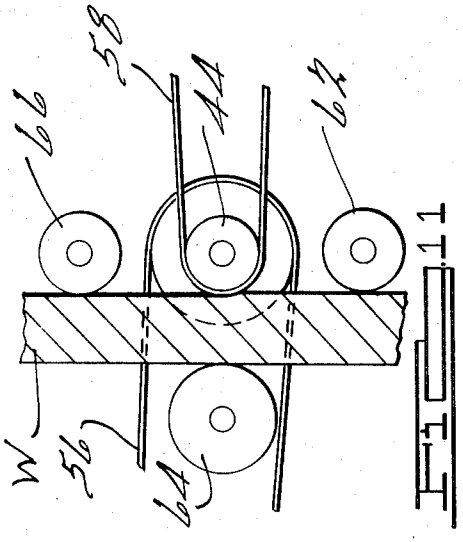
FIG. 7.

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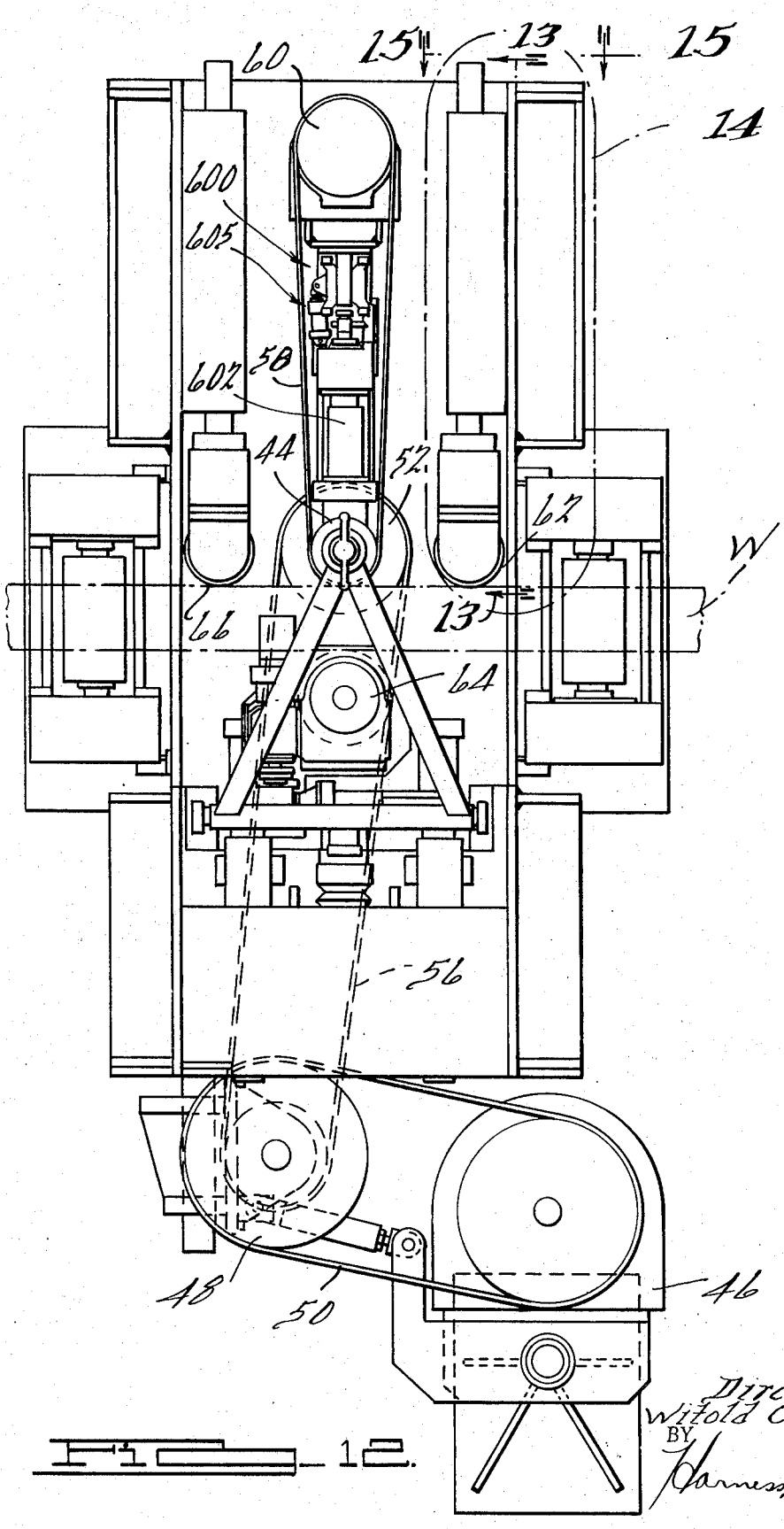


FIG. 12.

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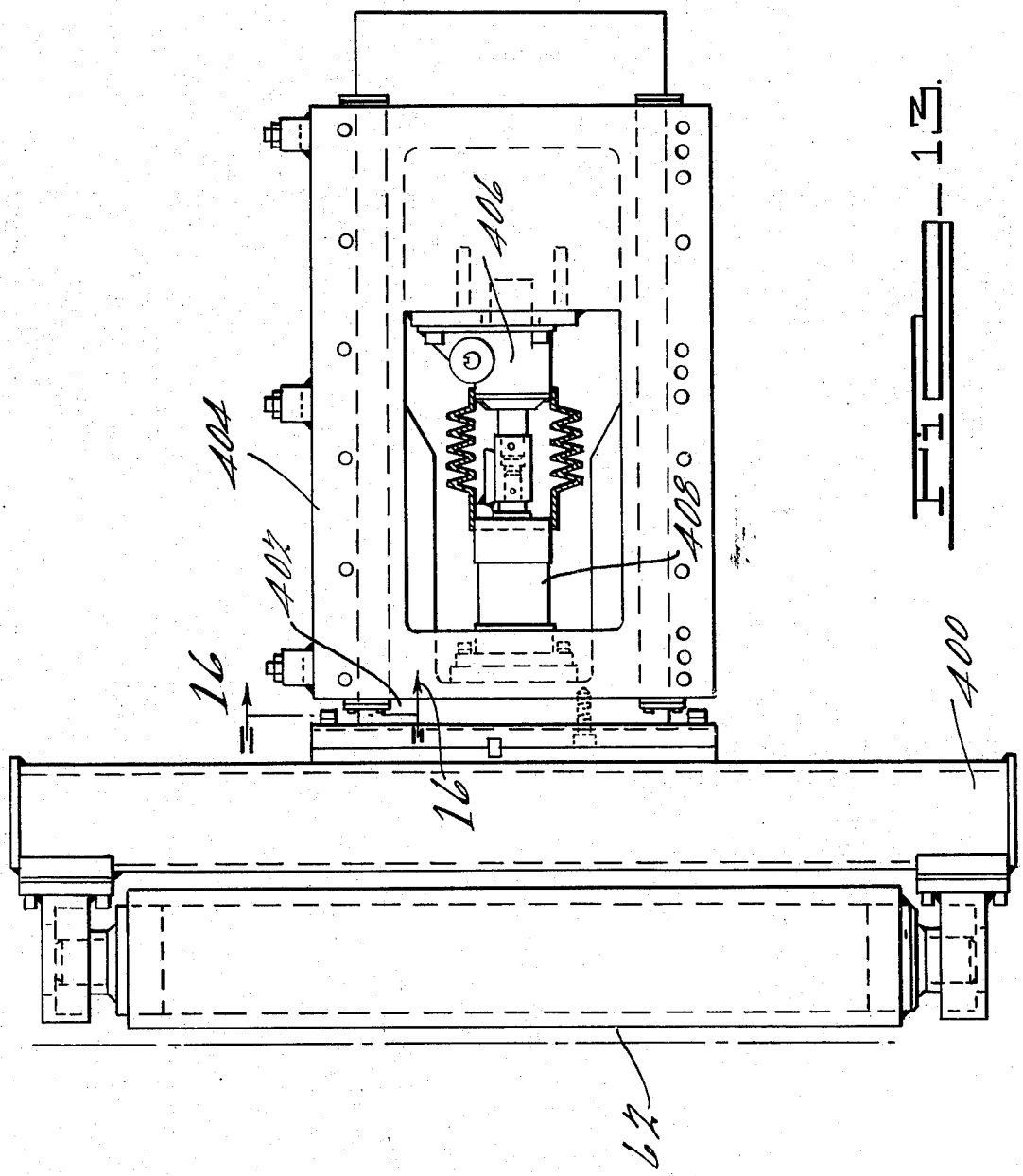


FIG. 12

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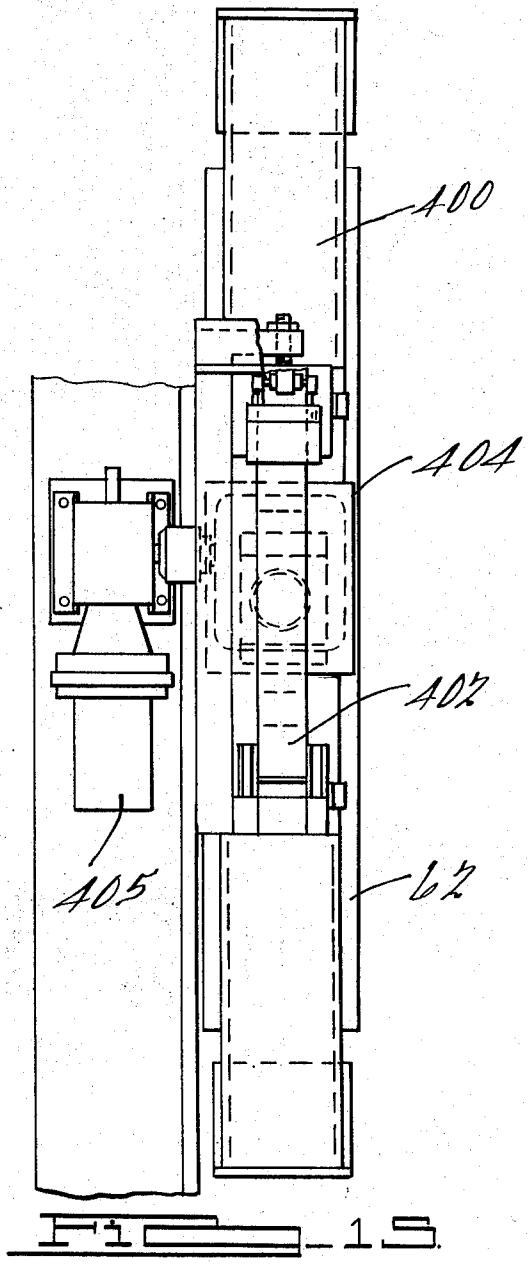


Fig. 13

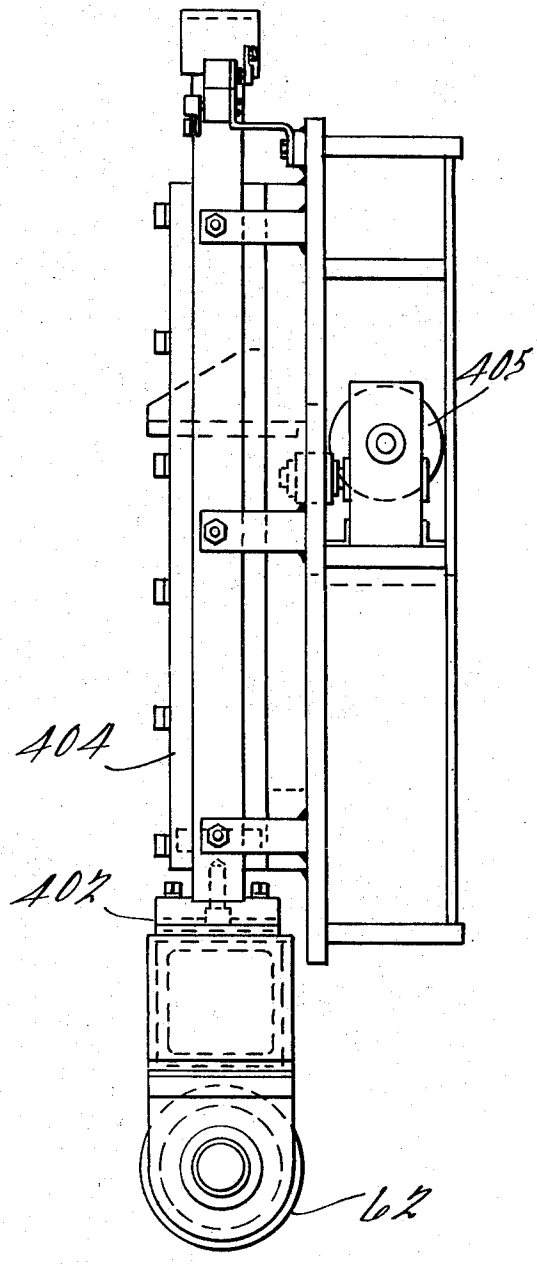


Fig. 14

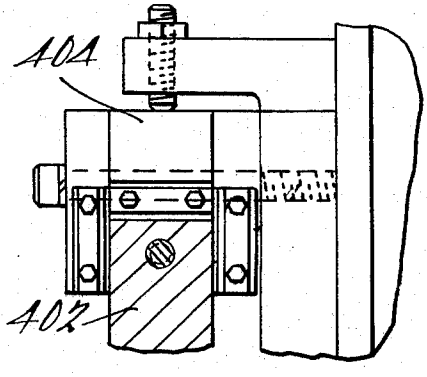


Fig. 15

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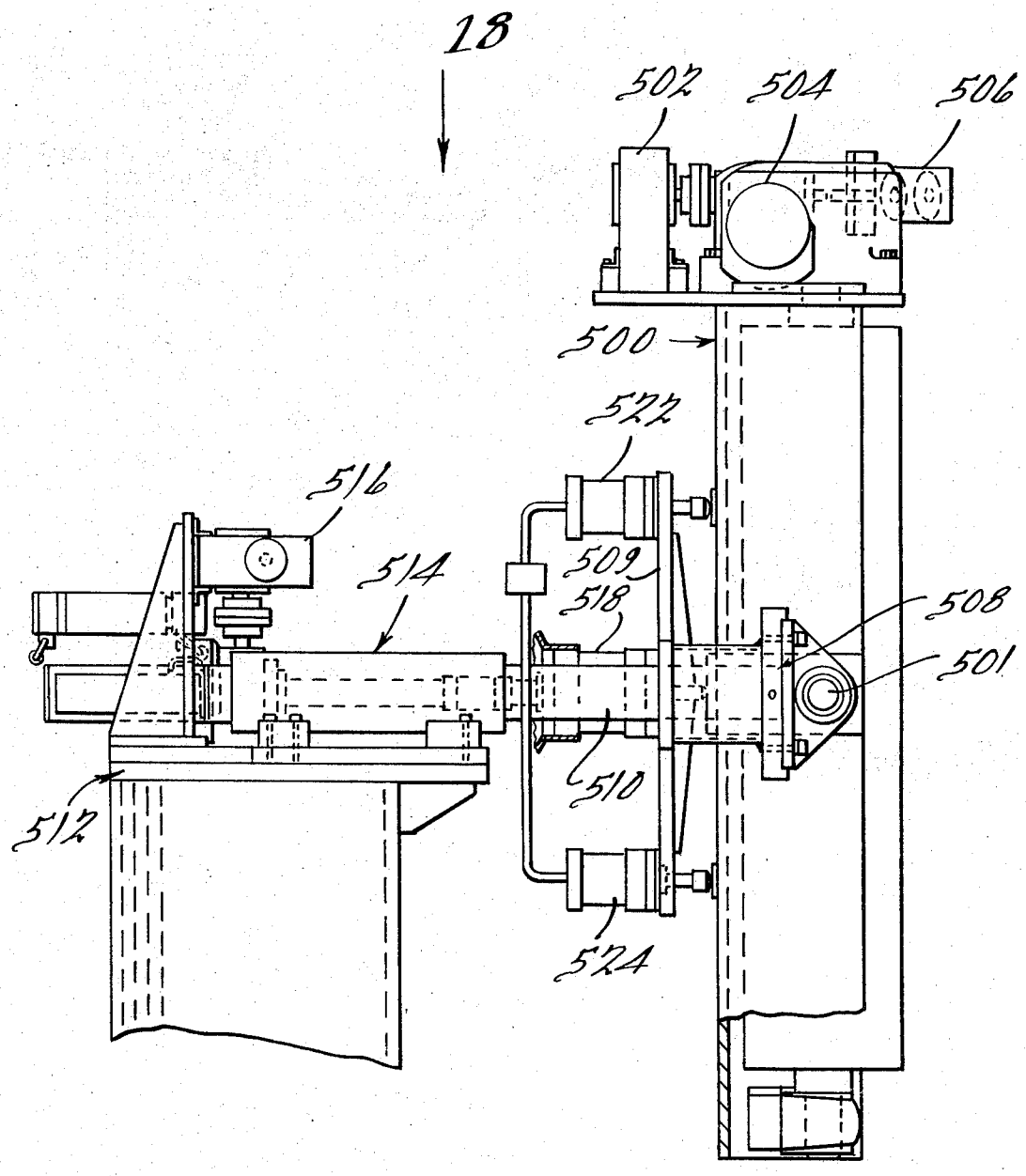


FIG. 17.

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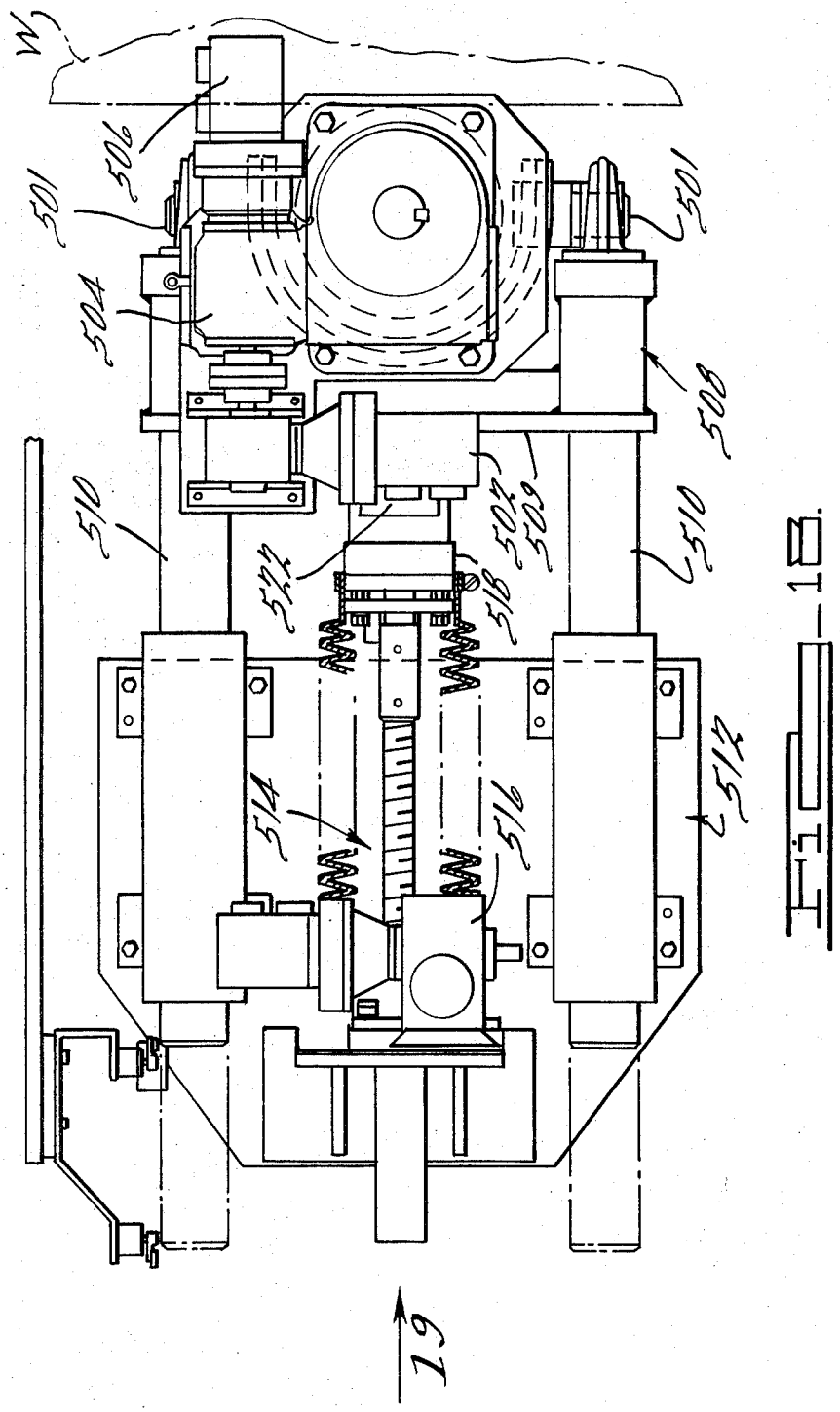


FIG. 18.

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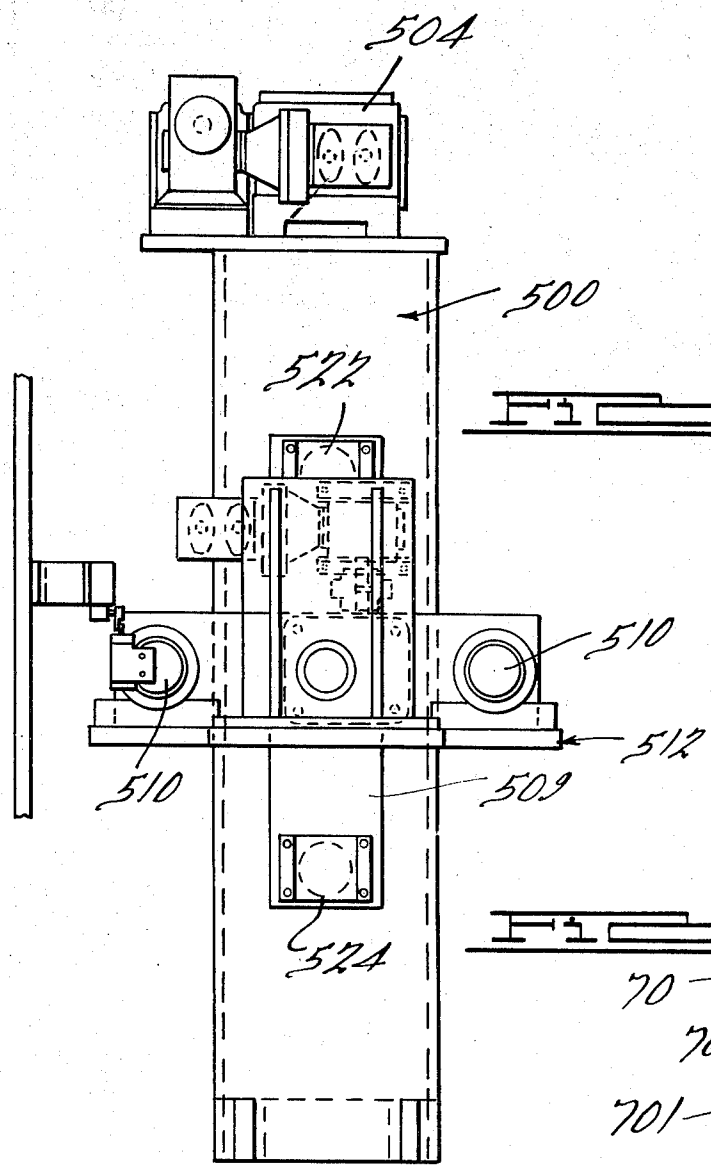


FIG. 19.

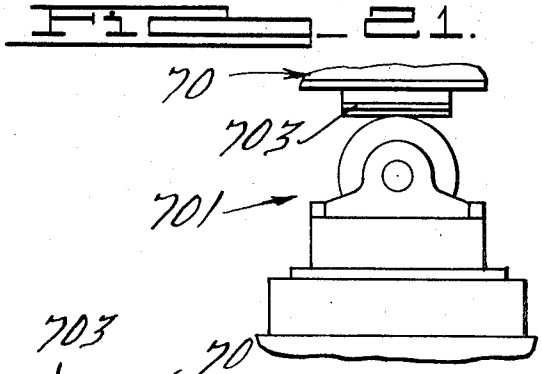


FIG. 21.

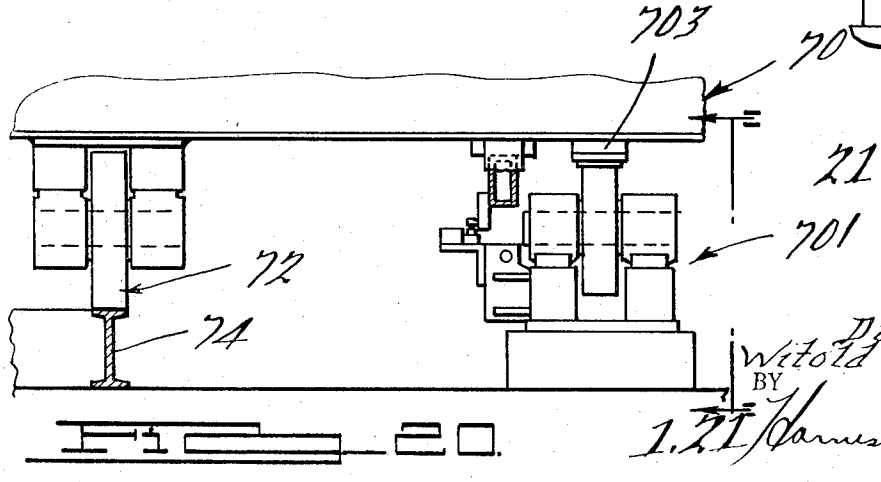


FIG. 20.

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GRINDER FOR GRINDING THE FACES OF EDGE-SUPPORTED WORKPIECES

SUMMARY BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for grinding relatively flat-surfaced workpieces such as slab, sheet, billet, and coil material. Thus, merely by way of example, material having a thickness of from about 0.05 inch to 8 inches, a face width of from about 10 inches to 52 inches, and a length of up to 25 feet and more, can be processed according to the invention.

While the present invention is specifically shown and described for use in grinding of metal slabs, it should be understood that features of the present invention can be utilized in other grinding applications on, for example, metal coil and sheet, as well as on nonmetal sheets and structures.

In many applications work materials, e.g., coil, plate, etc. are formed from large metal slabs. However, it is necessary in order to produce top quality, hence salable material, particularly high alloy stainless steel, that the metal slabs have substantially clean surfaces, i.e., be free of surface imperfections, seams, scale, oxides, etc. It is the practice to first process the metal slabs to remove the scale, etc. In the removal process, however, it is important that the surfaces be cleaned and, in the case of costly steel alloys, it is important that there be a minimum of stock removal and that a good surface be developed. In the past it has been common practice to grind the face of metal slabs, while supported horizontally, by abrasive wheels of limited width, e.g., about 3 inches in width; hence, multiple passes, longitudinally, with the grinding wheel were required in order to complete one grinding operation across the face of the slab. Such grinding procedure is not only time consuming, but most disadvantageously results in surface gouging, thus producing a scalloped surface which requires additional finishing. Moreover, slab grinding, using abrasive wheels, results in a relatively coarse finish and residual grinding lines show up that require further conditioning in, e.g., the production of coil by abrasive belt grinding. With the advent of new Steelmaking processes, slab quality is improved with respect to the amount of scale, etc. While such results in less conditioning of the slab, it requires that what conditioning is done results in a high quality surface with the minimum of stock removal. In the present invention, an abrasive member extending the complete width of the face of the slab to be ground is utilized, i.e., such as a wide, coated abrasive belt, a cylinder having an abrasive beltlike surface, wide abrasive wheels, or the like, hence simplifying the grinding operation.

In addition, in the method and apparatus of the present invention the slabs are supported on an edge with the surface to be ground extending vertically; this facilitates the grinding of opposite faces on the slab. Thus, in the present invention a face of the slab can be ground and the slab can be conveniently turned end for end by means of a turntable whereby the opposite side can be presented to the abrasive belt and ground. In another aspect, both faces of the slab can be ground in one pass through the apparatus by providing grinding means on both sides of the slab. Such vertical grinding as above mentioned is of great advantage in virtually eliminating the swarf problem. Swarf, in the process according to the invention, tends to drop off, thus aiding in the grinding process and, in the case of some metals, in the prevention of swarf rewelding. With horizontal slab grinding, particularly with heavy stock removal, a relatively large flood of oil is needed to remove the grinding swarf.

In the handling of metal slabs in many instances the surfaces to be ground, which from a distance appear to be flat are, on closer examination, in fact, found to be warped, curved, undulating and the like. A workpiece may even be found to be, more or less, tapered from one edge to the other. The apparatus of the present invention is particularly suited to handle such generally flat surfaced workpieces while still permitting effective and accurate grinding of the surface with a minimum

of stock removal. Hence, in comparison to past processes or apparatus, with the present invention grinding is facilitated while resulting in the generation of a better and more highly polished surface, better controlled material removal, and with the removal of less slab material. Moreover, the inspection of slabs for further processing is improved by belt finishing, as compared with wheel finishing, because surface imperfections are more readily observable. Therefore, it is an object of the present invention to provide a novel method and apparatus for grinding generally flat workpieces.

It is another object of the present invention to provide a method and apparatus for grinding generally flat workpieces in which the workpieces can be revolved 180° whereby opposite surfaces can be ground.

It is another object of the present invention to provide a method and apparatus for grinding metal slabs having warped and curved surfaces.

Other objects, features, and advantages of the present invention will become apparent from the subsequent description and the appended claims, taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a generally top elevational view depicting the grinding apparatus of the present invention;

FIG. **2** is a side elevational view of the apparatus of FIG. **1**;

FIG. **3** is a side elevational view to enlarged scale taken substantially along the lines **3–3** in FIG. **1**;

FIG. **4** is a sectional view to enlarged scale taken substantially along the lines **4–4** in FIG. **1**;

FIG. **5** is a plan view to enlarged scale taken in the direction of arrow **5** in FIG. **2**;

FIG. **6** is an elevational view of the apparatus of FIG. **4** taken in the direction of the arrow **6**;

FIG. **7** is an elevational view to enlarged scale taken substantially along the lines **7–7** of FIG. **2**;

FIG. **8** is a plan view to enlarged scale taken in the direction of the arrow **8** in FIG. **2**;

FIG. **9** is a sectional view taken generally along the lines **9–9** in FIG. **8**;

FIG. **10** is an elevational view to enlarged scale taken generally along the lines **10–10** in FIG. **1**;

FIG. **11** is a top plan view depicting the control rolls, billy roll and contact roll in working relationship with a slab to be ground;

FIG. **12** is a plan view to enlarged scale taken in the direction of the arrow **12** in FIG. **2**;

FIG. **13** is an elevational view of the control roll taken generally along the lines **13–13** in FIG. **12**;

FIG. **14** is a view to enlarged scale of the apparatus in the dot-dash lines of FIG. **12** indicated by the arrow **14**;

FIG. **15** is an elevational view to increased scale taken in the direction of the arrows **15–15** in FIG. **12**;

FIG. **16** is a sectional view to increased scale taken generally along the lines **16–16** in FIG. **13**;

FIG. **17** is an elevational view of the billy roll taken in the direction of arrow **17–17** in FIG. **1**;

FIG. **18** is a plan view taken in the direction of the arrow **18** in FIG. **17**;

FIG. **19** is an elevational view taken in the direction of the arrow **19** in FIG. **18**;

FIG. **20** is an elevational view of a part of the turntable;

FIG. **21** is an elevational view of the apparatus of FIG. **20** taken generally in the direction of the arrows **21–21**; and

FIG. **22** is a sectional view of the apparatus of FIG. **3** taken generally along the lines **22–22**.

Looking now to the drawings, the preferred embodiment of a grinding apparatus of the present invention is generally indicated by the numeral **10** and includes a grinding section **12**, a pair of identical feed sections **14** and **16** located on opposite sides of the grinding section **12** and a pair of guide sections **18** and **20** which are oppositely disposed in the grinder assembly **10** and located adjacent feed sections **14** and **16**, respectively. The guide sections **18** and **20** are similar except that guide section **18** is stationarily mounted while the guide section **20** is

mounted for rotatable movement whereby the opposite side of a workpiece can be presented to the grind section **12**.

The guide section **18** includes a plurality of identical, horizontally extending vertical support roll assemblies **22***a* through **22***e*. Each of the vertical support roll assemblies **22***a*—**22***e* includes a roll **24***a*—**24***e*, respectively, which is supported for rotation by means of a gearbox assembly **26***a* through **26***e*, respectively. The gearboxes **26***a*—**26***e* are interconnected by drive shafts **28** which are connected to be driven from a common source **29**. The rolls **24***a* to **24***e* can be selectively power driven in either direction such that a workpiece can be fed either toward or away from the grinding section **12**. The vertical height of the rolls **24***a* to **24***e* can be adjusted whereby workpieces having faces of different widths can be accommodated. Thus the workpiece W is supported on one edge on the rolls **24***a* through **24***e* and can be power driven away or towards the guide section **12**.

While the rolls **24***a*—**24***e* vertically support and locate the workpiece W, a plurality of vertical guide roll assemblies **30***a* through **30***c* are provided to horizontally locate and guide the workpiece W such as to properly align that surface of the workpiece W to be ground relative to the feed section **14** and grinding section **12**. Each of the guide roll assemblies **30***a*—**30***c* includes master roll subassemblies **32***a*—**32***c* located on one side of workpiece W and slave roll subassemblies **34***a*—**34***c* located on the opposite side of workpiece W. Each of the subassemblies **32***a*—**32***c* includes a vertically supported guide roll **36***a*—**36**respectively, while each of the subassemblies **34***a*—**34***c* includes a vertically supported guide roll **38***a*—**38***c*, respectively. The subassemblies **32***a*—**32***c* are master assemblies and are selectively actuable so that the rolls **36***a*—**36***c* can be moved in a horizontal plane to a position engaging the surface of the workpiece W to be ground and locating that surface in a preselected position for entrance into the feed section **14**. The subassemblies **34***a*—**34***c* are slave subassemblies and the rolls **38***a*—**38***c* associated therewith are moved horizontally relative to the associated rolls **36***a*—**36***c* of the master subassemblies **32***a* through **32***c*. In operation, first the master rolls **36***a*—**36***c* are moved to selected positions engaging the one surface of the workpiece W; next the slave rolls **38***a* through **38***c* are actuated to move toward the associated master rolls to engage the opposite side of workpiece W. Note that the master rolls t**36***a*—**36***c* are separately movable; thus the rolls **36***a*—**36***c* can be individually operated to maneuver the workpiece W such that its leading edge will be along the pass line so that it can be properly fed into the feed section **14**. Thus the workpiece W can be selectively engaged via the rolls **36***a*—**36***c* such as to position the workpiece W to be properly fed or guided into the feed section **14**. The rolls **36***a*—**36***c* and **38***a*—**38***c* are not powered but are supported to roll freely and the workpiece W will be moved by the vertical support rolls **24***a*—**24***e*. The details of the guide section **18** will be discussed later at which time the details of the other sections will also be discussed.

Next, the workpiece W is introduced into the feed section **14**. The feed section **14** comprises a pair of outer vertically extending pinch rolls **40***a* and **40***b* located on one side of the workpiece W and a pair of inner pinch rolls **42***a* and **42***b* which are located on the opposite side. The rolls **40***a*, **40***b* and **42***a*, **42***b* are normally located apart as the workpiece W is introduced therebetween. Next these rolls, which are power driven, are actuated to grip the workpiece W and to move it into the grinding section **12**. After the workpiece W has been gripped by the pinch rolls in the feed section **14**, the operator can release the guide roll assemblies **30***a* through **30***c*, since their primary function is to guide the workpiece W as it is fed into the feed section **14**. If desired, however, the operator can maintain a grip on the workpiece W with the guide roll assemblies, or any of them, in order to maintain pass line, particularly with respect to workpieces, having a high degree of curvature, warp, or the like. At the same time the support roll assemblies **22***a* through **22***e* can be disconnected from power and permitted to roll freely such that the workpiece W is moved solely by the pinch or feed rolls **40***a*, **40***b* and **42***a*, **42***b*. If desired or required the operator can maintain power to the vertical support rolls **22***a* through **22***e*. The feed rolls **40***a*, **40***b* and **42***a*, **42***b* are mounted for selected pivotal movement such that they can accommodate the twist or warpage of the surface of the workpiece W. The feed sections **14** and **16** include vertical support roll assemblies **23***a* and **23***b* which are similar to assemblies **22***a*—**22***e* and which are connected therewith for powered rotation via drive shafts **25**. The workpiece W is now ready to be fed into the grinding section **12**.

The grinding section **12** includes a vertically supported contact roll **44** which is driven by means of an electric motor **46** via wheels **48** and **52** and belts **50** and **56**. In a preferred form of the invention an endless coated abrasive belt **58** is utilized for grinding and is supported to extend over the contact roll **44** and over an idler roll **60**. The position of the contact roll **44** and hence grinding belt **58** is generally fixed and hence the workpiece W is manipulated relative to the roll **44** whereby the depth of cut is selected. The depth of cut is set by a backup or billy roll **64** which is selectively moved into a predetermined position to engage the opposite surface of the workpiece W. This position is determined by ascertaining, from inspection of the workpiece, the desired thickness of material to be removed therefrom, by means of a micrometer caliper, or the like, and then setting the position of the billy roll at the predetermined position in accordance with a position indicator. The billy roll **64** is mounted for pivotal movement in a vertical plane to accommodate for warpage and variations in the contour of the surface of the workpiece W opposite to the surface being ground. A control roll **62**, which is vertically supported and can be selectively moved in a horizontal plane relative to the axis of the contact roller **44**, engages the side of workpiece W to be ground and applies a force against the workpiece W through a mechanical system that permits the control roll **62** to slave the movements of the billy roll **64**. This force is restrained by the backup or billy roll **64**. Since the billy roll **64** is free to pivot in a vertical plane, this control roll holds the surface of workpiece W being ground parallel to the axis of contact roller **44**. While the control roll **62** is not powered but rotates freely the billy roll **64** is power driven to assist in moving workpiece W. The position of the billy roll **64** determines the amount of metal to be removed. Note that because of the irregular contour of the workpiece W the apparatus of the present invention is constructed such that the workpiece W is gripped adjacent to that part being ground with the remainder of the workpiece W being free to vary in position whereby these irregularities in contour are accommodated while a minimum of material is removed. However, in order to assure that the workpiece W is securely held, a second control roll **66** located on the opposite side of the contact roll **44** is positioned in line with the contact roll **44** so that it will engage the ground surface of workpiece W after it has passed the belt **58**. Thus workpiece W is firmly gripped by a three point contact as defined by control rolls **62** and **66** and billy roll **64** all of which are located proximate the area of grinding. As the workpiece W is fed through the grinding section **12**, the one surface is ground. The second control roll **66** is identical in function and operation to control roll **62** is set to apply a force or pressure to the workpiece W when such is moved through the grinding section **12** in an opposite direction while roll **62** at that time is set to apply a force corresponding to the prior support position of roll **66** whereby again the workpiece W will be firmly gripped by a three point contact.

As the workpiece is moved through the grinding section **12** its leading end is moved into the feed section **16**, which is similar to the feed section **14**, and the workpiece W is gripped and moved by the pinch or drive rolls **40***c*, **40***d* and **42***c*, **42***d*, which are similar in function and operation to the rolls **40***a*, **40***b* and **42***a*, **42***b*, respectively. The workpiece W is then driven by the combined effect of the feed sections **14** and **16** through grinding section **12** and into the guide section **20**. The guide section **20** is similar to the guide section **18** and includes

vertical support roll assemblies 22*f*—22*j* (similar to roll assemblies 22*a* to 22*e*) which vertically support the workpiece W along its edge. The workpiece W, as it is moved into the guide section **20**, is also moved through guide roll assemblies 30*d*—30*g* (similar to guide roll assemblies 30*a*—30*c*). As the workpiece W is passed into the guide section **20**, the rolls associated with the support roll assemblies 22*f*—22*j* are free rolling and the rolls associated with the guide roll assemblies 30*d*—30*g* are separated. Upon the completion of the grinding pass by the workpiece W and with workpiece W in guide section **20** the operator can then actuate the support roll assemblies 22*f*—22*j* and the guide roll assemblies 30*d*—30*g* to reverse the travel of workpiece W to move it through the grinding section **12** in the opposite direction. In this reverse direction the direction of rotation of the contact roll **44** is reversed and the depth of cut is determined by billy roll **64**. The feed section **16** performs the same function as initially performed by the feed section **14**, and vice versa, and the workpiece W is transmitted to guide section **18**.

If it is desired to grind the opposite side of the workpiece W, then with the workpiece W located in the guide section **20** the entire guide section can be rotated 180° such that the opposite surface of the workpiece W will then be presented to the grinding section **12** and the sequence of operations previously noted can be repeated. The guide section **18** is supported on a fixed platform **71**. In contrast guide section **20** is supported upon a turntable **70** which has a plurality of wheel assemblies **72** which are located upon a circular track **74** with a motor **75** providing power to rotate the turntable **70**. Thus, the guide section **20** can be rotated 180° in the direction of the arrow **76** to reverse the surface of the workpiece W to be ground and it can be rotated 180° in the direction of the arrow **78** back to its original position to again reverse the direction of the workpiece.

In the discussion that follows a detailed description of the various sections is given; note that in the drawings like components serving similar functions have been given the same number with a different letter suffix.

GUIDE SECTION

Since each of the support roll assemblies 22*a* to 22*e* is substantially identical, the description of only one is deemed sufficient to be shown and described in detail.

Looking now to FIGS. **3** and **22**, the support roll assembly 22*a* has its roll 24*a* supported at opposite ends on slides **80** which are slidably supported in grooves **81** in support assemblies **82** and are movable vertically to selected positions by hydraulically actuated screwjacks **83**, which can be selectively actuated by the operator. All of the support rolls can be similarly actuated whereby the support height of the workpiece W can be altered. In this way, workpieces W having various face widths can be located such as to be generally centrally positioned relative to the grinding section **12**.

As previously noted, the roll 24*a* is driven via the gearbox 26*a* from the common hydraulic motor **29**. The source **29** can be actuated whereby the workpiece W will be driven or can be deactuated such that roll 24*a* will be free to roll without power. The assemblies 22*f*—22*j* of guide section **20** are similar to assemblies 22*a*—22*e* of guide section **18**.

FIGS. **4**, **5** and **6** show the details of the guide roll assembly 30*a*. The guide roll assembly 30*a* includes the master roll assembly 32*a* and the slave roll assembly 34*a*. The master assembly 32*a* includes a frame assembly **84***a* which is fixed to the platform **71** and which supports a slide assembly **88***a* for slidable movement towards and away from the workpiece W on guide rods **89***a* supported in guides **91***a*. The guide roll **36***a* is rotatably supported upon a support assembly **90***a* which is pivotably supported at the forward end of the slide assembly **88***a* via a pivot structure **92***a*. Hence, the roll **36***a* is free to roll to thereby guide the workpiece W and is also free to pivot so as to follow the contour of the workpiece W. The roll support assembly **90***a* is held in position by balance spring assemblies **94***a* and **96***a* which include threaded shafts **98***a* and **100***a*, which are pivotally fixed to the upper end of the roller support assembly **90***a*. Balance springs **102***a* and **104***a* associated with rod **98***a* and balance springs **106***a* and **108***a* associated with rod **100***a* generally maintain roll **36***a* in a vertical position. However, the balance spring assemblies **94***a* and **96***a* operate in the manner known in the art to permit pivotal movement of the support **90***a*, and hence roll **36***a*, about the pivot assembly **92***a* with the balance spring assemblies **94***a* and **96***a* resiliently urging roll **36***a* to its original, upright position. The transverse position of the slide assembly **88***a*, and hence roll **36***a*, can be selectively varied by selective actuation of a hydraulically actuated piston **110***a* which is connected between the frame assembly **84***a* and the slide assembly **88***a*. Thus by actuation of the piston **110***a* the roll **36***a* can be moved transversely towards and away from the workpiece W.

The slave assembly **34***a* is of a construction similar to the master assembly **32***a* and like components have been given the same number with the addition of **100**, i.e., the equivalent of piston **110***a* for assembly **34***a* has number **210***a*, etc. The pistons **110***a* and **210***a* will generally maintain the rolls **36***a* and **38***a* in fixed positions. The piston **210***a* however is connected with a pressure relief mechanism **211***a*, of a type known in the art, such that when a preselected relative force is applied to roll **38***a* by workpiece W, the piston **210***a* will retract while still exerting the selected force. Thus piston **210***a* will permit roll **38***a* to accommodate variations in thickness of the workpiece W while the roll **36***a* is maintained fixed. In this way roll **36***a* can be fixed to determine the pass line of the workpiece W and the roll **38***a* can be moved whereby workpiece W will be securely gripped between rolls **36***a* and **38***a* with roll **38***a* being movable under preselected load conditions whereby variations in material thickness along the length of the slab W can be accommodated. In operation, individual ones or more of the assemblies 30*a*—30*c* (or 30*d*—30*g* in guide section **20**) can be actuated to properly orient the workpiece W relative to the feed section **14** (or feed section **16**). Guide projections **101***a* and **201***a* are provided at the upper ends of frame assemblies **84***a* and **184***a* to protect rolls **36***a* and **38***a* if the workpiece W is introduced vertically downwardly into the guide section **18**. The assemblies 30*d*—30*g* are similar to assemblies 30*a*—30*c* except that no projections corresponding to projections **101***a* and **201***a* are provided since the workpiece W is initially introduced into section **18** and not into section **20**.

FEED SECTION

The feed sections **14** and **16** are similar and hence only the feed section **14** will be described in detail. The pinch rolls **40***a* and **40***b* are located on the side of the workpiece W to be ground in a frame assembly **300**. The frame assembly **300** includes transversely extending upper guides **302***a*, **304***a* and **306***a* and corresponding lower transversely extending guides **302***b*, **304***b* and **306***b*. A main slide **308***a* is slidably supported between guides **302***a* and one side of guide **304***a* and a second main slide **310***a* is supported for slidable movement between the other side of the guide **304***a* and the guide **306***a*. Similar lower main slides such as **308***b*, **310***b* are slidably supported relative to guides **302***b*, **304***b* and **306***b*. Pistons **312***a* and **314***a* are connected between the frame **300** and main slides **308***a* and **310***a*. In a similar manner pistons such as **312***b* (not shown in the drawing), **314***b* are connected with the lower main slides. By selected actuation of the pistons **312***a*, *b* and **314***a*, *b* the position of the pinch rolls **40***a*, **40***b* can be selectively varied such as to be along the pass line in a position to engage the workpiece W. The rolls **42***a* and **42***b* are also movable with the upper main slides **308***a*, **310***a* and lower main slides, i.e., **310***b*. The pinch rolls **42***a* and **42***b*, however, are also supported upon secondary slides whereby these rolls can be moved separately on the main slides, i.e., **308***a*, **310***a*, **310***b*, etc. Thus, pinch roll **42***a* is supported at its upper end on secondary slide **320***a* and at its lower end by slide **320***b*. Slide

320*a* is actuable by a piston 322*a*, while slide 320*b* is actuable by piston 322*b*. The pistons 322*a* and 322*b* are connected between the corresponding main slides 310*a* and 310*b* and the secondary slides 320*a* and 320*b*. In a similar manner, the pinch roll 42*b* is supported on upper secondary slide 316*a* and a similar lower secondary slide which secondary slides are movable by pistons 318*a* and 318*b* relative to the associated main slides. The main slides are generally channel shaped to thereby slidably accommodate the associated secondary slides. Hence, in operation the pinch rolls 40*a*, 40*b* and 42*a*, 42*b* are first positioned (via the main slides) to bring the pinch rolls 40*a* and 40*b* generally in line with the pass line of the workpiece W by actuation of pistons 312*a*, 312*b* and 314*a*, 314*b*. The workpiece W is then moved in line with rolls 40*a* and 40*b*. Next, the secondary pinch rolls 42*a* and 42*b* are moved relative to the pinch rolls 40*a* and 40*b* by actuation of the secondary pistons to securely grip the workpiece W. With workpiece W gripped the rolls 40*a*, 40*b*, 42*a* and 41*b* can be provided to drive the workpiece W. With this construction it is possible to lock the pinch rolls in this position in engagement with the workpiece W. By the provision of suitable apparatus (not shown) the pinch rolls can be permitted to float together with relief valves acting on the main pistons 312*a*, 312*b* and 314*a*, 314*b*. In addition, the relief valves can be provided for the pistons 318*a*, 318*b* and 322*a*, 322*b* to permit relative movement of the secondary pinch rolls 42*a*, 42*b* to accommodate variations in thickness of the workpiece W. In addition, with the arrangements as shown by selective actuation of selected ones only of the pistons the pinch rolls can be selectively pivoted.

The pinch rolls are driven by means of drive shaft and universal joint assemblies 321 which in turn are driven by a hydraulic motor 324 acting through a gearbox 326. Thus, in operation, the workpiece W is introduced into the feed section 14 where the surface of the workpiece W to be ground is moved into a selected position along the pass line. In this position, the workpiece W is gripped by the guide rolls. Next, the primary pinch rolls 40*a* and 40*b* are moved into engagement with the surface of the workpiece W to be ground by actuation of the main pistons 312*a*, 312*b*, etc.; next, the secondary pinch rolls 42*a* and 42*b* are moved into engagement with the opposite side of the workpiece by actuation of the secondary pistons 318*a*, 318*b*, etc. Next, the operator can release the guide rolls and by actuating the fluid motor 324 can begin the movement of the workpiece W into the grinding section 12. Note that the feed section 16 is substantially similar to the feed section 14 and hence a detailed description thereof has been omitted for purposes of simplicity.

GRINDING SECTION

The control roll 62 (see FIGS. 13, 14, 15 and 16) is secured for rotation in a vertically extending support bracket 400 which is fixed to a slide assembly 402 which is slidably mounted in a holder frame 404. The bracket 400 is slidable relative to the frame 404 by a screwjack assembly 406 which can be hydraulically driven by a fluid motor 405 whereby the frame 400 can be moved transversely towards or away from the pass line of the workpiece W. Intermediate the screwjack 406 and the frame 400 is a hydraulically actuated cylinder 408 which serves a purpose to be described. In operation, the roll 62 is moved generally to the pass line and is then in a position which is transversely offset from the grinding abrasive belt 58. This can be set by actuation of the screwjack 406. The hydraulic cylinder and piston assembly 408 can be of a conventional construction and normally has its piston in a retracted position prior to grinding. During the grinding operation, however, the piston is pressurized to cause it to extend. Nevertheless, this force is opposed by workpiece W and billy roll 64 and no movement of the piston occurs. In the event of breakage of the belt 58, this occurrence is sensed, by means known in the art, and a signal is transmitted whereby fluid pressure will be supplied to piston 518 causing it to be actuated moving the billy roll 64 in the retracted position. Because piston 408 is pressurized the retraction of piston 518 results in the movement of control roll 62 and workpiece W away from the contact roll 44 whereby damage thereto will be prevented. Control roll 66 is similarly constructed and is operable in a similar manner and hence the details of its actuation need not be described.

On the opposite side of the workpiece, the backup or billy roll 64 is rotatably journaled to a frame 500 and is adapted to be power rotated by means of a hydraulically actuated low speed motor 502 through a gearbox 504. A second hydraulic high speed motor 506 can be connected to the gearbox 504 and can be alternatively actuated. Hence motors 502 and 506 provide for substantial range of speeds over which the billy roll 64 can be driven. The frame 500 is pivotally secured at supports 501 for pivotal movement in a transverse direction by means of a bifurcated support assembly 508 which straddles the frame 500 proximate its center. Support assembly 508 has an end plate 509 connected at opposite ends to rods 510 which are slidably connected to a frame 512 whereby the assembly 508 and hence the billy roll 64 can be moved transversely towards and away from the workpiece W. A hydraulically driven screwjack assembly 514 is centrally located and connected between the frame 512 and the support assembly 508 via plate 509. The jack assembly 514 is selectively driven by a fluid motor 516 whereby the position of the assembly 508 and hence of the billy roll 64 can be selectively adjusted by the operator to be in a position to engage the opposite side of the workpiece W. A hydraulically actuated piston member 518 is interposed between jack assembly 514 and plate 509 and is normally held actuated to its maximum outward position and hence does not normally vary the position of the billy roll 64. However, in the event of detection of breakage of the abrasive belt 58, the piston 518 is actuated to release pressure whereby the billy roll 64 can be quickly retracted. Note that both pistons 518 and 408 are normally in extreme positions and hence upon replacement of the grinding belt 58, the original positions of the control roll 62 and billy roll 64 can be readily reestablished merely by actuating the piston 408 to move back to its retracted position and by pressurizing the piston 518 to move the billy roll 64 to its outermost position.

As previously noted, the billy roll 64 is pivotally secured by means of the bifurcated mounting assembly 508. The plate 509 extends in opposite vertical directions from the assembly 508 and has an upper piston assembly 522 and a lower piston assembly 524 attached at opposite ends. The piston assemblies 522 and 524 can be actuated by the operator such as to bias the billy roll 64 substantially in a vertical position as shown. They can be interconnected by appropriate relief valves such that the billy roll 64 will be able to pivot on the pivot support 508 in response to a force tending to move one or the other of the piston assemblies 522, 524 whereby the billy roll 64 can follow the contour of the workpiece W.

The depth of cut is determined by the combined action of the control rolls 62 and 66 and billy roll 64. Thus now looking to FIG. 11 it can be seen that the position of the billy roll 64 is selected relative to the position of the feed-in control roll 62 and the contact roll 44 to determine the depth of cut on the workpiece W. The position of the other control roll 66 is located to be in line with the contact roll 44. With this arrangement, the workpiece W is firmly gripped and held in position by the three point contact as provided by the control rolls 62 and 66 and the billy roll 64. Note that when feeding the workpiece W through the grinder section 12 in the opposite direction, the positions of the control rolls 62 and 66 would be reversed.

Looking now to FIGS. 10 and 12, as previously noted, the contact roll 44 is driven by means of the electrical motor 46 via the wheels 48, 52 and by the belts 50 and 56. The abrasive belt 58 is supported to extend over the contact roll 44 and over the idler roll 60. The contact roll 44 and idler roll 60 are held in support assembly 600 which includes hydraulic cylinder 602 whereby the idler roll 60 and contact roll 44 can be held a selected distance apart maintaining tension on the

abrasive belt **58**. An oscillating assembly **605** includes means whereby the idler roll **60** will be pivoted in a vertical plane whereby the belt **58** can be made to move in selective directions axially relative to the contact roll **44** and whereby the belt **58** will be kept on the contact roll **44**. Since such belt oscillating apparatus is well known in the art and since the specific details do not constitute a part of the present invention, the details have been omitted for the purpose of simplicity. Note that the motor **46** is reversible such that the grinding belt **58** can be rotated in either direction and hence as the workpiece W is reversed in its direction to the grinding section **12**, the direction of rotation of the belt **58** can be reversed, if necessary.

As the workpiece W is fed through the grind section **12** into the feed section **16**, the feed section **16** (similar to the feed section **14**), can be actuated to grip the workpiece W and assist in driving it through the grind section **12**. At this time the workpiece W is received upon the vertical support roll assemblies **22***f* to **22***j*, with the guide roll assemblies **30***d* to **30***g* being maintained apart.

When the workpiece W is received into the guide section **20** the section can be actuated to reverse the direction of the workpiece W whereby another grinding operation will be performed upon the surface previously ground. As noted, in this situation the control rolls **66** and **62** will be switched in position.

It is important that both sides of the workpiece W be finished to remove scale, etc. To accomplish this, the guide section **20** can be revolved 180°. Looking now to the FIGS. **20** and **21**, the guide section **20** is generally supported upon a support plate **70** which in turn is supported by roll assemblies **72** which are adapted to ride upon the circular track **74**. The support plate **70** is connected to a hydraulic motor and gear assembly **75** at its center whereby upon actuation of the motor and gear assembly **75** the entire plate **70** and guide section **20** will be rotated 180° whereby the opposite surface of the workpiece W can be ground. A locating and locking assembly **701** is operative with a locating button **703** to accurately position the support plate **70** and hence the guide section **20**.

While it will be apparent that the preferred embodiment of the invention disclosed is well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the invention.

What we claim is:

1. Apparatus for grinding generally flat surfaced workpieces comprising: feed means for vertically supporting and feeding said workpieces to a grinding section, grinding means at said grinding section for grinding at least one face of the workpiece as it is moved therethrough, said grinding means including abrading means for removing material from a vertical face of said workpiece and support means adjacent said abrading means for supporting the workpiece at at least two horizontally spaced points on one side of the workpiece and a third point located intermediate each of said two at least horizontally spaced points and on the opposite side of the workpiece, said support means each being selectively movable toward and away from the workpiece to a position for gripping the workpiece and locating it relative to said abrading means whereby the depth of cut is determined, said horizontally spaced support means each including actuating means for rapidly applying a force against the workpiece for rapidly moving the workpiece away from the abrading means in the event of a predetermined occurrence, said intermediate support means including release means for providing for rapid movement of the intermediate support means from the workpiece in the event of said predetermined occurrence.

2. Apparatus according to claim **1** wherein said feed means supports the workpiece on an edge.

3. The apparatus of claim **1** wherein said support means supports the workpiece at only two horizontally spaced points on one side of the workpiece and at a third point located intermediate said two points and on the opposite side.

4. The apparatus of claim **3** with said support means comprising three roll members located at said three points and said abrading means including an abrasive belt supported on a contact roll being located between said two points and generally opposite said one point with the one of said roll members at said one point being a billy roll.

5. The apparatus of claim **4** with said billy roll being power driven.

6. The apparatus of claim **5** with said release means and said actuating means each comprising a piston movable rapidly from a first fixed position to a second fixed position whereby in the event of replacement of the belt after breakage each said piston can be actuated to its original first fixed position whereby the original depth of cut can be quickly reobtained.

7. The apparatus of claim **6** with said intermediate support means including pivot means for supporting said billy roll for pivotal movement about a longitudinal, horizontal axis.

8. The apparatus of claim **7** with said pivot means including pivot actuating means for biasing said billy roll in a substantially vertical position.

9. The apparatus of claim **8** with said pivot-actuating means comprising at least one fluid actuated piston and cylinder assembly located at one vertical side of said axis.

10. The apparatus of claim **1** with said feed means including workpiece feed means located on opposite sides of said grinding means for selectively feeding the workpiece in said grinding means from opposite directions.

11. Apparatus according to claim **10** wherein said feed means comprises a first feed means and a second feed means associated therewith, said second feed means being disposed adjacent to, and feeding the workpiece into said grinding section.

12. The apparatus of claim **11** with said first feed means including guide means associated therewith for guiding the workpiece into the associated second workpiece feed means.

13. The apparatus of claim **12** including rotatable means for supporting one of said guide means and for rotating said one of said guide means to a position at which the workpiece can be guided into the associated one of said second feed means whereby the opposite side of the workpiece can be ground.

14. The apparatus of claim **13** with said first feed means comprising a plurality of support rolls supported to rotate on transverse, horizontal axes and means selectively actuable for varying the vertical position of said support rolls.

15. The apparatus of claim **14** with said guide means comprising a plurality of pairs of guide rolls supported to rotate on vertical axes and located on opposite sides of the workpiece for guiding the workpiece and moving means for independently moving each of said pairs of guide rolls towards each other to grip the workpiece or away from each other to release the workpiece.

16. The apparatus of claim **15** wherein the guide rolls are pivotally supported.

17. The apparatus of claim **16** including means for maintaining said guide rolls in a generally vertical position.

18. The apparatus of claim **15** in which said moving means supports one roll of said pair of guide rolls for movement in response to variations in thickness of the workpiece.

19. The apparatus of claim **18** including drive means selectively actuable for driving said support rolls whereby the workpiece can be moved longitudinally.

20. The apparatus of claim **19** with each of said second workpiece feed means comprising a pair of pinch rolls supported for selective simultaneous movement relative to the workpiece and for selective movement relative to each other.

21. The apparatus of claim **20** with each of said pinch rolls being supported for pivotal movement about a longitudinally extending horizontal axis to fixed positions angulated relative to the vertical.

22. The apparatus of claim **18** including means supporting said guide rolls for pivotal movement about a horizontal, longitudinal axis.

23. Apparatus for grinding generally flat workpieces comprising: conveying means for supporting the workpiece on an

edge, grinding means for grinding a vertical face on the workpiece as it is moved therethrough, and feed means for feeding the workpiece into said grinding means, said grinding means including abrading means for removing material from said face, said conveying means and said feed means including workpiece feed means located on opposite sides of said grinding means for selectively feeding the workpiece in said grinding means from opposite directions, said conveying means including guide means associated with said workpiece feed means for guiding the workpiece into the associated one of said feed means and rotatable means for supporting one of said guide means and for rotating said one of said guide means to a position at which the workpiece can be guided into the associated one of said feed means whereby the opposite side of the workpiece can be ground.

24. Apparatus for grinding generally flat workpieces comprising: conveying means for supporting the workpiece on an edge, grinding means for grinding a vertical face on the workpiece as it is moved therethrough, feed means for feeding the workpiece into said grinding means, said grinding means including abrading means for removing material from the vertical face, said conveying means including guide means associated with said feed means for guiding the workpiece into said feed means, said guide means comprising a plurality of pairs of guide rolls supported to rotate on vertical axes and located on opposite sides of the workpiece for guiding the workpiece and moving means for independently moving each of said pairs of guide rolls toward each other to grip the workpiece and away from each other to release the workpiece.

25. The apparatus of claim **24** including means supporting said guide rolls for pivotal movement about a horizontal, longitudinal axis.

26. Apparatus for grinding generally flat workpieces comprising: conveying means for supporting the workpiece on an edge, grinding means for grinding a vertical face on the workpiece as it is moved therethrough, feed means for feeding the workpiece into said grinding means, said grinding means including abrading means for removing material from the vertical face, said feed means comprising a pair of rolls located on opposite sides of the stock, support means selectively actuable in one condition for moving said pair of rolls together and in another condition for independently moving one of said rolls relative to the other.

27. The apparatus of claim **26** with said support means being actuable to pivot said rolls to selected positions about a horizontal, longitudinal axis.

28. Apparatus for grinding generally flat surfaced workpieces comprising: first feed means for vertically supporting the workpiece, grinding means for grinding a vertical face on the workpiece as it is moved therethrough, second feed means for feeding the workpiece into said grinding means, said grinding means including abrading means for removing material from the vertical face and support means adjacent said abrading means for supporting the workpiece on opposite sides of the workpiece, said support means comprising a billy roll located generally opposite said grinding means and a control roll located adjacent said grinding means, said abrading means including an abrasive belt supported on a contact roll, first support means for supporting said billy roll for selective movement toward and away from the stock, second support means for supporting said control rolls for selective movement toward and away from the stock, said first and second support means including actuating means for rapidly moving said billy roll and said control rolls to positions moving the workpiece away from said contact roll in response to the occurrence of a preselected event.

29. The apparatus of claim **28** with said preselected event being belt breakage.

30. The apparatus of claim **29** with said actuating means comprising a piston movable rapidly from a first fixed position to a second fixed position whereby in the event of replacement of the belt after breakage said piston can be actuated to its original first fixed position whereby the original depth of cut can be quickly reobtained.

31. The apparatus of claim **30** with said actuating means being associated with said first support means and with said first support means including pivot means for supporting said billy roll for pivotal movement about a longitudinal, horizontal axis, said actuating means rapidly moving said billy roll away from the stock.