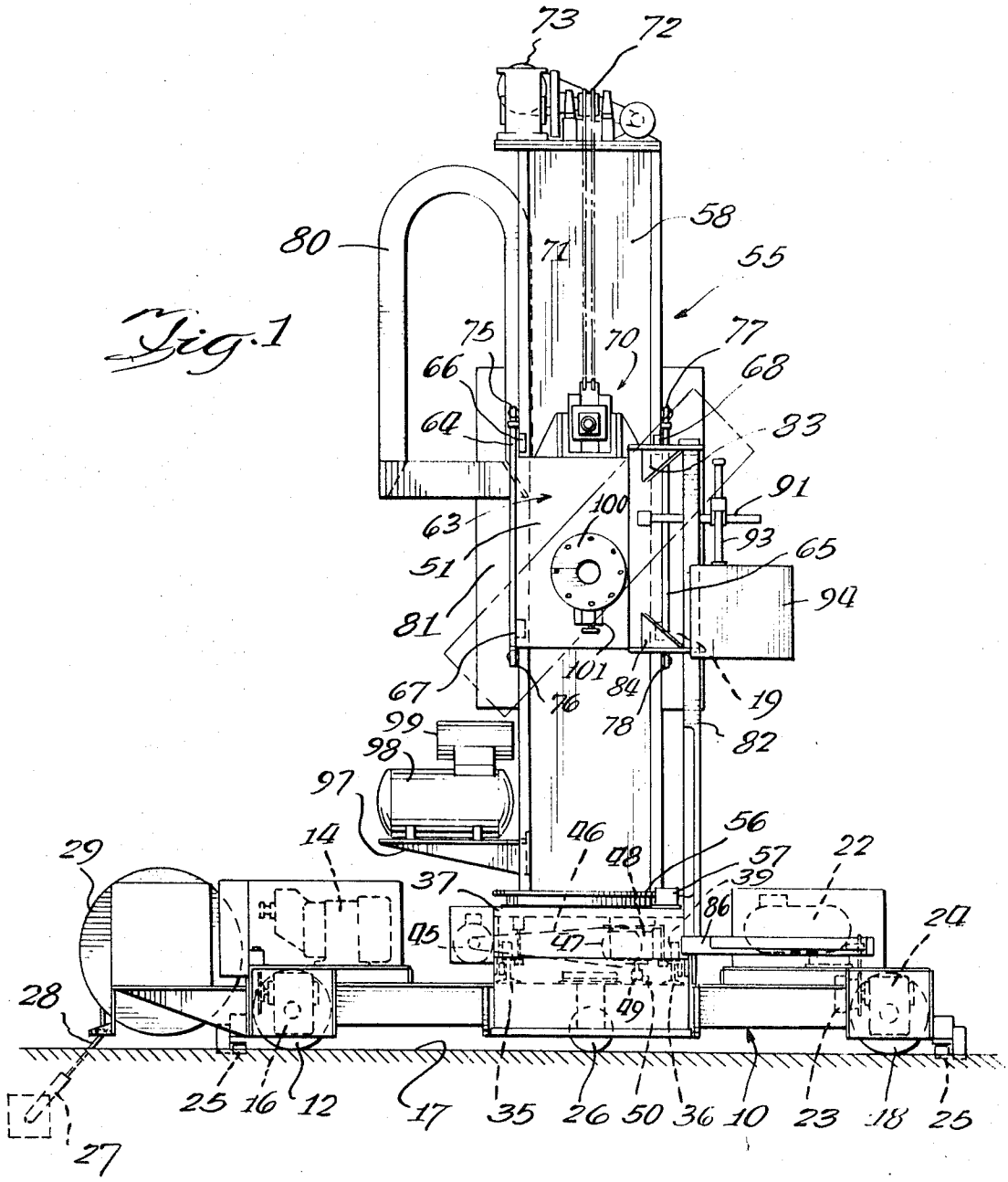
Sept. 28, 1971 J. B. McCORMACK ET AL 3,608,246

AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

Filed July 3, 1969 9 Sheets-Sheet 1

Fig. 1



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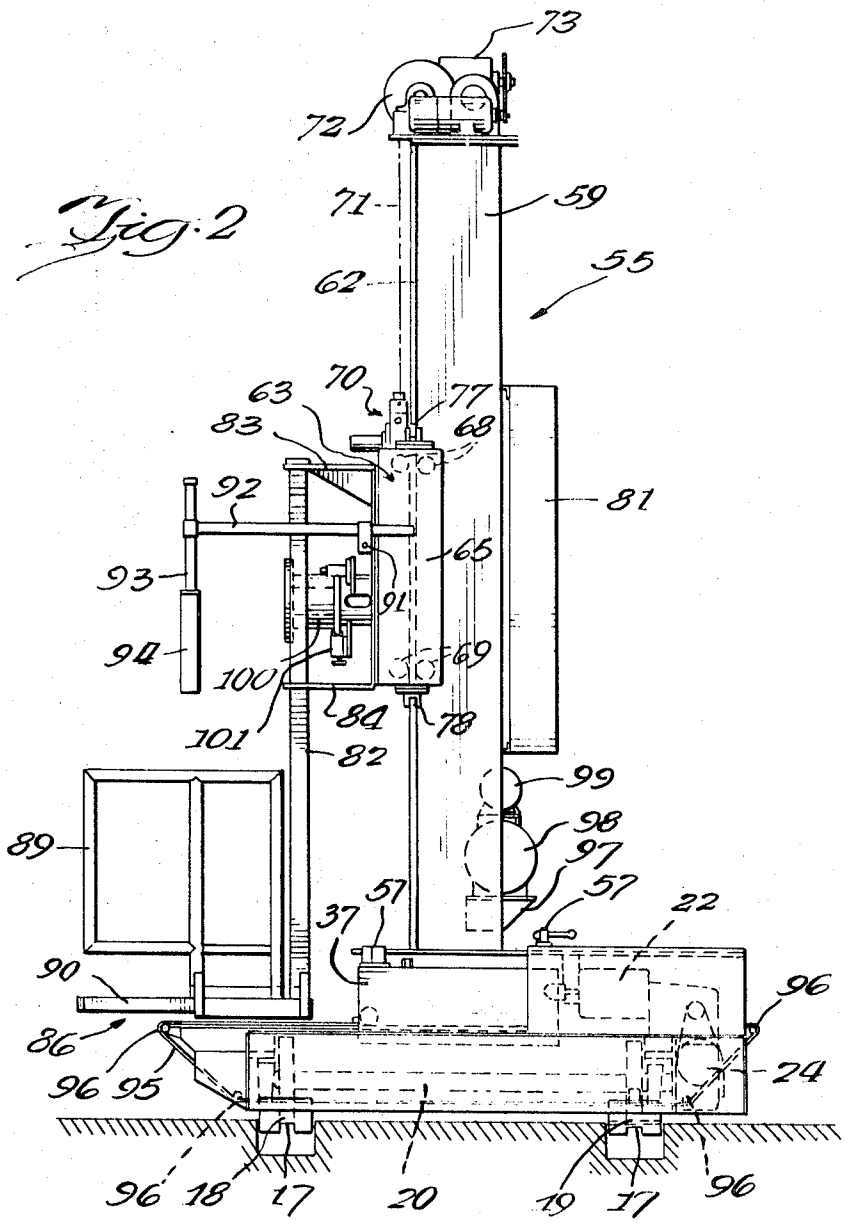
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Sept. 28, 1971 J. B. McCORMACK ET AL 3,608,246

AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

Filed July 3, 1969 9 Sheets-Sheet 2

Fig. 2



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AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

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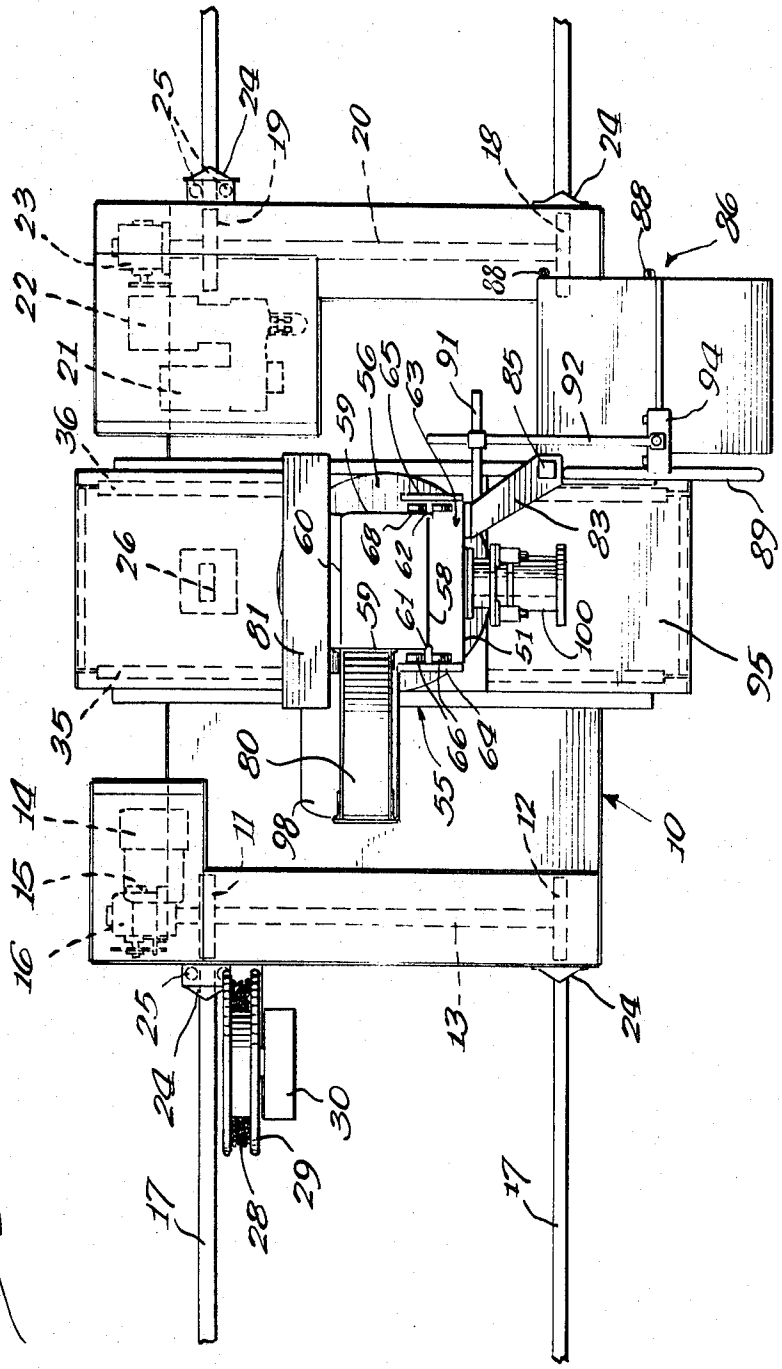


Fig. 3

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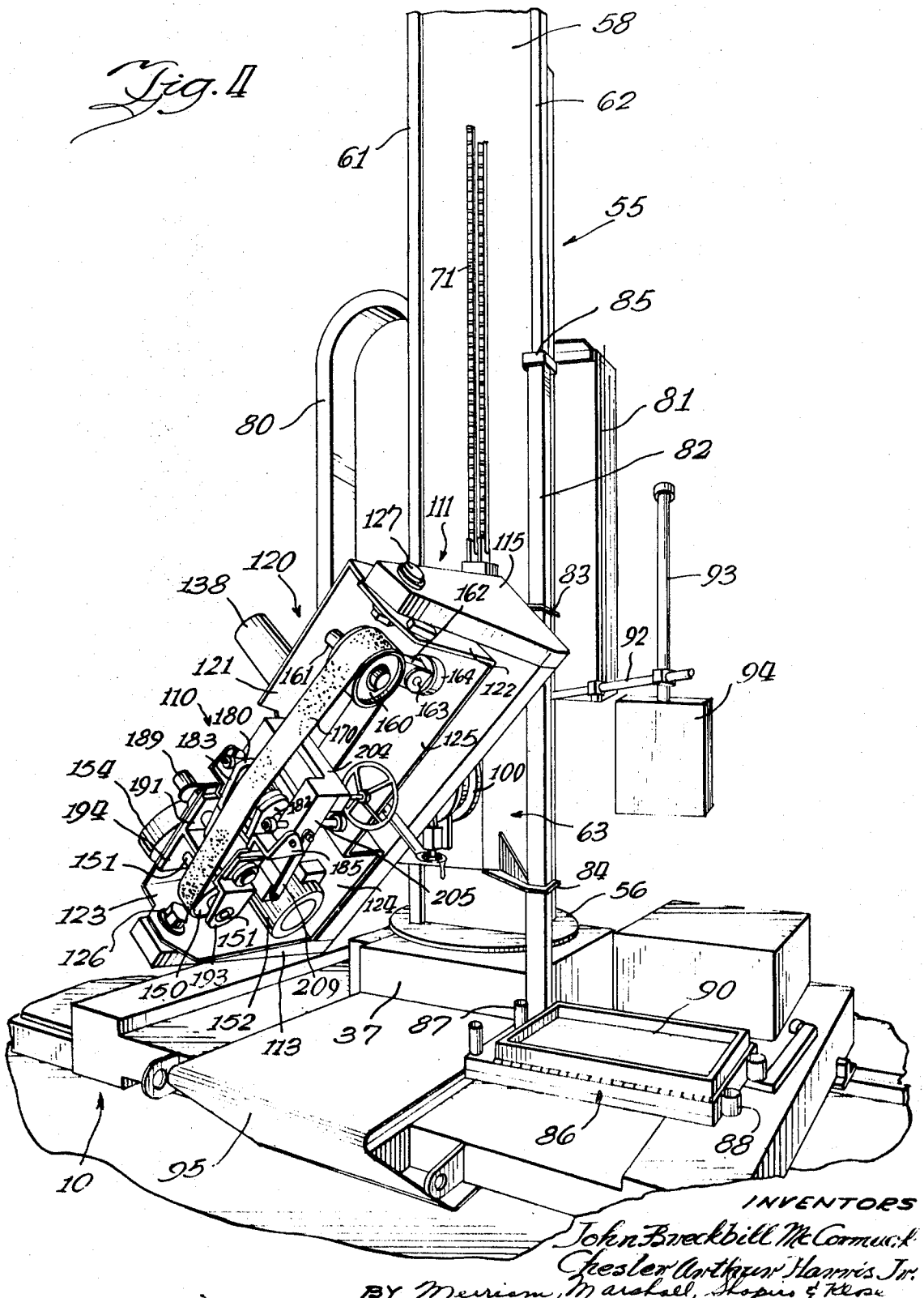
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AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

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Fig. 4



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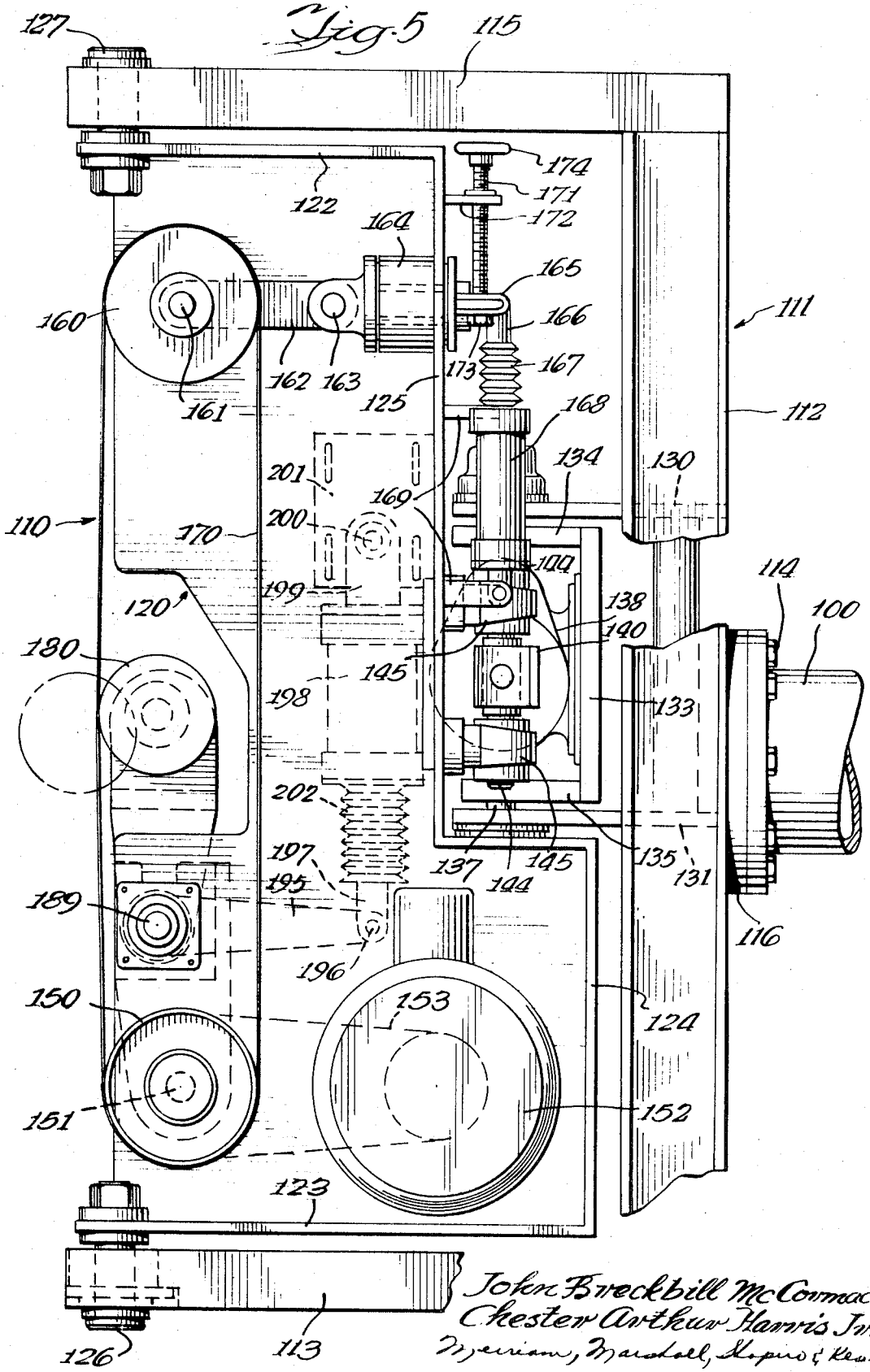
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AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

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Fig. 5



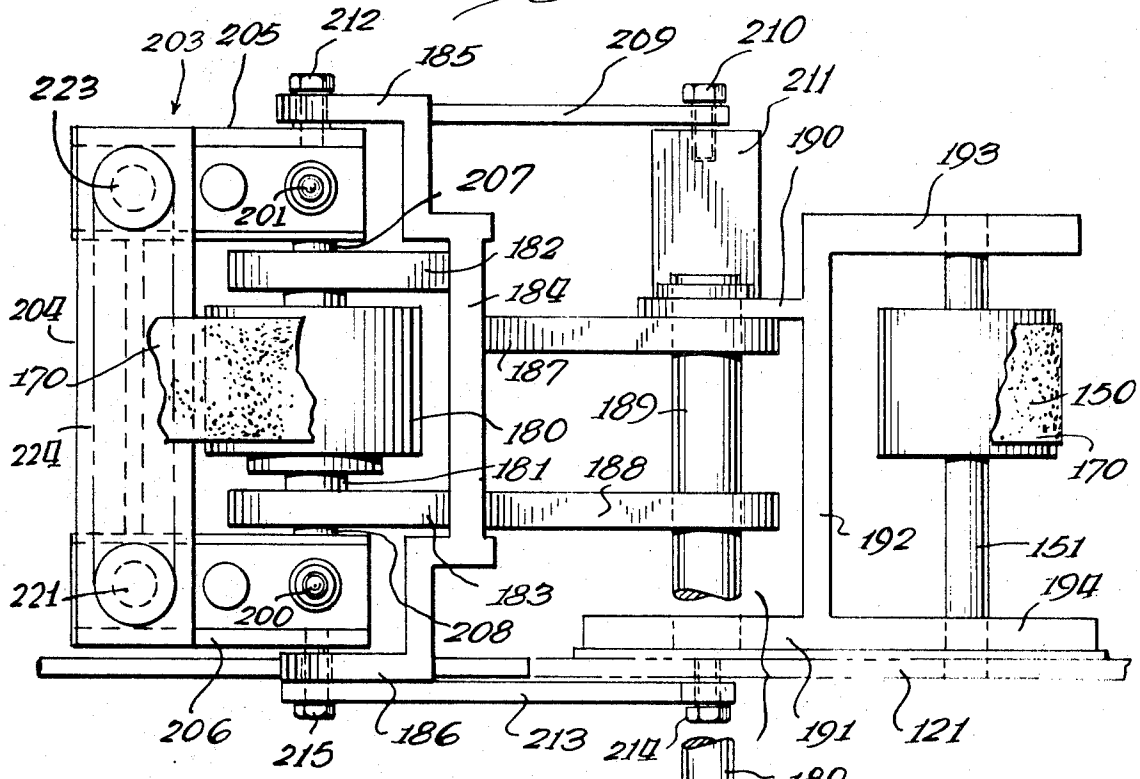
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AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

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Fig. 6



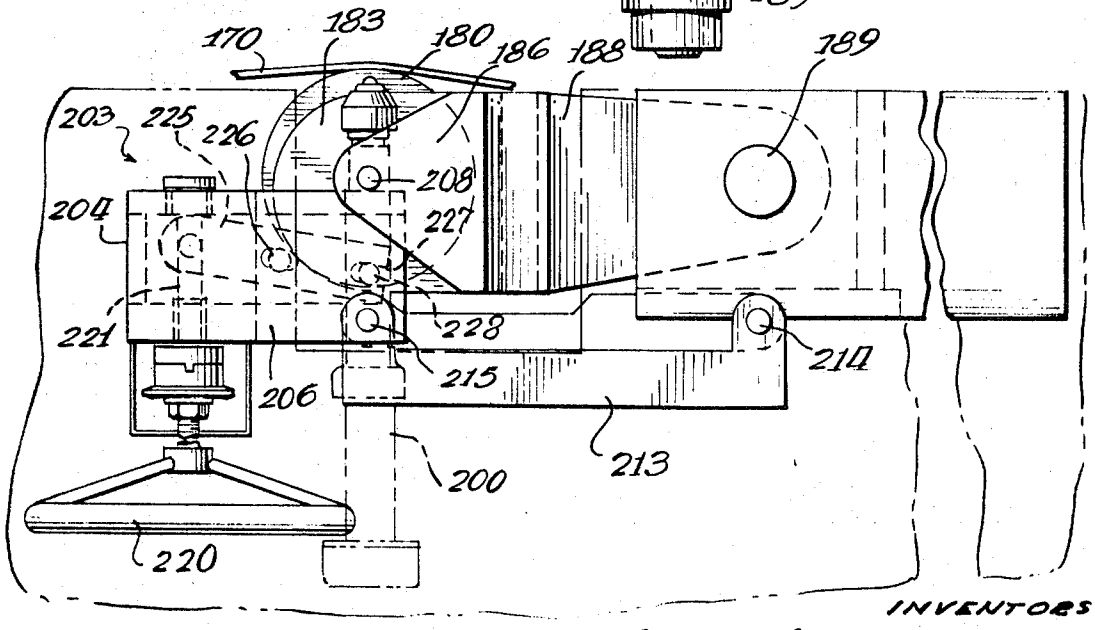


Fig. 7

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AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

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Fig. 9

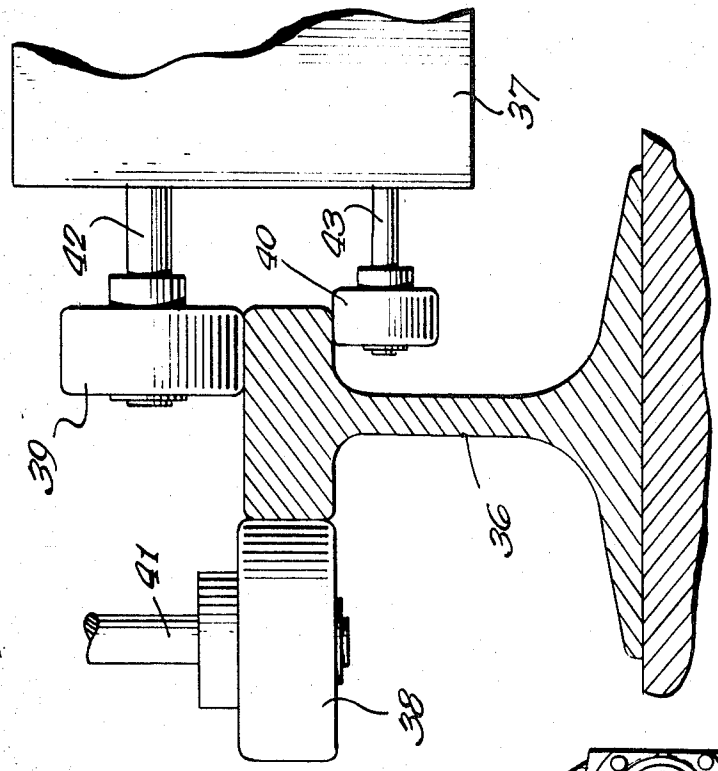
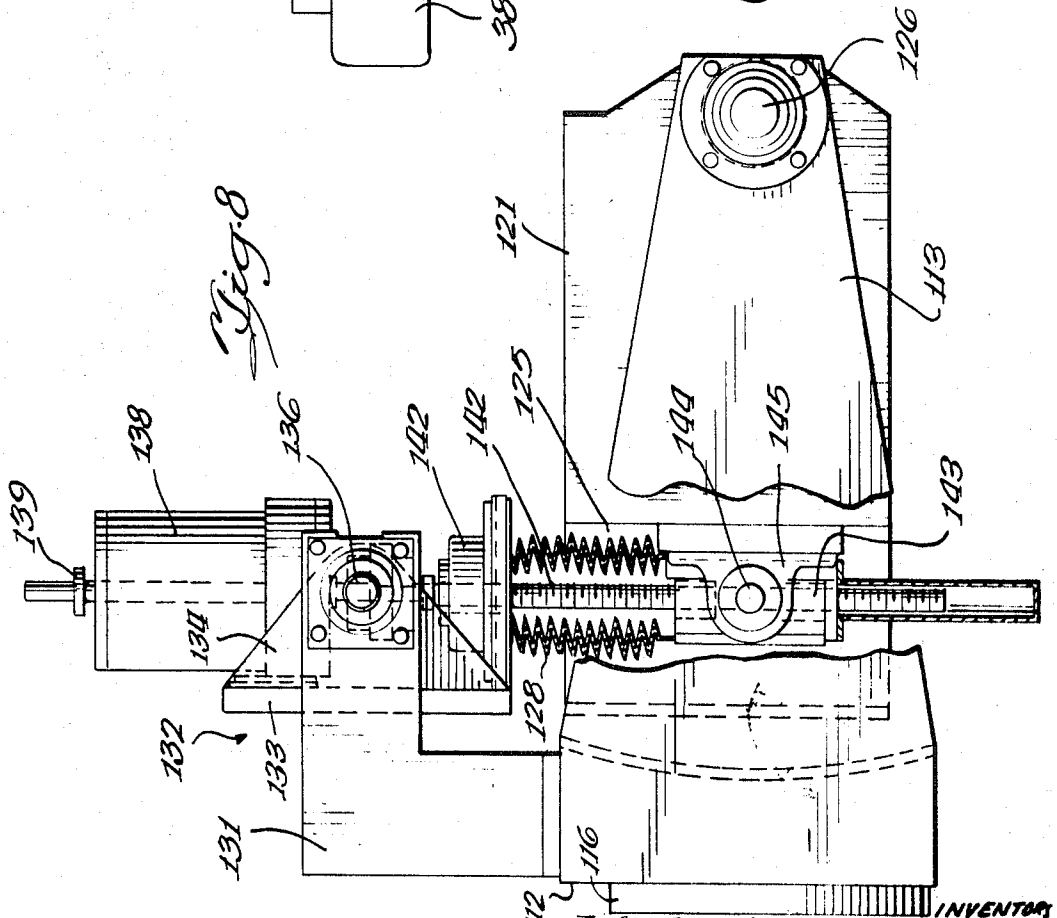


Fig. 8



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AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS
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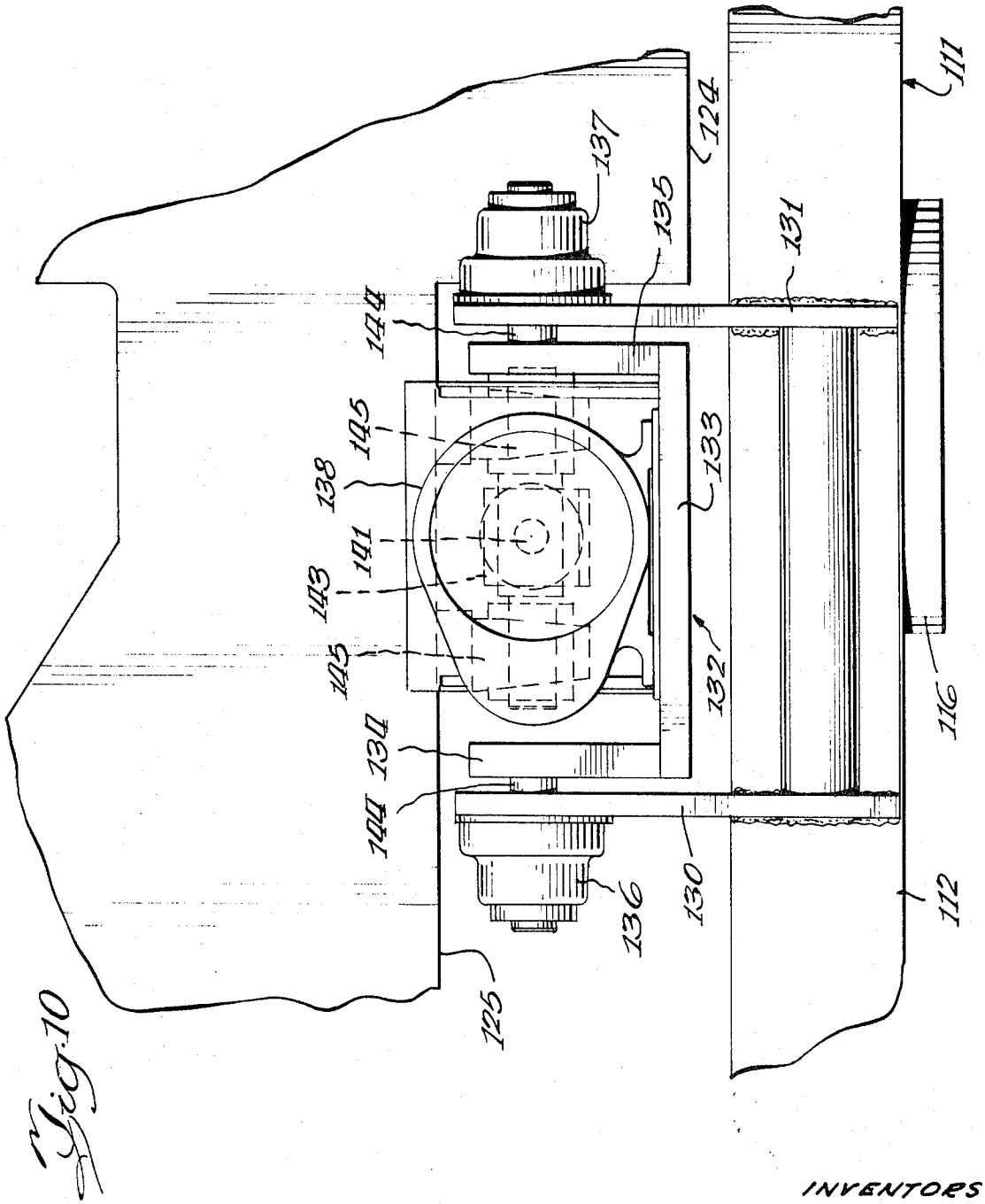


Fig. 10

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AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

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Fig. 13

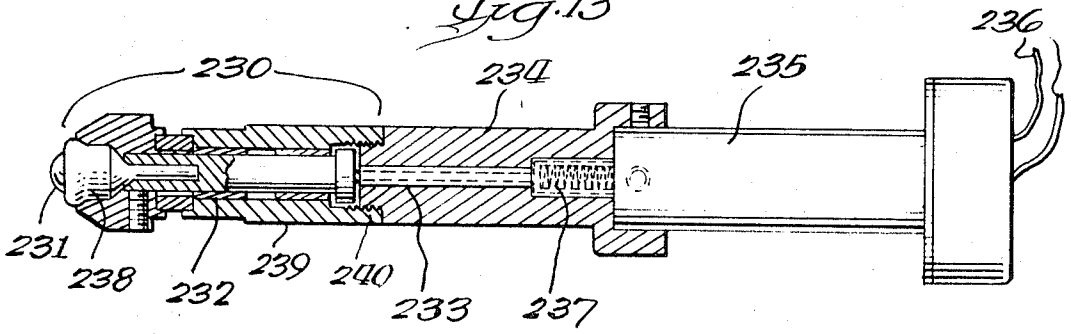


Fig. 12

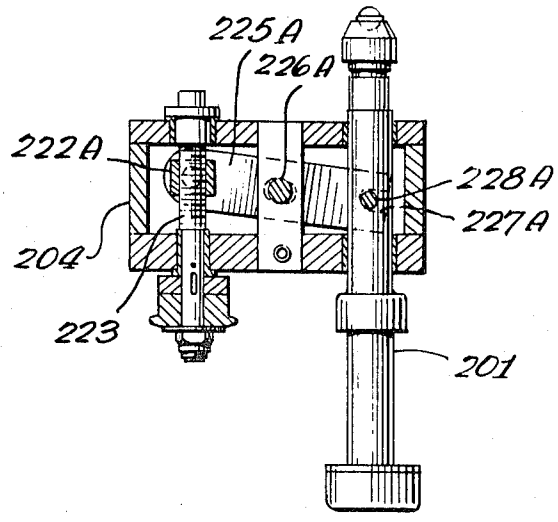
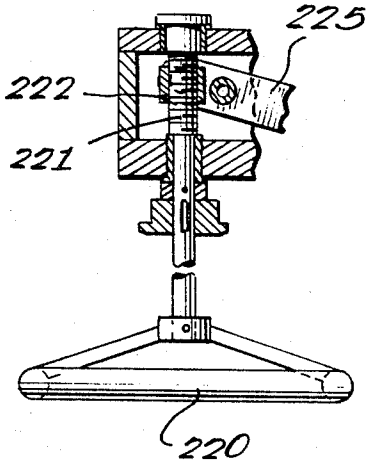


Fig. 11



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3,608,246

AUTOMATIC GRINDING MACHINE FOR GRINDING LONGITUDINAL EXTERNAL WELDS ON CYLINDERS

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Filed July 3, 1969, Ser. No. 838,734
Int. Cl. B24b 21/00
U.S. Cl. 51—135 25 Claims

ABSTRACT OF THE DISCLOSURE

A grinding machine for grinding longitudinal external welds on large cylindrical metallic bodies. It grinds welds smooth adjusting automatically to changes in surface contour as grinding progresses from one end of the weld to the other end. Sensing probes cause the grinding means to rotate to effect grinding tangential to the cylindrical body.

The grinding machine contains adjustable pressure applying means which urges the grinder against the workpiece.

The grinding machine utilizes a grinding belt. The belt is supported by three wheels in a grinder mounting. One wheel is a grinding belt drive wheel, another is for applying tension to the grinding belt and the third is for applying pressure to the grinding belt and to the workpiece. The probes are adjacent the pressure wheel and aid in regulating pressure applied to belt and workpiece. The pressure applying wheel is pivotally mounted to a lever arm which rotates to increase or decrease pressure on the belt.

The grinder mounting is pivotally mounted in an outer support frame having means to rotate the grinder mounting relative to the outer support frame. The outer support frame is mounted on a spindle for rotation about an axis normal to the axis of rotation of the grinder mounting relative to the outer support frame.

The spindle is mounted on a headstock mounted on a vertical mast supported on a mast base. The mast rotates on the mast base about a vertical axis. The mast base is mounted to roll on rails supported on a base frame which has wheels which roll on tracks normal to the rails. The base frame has a drive for moving it parallel to a weld to be ground at a speed suitable for grinding.

This invention relates to machines for grinding, particularly metal grinding. More particularly, this invention is concerned with a machine for grinding surfaces, such as welded joints.

In the production of large metallic cylinders, metal plate is usually rolled into a cylinder, or a cylindrical segment, and the abutting adjacent edges are then welded together. Under some circumstances, it is desirable to grind the welded joint smooth with the adjacent external surfaces. This is in fact necessary in the fabrication of multiple layer cylindrical bodies used in producing vessels. By grinding the welded joints of each layer of plate smooth, each subsequent layer can be placed in substantially total contact with the previous layer thereby providing a cylindrical body whose strength can be analyzed with an accuracy not otherwise attainable.

The grinding of welded longitudinal joints on large cylindrical vessels has heretofore been a hand operation since no suitable grinding machine has been available to do the job. Hand grinding the many longitudinal welds necessarily used in fabricating a multiple layer cylindrical body is expensive because of the time and labor involved. It is also a tiring job not sought after by

workmen. There has thus been a need for a suitable machine for grinding longitudinal external welds on a cylindrical body. This need has been met by the subject invention.

According to the present invention, there is provided a grinding machine which is particularly useful for grinding longitudinal external welds on large cylindrical metallic bodies. The grinding machine is man operated but otherwise grinds the welds smooth adjusting automatically to changes in surface contour as grinding progresses from one end of the weld to the other end. The grinding machine employs sensing or feeling probes which cause the grinding means to rotate as needed to effect grinding tangential to the cylindrical body at the location of the weld.

The grinding machine also contains an adjustable pressure applying means which urges the grinder against the workpiece weld to facilitate grinding the weld down as fast as possible without forcing the workpiece out of its holder, yet applying sufficient force to be compatible with the forward travel speed of the grinding means. The probes are adjustable with respect to the grinding means to accommodate different size cylinders and to achieve flexibility in the depth of grinding to handle different size welds. They also act as a limit for the grinding means beyond which the pressure applying means cannot force the grinding means. The probes, along with their adjustment, and the grinding means are advisably mounted in the same support for simultaneous movement in positioning the grinder.

The grinding machine utilizes a grinding belt although other grinding means can be used. The grinding belt is supported by three wheels in a grinder mounting. One of the wheels is a grinding belt drive wheel, another wheel is for applying tension to the belt and the third wheel is for applying pressure to the grinding belt and through it to the workpiece. The probes are positioned adjacent to the pressure wheel and limit the travel of the pressure wheel according to a setting variably established with an adjustable means prior to grinding, and as grinding progresses down the weld joint.

The grinder mounting is advisably pivotally mounted in an outer support frame having means to rotate the grinder mounting relative to the outer support frame and hold it in a stationary position. It is also a feature of the invention to have the outer support frame mounted on a spindle for rotation about an axis normal to the axis of rotation of the grinder mounting relative to the outer support frame.

For flexibility of operation and to best position the grinder according to an increase or decrease in cylinder size and the height of the longitudinal weld from the floor, the spindle is best mounted horizontally on a headstock movable up and down on guideways, advisably vertically mounted on a vertical mast. Such a mast is advisably mounted on a mast base. The mast can also be set to rotate on the mast base about a vertical axis. For ease in bringing the mast into working position for grinding, the mast base can be mounted to roll on rails, advisably supported on a base frame having wheels to roll on tracks normal to the rails. The base frame is provided with means to drive the base frame and all apparatus mounted thereon in a direction essentially parallel to the weld to be ground at a speed suitable for effecting the grinding in a continuous manner. These and other important novel features of the invention will be further described in conjunction with the attached drawings in which:

FIG. 1 is a front elevational view of a grinding machine of this invention;

FIG. 2 is a right side elevational view of the grinding machine;

FIG. 3 is a plan view of the grinding machine;

FIG. 4 is a perspective view of the grinding machine;

FIG. 5 is a bottom view of the grinder head of the grinding machine;

FIG. 6 is a front elevational view of part of the grinder head in upside down position and shows the mechanism for moving the grinding belt adjustable pressure wheel;

FIG. 7 is a rear plan view of the mechanism for holding and moving the probes located adjacent to the grinding belt adjustable pressure wheel. This mechanism essentially controls grinding belt depth of cut relative to the probes;

FIG. 8 is a side elevational view of that part of the grinder head mechanism which adjusts the angle of the grinding belt relative to a workpiece by pivoting the grinder mounting;

FIG. 9 is an enlarged view of one of the roller arrangements used to stabilize the grinding machine mast base frame on the rails which in turn moves the mast to and from a workpiece;

FIG. 10 is a plan view of the mechanism shown in FIG. 8;

FIG. 11 is an elevational view, partly in section, showing in more detail the probe adjusting mechanism of FIG. 7;

FIG. 12 is an elevational view, partly in section, showing further details of the probe adjusting mechanism; and

FIG. 13 is an enlarged view, partly in section, of a typical probe.

So far as is practical, the same or similar elements which appear in the various drawings will be identified by the same number.

With reference to FIGS. 1 to 4, the grinding machine of this invention has a base frame **10** mounted on wheels for longitudinal traverse. Mounted on the left side of base frame **10** is a pair of wheels **11** and **12** supported by axle **13**. The wheels are flat faced and contain no rims or flanges. Electric motor **14** communicates with hydraulic coupling **15** which in turn communicates with gear reduction system **16** by a chain and sprocket arrangement for driving axle **13**. This drive system provides high speed traverse to move the grinding machine along tracks **17** at a high speed, such as at about 100 feet per minute.

At the right side of base frame **10** is located a pair of wheels **18** and **19** mounted on axle **20**. These wheels are also flat faced. Motor **21** is in communication with gear drive unit **22** which in turn is connected to low speed variable drive unit **23** by a direct drive through an electric clutch and chain drive. Low speed variable drive **23** is in operating connection with axle **20** to thereby drive wheels **18** and **19**. This drive system provides low speed traverse for moving the grinder along track **17**, such as at speeds of about 6 inches to 60 inches per minute, during grinding operations such as of horizontal seams on on tanks or vessels.

Since the wheels **11**, **12**, **18** and **19** are flat faced, guide rollers **25** are positioned on the ends of the base frame **10** to maintain the grinding machine on the tracks. Way wipers **24** are provided to wipe the tracks clean as the grinding machine moves along the tracks.

A fifth wheel **26** is provided towards the rear of base frame **10** and is located so that it is always in contact with the track. It is positioned to be slightly lower than wheels **11** and **19** so that in normal traverse of the grinding machine on tracks **17** only wheels **12**, **18** and **26** are in contact with the tracks. If the grinding machine should tilt to the left, wheel **11** will contact the track and restrict further tilting. Similarly, if the grinding machine should tilt to the right, wheel **19** will be placed in contact with the track and restrict further tilting.

Off to the left side of the grinding machine is an electric line power inlet **27** (FIG. 1) joined to an electrical cable **28** which is wound on electric cable reel **29**. Spring housing **30** (FIG. 3) is associated with electric cable reel **29** to maintain the electric cable wound thereon but yet to permit it being unreeled as the grinding machine moves along track **17** away from power inlet **27**.

Mounted on the central area of base frame **10** are rails **35** and **36**. These rails support a mast base **37**. As shown more clearly in FIG. 9, mast base **37** is supported on one side on rails **36** and movement up and down and to either side is restricted by eccentrically adjustable rollers **38**, **39** and **40** suitably mounted on axles **41**, **42**, and **43** respectively. The axles are secured in suitable housings of appropriate parts of mast base **37**. Of course, the other rail **35** supports a similar roller system for the other side of mast base **37**.

Movement of mast base **37** along rails **35** and **36** is effected by means of motor **45** (FIG. 1) with drive chain **46** communicating with a sprocket **47** mounted on gear reduction box **48**. Gear reduction box **48** has a pinion gear **49** extending out from the bottom thereof which meshes with gear rack **50** mounted on base frame **10**. In this way, mast base **37** can be moved along rails **35** and **36** to move grinding belt **170** (FIG. 4) into contact with the work as will be described more fully hereinafter.

Mounted on top of mast base **37** is grinding machine mast **55**. Mast **55** rests on a circular plate **56**. The mast can be swivelled 360° by hand to thereby rotate the mast in a complete circle and thus position the grinding belt at any desired location. Two swivel locking devices **57** (FIG. 2) are provided for securing swivel plate **56** in position.

As shown in FIGS. 1 to 4, mast **55** is made of metal plates and has a front plate **58**, two side plates **59** and a back plate **60**. The mast is thus hollow. Front plate **58** is provided with spaced apart guideways **61** and **62** (FIGS. 3 and 4) which support grinder headstock **63** and guide its movement up and down. The headstock **63** has a left vertical plate **64**, a right vertical plate **65** and a front plate **51**. At the top of plate **64** is a pair of rollers **66** and at the lower end is a pair of rollers **67** which ride on each side of guideway **61**. Similarly, a pair of rollers **68** is placed at the top of plate **65** and a pair of rollers **69** is placed at the bottom of plate **65**, with one of each pair of rollers against opposite sides of guideway **62**. As shown in FIGS. 1 and 2, also mounted on top of plate **64** of headstock **63** is guide roller **75** with a similar roller **76** placed on the bottom of the plate. These rollers contact the outer edge of guideway **61**. In a like manner, a roller **77** is placed on top of plate **65** and a similar roller **78** is placed on the bottom thereof. These rollers contact the outer edge of guideway **62**. All of the rollers described aid in stabilizing headstock **63** during vertical movement thereof. In this way, headstock **63** can move up and down on mast **55** in a precise path.

Mounted on top of headstock **63** is anti-fall device **70**. Joined to anti-fall device **70** is chain **71** which engages with chain sprocket drive **72** mounted on the top of mast **55**. Motor **73** operates chain sprocket drive **72** to raise and lower headstock **63** by means of chain **71**. The other end of chain **71** extends downwardly inside of hollow mast **55** and is joined to a counterweight which is free to move up and down inside the mast. In the event chain **71** should break or fail, anti-fall device **70** will engage with a toothed rack, not shown, mounted on mast **55** to thereby stop downward movement of the headstock thereby avoiding possible injury to the operator and destruction of the machine.

A power cable supply rack **80** is mounted on the left side of mast **55** and, in the rear of the mast, an electrical control panel is provided (FIGS. 1 to 4).

Vertical tubular member **82** is slidably mounted in holes in support arms **83** and **84** joined to headstock **55**. A restricting cap **85** is placed on top of tubular member **82**. Joined to the lower end of tubular member **82** is operator platform **86** on which a man can stand when using the grinding machine for its intended purpose. Normally, operator platform **86** will rest on base frame **10**. However, with upward movement of headstock **63**, bracket

83 will come in contact with cap 85 and result in lifting of operator platform 86, thus, keeping the operator positioned conveniently for operating the grinder. Pipe studs 87 and 88 are used for holding movable hand railings, such as railing 89 shown in FIG. 2. Platform 86 has a hinged section 90 which can be hinged forward 180° to provide an enlarged platform.

Horizontal tubular member 91 (FIGS. 1 to 3) is joined to headstock 63 and from it another tubular member 92 projects forward at a 90° angle. Tubular member 92 supports vertical tubular member 93 at its end in a slidable manner. Tubular member 93 in turn supports an operator control panel 94 which contains appropriate switches for effecting all of the desired movements of the grinding machine. Tubular members 92 and 93 are slidably mounted so that adjustments can be made to alter the position of control panel 94 to place it in the most convenient position for the operator.

A flexible cover 95 (FIGS. 2 and 4) is joined at one end to the front bottom of mast base 37 and the other end is joined to the back bottom thereof. The flexible cover 95 runs over a series of rollers 96 which keep it tight. When mast base 37 is moved forward and backward, flexible cover 95 is displaced an equal distance in the manner of an endless belt and serves to keep grinding dust from accumulating in base frame 10.

Also mounted on mast 55 is bracket 97 which supports air tank 98 on which air compressor 99 is mounted as shown in FIGS. 1 and 2. Air tank 98 supplies air under pressure to actuate double acting pistons in the grinding head as will be described hereinafter.

Mounted on headstock 63 is grinder support spindle 100. Spindle 100 is constructed so that it can rotate 360° and, when in the desired position, lock 101 is fixed to bar further rotation of the spindle.

The structure of grinding head 110 is best shown with reference to FIGS. 4 to 8. The grinder head 110 has an outer support frame 111 comprised of a back plate frame structure 112 and end plate assemblies 113 and 115. Plate frame 112 is joined to spindle 100 such as by a series of bolts 114 which screw into support plate 116.

Grinder mounting 120 (FIGS. 4 and 5) has a top plate 121, a right side plate 122, a left side plate 123 and a rear plate 124 which has an inward offset section 125 on the right rear part when viewed upright as in FIG. 4. Grinder mounting 120 is pivotally joined to grinder outer support frame 110 by pivot pins 126 and 127.

Mounted on the rear upper surface of outer support frame 110, on top of its rear plate frame 112, is a pair of brackets 130 and 131 as shown in FIGS. 5, 8 and 10. Each of the brackets has an upper portion which projects forward. A motor support frame 132 having a rear plate 133 and side plates 134 and 135 is pivotally supported between brackets 130 and 131 by pivot means 136 and 137. Frame 132 has motor 138 mounted thereon. An electric solenoid operated brake 139 is mounted on top of the motor to secure the shaft against inadvertent rotation (which can be caused by gravity, making the grinder mount tend to fall). Motor 138 is interconnected through a coupling 142 to an elongated screw 141 in protective cover 128. Screw 141 is threaded into elongated nut 143 which is mounted in pivot 144 supported in brackets 145. Brackets 145 are joined to the surface or face of plate 125 comprising part of grinder mounting 120. Thus, by means of motor 138 and the described pivotally mounted drive system, grinder mounting 120 can be moved about pivot pins 126 and 127 to thereby change the angle of the grinding belt face in relation to the workpiece to be ground. After it is set in an approximate desired position, which normally places the grinding belt tangent to the point of the curved surface to be ground, additional pivoting is made in response to signals from the probes when they indicate the belt is not properly tangentially aligned with the workpiece.

Three wheels support and regulate the abrasive grinding belt 170 which does the grinding and they, together with related control mechanisms, are mounted on grinder mounting 120. Fixed grinding belt drive wheel 150 is supported on shaft 151 (FIGS. 4 and 5). A motor 152 mounted on top of plate 121 is used to drive wheel 150 by a V-belt 153 and suitable pulleys associated with the motor and the wheel. Cover 154 provides protection around V-belt 153 and the pulleys used to drive shaft 151 by motor 152.

With reference to FIGS. 4 and 5, grinding belt tensioning wheel 160 is mounted on shaft 161. Shaft 161 is supported by arm 162 which pivots on pin 163. Pin 163 is supported by bracket arrangement 164 which is joined to plate 125. Arm 162 extends through a hole in bracket 164 and a hole in plate 125 and projects outwardly therefrom as extension 165. Extension 165 is joined to the end of connecting arm 166 which extends through protective cover 167 to a piston in double acting air cylinder 168 which is held on the rear of plate 125 by brackets 169. Air is supplied to cylinder 168 by means of suitable hoses from air tank 98. By means of air cylinder 168 acting through connecting rod 166 to arm 162, tension is applied to abrasive grinding belt 170 which goes around belt tensioning wheel 160. Tension on the belt is limited by means of screw 171, mounted in bracket 172, and nut 173 placed on the end of the screw. This limits the swing of arm 162 and thus the maximum desired tension applied on the belt. Hand wheel 174 on screw 171 aids in making the tension adjustment.

Backup wheel 180 is used to apply adjustable pressure in back of grinding belt 170 during the grinding operation. Belt 170 thus travels around wheels 150, 160 and over the outer forward surface area of pressure wheel 180. As shown in FIGS. 4, 5 and 6 and 7, wheel 180 is supported by an axle 181 which rests in suitable bearings mounted in bracket arms 182 and 183. The brackets 182 and 183 are joined to plate 184 which has an extension 185 at one end and an extension 186 at the other end. Plates 187 and 188 also extend outwardly from plate 184 and are pivotally connected by pin 189 to arms 190 and 191 joined to plate 192, from which arms 193 and 194 also extend. Arms 193 and 194 provide support for the shaft supporting fixed drive wheel 150.

Pivot pin 189 extends through and above plate 121 of the grinder mounting and to it is connected crank arm 195 (FIG. 5) which is connected through pivot pin 196 to connecting rod 197 which is connected to a piston in double acting air cylinder 198 supplied with air under pressure from air tank 98. Arm 199 supports air cylinder 198 by pivot pin 200 secured in bracket 201 mounted on the top of plate 121. Thus, through action of the air cylinder 198, arm 195 is caused to move and through arms 187 and 188 plus arms 182 and 183, backup wheel 180 is caused to apply pressure against abrasive grinding belt 170, or to release pressure thereon, depending on the direction of air cylinder piston travel. A flexible boot 202 is placed around connecting rod 197 to exclude dirt from air cylinder 198.

To automatically set the angle of the abrasive grinding belt 170 in proper alignment with the surface to be ground, a pair of probes 200 and 201 (FIGS. 6 and 7) are provided adjacent to the backup wheel 180. The pair of probes 200 and 201 is mounted in a probe support bracket 203 which has means to keep the probes vertically aligned with the work throughout changes in position of backup wheel 180. In addition, probe support bracket 203 is provided with means for advancing and retracting the probes to adjust the distance between the ends of the probes and backup wheel 180 to regulate the depth of the grinding and to accommodate cylinders of various diameters having longitudinal joints to be ground.

Probe frame 203 has a central portion 204 and two arms 205 and 206 extending therefrom. Each of the arms 205 and 206 is pivotally connected by pivot pins 207 and 208 to arms 185 and 186. Arm 209 is joined by pivot 210

to block **211** which, in turn, is joined to arm **190**. The other end of arm **209** is joined by pivot pin **212** to arm **205**. A similar arm **213** is joined by pivot pin **214** to plate **121** and the other end of arm **213** is joined by pivot **215** to arm **206**. The result of arms **209** and **213** is that, together with pivot pins **189** and **208**, movement of backup wheel **180** by means of arm **195** results in a pantagraph-type action which causes the probes **200** and **201**, supported by probe frame **203**, to be directed in perpendicular manner to the workpiece being ground and maintains a constant set depth of grind on the workpiece even though grinding wheel **180** may be floating in or out through four inches of travel as base frame **10** may move away from or toward the workpiece as grinding progresses down the workpiece.

Advancing and retracting probes **200** and **201** with respect to the surface of the abrasive grinding belt and the workpiece is achieved through rotation of hand wheel **220** (FIGS. 7 and 11). Hand wheel **220** turns a screw **221**, on one end of central portion **204** of probe frame **203**, on which follower block **222** is threaded. A similar screw **223** is provided at the other corner of probe frame **203** and a follower block **222A** is also threaded thereon. Chain **224** (FIG. 6) is used to effect simultaneous unidirectional rotational movement of screws **221** and **223**. Chain **224** passes over a sprocket wheel mounted on each of the screws **221** and **223**. Pivotally joined to follower block **222** is lever arm **225**. Arm **225** pivots around pin **226** in arm **206**. The end of lever arm **225** has a slot **227** which engages pin **228** mounted on the body of probe **200**. A similar lever arm **225A** is engaged with follower block **222A** on screw **223** and engages probe **201** in the same way as arm **225** engages probe **200**. Lever arm **225A** pivots on pin **226A** in arm **205**, and slot **227A** in the end of arm **225A** engages pin **228A** on probe **201** to move it in and out. When screws **221** and **223** are rotated in one direction, probes **200** and **201** are caused to simultaneously move forward and, when rotated in the other direction, the probes are caused to simultaneously move backward at the same rate and for the same distance.

FIG. 13 illustrates the structure of each of the probes **200** and **201**. Each probe has a probe head assembly **230** with a sleeve **239** which is threadably joined **240** to probe sensor holder **234**. The forward end of probe head assembly **230** has a guide roller **231** which rides on or against a surface to be ground. The guide roller pushes against the surface with a force of up to 250 pounds per square inch, depending upon the air cylinder **198** pressure setting. Guide roller **231** is mounted in socket holder **238** which is held by probe link pin **232** in sleeve **239**. Link pin **232** touches the forward face of probe finger **233** which is pushed outwardly by probe finger spring **237**. When the probe is in the off position, spring **237** pushes out finger **233**, pin **232** and socket holder **238** as related to the position of sleeve **239** and holder **234**. When roller **231** touches a workpiece, movement is transferred back through roller **231**, socket holder **238**, pin **232** and finger **233** to actuate a microswitch in sensor **235** held in holder **234**. By wires **236**, control information from the sensor is communciated to the electric control panel which in turn operates pivot drive motor **138**. Roller **231** only moves link pin **232** and finger **233** a short distance of about $\frac{3}{16}$ inch before the sensor microswitch closes. Spring **237** effects a similar reverse movement to open the microswitch. The entire probe is constructed to be dustproof so as to avoid interference by grinding dust.

The described grinding machine is particularly useful for grinding longitudinal weld joints flush on rolled cylinders by positioning the cylinder horizontally out in front of the grinding machine with the seam to be ground located in the 3 o'clock position. The grinding machine is then rolled on tracks running parallel to the longitudinal axis of the cylinder using the rapid traverse power driving system to place the machine at one end of the cylinder. The grinding head is then moved up or down the mast to place the grinding belt opposite the weld and then the grinding head is moved forward by driving the mast base forward. When the grinding belt is in close proximity to the weld (i.e., 2 inches) the forward motion of the mast is stopped and contact with the workpiece is made by energizing air cylinder **198** which forces out probes **200** and **201** and backup wheel **180**. One or the other of the two probes makes contact with the cylinder first. As soon as one of the probes touches the cylinder, it closes an electrical circuit so that power is supplied to motor **138** to drive screw **141** in a direction which will bring the other probe into contact with the cylinder. When both probes are in contact with the cylinder, each closes a respective electrical circuit, motor **138** is inactivated and grinding belt **170** is positioned tangent to the weld. The grinding machine is then turned on causing the belt to rotate. Handwheel **220** is then rotated, forcing backup wheel **180** to push the grinding belt **170** into the workpiece with cutting starting to occur. No forward motion of the base frame takes place at this time. The depth of cut is regulated by the handwheel setting as it controls the distance between the ends of the probes and front surface of backup wheel **180**. By reversing operation of air cylinder **198**, visual inspection of depth of cut can readily be made. With the depth of cut established, slow speed motion of the base frame **10** is started with grinder belt cutting. The probes follow the contour of the cylinder on an air cushion as the grinding belt removes all metal which exceeds the set distance between the probe ends and the backup wheel. Any misalignment up to plus or minus two inches between the longitudinal axis of the cylinder being ground and the base frame rails running parallel to the cylinder, are compensated for by the travel distance of aid cylinder **198**. If either probe should lose contact with the surface being followed, it will activate motor **138** to drive screw **141** in a direction which will bring the probe back into contact with the cylinder. Thus, a flat surface tangent to the cylinder curvature is ground. However, by using a contoured pressure backup wheel **180**, the ground surface may be made equal in curvature to the cylinder curvature.

Base frame speed is adjusted so that removal of excess weld material on the workpiece by the grinding belt is completed prior to the base frame passing that point.

Quality grinding is obtained by operating the grinding belt rotated to a position plus or minus 30° to 45° as related to the line of weld joint. 360° rotation of the grinding head permits random weld joint positioning requiring only that it pass through or be placed in an approximate 3 o'clock position during grinding.

What is claimed is:

1. A grinding machine comprising:

a grinder mounting having three grinding belt wheels supported thereby, one of said wheels being a grinding belt drive wheel, another of said wheels being a grinding belt tension applying wheel and the third wheel being a pressure applying wheel for pressing a grinding belt, supported by the wheels, against a workpiece;

probe means adjacent to the pressure wheel for positioning the grinding belt relative to a workpiece and having means for regulating the pressure applied to the grinding belt and workpiece by the pressure applying wheel, the probe means comprising two probes, mounted one adjacent each side of the pressure applying wheel; and

means for advancing and retracting the probes simultaneously relative to the outer surface of the pressure applying wheel.

2. A grinding machine comprising:

a grinder mounting having three grinding belt wheels supported thereby, one of said wheels being a grinding belt drive wheel, another of said wheels being a grinding belt tension applying wheel and the third

wheel being a pressure applying wheel for pressing a grinding belt, supported by the wheels, against a workpiece;

the grinder mounting is pivotally mounted in an outer support frame having means to rotate the grinder mounting relative to the outer support frame and hold it in a stationary position; and

the outer support frame is mounted on a spindle for rotation about an axis normal to the axis of rotation of the grinder mounting relative to the outer support frame.

3. A grinding machine according to claim **2** in which the spindle is mounted on a headstock movable back and forth on guideways.

4. A grinding machine according to claim **3** in which the guideways are positioned vertically on an upright mast.

5. A grinding machine according to claim **4** in which the mast is rotatable about a vertical axis and has means to lock it in position on a mast base.

6. A grinding machine according to claim **4** in which power means is mounted on the mast to move the headstock, and the headstock and apparatus supported by it are counterweighted by a weight carried by the mast.

7. A grinding machine according to claim **4** in which the headstock has bracket means for supporting an operator's platform and raising the platform with the headstock during upward movement of the headstock above a predetermined height.

8. A grinding machine according to claim **4** in which the headstock carries an operator's control panel.

9. A grinding machine according to claim **5** in which the mast base is mounted on rollers which ride on rails on a base frame to move the grinding belt into and out of position with a workpiece.

10. A grinding machine according to claim **9** in which the mast base is moved on the rails by power means.

11. A grinding machine according to claim **9** in which the base frame against excessive tilting.

zontal tracks running normal to the rails on which the mast base rolls.

12. A grinding machine according to claim **11** in which normally three support wheels are used to roll the base frame on the tracks and two additional wheels restrain the base frame against excessive tilting.

13. A grinding machine according to claim **11** in which a power means drives one of the wheels for rapid traverse of the grinding machine along the tracks and a second power means drives another one of the wheels for slow traverse of the grinding machine along the tracks during grinding on a workpiece.

14. A grinding machine comprising:

a base frame on wheels positioned to roll on horizontal tracks;

a mast base mounted on rollers which ride on horizontal rails, on the base frame, normal to the tracks;

an upright mast mounted on the mast base;

vertical guideways on the mast;

a headstock mounted to move vertically on the guideways, and to be secured in a specific position thereon;

grinding means supported by the headstock;

a power means for driving at least one of the wheels supporting the base frame for rapid traverse of the grinding machine along the tracks; and

a second power means for driving at least one of the other wheels supporting the base frame for slow traverse of the grinding machine along the tracks during grinding on a workpiece.

15. A grinding machine comprising:

a base frame on wheels positioned to roll on horizontal tracks;

a mast base mounted on rollers which ride on horizontal rails, on the base frame, normal to the tracks;

an upright mast mounted on the mast base;

vertical guideways on the mast;

a headstock mounted to move verticaly on the guideways, and to be secured in a specific position thereon;

a spindle on the headstock;

an outer support frame mounted on the spindle for rotation thereon; and

a grinding means mounted in the outer support frame.

16. A grinding machine according to claim **15** in which the grinding means has a grinder mounting pivotally mounted in the outer support frame to rotate a grinder therein about an axis normal to the axis of rotation of the outer support frame on the spindle.

17. A grinding machine according to claim **16** in which the grinder mounting supports a grinding belt mounted on three wheels, one of said wheels being a grinding belt drive wheel, another of said wheels being a grinding belt tension applying wheel and the third wheel being a pressure applying wheel for pressing the grinding belt against a workpiece.

18. A grinding machine according to claim **17** having probe means adjacent the pressure wheel for positioning the grinding belt relative to a workpiece and regulating pressure applied to the grinding belt and workpiece by the pressure applying wheel.

19. A grinding machine according to claim **18** having means to maintain the probe means in substantially the same direction with change in position of the pressure applying wheel.

20. A grinding machine according to claim **18** in which the probe means comprises two probes, mounted one adjacent each side of the pressure applying wheel, and the machine has means for adjustably advancing and retracting the probes relative to the outer surface of the pressure applying wheel.

21. A grinding machine according to claim **20** in which the pressure applying wheel floats on an air cushion and the grinding belt grinds a surface to an adjustable depth as determined by the distance from the ends of the probes, in contact with a workpiece, to the pressure applying wheel.

22. A grinding machine comprising:

a base frame on wheels positioned to roll on horizontal tracks;

a mast base mounted on rollers which ride on horizontal rails, on the base frame, normal to the tracks;

an upright mast mounted on the mast base;

vertical guideways on the mast;

a headstock mounted to move vertically on the guideways, and to be secured in a specific position thereon;

grinding means supported by the headstock;

power means to move the headstock on the mast guideways; and

a counterweight supported by the mast to counterbalance the headstock and apparatus mounted thereon.

23. A grinding machine comprising:

a base frame on wheels positioned to roll on horizontal tracks;

a mast base mounted on rollers which ride on horizontal rails, on the base frame, normal to the tracks;

an upright mast mounted on the mast base;

vertical guideways on the mast;

a headstock mounted to move vertically on the guideways, and to be secured in a specific position thereon;

grinding means supported by the headstock; and

bracket means on the headstock for supporting an operator's platform and raising the platform with the headstock during upward movement of the headstock above a predetermined height.

24. A grinding machine comprising:

a base frame on wheels positioned to roll on horizontal tracks;

a mast base mounted on rollers which ride on horizontal rails, on the base frame, normal to the tracks;

an upright mast mounted on the mast base;

vertical guideways on the mast;

a headstock mounted to move vertically on the guideways, and to be secured in a specific position thereon; and

grinding means supported by the headstock;

said grinding means comprising a grinding belt mounted on three wheels, one of said wheels being a grinding belt drive wheel, another of said wheels being a grinding belt tension applying wheel and the third wheel being a pressure applying wheel for pressing the grinding belt against a workpiece.

25. A grinding machine comprising:

a grinder mounting having three grinding belt wheels supported thereby, one of said wheels being a grinding belt drive wheel, another of said wheels being a grinding belt tension applying wheel and the third wheel being a pressure applying wheel for pressing a grinding belt, supported by the wheels, against a cylindrical workpiece;

sensing probe means adjacent to the pressure wheel adapted to contact a workpiece to activate means to position the grinding belt tangentially relative to the workpiece to regulate the pressure applied by the

pressure applying wheel to the grinding belt and workpiece; and

means to maintain the sensing probe means in substantially the same direction with change in position of the pressure applying wheel.

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WILLIAM R. ARMSTRONG, Primary Examiner

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,608,246 Dated September 28, 1971

Inventor(s) John Breckbill McCormack and Chester Arthur Harris, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 22, delete the spacer line and place it after line 49 where the Abstract ends. Col. 3, line 54, delete "on". Col. 7, line 9, insert --a-- before "perpen-". Col. 9, lines 39 to 41, should be --the base frame is on wheels positioned to roll on horizontal tracks running normal to the rails on which the mast base rolls.-- Col. 10, line 1, "verticaly" should be --vertically--.

Signed and sealed this 14th day of March 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents