Nov. 17, 1970 W. E. REASER ET AL 3,540,158

AUTOMATIC POLISHING MACHINE

Filed June 19, 1968 7 Sheets-Sheet 1

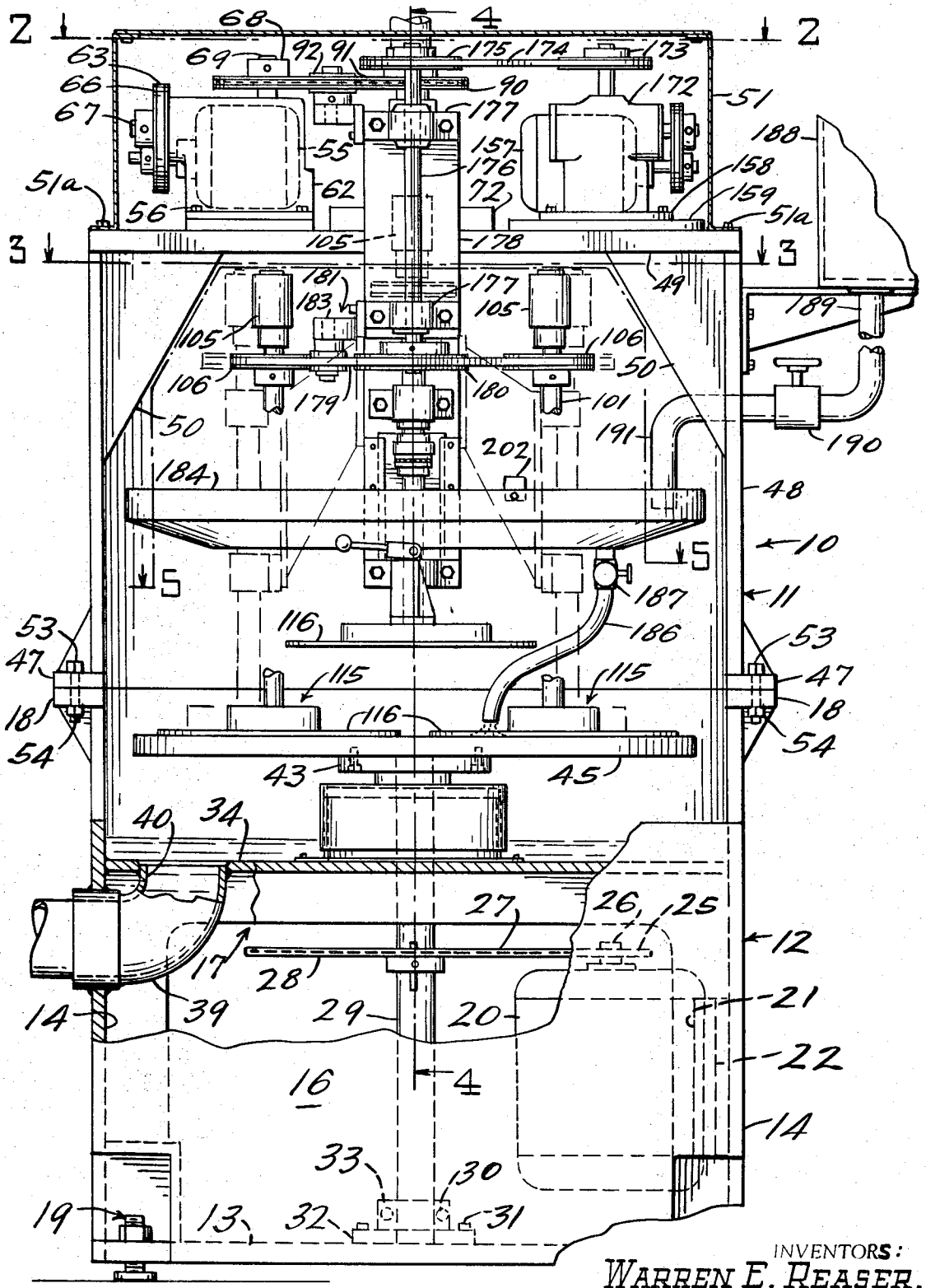


FIG-1-

INVENTORS:
WARREN E. REASER,
EARLE M. POWERS, JR.
BY Owen & Owen
ATT'YS.

Nov. 17, 1970 W. E. REASER ET AL 3,540,158

AUTOMATIC POLISHING MACHINE

Filed June 19, 1968 7 Sheets-Sheet 2

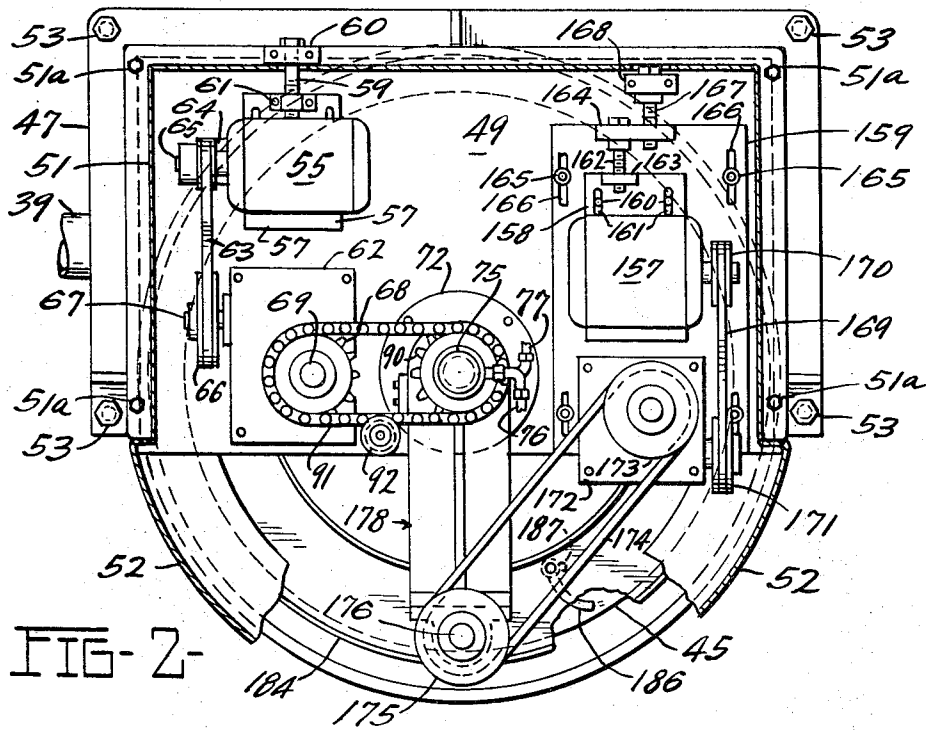


FIG-2-

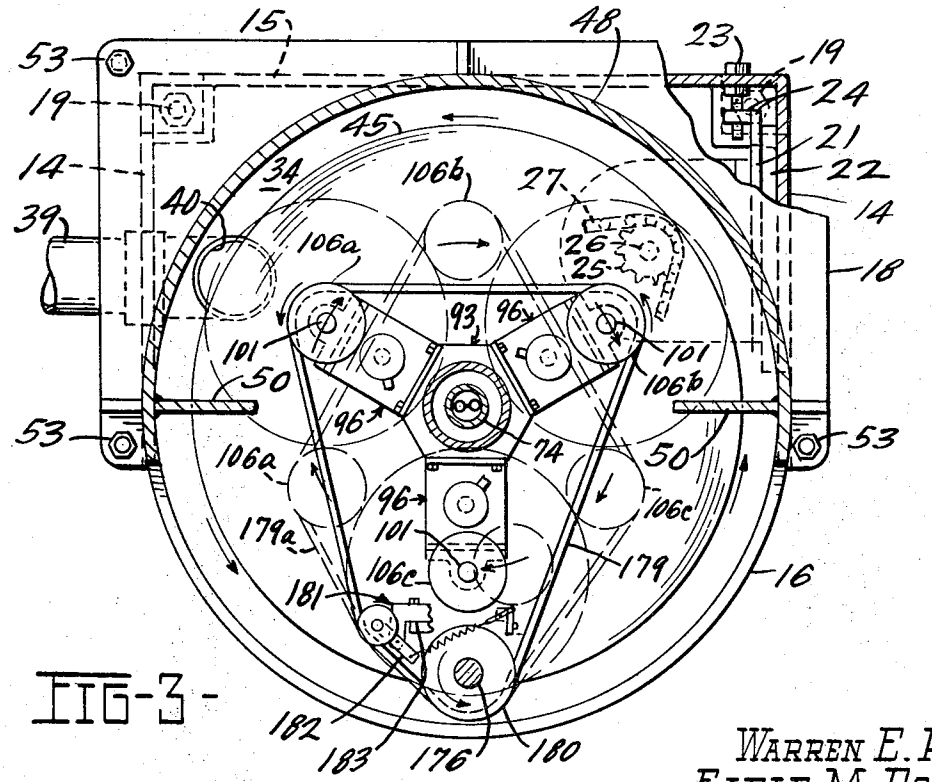


FIG-3-

INVENTORS:
WARREN E. REASER,
EARLE M. POWERS, JR.
BY Owen & Owen
ATT'YS.

Nov. 17, 1970 W. E. REASER ET AL 3,540,158

AUTOMATIC POLISHING MACHINE

Filed June 19, 1968 7 Sheets-Sheet 3

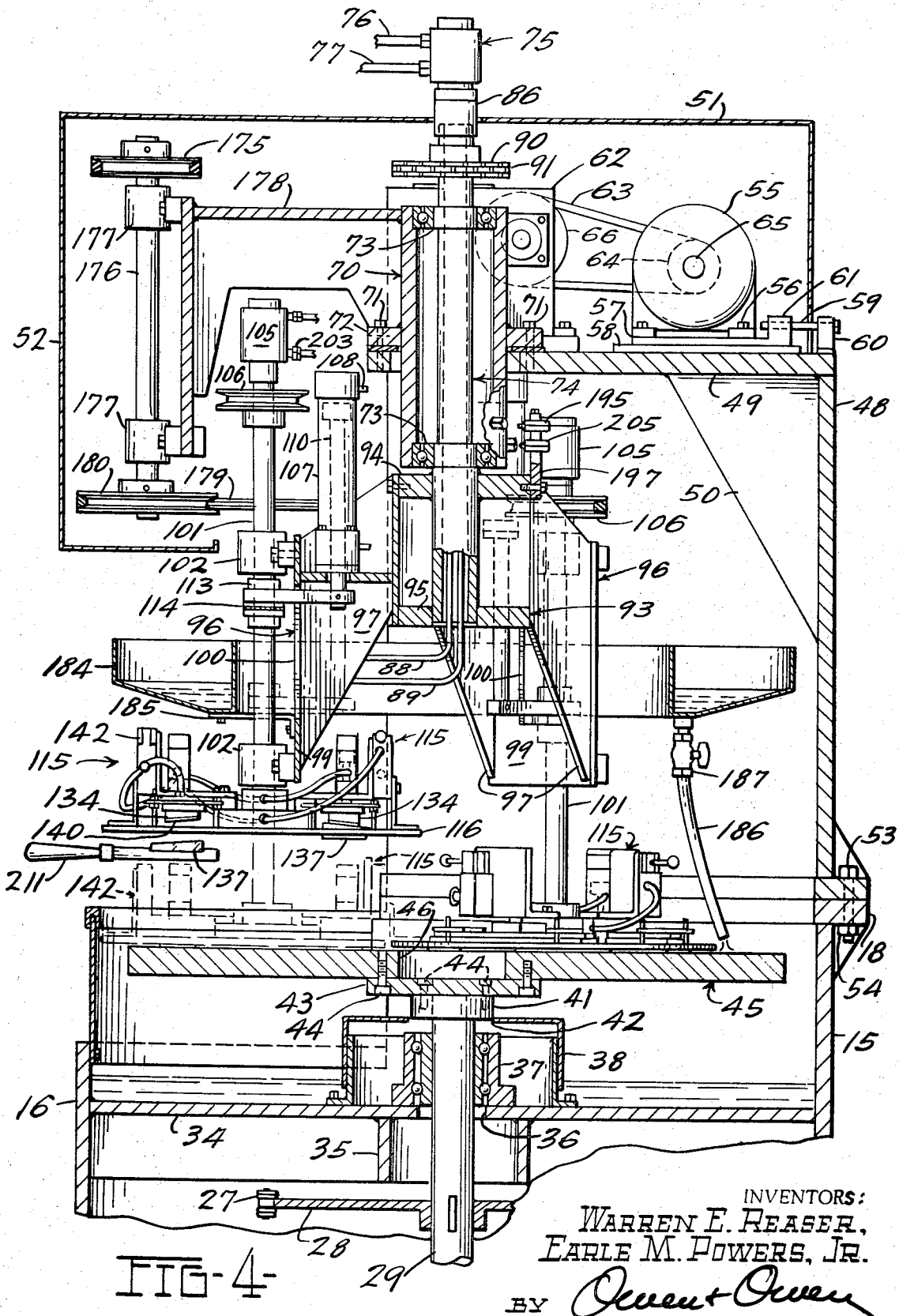


FIG-4-

INVENTORS:
WARREN E. REASER,
EARLE M. POWERS, JR.
BY Owen + Owen
ATT'YS.

Nov. 17, 1970 W. E. REASER ET AL 3,540,158

AUTOMATIC POLISHING MACHINE

Filed June 19, 1968 7 Sheets-Sheet 4

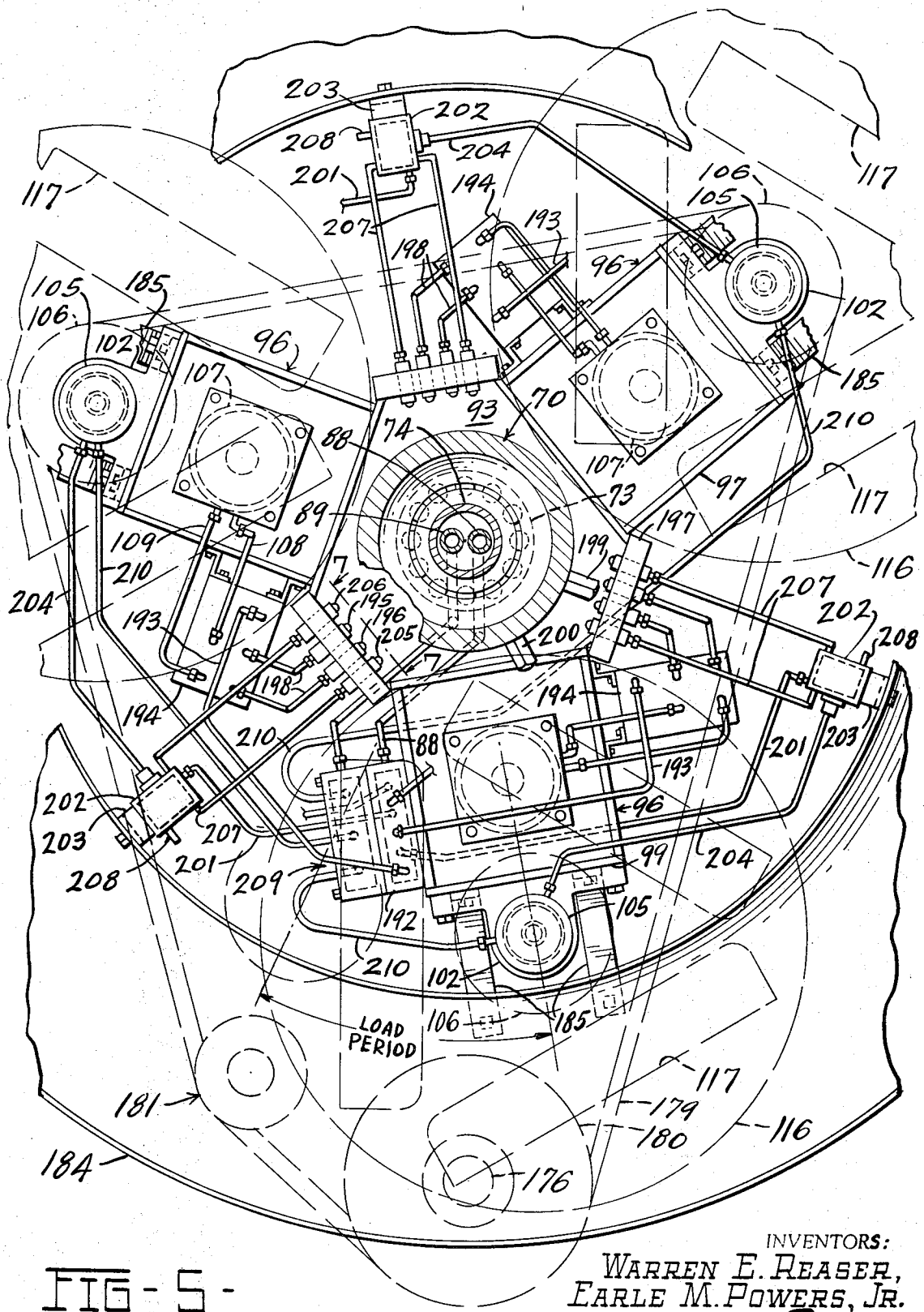


FIG-5-

INVENTORS:
WARREN E. REASER,
EARLE M. POWERS, JR.
BY Owen & Owen
ATT'YS.

Nov. 17, 1970 W. E. REASER ET AL 3,540,158

AUTOMATIC POLISHING MACHINE

Filed June 19, 1968 7 Sheets-Sheet 5

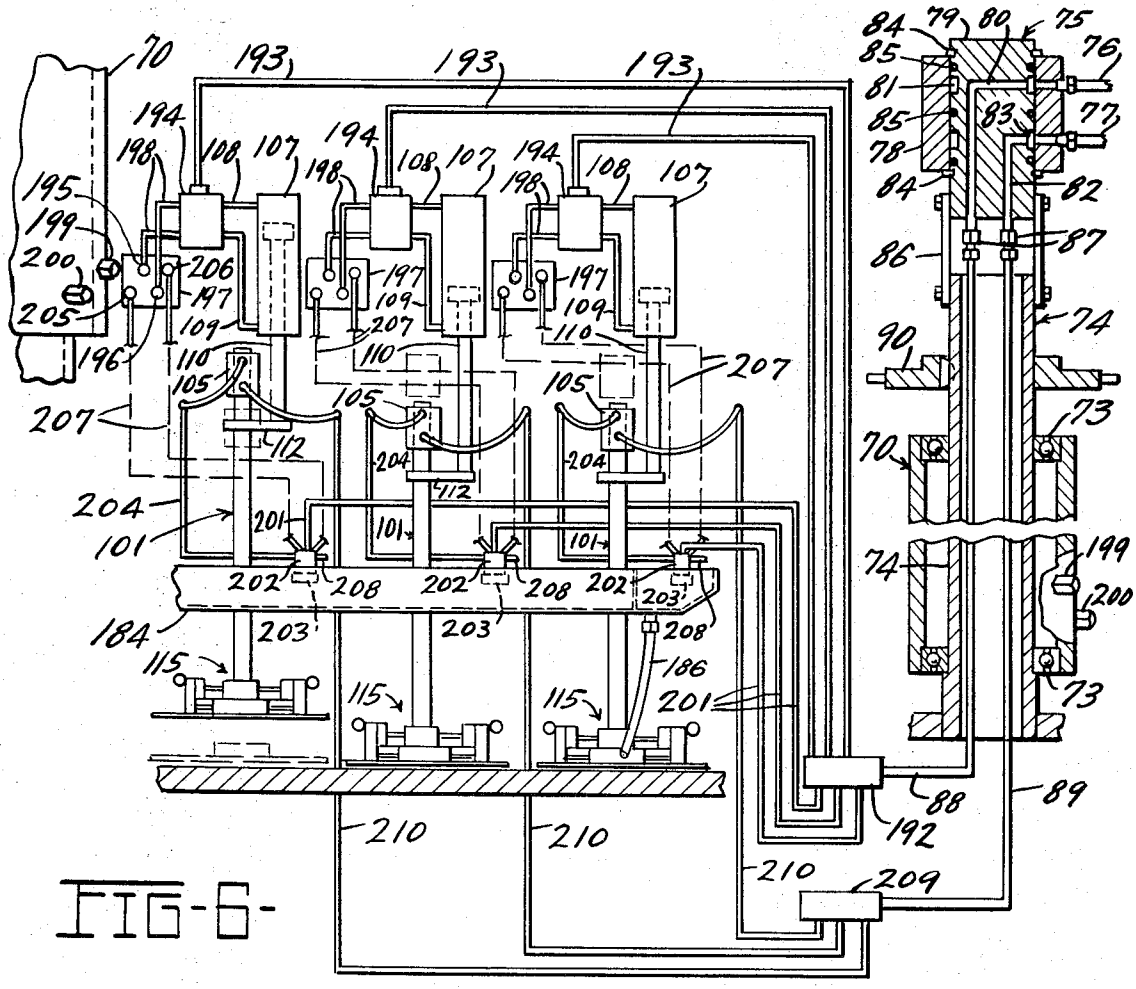


FIG-6-

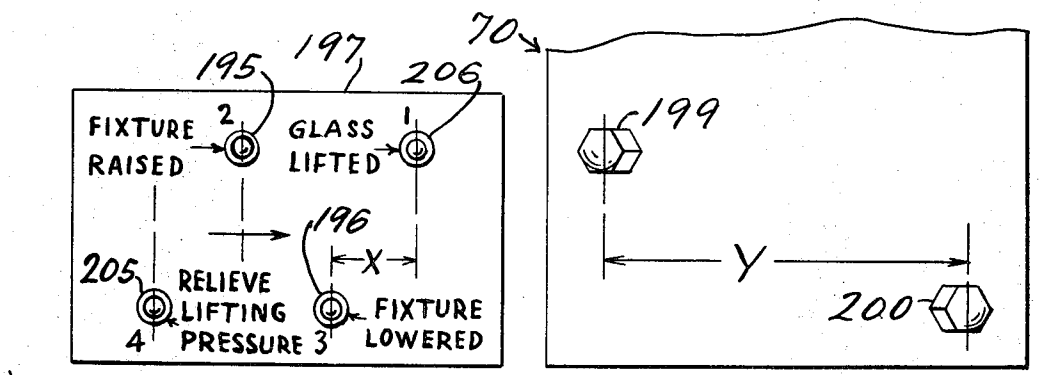


FIG-7-

INVENTORS:
WARREN E. REASER,
EARLE M. POWERS, JR.
BY Owen + Owen
ATT'YS.

Nov. 17, 1970 W. E. REASER ET AL 3,540,158

AUTOMATIC POLISHING MACHINE

Filed June 19, 1968 7 Sheets-Sheet 6

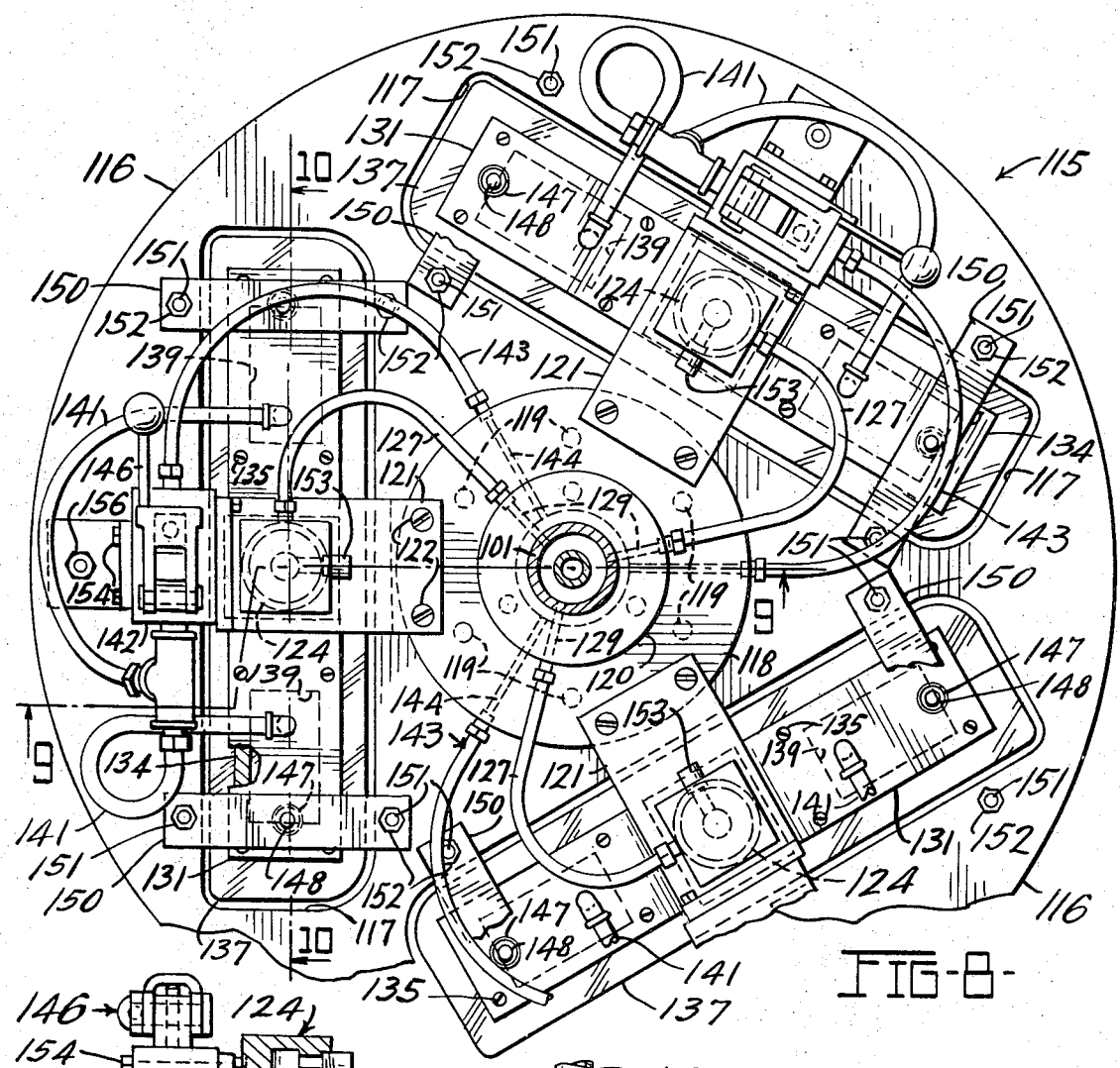


FIG-8-

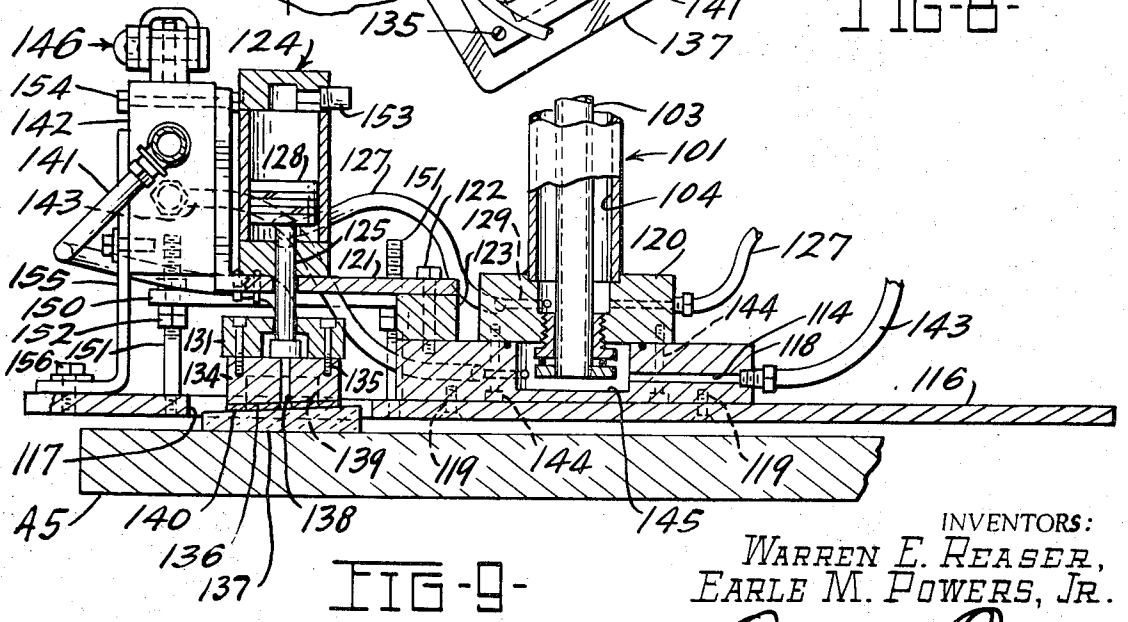


FIG-9-

INVENTORS:
WARREN E. REASER,
EARLE M. POWERS, JR.
BY Owen & Owen
ATT'YS.

Nov. 17, 1970 W. E. REASER ET AL 3,540,158

AUTOMATIC POLISHING MACHINE

Filed June 19, 1968 7 Sheets-Sheet 7

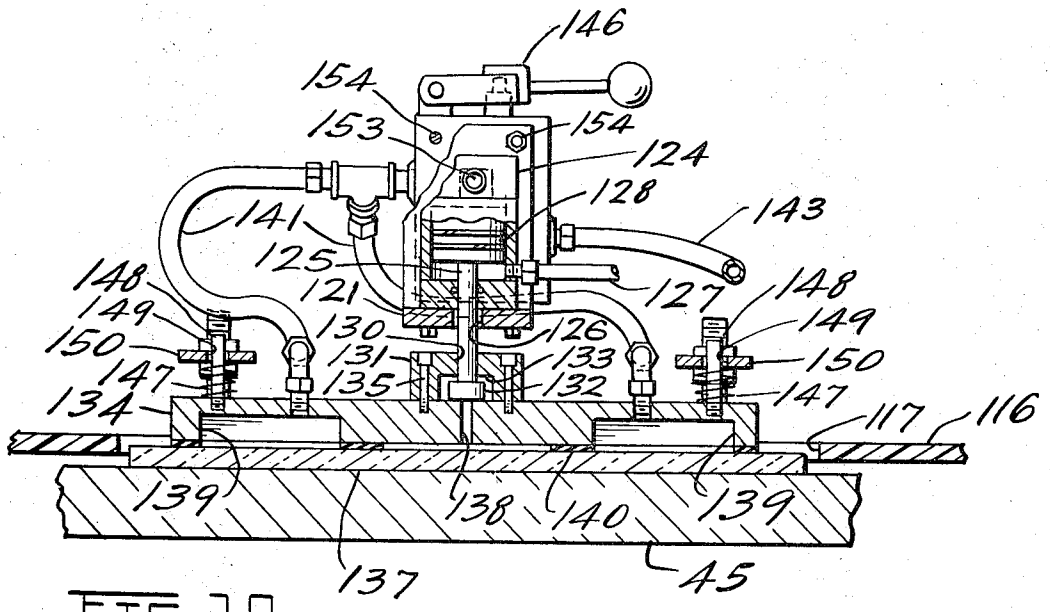


FIG-10-

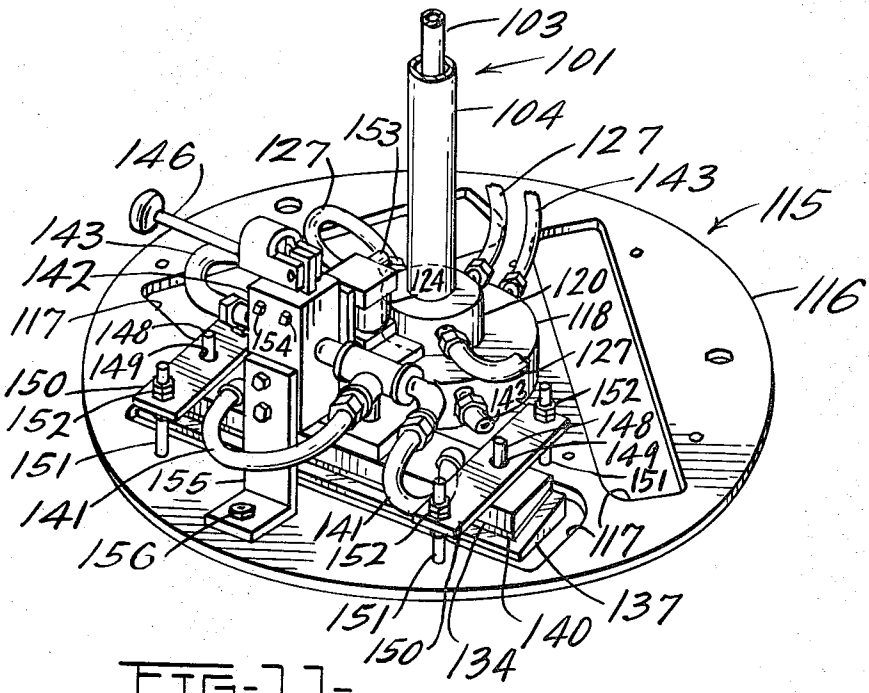


FIG-11-

INVENTORS:
WARREN E. REASER,
EARLE M. POWERS, JR.
BY Owen & Owen
ATT'YS.

United States Patent Office 3,540,158 Patented Nov. 17, 1970

3,540,158

AUTOMATIC POLISHING MACHINE

Warren E. Reaser, Brooklyn, Mich., and Earle M. Powers, Jr., Toledo, Ohio, assignors to Sun Tool & Machine Company, Toledo, Ohio, a corporation of Delaware

Filed June 19, 1968, Ser. No. 738,267
Int. Cl. B24b 5/00
U.S. Cl. 51—133 8 Claims

ABSTRACT OF THE DISCLOSURE

A machine for lapping and polishing the surfaces of small workpieces such as automobile rearview mirrors and the like. The machine includes a frame, a horizontal polishing table rotatably mounted on the frame on a vertical axis, an independently rotatable head mounted above the table coaxially with the table, and a plurality of individually rotatable fixtures that are carried by the head and rotatable on axes parallel to the axis of the head. The fixtures have means for holding a plurality of workpieces in contact with the surface of the rotatable table onto which a grinding compound is supplied. Each of the fixtures is movable axially relative to the head in order to lift the workpieces out of contact with the surface of the rotatable table when the fixture rotates to a predetermined loading position to allow finished workpieces to be removed from the fixture and raw workpieces to be inserted. The machine has drive mechanisms for rotating the table, the head and the fixtures, and control mechanism which stops the rotation of each fixture and causes it to be elevated at the loading position.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a machine used for lapping and/or polishing the surfaces of glass pieces, and the like, and has particular utility when used to lap or polish rearview mirrors of automobiles.

Rearview mirrors of automobiles are conventionally made by cutting blanks from sheets of glass, rough grinding the blanks to the desired degree, and then lapping and polishing them to remove surface irregularities. Lapping is an intermediate step between rough grinding and polishing. Substantially, the only difference between lapping and polishing is in the nature of the abrasive used. The abrasive used in the lapping operation is generally aluminum oxide or garnet, whereas rouge is conventionally used in the polishing operation.

Automobile rearview mirrors which are adjustable for day or night driving have an angled surface relative to the back side thereof. It is extremely important that the mirror be ground to the proper angle and the surface be completely smooth in order to eliminate distortion.

The prior art

In the prior art, automobile rearview mirrors were first rough ground on one machine, and then transferred to a second machine for fine grinding or lapping, and to still another for polishing. A typical machine used for this purpose consists essentially of a large rotating table (about 42" in diameter), and an opposing rotating fixture of approximately the same diameter. A plurality of mirror blanks (usually 40 or more) are adhered to the fixture with hot pitch. After each operation, in order to maintain the blanks in the same attitude for the subsequent operation, the entire fixture is removed from the first machine and transferred to a second or third machine. Because of the heavy weight of the fixture, two or more men are required to effect the transfer. In addition, there is considerable down time in transferring from one machine to another. This is, of course, uneconomical and undesirable.

SUMMARY OF THE INVENTION

In general, the machine comprises a frame having a horizontal polishing table rotatably mounted on a vertical axis. Mounted above the table on the same axis is an independently rotatable head. A plurality of individually rotatable fixtures are carried by the head and are individually rotatable on axes parallel to the axis of rotation of the head. The fixtures hold the workpieces in contact with the table when in normal operative position. The workpieces are held in place on the fixtures by a vacuum system and are urged against the table by air pressure. Each fixture is movable between a lower working position adjacent the table and an upper loading position by an air cylinder. Driving means are mounted on the frame to rotate the table, the head, and the fixtures.

Switching means are mounted on the apparatus to actuate the air cylinder associated with each individual fixture when the fixture reaches a loading station at a predetermined position of rotation. The cylinder raises the fixture allowing the finished workpieces to be removed, and new ones inserted. When the fixture reaches another predetermined position, air to the cylinder is reversed and the fixture resumes its original position.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view in elevation of a machine embodying the invention with parts broken away, some parts in section and parts shown in phantom;

FIG. 2 is a plan view taken from the position indicated by the line **2—2** of FIG. 1 and showing the driving means for the head of the machine and a portion of the driving means for the fixtures;

FIG. 3 is a horizontal sectional view taken along the line **3—3** of FIG. 1 and showing another portion of the driving means for the fixtures;

FIG. 4 is a vertical sectional view on an enlarged scale, of the machine taken generally along the line **4—4** of FIG. 1, with parts broken away;

FIG. 5 is a fragmentary, horizontal sectional view taken along the line **5—5** of FIG. 1, with parts broken away and parts in phantom, and showing various air and vacuum connections and valve means of the machine of this invention;

FIG. 6 is a diagrammatic illustration of the air and vacuum system of the machine of the invention;

FIG. 7 is a fragmentary, diagrammatic view illustrating the sequential actuation of certain valving;

FIG. 8 is a fragmentary, plan view of an individual fixture of the machine of the invention, shown on an enlarged scale relative to FIG. 1;

FIG. 9 is a fragmentary, vertical sectional view with parts broken away, taken along the line **9—9** of FIG. 8;

FIG. 10 is a fragmentary, vertical sectional view taken along the line **10—10** of FIG. 8; and

FIG. 11 is a fragmentary view in perspective of a of a fixture.

DESCRIPTION OF PREFERRED EMBODIMENT

In the preferred embodiment of this invention, a main frame **10** has an upper half **11** and a lower half **12**. The lower half **12** comprises a horizontal base plate **13** and heavy, vertical plates forming sides **14**, a back **15**, and an arcuate front **16** welded together to form a rigid enclosing hollow structure. The hollow structure thus formed is braced by a cross bridge **17**. A horizontal flange **18** extends around the top edges of the sides **14**, and back **15**, for supporting the upper half **11**.

The machine can be leveled by means of leveling screws **19** which are threaded through the base plate **13** at four approximate corners.

A table drive motor **20** (see also FIG. 3) is mounted on a gib **21** in a way **22** that is secured to one of the sides **14**. The motor **20** is movable horizontally by an adjusting bolt **23** threaded through the back **15** into an ear **24** of the gib **21**. A sprocket **25** on a shaft **26** of the motor **20** is engaged by a drive chain **27** which also engages a driven sprocket **28** mounted on and keyed to a vertically extending table drive shaft **29**. The lower end of the drive shaft **29** is journaled by a bearing **30** attached to the base plate **13** in the center thereof by screws **31** which extend through a flange **32** in a bearing housing **33** and into the base plate **13**.

A horizontal support plate **34** (see FIG. 4) is welded to the sides **14**, back **15** and front **16**, and rests on cross members **35** of the bridge **17**. The upper end of the table drive shaft **29** extends through a central opening **36** in the support plate **34**, and a bearing **37** mounted on the plate **34**. The bearing **37** is protected by a shroud **38** that also is mounted on the plate **34**.

A conduit **39** (FIG. 1) leads from an orifice **40** in the support plate **34** through the side **14** for disposal of grinding or polishing material which flows into the well formed by the support plate **34** and the upper parts of the sides **14**, back **15**, and front **16** of the lower half **12** of the frame **10**.

A head **41** of the table drive shaft **29** protrudes through a top opening **42** in the shroud **38**. A hub **43**, removably connected by machine screws **44** to the head **41**, supports a heavy circular table **45**, preferably fabricated from cast iron. The heads of the screws **44** are accessible through a central opening **46** in the table **45**.

The upper half **11** of the frame **10** comprises a horizontal plate **47** (see FIG. 3) which rests on the flange **18** of the lower half **12**, covering the rear corners of the lower half **12**, and which supports a vertically extending semi-cylindrical side plate **48** that is welded thereto. A top plate **49** (FIGS. 1 and 4) is welded on the top edge of the side plate **48**. The top plate **49** is supported also by internal triangular braces **50**. A protective cover **51** for the machine is mounted on the top plate **49** by screws **51***a* and has a front, lower portion **52** enclosing portions of the mechanism to be described below. The upper half **11** of the frame **10** is connected to the lower half **12** by heavy bolts **53** which extend through the edges of the plate **47** and the flange **18**. The bolts **53** are secured by nuts **54**.

A head drive motor **55** (FIG. 4) is mounted on the top plate **49** by screws **56** on a gib plate **57** which slides in a way plate **58**. The motor **55** is movable horizontally by an adjusting bolt **59** which extends through an ear **60** on the top plate **49** and is threaded into an ear **61** of the gib plate **57**.

The motor **55** drives a reduction gear box **62** by means of a belt **63** engaging a pulley **64** on a shaft **65** of the motor **55** and a pulley **66** on an input shaft **67** of the gear box **62**. A drive sprocket **68** is mounted on a vertically extending output shaft **69** of the gear box **62**.

A vertically extending, hollow cylindrical housing **70** (see FIGS. 4 and 6), is mounted at the front center of the top plate **49** and extends above and below the top plate **49** being secured thereto by machine bolts **71** which extend through a heavy annular flange **72** which lies on the top plate **49**. Bearings **73**, mounted in the upper and lower ends of the housing **70**, journal a tubular head drive shaft **74**.

As can best be seen in FIG. 6, a two-line rotary coupling **75** is mounted on the upper end of the shaft **74**. An air conduit **76** and a vacuum conduit **77** are connected to ports in a sleeve **78** which is retained against rotation. A rotating body **79** has an inner air passageway **80** opening radially into an annular groove **81** and an inner vacuum passageway **82** opening radially into a similar annular groove **83**. Snap rings **84** retain the body **79** in place in the sleeve **78** with the ports of the air conduit **76** and vacuum conduit **77** aligned with the annular grooves **81** and **83**, respectively. "O" rings **85** seal the body **79** in the sleeve **78**. The rotary coupling **75** is attached to the top of drive shaft **74** by means of a collar **86**. The air passageway **80** and vacuum passageway **82** in the body **79** have nipples **87** for connection to an air line **88** and a vacuum line **89** extending downwardly through the tubular shaft **74**.

A sprocket **90** (FIG. 4) is keyed to the shaft **74** below the coupling **75** and above the housing **70**. The sprocket **90** is connected by a drive chain **91** (FIG. 2) to the sprocket **68** of the reduction gear box **62**. A movable idler sprocket **92** (see also FIG. 2) is mounted on the drive shaft housing **70** and engaged with the chain **91** in order to adjust tension in the chain **91**.

A six-sided head **93** (FIGS. 3 and 4) comprises upper and lower plates **94** and **95** which are welded to the end of the shaft **74** beneath the housing **70**. Three spider spindle brackets **96** are secured to alternate facets of the head **93**, extending outwardly and downwardly therefrom and spaced 120° from each other. Each of the brackets **96** comprises two spaced, parallel, vertical plates **97**, a horizontal brace plate **98** and a vertical end plate **99**. The plates **99** have rectangular cut outs **100**.

A tubular spider spindle **101** (see also FIGS. 8 and 9) is journaled by bearings **102** mounted one at the top and one at the bottom of the plate **99**, a vacuum conduit **103** extends downwardly through the spider splindle **101** and the annular space between the vacuum conduit **103** and the wall of the spindle **101** forms an air conduit **104** which extends through its length. A rotary coupling **105** is mounted on the upper end of each of the spindles **101**. A spindle drive pulley **106** is pinned on the spindle **101** just below the rotary coupling **105**.

An air cylinder **107** that is supplied by lines **108** and **109** (FIGS. 5 and 6) is mounted on the horizontal plate **98** in the bracket **96** and its piston rod **110** extends through an opening **111** in the brace plate **98**. An arm **112** extends radially through the cut out **100**, and is connected by thrust collars **113** and a thrust bearing **114** to the spider spindle **101**. As will later be described in detail, when air is admitted through the line **108** to the top of the cylinder **107**, its piston rod **110** is extended downwardly to lower the spindle **101** and a fixture **115** carried thereby into polishing position.

One of the fixtures **115** (see FIGS. 8–11) is mounted on the lower end of each of the spider spindles **101**. Each of the fixtures **115** comprises a horizontal disk shaped loading guide **116** having a plurality of cut outs **117** in the approximate shape of the workpiece to be treated. In the embodiment shown, there are three cut outs **117**. The loading guide **116** is attached to a spindle drum **118** by screws **119** and the spindle drum **118** is in turn attached to a hub **120** mounted on the end of the spider spindle **101**. A support bracket **121** for each of the cut outs **117** is attached to the drum **118** by screws **122** extending through a spacer **123**.

An air cylinder **124** is mounted on each support bracket **121** directly over the corresponding cut out **117** in the loading guide **116**, and its piston rod **125** extends downwardly through an opening **126** in the support bracket **121**. An air line **127** is coupled to the air cylinder **124** at a level beneath its piston **128** and to an air passage **129** in the hub **120** which communicates with the air conduit **104** in the spindle **101**.

The end of the piston rod **125** extends through a counterbored opening **130** in a retainer **131** and a cap **132** is threaded onto its lowermost end. The cap **132** is thus positioned in an enlarged pocket **133** formed in the undersurface of the retainer **131**. The retainer **131** is secured to a pressure plate **134** by machine screws **135** (FIG. 10). The pressure plate **134** has a bevelled bottom surface **136** that is complementary to an angle to be ground on

the surfaces of workpieces **137** to be polished. A vent **138** extends upwardly from the surface **136** to the pocket **133**. A pair of generally rectangular pockets **139** (FIG. 10) are cut in the undersurface of the pressure plate **134** and each of them is surrounded by a cushion **140**.

The pockets **139** are connected by vacuum lines **141** to a manually operated valve **142**. A vacuum line **143** connects the valve **142** to a radial passageway **144** (FIG. 9) in the spindle drum **118** and to a central vacuum chamber **145** communicating with the lower end of the vacuum conduit **103**. A manual valve handle **146** is provided for actuating the valve **142**. When the valve **142** is opened to connect the pockets **139** through the vacuum lines **141** to the vacuum conduit **103**, negative pressure in the pockets **139** functions to retain a workpiece **137** against the cushions **140** on the bottom of the pressure plate **134**. Conversely, when it is desired to remove a polished workpiece **137**, the valve **142** is closed, releasing the negative pressure in the pockets **139** to release the finished workpiece **137**.

The workpiece **137** is pressed downwardly on the polishing table **45** by springs **147** (FIG. 10) one of which is positioned around each of a pair of pins **148** (see also FIGS. 8 and 11) that are threaded into the top surface of the pressure plate **134** near its ends, and that extend upwardly through clearance openings **149** in bridge plates **150**. As can also be seen in FIGS. 8 and 11, each of the bridge plates **150** is positioned across one end of its respective pressure plate **134** by a pair of threaded posts **151**, the posts **151** being threaded into the retainer plate **116**. The vertical position of the bridge plates **150** relative to the retainer plate **116** and thus the force exerted by the springs **147** on the pressure plate **134**, is adjustable by varying the position of upper and lower sets of lock nuts **152** threaded on the post **151** above and below the bridge plates **150**.

During a polishing cycle, as will be more fully described below, and after the workpiece **137** has been polished, compressed air is supplied to the air conduit **104** in the spindle **101** and thus to the cylinder **124** beneath its piston **128** to pull its piston rod **125** upwardly, lifting the pressure plate **134** and the workpiece **137** which is retained thereon above the level of the table **45** and against the pressure of the springs **147**. After the polished workpiece **137** is removed by releasing the vacuum in the vacuum pockets **139** and a rough or unpolished workpiece **137** is placed on the pressure plate **134**, air pressure in the line **127** and beneath the piston **128** is relieved allowing the springs **147** to expand and to urge the pressure plate **134** downwardly with predetermined pressure. Freedom of movement of the piston **128** is assured by reason of an exhaust vent **153** in the cylinder **124** at a level above the piston **128**.

The cylinder **124** is rigidly connected to the body of the valve **142** and the support bracket **121** by machine screws **154**, and the body of the valve **142** is also supported on the loading guide **116** by an outboard bracket **155** that is fixed on the loading guide **116** by a machine screw **156**.

A spindle drive motor **157** (see FIGS. 1 and 2) is mounted on top of the top plate **49** by a motor base plate **158** which is carried on a motor and transmission support plate **159**. The motor base plate **158** is connected to the support plate **159** by machine screws **160** which extend through elongated slots **161** in the base plate **158**. An adjustment screw **162** is engaged with an ear **163** on the motor base plate **158** and with a flange **164** on the support plate **159**. The support plate **159** is, in turn, adjustably mounted on the main top plate **49** by machine screws **165** which extend through elongated slots **166** in the support plate **159** and its position may be adjusted by means of an adjusting screw **167** extending through an ear **168** on the top plate **49** and threadably engaged with the flange **164** on the support plate **159**.

A drive belt **169** is engaged with a motor pulley **170** and with an input pulley **171** of a reduction gear box **172** which is also mounted on the support plate **159**. Adjustment of the position of the motor base plate **158** on the support plate **159** provides for tensioning the belt **169**. A gear box output pulley **173** drives a transmission belt **174** which is also engaged with a pulley **175** keyed to the upper end of a jack shaft **176**. The jack shaft **176** is rotatably journaled in bearings **177** that are mounted on the forward vertical face of a heavy jack shaft bracket **178** erected on the front side of the top plate **49** so that the jack shaft **176** extends downward parallel to the tubular drive shaft **74** and the spindles **101** (see also FIG. 4).

A spindle drive belt **179** (see also FIG. 3) is engaged with a pulley **180** pinned to the lower end of the jack shaft **176** and is also engaged at all times with a least two of the three spindle pulleys **106**. Referring particularly to FIG. 3, it will be seen that as the head **93** rotates, the several spindles **101** are revolved around the center defined by the drive shaft **74** while remaining in driving contact with the spindle drive belt **179** except during the approximately 30° of circumferential movement at the front of the machine. The drive belt **179** is shown in FIG. 3 in solid lines while it is in engagement with two of the spindle drive pulleys **106***a* and **106***b* at the rear of the machine, and out of engagement with the spindle drive pulley **106***c* of the spindle **101** located at the front center of the machine. The spindle drive belt **179** is shown in dotted lines, indicated by the reference number **179***a* in FIG. 3, when it is engaged with all three of the spindle drive pulleys **106***a*, **106***b* and **106***c* indicated by the dotted lines. During the rotary movement of the head **93** (clockwise in FIG. 3), while one of the spindle drive pulleys **106***c* is disengaged from the spindle drive belt **179**, valving means to be later described, is automatically actuated to feed air through the air line **109** to the bottom of the spindle cylinder **107** to pull its rod **110** upwardly lifting the particular spindle **101** and its fixture **115** to the upper position, as shown at the left in FIG. 4. The particular spindle **101** coasts to a stop during the disengagement of its pully **106** from the spindle drive belt **179**, enabling the operator to remove a polished workpiece **137** and to replace it with a rough workpiece **137**.

A belt tensioning device **181** (FIGS. 1 and 3) is engaged with the belt **179** at all times, being mounted on the end of a spring urged rocker **182** that is pivotally mounted on a finger **183** mounted on the jack shaft bracket **178**.

A rotating slurry trough **184** is carried by three trough brackets **185** (FIG. 4), each of which is mounted on and extends outwardly from one of the vertical end plates **99** of the spindle brackets **96**. The slurry trough **184** rotates with the head **93** and the spindles **101** and delivers slurry to the surface of the grinding table **45** through a depending pipe **186** with the rate of flow therethrough being controlled by a valve **187**. Grinding slurry is supplied to the trough **184** from a supply tank **188** (FIG. 1) through a pipe **189**, the rate of flow being controlled by a cock **190** connecting the pipe **189** to a nozzle **191** which overlies the slurry trough **184**.

OPERATION

Referring now particularly to FIGS. 5 and 6, compressed air is fed through the air source conduit **76** and the air passageway **80** to the air nipple **87** and thence downwardly through the air supply line **88** interiorly of the tubular drive shaft **74**. The line **88** is connected to an air manifold **192** and, through air lines **193** to air valves **194** for the spindle lowering cylinders **107**. Each of the air valves **194** is mounted on the side of the associated one of the spindle brackets **96** and is connected by the air lines **108** and **109** to the top and bottom, respectively, of one of the spindle air cylinders **107**. Each of the air valves **194** is controlled by a pair of pilot valves **195** and **196** (see also FIGS. 4–7) which are positioned in a vertical plate **197** carried on and extending upwardly from its

respective spindle bracket **96**. Each valve **194** is connected by pilot valve lines **198** to its pilot valves **195** and **196**. The pilot valves **195** and **196** have small inwardly directed plungers which are successively engaged by projections **199** and **200** protruding from the outer wall of the main drive shaft housing **70**. The compressed air manifold **192** is also connected by air lines **201** to three valves **202**. Each of the valves **202** is mounted by a small bracket **203** on the inner rim of the coolant trough **184** and is connected by an air line **204** to the respective one of the rotary couplings **105** on one of the spindles **101**. As has earlier been explained, this connects the compressed air manifold **192** to the annular air conduit **104** in the spindle **101** and thence to the air lines **127** and to the three cylinders **124** of the fixtures **115**. Each of the air valves **202** is controlled by a pair of pilot valves **205** and **206** that are mounted on the plate **197** (see FIGS. 5–7) in line to be engaged by the projections **199** and **200**. The pilot valves **205** and **206** are connected to the respective valve **202** by a pair of pilot valve lines **207**. Each of the valves **202** also has an exhaust vent **208**.

As can best be seen by reference to FIGS. 6 and 8, the air supply through the manifold **192** to the respective valves **194** and **202** and thus to the fixture lifting cylinders **107** and the air cylinders **124** is controlled by the pilot valves **195, 196, 205** and **206**. The two projections **199** and **200** are spaced circumferentially around the housing **70** a distance indicated in FIG. 7 by the letter *y*. This distance, when added to the horizontal distance between the pilot valve **206** and the pilot valve **196**, indicated by the letter *x* in FIG. 7, comprises 35° of angular rotation of the head **93** and thus of the fixtures **115**. This is the area at the front of the machine wherein the spindle drive pulleys **106** are out of engagement with the spindle drive belt **179** as has been discussed above with reference to FIG. 3.

As the head **93** rotates in the direction of movement indicated by the arrow on the plate **197** in FIG. 7 (clockwise in FIG. 5), the pilot valve **206** is first engaged by the projection **199**. This actuates the respective valve **202** to supply air under pressure to the air cylinder **124**, thus to lift its particular pressure plate **134** and raise a workpiece **137** off of the table **45**. Immediately thereafter, the pilot valve **195** engages the projection **199** to actuate the valve **194** and deliver air under pressure through the air line **109** to the bottom of the spindle air cylinder **107**. This raises the entire fixture **115** to its upper position (FIGS. 4 and 6) and, because the spindle drive pulley **106** of that fixture is no longer engaged with the spindle drive belt **179** (FIG. 3), this fixture **115** comes to a stop to allow the operator to remove the polished workpieces **137** from that fixture **115** and replace them with fresh workpieces **137**. As the head **93** continues to rotate and approaches the limit of the 35° loading area, the operator has removed the polished workpieces from the three pressure plates **134** of the particular fixture **115** and has reactivated the vacuum to hold the workpieces **137** in place.

At this point, the pilot valve **196** engages the projection **200** and actuates the respective valve **194** to apply air through the line **108** to the cylinder **107**. This extends the piston rod **110** and lowers the respective fixture **115** back downwardly to its lower or operating position. Immediately thereafter, the pilot valve **205** engages the projection **200** and actuates the respective valve **202** opening the valve **202** to exhaust through its vent **208** and relieving the lifting pressure in the particular air cylinder **124** from beneath the piston **128**. This allows the pressure springs **147** to thrust the pressure plates **134** of that fixture **115** downwardly, bringing the workpieces **137** into engagement with the table **45**.

As each successive one of the fixtures **115** completes its single revolution around the machine, it reaches the front loading area and the respective ones of the pilot valves **195, 196, 205** and **206** are actuated in the sequence: (1) pilot valve **206** to lift the workpiece **137** off of the table **45**; (2) pilot valve **195** to raise the fixture **115**; (3) pilot valve **196** to lower the fixture **115**; (4) pilot valve **205** to relieve the lifting pressure in the respective cylinder **124**.

The main vacuum line **89** extending downwardly through the head drive shaft **74** is connected to a vacuum manifold **209** that is secured to the air manifold **192** (FIG. 5) and carried around with the head **93**. The vacuum manifold **209** is connected by vacuum lines **210** to the rotary couplings **105** on the spindles **101** and then through the vacuum conduits **103** (FIG. 9) and the lines **143** to the manually operable valves **142**. Because the valves **142** are manually controlled by an operator, as described above, no additional valving is provided in the vacuum system.

In order to facilitate the insertion of rough workpieces **137** into their respective cut outs **117**, the operator may employ a device such as the hand fixture **211** shown in FIG. 4 by which he can lift a rough workpiece **137** upwardly to insert it through a cut out **117** in the loading guide **116** and up against the undersurface of the pressure plate **134**, holding the workpiece **137** in place while he actuates the valve **142** to reapply vacuum into the pockets **139**. Because each of the individual pressure plates **134** has its own vacuum line **143** (FIGS. 8 and 9) which is controlled by its respective valve **142**, actuation of one of the individual valves **142** has no effect, of course, upon the vacuum present in the pockets **139** of the other two pressure plates **134** of that particular fixture **115**.

Having described our invention, we claim:

1. A machine for polishing the flat front surfaces of a plurality of identical, plate-like workpieces, said machine comprising, in combination, a rotatable flat polishing table and means for rotating the table at a constant speed, a spider-like head mounted for rotation on an axis concentric with the axis of rotation of said table, a plurality of fixtures carried by said head and individually rotatable therein on axes parallel to the axis of rotation of said head for revolution around said axis in planetary relationship thereto, means for rotating each of said fixtures, each of said fixtures having a shaft and a disc-like loading guide at the lower end of said shaft, said guide lying generally parallel to the surface of said polishing table, means for moving each of said guides between a working position adjacent said polishing table and a loading position remote therefrom, a plurality of platen-like workpiece holders carried by each of said fixtures, said holders having surfaces complementary to the back surfaces of the workpieces for holding the front faces thereof parallel to the surface of said table, individually releasable means for retaining each workpiece against the respective one of said workpiece holders, and means mounted on said fixtures for resiliently urging each of said workpiece holders toward and the respective workpieces against the surface of said table.

2. A machine according to claim **1** in which the means for rotating said fixtures comprises, in combination, a fixture drive pulley mounted on the upper end of each of said fixture shafts, a belt extending generally circumjacently of the axis of rotation of said head, and engageable with said fixture pulleys when said fixtures are in working position, a belt drive shaft mounted on said machine for rotation on an axis parallel to and spaced from the axis of rotation of said head, a belt drive pulley mounted on said belt drive shaft and continuously engaged with said belt, the axis of rotation of said belt drive shaft lying outside of the path of revolution of the axes of said fixture drive shafts a distance such that, and the diameter of said belt drive pulley being such that, each of said fixture drive pulleys disengages from said belt as the respective one of said fixtures reaches a predetermined position near said belt drive shaft and passes between said belt drive shaft and the axis of rotation of said head and re-engages

with said belt after said fixture reaches a second predetermined position beyond said belt drive shaft.

3. A machine according to claim 2 and control means actuated after disengagement of each of said fixture drive pulleys from said belt for actuating the respective one of said means for moving said fixture guides from working position to loading position and for returning said fixture guides to working position before said fixture reaches the position of re-engagement of said fixture drive pulley with said belt.

4. A machine according to claim 2 in which each of said means for moving each of said fixture guides between working and loading positions is a vertical double-acting fixture air cylinder and each of said means for resiliently urging each of said workpiece holders toward said table is a vertical double-acting holder air cylinder and in which said control means comprises a pair of valves for each fixture air cylinder and a pair of valves for all of said holder air cylinders on the respective fixture, each group of four of said valves for a fixture being mounted on said head and rotatable therewith, and a pair of valve actuators positioned for engagement by said valves during the period when the respective one of said fixture drive pulleys is disengaged from said belt in the sequence: workpiece holder raised, fixture raised, fixture lowered and workpiece holder lowered.

5. A machine according to claim 1 in which said polishing table is horizontal and is mounted on the upper end of a vertical shaft, said spider-like head is mounted on the lower end of an overhead shaft coaxial with said table shaft and the means for moving the loading guides are air cylinders carried by said head and yoked to said fixture shafts for vertically moving each of said fixtures.

6. A machine according to claim 1 in which each of the loading guides is a horizontal disc having a plurality of cutouts therethrough that are equidistantly spaced around the fixture shaft, each cutout being of substantially the same shape as and slightly larger than an individual workpiece and in which each of said workpiece holders is positioned above a respective one of said cutouts for holding a workpiece in the respective cutout with its front surface protruding beyond the surface of said disc.

7. A machine according to claim 6 in which each of said workpiece holders comprises an air cylinder and piston rod carried on said disc that is centered above the respective one of said cutouts and the means for retaining a workpiece on said holder comprises a hollow platen mounted on the end of said piston rod and engaging the back surface of the workpiece, a vacuum line connected through said fixture shaft to said platen and a manual valve in said vacuum lines for each of said platens.

8. A machine according to claim 1 and an annular polishing slurry trough supported in position underlying said polishing table and extending upwardly and around the edge of said table for collecting slurry thrown off of said table by rotation and revolution of said fixtures.

References Cited

UNITED STATES PATENTS

626,895	6/1899	Fondu	51—133 X
266,840	10/1882	Kelly	51—133
971,861	10/1910	Nickerson	51—133
2,963,830	12/1960	Hook	51—131

HAROLD D. WHITEHEAD, Primary Examiner

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,540,158 Dated November 17, 1970

Inventor(s) W. E. Reaser, et al

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

Column 2, line 60, after "of a" insert -- portion --

Column 6, line 15, after "with" delete "a" and inser
-- at --.

SIGNED AND
SEALED
FEB 23 1971

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR
Commissioner of Patents