June 7, 1955 H. S. INDGE 2,709,876

LAPPING MACHINE

Filed April 20, 1954 5 Sheets-Sheet 1

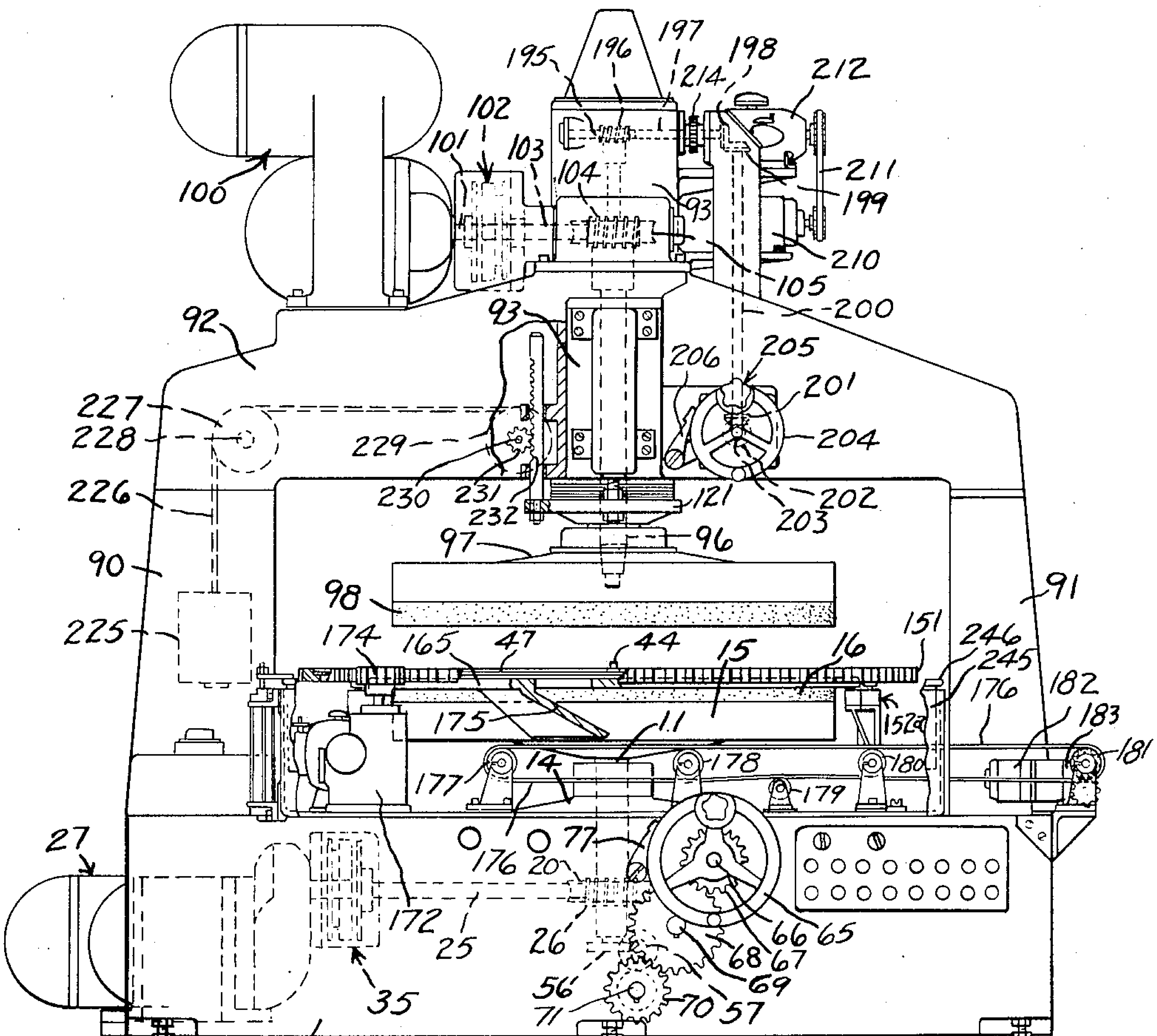

Fig. 1

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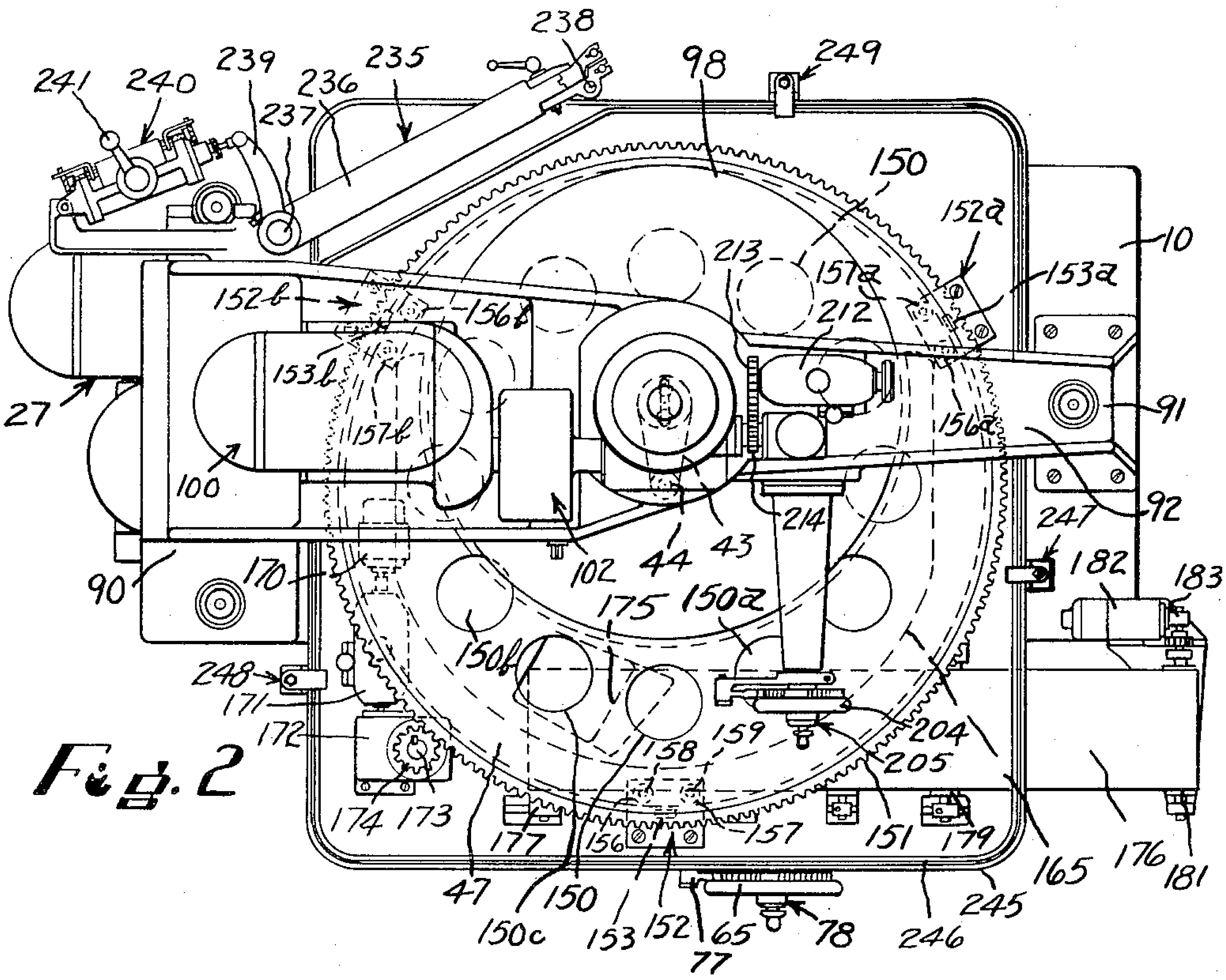
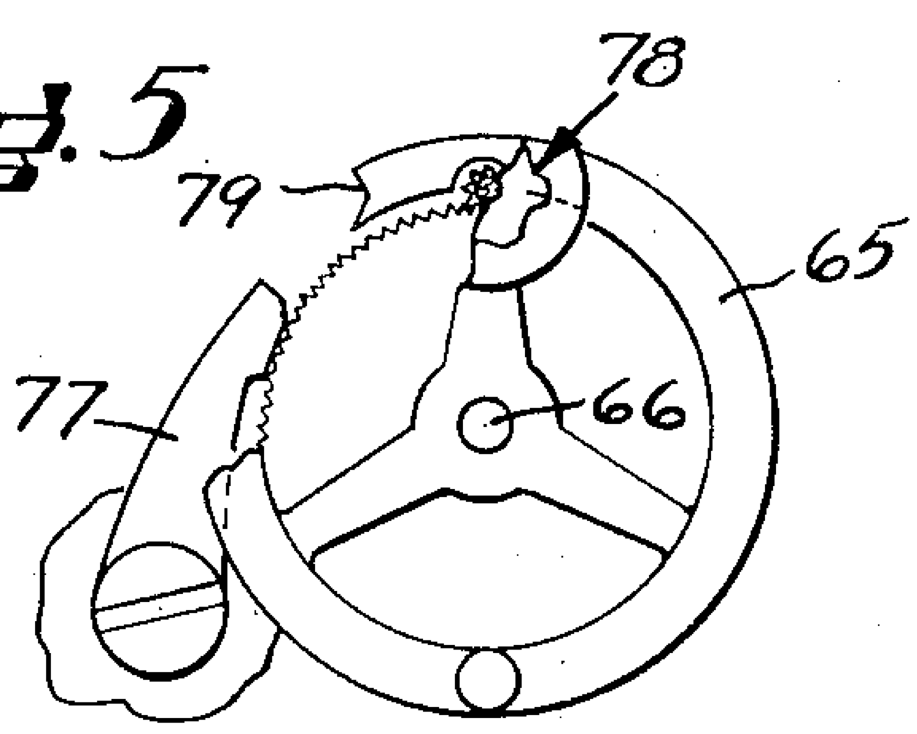


Fig. 2

Fig. 5



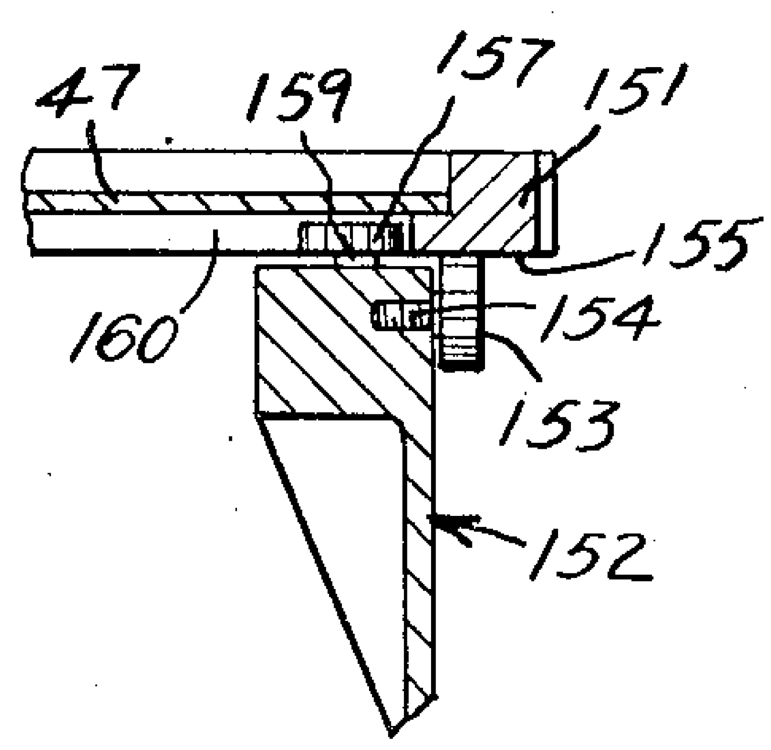


Fig. 6

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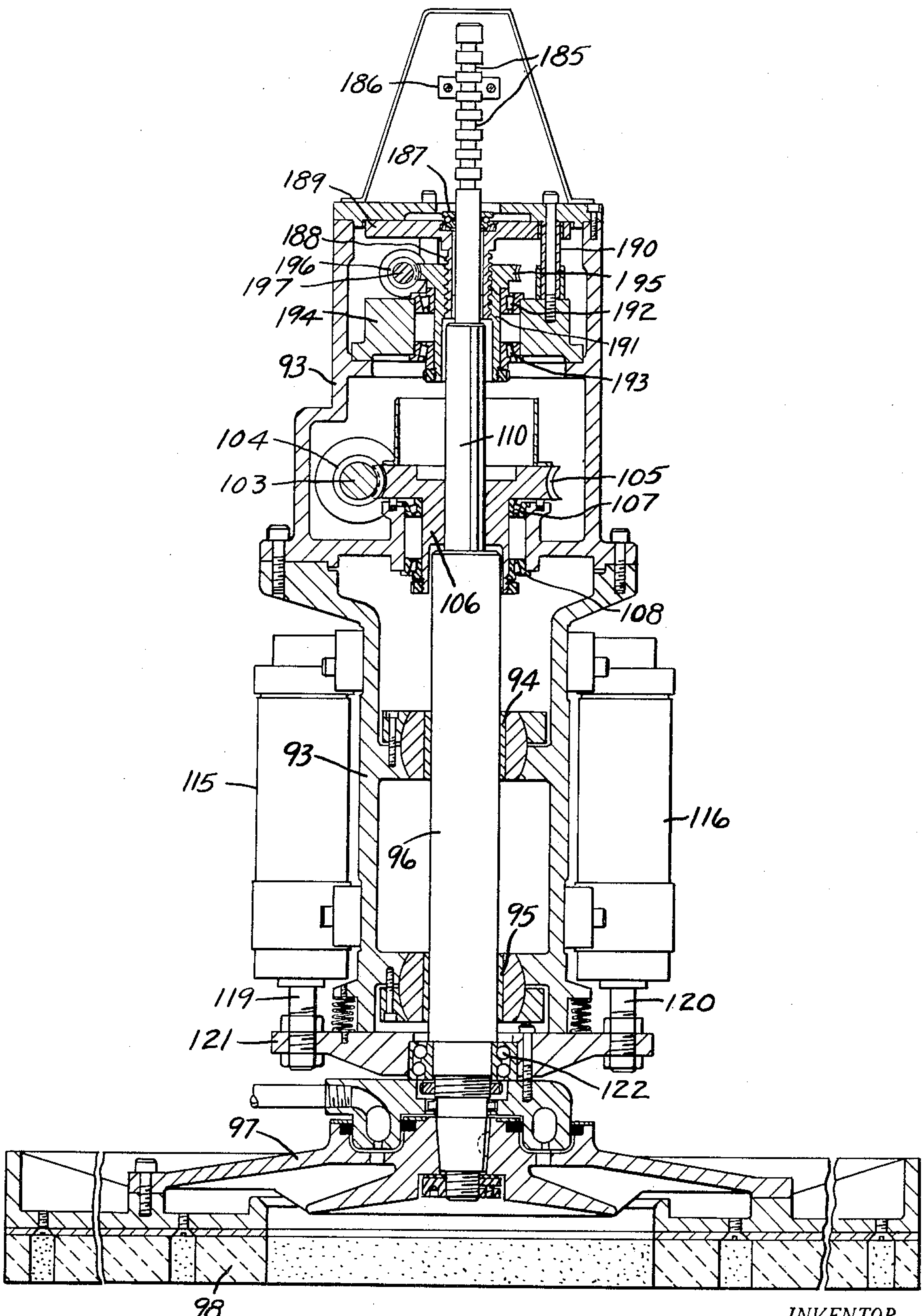

Fig. 3

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LAPPING MACHINE

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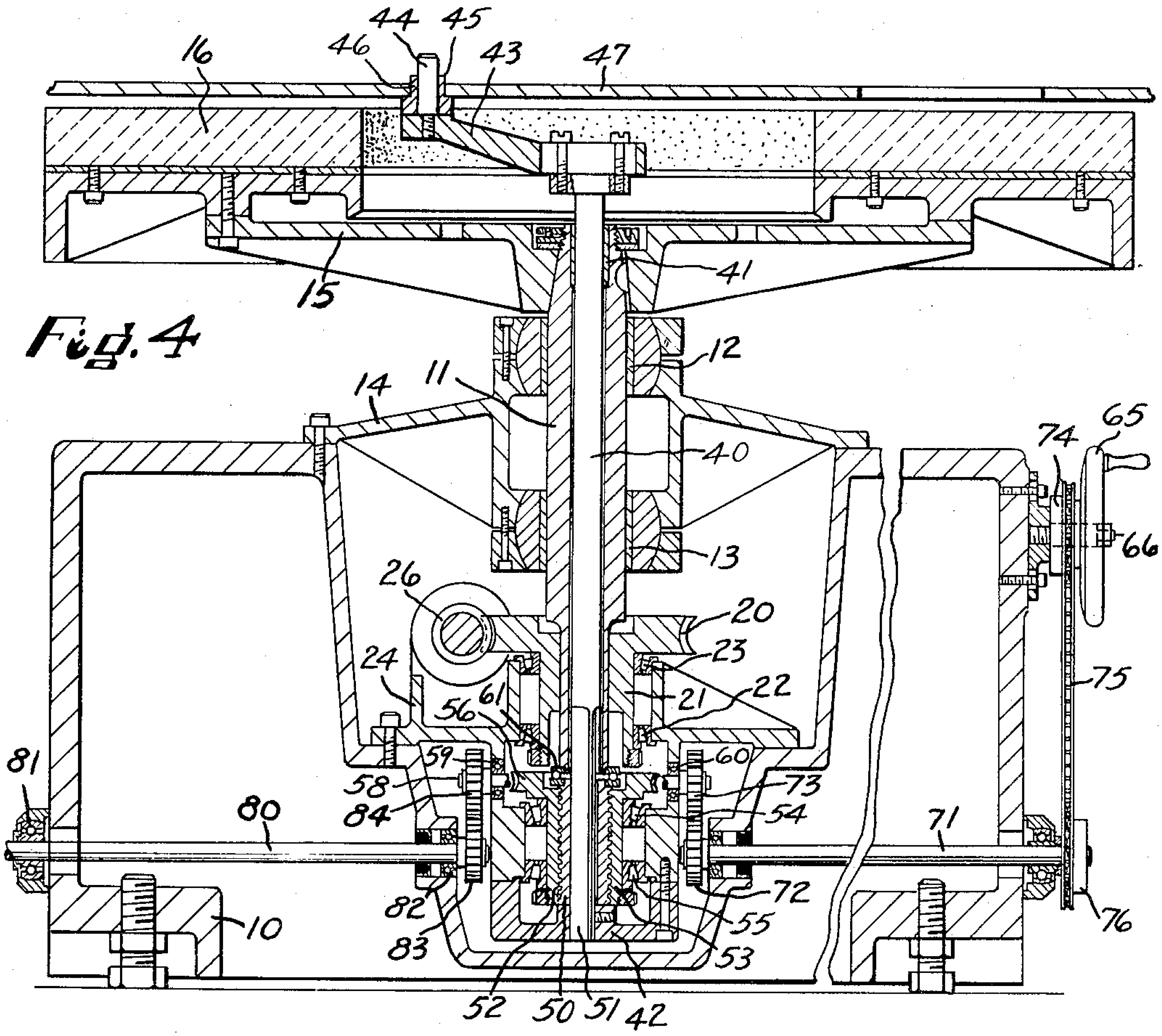

Fig. 4

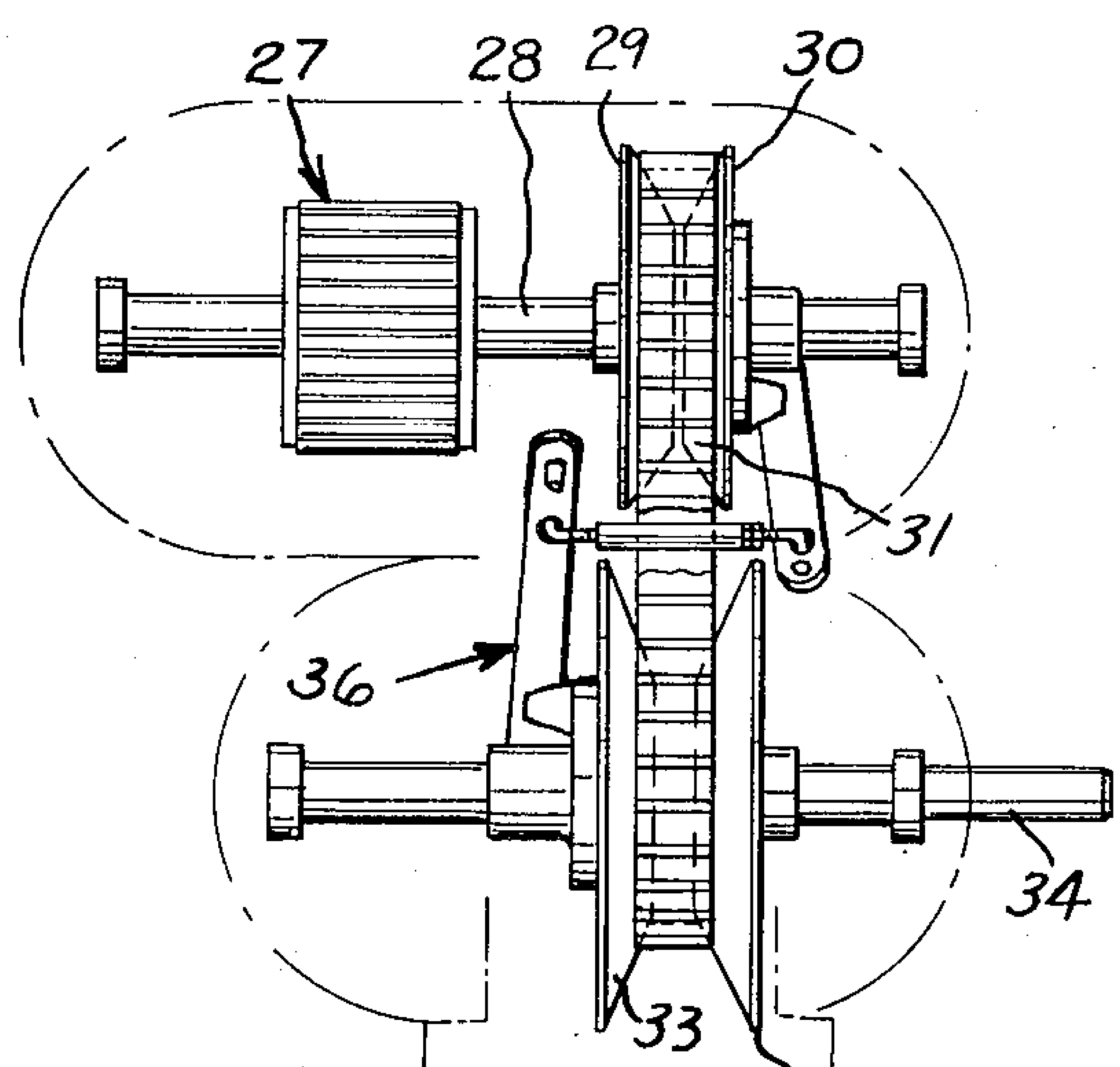

Fig. 7

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LAPPING MACHINE

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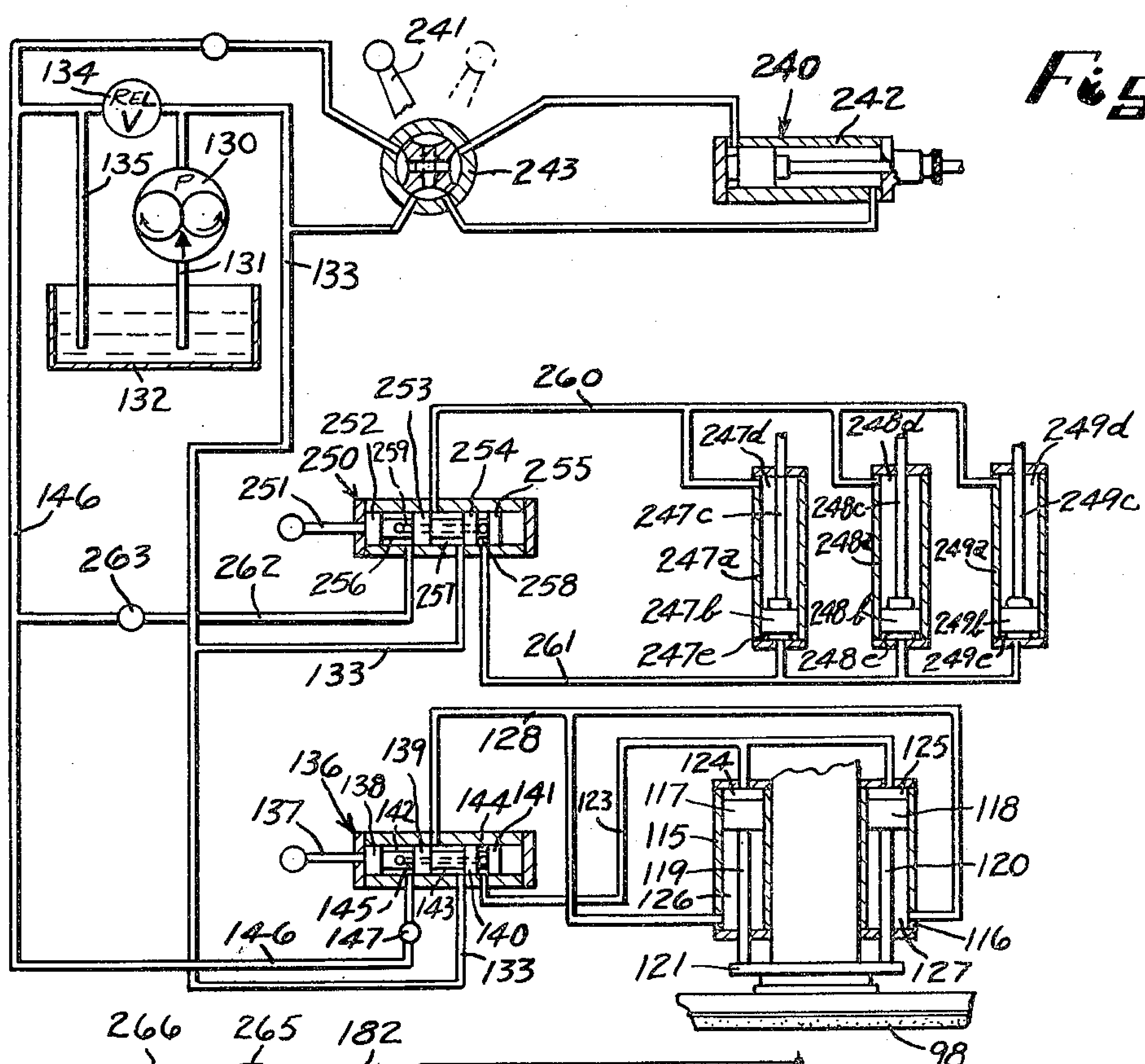

Fig. 8

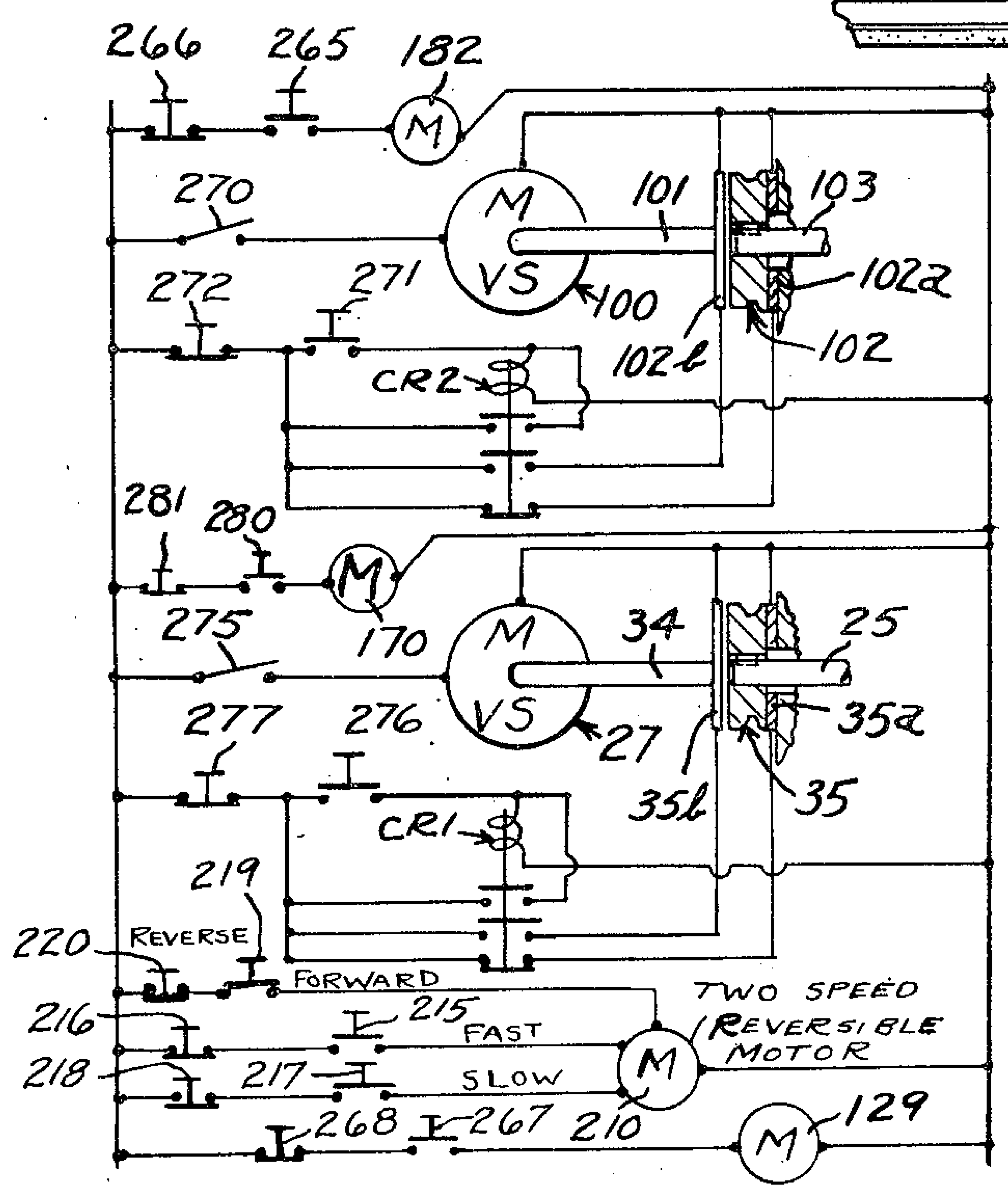

Fig. 9

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2,709,876

LAPPING MACHINE

Herbert S. Indge, Westboro, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application April 20, 1954, Serial No. 424,325

6 Claims. (Cl. 51—118)

The invention relates to lapping machines, and more particularly to a motor driven hydraulically operated lapping machine.

One of the objects of the invention is to provide a simple and thoroughly practical hydraulically operated lapping machine. Another object is to provide an independent motor driven variable speed mechanism for driving the lapping wheels, work cage and discharge conveyor. Another object is to provide a hydraulically operated mechanism for producing a rapid approaching and receding movement of one of the lapping wheels. Another object is to provide a manually operable and an independent fluid motor driven nut and screw mechanism for imparting a feeding adjustment to the upper lapping wheel. Another object is to provide a reversible electric motor driven fluid motor actuated nut and screw mechanism to feed the upper lapping wheel either toward or from engagement with the work pieces to be lapped.

Another object is to provide a manually operable nut and screw supporting mechanism having a micrometer stop for precisely adjusting the position of the lower lapping wheel to compensate for wheel wear so as to maintain the operative face in a predetermined position relative to the work cage. Another object is to provide a motor driven work discharge mechanism to convey lapped work pieces from the work cage to the side of the machine. Other objects will be in part obvious or in part pointed out hereinafter.

In the accompanying drawings, in which is shown one of various possible embodiments of the mechanical features of this invention,

Fig. 1 is a front elevation of the lapping machine;

Fig. 2 is a plan view of the lapping machine as shown in Fig. 1;

Fig. 3 is a vertical sectional view, on an enlarged scale, through the upper lapping wheel assembly;

Fig. 4 is a vertical sectional view, on an enlarged scale, through the lower lapping wheel assembly;

Fig. 5 is a fragmentary detailed view, on an enlarged scale, of one of the manually operable hand wheels for adjusting the position of the lapping wheels;

Fig. 6 is a fragmentary sectional view, on an enlarged scale, of one of the roller supports for the work cage;

Fig. 7 is a fragmentary detailed view of the variable speed driving unit for the lapping wheels;

Fig. 8 is a hydraulic diagram of the actuating mechanisms of the machine; and

Fig. 9 is an electrical diagram of the electrical controls of the machine.

A lapping machine has been illustrated in the drawings having a base 10 which supports a vertically arranged hollow spindle 11. A spindle 11 is supported in spaced bearings 12 and 13 carried by a housing 14 which is fixedly mounted on the base 10. A platen 15 is keyed on the upper end of the spindle 11 and serves as a support for a lower lapping wheel 16 having a plane operative face.

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A driving mechanism is provided for driving the spindle 11 and the lower lapping wheel 16 comprising a worm gear 20 (Fig. 4) which is provided with an integral hub 21. A hub 21 is supported by a pair of spaced bearings 22 and 23 carried by a housing 24 which is fixedly mounted on the base 10. A horizontally arranged rotatable shaft 25 (Fig. 1) is provided with a worm 26 which meshes with the worm gear 20.

It is desirable to provide a variable speed drive for the lower lapping wheel 16. Any one of the various commercial variable speed driving units may be utilized, such as, for example, the Special Speed-Trol unit which is manufactured by the Sterling Electric Motors Inc., of New York city. The Speed-Trol unit has been illustrated in Fig. 7 and comprises an electric motor 27 having a motor shaft 28 for driving a variable speed cone pulley arrangement comprising a fixed frusto-conical member 29 mounted on the shaft 28 and an opposed frusto-conical pulley member 30 which is slidable axially on the shaft 28. The pulley 29—30 is connected by a V-belt 31 with an adjustable cone pulley 32—33 mounted on a driven shaft 34. The pulley 32—33 comprises a frusto-conical pulley member 32 which is fixedly mounted on the shaft 34 and a frusto-conical pulley member 33 which is axially movable on the shaft 34. A lever mechanism 36 is provided for simultaneously actuating the cone pulleys 29—30 and 32—33 so as to vary the speed of the driven shaft 34. When the lever mechanism 36 is moved to cause the pulley members 29—30 to approach each other a corresponding movement is imparted to separate the pulley members 32—33 to facilitate varying the speed of the driven shaft 34. The driven shaft 34 is connected through a clutch 35 to rotate the shaft 25. The clutch 35 may be a standard commercial clutch such as, for example, a motor brake-clutch such as manufactured by the Warner Electric Brake Manufacturing Company of Beloit, Wisconsin. It will be readily apparent from the foregoing disclosure that when the motor 27 is started, a rotary motion will be imparted to the lower lapping wheel 11 at a speed governed by the variable cone pulley drive mchanism above described.

The hollow spindle 11 contains a vertically arranged shaft 40, the upper end of which is supported in a bearing 41 carried by the spindle 11. The lower end of the shaft 40 is fixedly mounted in a cup-shaped member 42 which is fixedly mounted on the lower portion of the housing 24 and the upper end of the shaft 40 is fixedly mounted within the cup-shaped member 42 and is thereby held against rotation. The upper end of the shaft 40 is provided with an arm 43 which supports a vertically arranged stud 44 having a flanged bushing 45 mounted thereon. The flanged bushing is arranged to engage a central aperture 46 of a work supporting cage 47. The stud 44 is offset relative to the axis of the shaft 40 and the spindle 11 so as to locate the work cage 47 eccentric relative to the lapping wheel 16.

It is desirable to provide a feed adjusting mechanism to facilitate a vertical adjustment of the spindle 11 and the lapping wheel 16 so that the plane operative face of the lapping wheel 16 may be maintained in a predetermined plane relative to the work cage 47. When the lapping wheel wears away due to lapping operations and truing, the lapping wheel may be adjusted vertically to maintain the opertaive face thereof in the desired relation with the work cage 47. A sleeve 50 is provided with a central aperture which mates with a tri-lobe portion 51 of the shaft 40 so that the sleeve 50 is held against rotation. The outer surface of the sleeve 50 is provided with a screw thread 52 which mates with or meshes with an internal thread formed in a rotatable nut 53 which surrounds the sleeve 50. The nut 53 is rotatably supported by spaced anti-friction bearings 54 and 55 carried by the housing 24. A worm gear 56 is formed integral with the nut 53. The worm gear 56 meshes with a worm 57 fixedly mounted on a shaft 58 which is journalled in spaced bearings 59 and 60 carried by the housing 24. An anti-friction end thrust bearing 61 is supported on the upper end of the sleeve 50 and serves as an end thrust bearing for the spindle 11. A suitable manually operable mechanism is provided for actuating the worm and worm gear feeding mechanism which may comprise a hand wheel 65 (Fig. 1) which is supported on the outer end of a shaft 66 on the front of the machine base 10. The shaft 66 carries a gear 67 which meshes with a gear 68 mounted on a rotatable shaft 69. The gear 68 meshes with a gear 70 mounted on the outer end of a rotatable shaft 71. The inner end of the shaft 71 is provided with a gear 72 which meshes with a gear 73 mounted on the right hand end of the shaft 58 (Fig. 4). It will be readily apparent from the foregoing disclosure that a rotary motion of the feed wheel 65 will be imparted to cause a rotary motion of the nut 53 which in turn imparts a vertical adjustment to the threaded sleeve 50 thereby vertically adjusting the position of the spindle 11 within its bearings 12 and 13 and imparting a corresponding vertical adjustment to the lower lapping wheel 16.

An alternative driving mechanism is provided between the hand wheel 65 and the shaft 71, as shown in Fig. 4, a sprocket 74 is fixedly mounted to rotate with the hand wheel 65. The sprocket 74 is connected by a link chain 75 with a sprocket 76 mounted on the outer end of the shaft 71. A pivotally mounted stop pawl 77 is provided on the front of the machine base to facilitate positively stopping rotary motion of the feed wheel 65 to maintain the operative surface of the lapping wheel in the desired relationship. The feed wheel 65 may be provided with a micrometer adjusting mechanism so that a stop abutment 79 carried by the wheel 65 may be varied to compensate for wear on the lapping wheel.

Due to the size of this improved lapping machine, it may be desirable to provide a feed adjustment which may be operated from the rear of the machine adjacent to the truing apparatus to be hereinafter described. This mechanism may comprise a rotatable shaft 80 which is supported in bearings 81 and 82. The inner end of the shaft 80 is provided with a gear 83 which meshes with a gear 84 mounted on the left hand end of the shaft 58. A manually operable feed wheel may be provided for imparting a rotary motion to the nut 50. This feed wheel and its connection with the shaft 80 is identical with that just described and consequently has not been illustrated or described herein.

The base 10 supports a pair of spaced vertically extending columns 90 and 91. A cross head 92 is fixedly mounted on the upper ends of the columns 90 and 91. The cross head 92 serves as a support for a vertically arranged housing 93 having a pair of spaced spindle bearings 94 and 95 (Fig. 3). A rotatable spindle 96 is journalled in the bearings 94 and 95 and is provided at its lower end with a face plate 97 which supports an upper lapping wheel 98 having a plane operative face which is parallel to the operative face of the lower lapping wheel 16.

A driving mechanism is provided for driving the spindle 96 and the lapping wheel 98 at a predetermined lapping speed. A Speed-Trol unit 100 is provided having a driven shaft 101. The Speed-Trol unit is identical with that previously described for driving the lower lapping wheel. The driven shaft 101 is connected by a brake-clutch 102 to the left hand end of a rotatable shaft 103. The shaft 103 is provided with a worm 104 which meshes with a worm gear 105. The worm gear 105 is provided with a downwardly extending integral hub 106 which is journalled in a pair of spaced anti-friction bearings 107 and 108. The worm gear 105 and the hub 106 are provided with a central aperture which is shaped to mate with a tri-lobe portion 110 formed on the upper end of the spindle 96. This tri-lobe shaft connection with the worm gear 105 forms a splined driving connection which allows rotation of the spindle 96 and at the same time permits a vertical axial movement of the spindle for positioning the upper lapping wheel.

A hydraulically operated mechanism is provided for raising and lowering the spindle 96 and the lapping wheel 98 to move the same to and from an operative position. This mechanism preferably comprises a pair of spaced diametrically arranged cylinders 115 and 116 arranged on diametrically opposite sides of the spindle 96. The cylinders 115 and 116 contain slidably mounted pistons 117 and 118 respectively. The pistons 117 and 118 are connected to the upper ends of a pair of piston rods 119 and 120 respectively. The lower end of the piston rods 119 and 120 are fixedly connected to opposite ends of an arm 121. The arm 121 is supported by an anti-friction bearing 122 which is fixedly mounted on the lower portion of the spindle 96. It will be readily apparent from the foregoing disclosure that when fluid under pressure is passed through a pipe 123 into cylinder chambers 124 and 125 respectively, the pistons 117 and 118 will be moved downwardly to cause a downward movement of the spindle 96 and the lapping wheel 98. By arranging the hydraulic pistons and cylinders on diametrically opposite sides of the spindle, the pressure exerted upon the spindle adjacent to the upper lapping wheel 98 is equalized. During a downward movement of the spindle 96, fluid within a pair of spaced cylinder chambers 126 and 127 may exhaust through a pipe 128.

A fluid pressure system is provided for supplying fluid under pressure to the operating parts of the machine. This mechanism comprises motor driven fluid pump 130, driven by a motor 129, which draws fluid through a pipe 131 from a fluid reservoir 132 and forces fluid under pressure through a pipe 133 to the various actuating mechanisms of the machine. An adjustable relief valve 134 is provided in the pipe line 133 to facilitate exhausting excess fluid under pressure through a pipe 135 into the reservoir 132 thereby maintaining the desired operating pressure within the system.

A manually operable control valve 136 is provided for controlling the admission to and exhaust of fluid from the cylinders 115 and 116. The valve 136 is preferably a piston-type valve comprising a valve stem 137 having a plurality of valve pistons 138, 139, 140 and 141 formed integrally therewith so as to form a plurality of valve chambers 142, 143 and 144.

In the position of the valve (Fig. 8) fluid under pressure passing through the pipe 133 enters the valve chamber 143 through the pipe 128 into the cylinder chambers 126 and 127 to move the pistons 117 and 118 together with the spindle 96 and upper lapping wheel 98 upwardly to an inoperative position. During this movement of the pistons 117 and 118 fluid is exhausted from the cylinder chambers 124 and 125 through the pipe 123 into the valve chamber 144, through a central passage 145 into the valve chamber 142 and passes out through an exhaust pipe 146 into the reservoir 132. A throttle valve 147 is provided in the pipe 146 to facilitate regulating the return of exhaust of fluid from the valve 136 and thereby regulating the rate of movement of the spindle 96 and the upper lapping wheel 98.

When it is desired to move the lapping wheel 98 downwardly into an operative position in lapping engagement with the work pieces to be lapped, the valve stem 136 is moved toward the right (Fig. 8) to reverse the flow of fluid to the cylinders 115 and 116. In this position of the valve 136, fluid under pressure in the pipe 133 passes through the valve chamber 143, through the pipe 123 into the cylinder chambers 124 and 125 to cause a downward movement of the pistons 117 and 118 respectively to cause a corresponding movement of the spindle 96 and the upper lapping wheel 98.

The work cage 47 is provided with a plurality of work receiving apertures **150** to carry work pieces between the operative faces of the lapping wheels **16** and **98**. The periphery of the work cage **47** is supported and driven by a ring gear **151** which is supported by three roller supports **152**, **152*a*** and **152*b***. Each of the roller supports is provided with a plurality of rollers including a roller **153** which is arranged to rotate about a horizontal stud **154**. The roller **153** is arranged to engage the lower plane face **155** of the ring gear **151** (Fig. 6). Each of the roller supports **152**, **152*a*** and **152*b*** are also provided with a pair of spaced rollers **156** and **157** which are arranged to rotate about vertically arranged studs **158** and **159** respectively. The rollers **156** and **157** are arranged to engage an internal cylindrical surface **160** formed on the ring gear **151**. The rollers for the units **152*a*** and **152*b*** are identical with those just described in connection with unit **152**. The rollers **153**, **153*a*** and **153*b*** determine the plane of rotation of the ring gear **151**. The rollers **156—157**, **156*a*—157*a*** and **156*b*—157*b*** are positioned to guide the ring gear as it rotates about the axis of the stud **44**.

As previously explained, the axis of the stud **44** and also the axis of rotation of the work cage **47** are eccentric to the axes of the lapping wheels **16** and **98** respectively so that the work pieces are carried in an eccentric path across the operative faces of the opposed lapping wheels **16** and **98**. As shown in Fig. 2, a platen **165** is fixedly mounted relative to the base of the machine and is provided with an upper plane face which lies in the same plane with the upper operative face of the lower lapping wheel **16**. The platen **165** serves to support work pieces when they are loaded into the cage in aperture **150*a***. The cage then carries the work pieces into lapping engagement with the operative faces of the lapping wheels in an eccentric path until they reach the position aperture **150*b*** (Fig. 2).

The ring gear **151** is driven by an electric motor **170** which drives a variable speed hydraulic transmission unit **171**. This unit may be any of the well known commercial units such as, for example, that manufactured by Vickers Inc. of Detroit, Michigan. The transmission unit **171** drives a gear reduction unit **172** which may be of a standard commercial variety. The gear reduction unit is provided with a vertically arranged driven shaft **173** which is provided with a gear **174** meshing with the ring gear **151**. When the motor **170** is started, a rotary motion will be imparted through the mechanism above described to rotate the ring gear **151** and the work cage **47** at a predetermined but adjustable speed.

The work pieces carried by the cage **47** make one pass between the operative faces of the lapping wheels and then are carried onto the platen **165** by the cage apertures. When the work pieces reach the position indicated by aperture **150*c***, the work pieces drop out onto a discharge chute **175** (Fig. 1) onto an endless conveyor belt **176** which carries the lapped work pieces to the right hand side of the machine.

The conveyor belt **176** is supported by a plurality of rollers **177**, **178**, **179**, **180** and **181**. The conveyor belt **176** is driven by an electric motor **182** through a gear reducer unit **183** at the desired and predetermined speed. It will be readily apparent from the foregoing disclosure that work pieces are loaded manually into the work cage into aperture **150*a*** (Fig. 2) and are moved in a counterclockwise direction in an eccentric path between the operative face of the lapping wheels **16** and **98** after which they are automatically discharged when apertures reach position **150*c*** onto the conveyor belt **176** which conveys the finished lapped work piece to the right hand side of the machine where it may be removed manually or dropped into a container (not shown).

It is desirable to provide a positive stop for limiting the rapid downward movement of the spindle **96** and the upper lapping wheel **98**. The upper end of the wheel spindle **96** is provided with a plurality of spaced grooves **185** to which a stop **186** may be clamped. The stop **186** may be adjusted and positioned in any one of the grooves **185** as desired. The rapid downward movement of the spindle **96** continues until the stop **186** engages the upper face of an anti-friction thrust bearing **187** which serves to position the lapping wheel **98** as desired.

The hydraulic mechanism previously described serves to cause a rapid positioning movement of the upper lapping wheel **98** to and from an operative position. It is desirable to provide a suitable feeding mechanism to facilitate adjusting the upper lapping wheel **98** so as to apply the desired lapping pressure of the wheel upon the work being lapped and to also facilitate compensating for wear or truing of the operative face of the upper lapping wheel **98**. This mechanism may comprise a hollow screw **188** (Fig. 3) which surrounds the upper portion of the spindle **96** and is provided with an integral flange **189**. The flange **189** serves as a support for the thrust bearing **187**. A vertically arranged guide sleeve **190** is provided to hold the flange **189** and the screw **188** against rotation but permitting it to move in an axial direction as will be hereinafter described. A nut **191** engages or meshes with the screw **188**. The nut **191** is rotatably supported in a pair of spaced bearings **192** and **193** which are fixedly mounted within a collar **194**. The collar **194** is fixedly mounted within the upper portion of the housing **93**. A worm gear **195** is formed integral with the upper portion of the nut **191**. The worm gear **195** meshes with a worm **196** mounted on the end of a rotatable shaft **197**. A suitable mechanism is provided for actuating the nut **191** either manually or by power.

A manual feeding mechanism is provided comprising a bevel gear **198** mounted on the right hand end of the shaft **197** (Fig. 1). The bevel gear **198** meshes with a bevel gear **199** mounted on the upper end of a vertical shaft **200**. The lower end of the shaft **200** is provided with a bevel gear **201** which meshes with a bevel gear **202** mounted on the rear end of a horizontal shaft **203** which supports a manually operable feed wheel **204**. The feed wheel **204** is provided with a micrometer feed adjusting mechanism **205** to facilitate adjusting the position of a stop abutment (not shown) which moves in the path of a pivotally mounted stop pawl **206**. The feed wheel and associated parts are identical with that shown in Fig. 5 for controlling the vertical feeding movement of the lower lapping wheel **16**.

A power operated mechanism is provided for actuating the nut **191** which comprises a motor driven mechanism including a two speed reversible motor **210** which is connected by a V-belt **211** with a hydraulic variable speed transmission unit **212** such as, for example, the well known hydraulic variable speed transmission unit manufactured by Vickers Inc. of Detroit, Michigan. The driven shaft of the transmission unit **212** is provided with a gear **213** which meshes with a gear **214** mounted on the shaft **197**. It will be readily apparent from the foregoing disclosure that when the motor **210** is started in either direction, a rotary motion will be imparted through the shaft **197**, the worm **196**, and the worm gear **195** to rotate the nut **191** and thereby impart a vertical feeding movement to the speed **96** and the upper lapping wheel **98**. As shown diagrammatically in Fig. 9, a push button start switch **215** is provided to start the motor **210** at its fast speed and a push button stop switch **216** is provided to stop the motor when desired. Similarly a push button start switch **217** is provided to start the motor **210** at a slow speed and a push button stop switch **218** is provided to stop the motor **210** when desired. Similarly a push button start switch **219** is provided for starting the motor **210** in a reverse direction and a push button stop switch **220** is provided for stopping the motor **210** when operating in a reverse direction.

A counterbalance mechanism is provided for counterbalancing the weight of the upper lapping wheel and its supporting assembly. This mechanism may comprise a weight **225** (Fig. 1) which is attached to the end of a flexible chain or cable **226**. The chain or cable **226** passes over an idler pulley **227** mounted on a shaft **228**. The other end of the cable **226** is attached to the peripheral portion of a pulley **229** which is supported on a shaft **230**. A gear **231** fixedly mounted to rotate with the pulley **229** meshes with a vertically arranged rack bar **232**, the lower end of which is attached to the arm **121**.

A truing apparatus is provided to facilitate truing both the upper lapping wheel **98** and the lower lapping wheel **16** either one at a time or simultaneously, as desired. This mechanism comprises a truing apparatus **235** (Fig. 2) having an arm **236** fixedly mounted on a rock shaft **237**. The right hand end of the arm **236** is provided with a pair of adjustably mounted diamonds or truing tools **238**, only one of which has been illustrated in Fig. 2. These truing tools are arranged so that one is arranged to true the upper lapping wheel and the other the lower lapping wheel and both are adjustably positioned relative to the arm **236**. An arm **239** is also fixedly mounted on the rock shaft **237** so that the arms **236—239** serve as a bell crank lever. A hydraulically operated mechanism is provided for oscillating the bell crank lever **236—239** comprising a fluid pressure unit **240** controlled by a manually operable lever **241**. By actuation of the lever **241**, the bell crank lever **236—239** may be caused to swing in an arcuate path to pass the truing tools across the operative faces of the lapping wheels **16** and **98**. This hydraulic actuating mechanism and the adjustable mounts for the truing tools are identical with that shown in my prior U. S. Patent No. 2,285,717 dated June 9, 1942, to which reference may be had for details of disclosure not contained herein. The hydraulic mechanism for actuating the truing apparatus has been shown diagrammatically in Fig. 8 and comprises a piston and cylinder mechanism **242** which is controlled by a control valve **243** actuated by the control lever **241**.

A suitable rectangularly shaped pan **245** is fixedly mounted on the base **10** and is provided with an upwardly extending side wall. A vertically slidable extension **246** is provided for the pan **245** which is arranged so that it may be raised and lowered before and after a lapping operation to confine fluid used in the lapping operation. A fluid pressure actuated mechanism is provided to facilitate raising and lowering the pan comprising a plurality of fluid pressure actuated units **247**, **248** and **249**. These units each comprise a cylinder **247***a*, **248***a* and **249***a* which contain slidably mounted pistons **247***b*, **248***b* and **249***b* respectively. The pistons are connected to the lower ends of piston rods **247***c*, **248***c* and **249***c*, the upper ends of which are connected to the rim of the pan extension **246**.

A control valve **250** is provided for controlling the admission to and exhaust of fluid from the units **247**, **248** and **249**. The valve **250** is a piston type valve comprising a valve stem **251** having a plurality of valve pistons **252**, **253**, **254** and **255** formed integrally therewith to form spaced valve chambers **256**, **257** and **258**. The valve member is provided with a central aperture **259**. In the position of the valve **250** (Fig. 8) fluid under pressure in the pipe **133** passes through the valve chamber **257**, through a pipe **260** into cylinder chambers **247***d*, **248***d* and **249***d* to move the pistons **247***b*, **248***b* and **249***b* downwardly to move the pan extention **246** downwardly to an inoperative position. During this movement fluid within cylinder chambers **247***e*, **248***e* and **249***e* is exhausted through a pipe **261** into the valve chamber **258**, passes through the central passage **259** into the valve chamber **256** and passes out through a pipe **262**, through a throttle valve **263** into the exhaust pipe **146** and the reservoir **132**. By manipulation of the throttle valve **263**, the rate of movement of the pan extension **246** to and from an operative position may be readily controlled.

When it is desired to raise the pan extension **246** to an operative position, the valve stem **251** is moved toward the right (Fig. 8) so that the flow of fluid is reversed and fluid under pressure passes through the pipe **261** to the cylinders **247***a*, **248***a* and **249***a* to raise the pistons **247***b*, **248***b* and **249***b* to raise the pan extension **246** vertically to an operative position.

As shown in Fig. 9, a push button switch **265** is provided for starting the conveyor belt driving motor **182**. A push button stop switch **266** is provided to stop the motor **182**. A push button start switch **267** is provided for starting the fluid pump driving motor **129**. A push button stop switch **268** is provided to stop the motor **129**. A push button start switch **280** is provided to start the cage driving motor **170**. A push button stop switch **281** is provided to facilitate stopping the cage driving motor **170** when desired.

A switch **270** is provided to start the motor in the Speed-Trol unit **100**. In the position of the brake clutch **102** (Fig. 9) the brake portion **102***a* is engaged to hold the driven shaft **103** against rotation. When it is desired to start rotation of the upper lapping wheel **98**, a push button start switch **271** is actuated to energize a relay switch CR2 which serves to set up a holding circuit to hold the relay switch CR2 energized and at the same time breaks the circuit to deenergize the magnetic brake **102***a* and makes a circuit to engage the clutch portion **102***b* to start rotation of the driven shaft **103** and thereby start rotation of the lapping wheel **98**.

Similarly a switch **275** is provided for starting the electric motor of the Speed-Trol unit **27**. As shown diagrammatically in Fig. 9 the magnetic brake **35***a* of the brake clutch unit **35** is engaged to hold the driven shaft **25** stationary. When it is desired to start the rotation of the lower lapping wheel **16**, a push button start switch **276** is actuated to energize a relay switch CR1 which sets up a holding circuit to hold CR1 energized, breaks a circuit to deenergize the magnetic brake **35***a*, and makes a circuit to engage the clutch **35***b* to start rotation of the driven shaft **25** and thereby to start rotation of the lower lapping wheel **16**. A push button stop switch **277** is provided to facilitate deenergizing the relay CR1 so as to disengage the clutch **35***b* and to energize the brake **35***a* when it is desired to stop the rotation of the driven shaft **25** to stop rotation of the lower lapping wheel **16**.

The operation of the improved lapping machine will be readily apparent from the foregoing disclosure. Work pieces are loaded in the apertures **150** and **150***a*. The switches **270** and **275** are closed to start the Speed-Trol motors **100** and **27** respectively. The push button switches **271** and **276** are then closed to start the rotation of the lapping wheels **98** and **16** respectively. The switch **280** is then closed to start the cage driving motor **170**. The switch **265** is then closed to start the motor **182** so as to start the conveyor belt **176**. The valve **250** is then actuated to raise the pan extension vertically to an operative position. The valve **136** is then actuated to cause a downward movement of the lapping wheel which continues at a rapid rate until the stop **186** engages the upper face of the thrust bearing **187** to position the upper lapping wheel **98**. The hand wheel may then be rotated to feed the upper lapping wheel downwardly to establish the desired lapping pressure between the lapping wheels **98** and **16** and the work pieces carried within the cage apertures. The rotation of the cage **47** carries work pieces within the aperture **150** in an eccentric path relative to the lapping wheels to lap the opposite faces of the work piece in a single path between the wheels. When the work pieces reach the position indicated by aperture **150***c*, they drop by gravity onto the discharge chute **175** and onto the conveyor belt **176** which carries the lapped work pieces to the right hand side of the machine.

If desired the motor **210** may be started to cause the downward feeding movement of the lapping wheel to apply the desired pressure by actuating either the switch **215** to give a fast downward movement of the upper lapping wheel **98** or by closing the switch **217** to impart a slow downward feeding movement to the upper lapping wheel **98**.

When a truing operation is desired, the bell crank arm **239—236** is oscillated by movement of the control lever **241**. The micrometer adjusting mechanism **78** is reset and the hand wheel **65** rotated in a clockwise direction until the stop abutment **79** engages the stop pawl **77** to raise the lower lapping wheel **16** by an amount equal to that desired to be trued therefrom during the truing operation. The upper lapping wheel may then be positioned by manual actuation of the feed wheel **204** to position the operative face of the upper lapping wheel **98** for a truing operation. The operative face of the lower lapping wheel **16** is maintained in a predetermined relationship with the plane of the work cage so that there is no necessity for adjusting or repositioning the work cage as the lower lapping wheel wears away.

It will thus been seen that there has been provided by this invention apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinabove set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a lapping machine having a base, an upper and a lower opposed axially-aligned plane-faced rotatable lapping wheel supported thereby, means including an independent motor driven variable speed driving mechanism to rotate each of said wheels, a work cage between said wheels having a plurality of work receiving apertures, means including a plurality of symmetrically arranged rollers to support said cage for rotation about an axis eccentric to the axes of said wheels, means including a piston and cylinder mechanism rapidly to move one of said wheels toward and from the other to position said wheel in an operative position, a positive stop to limit the rapid approaching movement of said upper lapping wheel, a manually operable feeding mechanism to impart a feeding movement to said upper lapping wheel to obtain the desired lapping action, and means including an independent manually operable feeding mechanism to adjust the position of the lower lapping wheel to compensate for wheel wear so as to maintain the operative face of the latter wheel in a predetermined position relative to the work cage.

2. In a lapping machine, as claimed in claim 1, in combination with the parts and features therein specified of an independent motor driven variable speed driving mechanism operatively connected to rotate said cage at a predetermined speed, a work discharge chute to receive lapped work pieces from said cage after a single pass between said lapping wheels, and a motor driven variable speed discharge conveyor to convey work pieces from the discharge chute to the side of the machine.

3. In a lapping machine as claimed in claim 1, in combination with the parts and features therein specified of a nut and screw feeding mechansim for the upper lapping wheel including a non-rotatable screw, a rotatable nut on said screw, anti-friction bearings rotatably to support said nut and to hold it against axial movement, an adjustably mounted positive stop which is engageable with the end of said screw positively to limit the movement of said upper lapping wheel in one direction, means including a manually operable feed wheel operatively connected to rotate said nut so as to impart a feeding movement to said upper lapping wheel, a micrometer adjusted stop mechanism for said feed wheel precisely to position said upper lapping wheel, and an independent reversible motor operatively connected to rotate said nut so as to cause a feeding movement of the upper lapping wheel in either direction.

4. In a lapping machine, as claimed in claim 1, in combination with the parts and features therein specified of a nut and screw mechanism operatively connected to feed the upper lapping wheel, a manually operable feed wheel to actuate said mechanism, means including a micrometer adjusted stop mechanism to limit rotation of said feed wheel in one direction to facilitate precisely positioning the upper lapping wheel, and an independent nut and screw mechanism operatively connected to feed the lower lapping wheel vertically to compensate for wheel wear.

5. In a lapping machine, as claimed in claim 1, in combination with the parts and features therein specified of a nut and screw mechanism operatively connected to feed the upper lapping wheel, a manually operable feed wheel to actuate said mechanism, means including a micrometer adjusted stop mechanism to limit rotation of said feed wheel in one direction to facilitate precisely positioning the upper lapping wheel, an independent nut and screw mechanism operatively connected to feed the lower lapping wheel vertically, and a manually operable feed wheel including a micrometer adjusted stop to actuate said latter nut and screw mechanism to facilitate imparting a feeding movement to the lower lapping wheel to compensate for wheel wear.

6. In a lapping machine having a base, an upper and a lower opposed axially-aligned plane-faced lapping wheel, a pair of vertically axially-aligned rotatable spindles supported by said base to support said lapping wheels, means including an independent motor driven variable-speed driving mechanism to rotate each of said wheels, a work cage between the operative faces of said lapping wheels having a plurality of work receiving apertures therein, means rotatably to support said cage for rotation about an axis eccentric to the axes of said wheels, a motor driven variable speed driving mechanism operatively connected to rotate said cage, means including a piston and cylinder rapidly to move the upper lapping wheel toward and from the lower wheel, a positive stop adjustably mounted on the upper lapping wheel spindle positively to limit the rapid approaching movement of said upper lapping wheel, a manually operable feeding mechanism including hollow non-rotatable screw surrounding the upper lapping wheel spindle which is arranged in the path of said stop, a rotatable nut meshing with and surrounding said screw, and a manually operable feed wheel operatively connected to actuate said nut to feed the upper lapping wheel to obtain the desired lapping action on the opposite faces of the work pieces being lapped.

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