March 5, 1940. W. A. LOCKHART 2,192,486

LENS GRINDING AND POLISHING MACHINE

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FIG. 1.

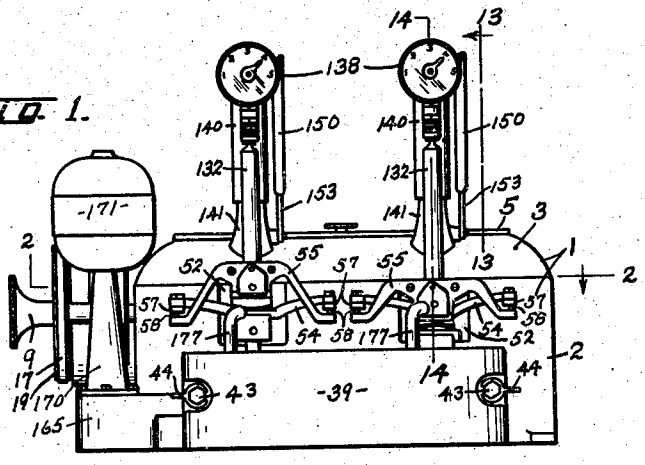
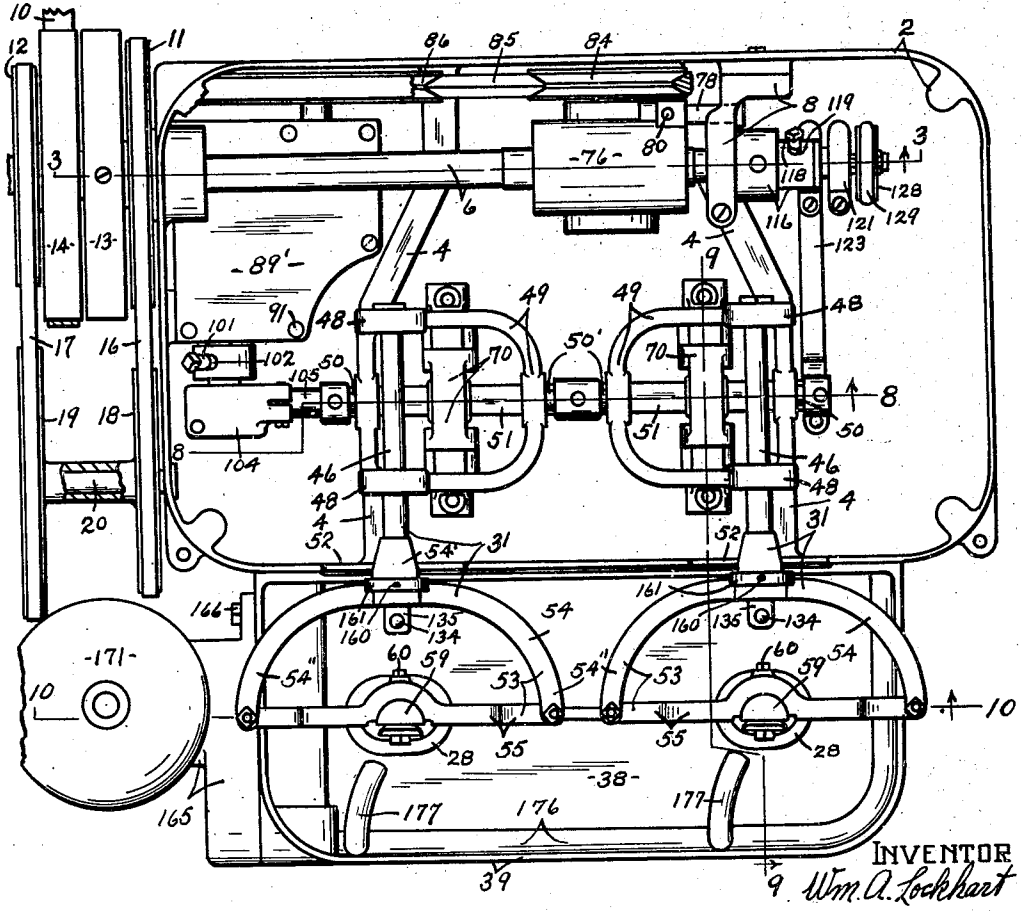


FIG. 2.



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FIG. 3.

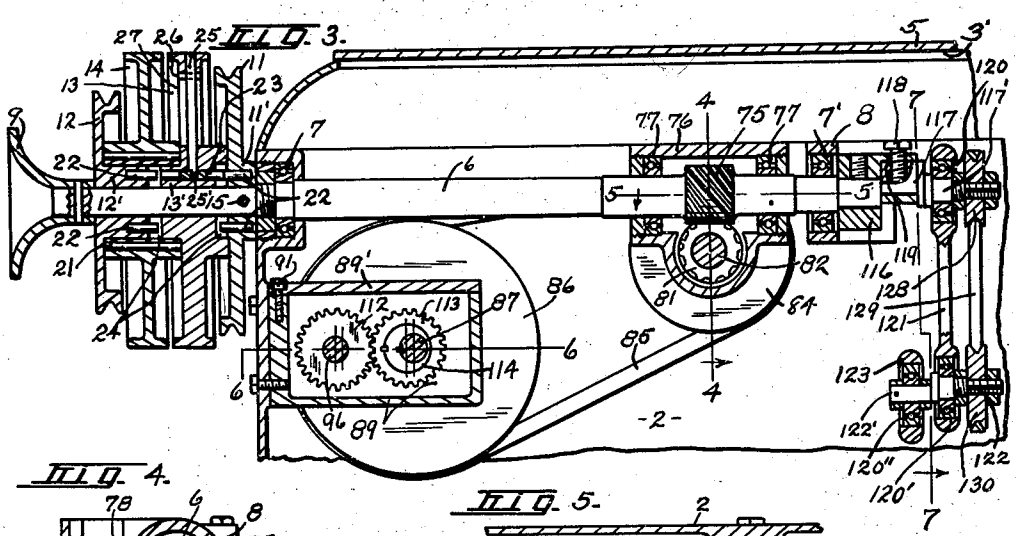


FIG. 4.

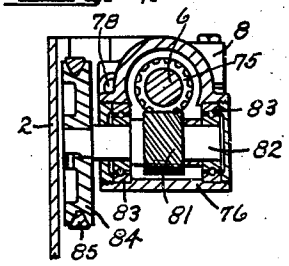


FIG. 5.

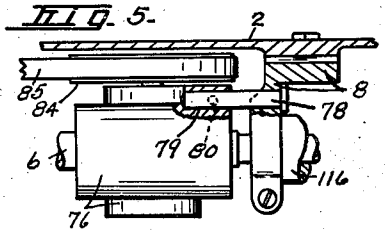


FIG. 6.

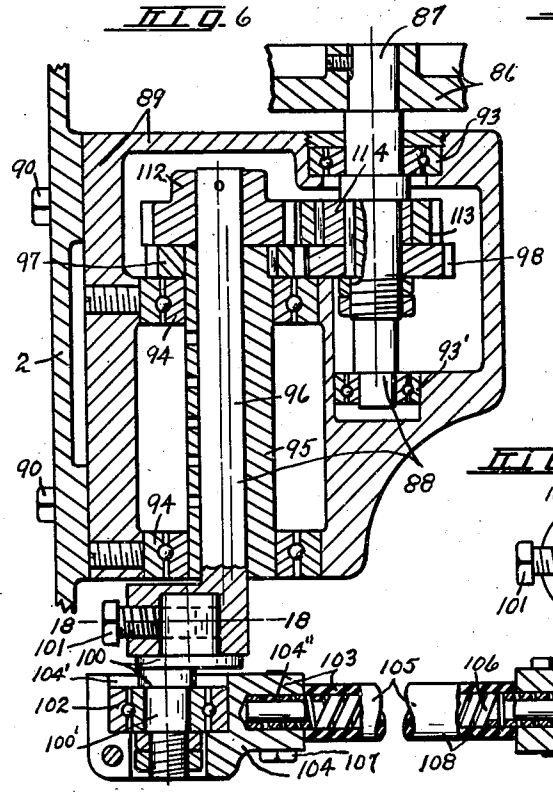


FIG. 7.

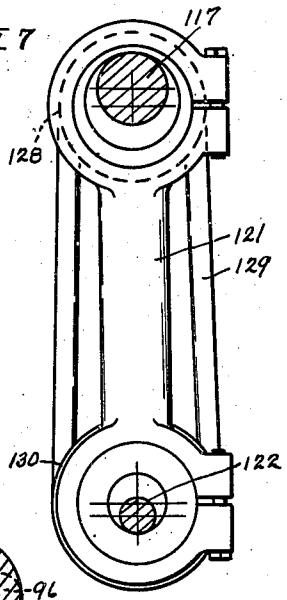
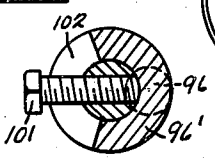


FIG. 18.



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FIG. 8.

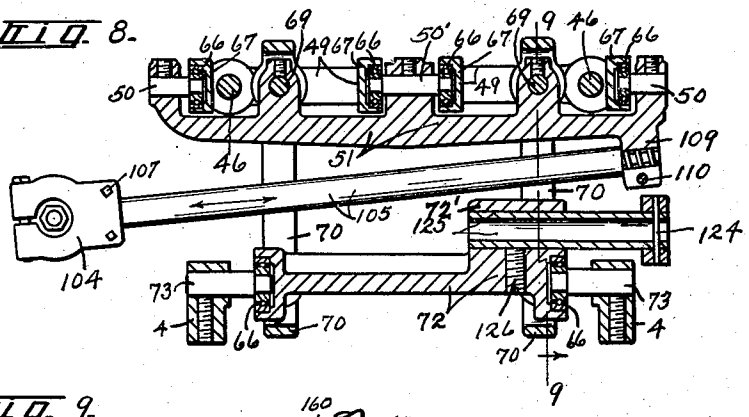


FIG. 9.

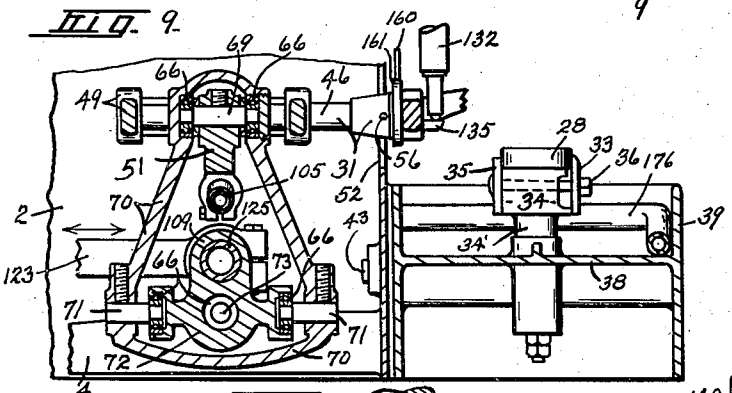


FIG. 10.

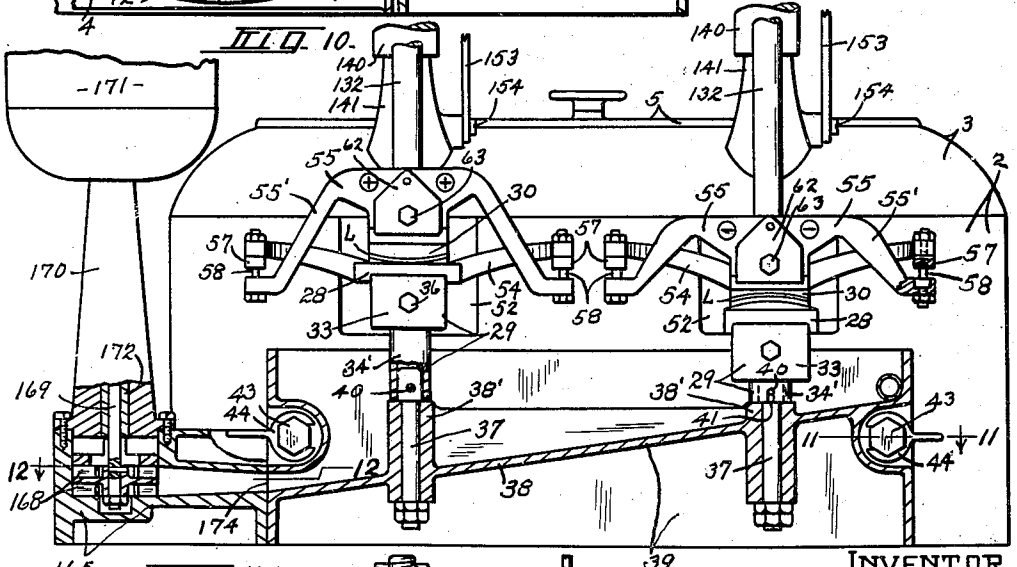
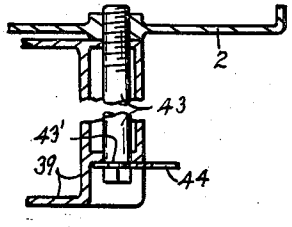


FIG. 11.



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FIG. 12.

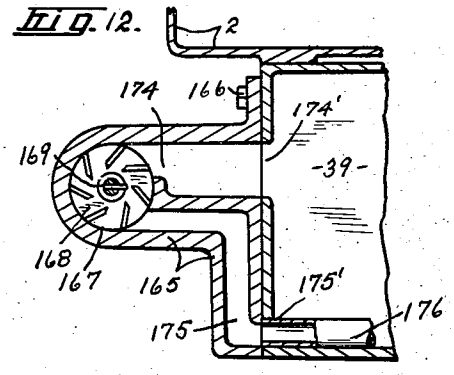


FIG. 13.

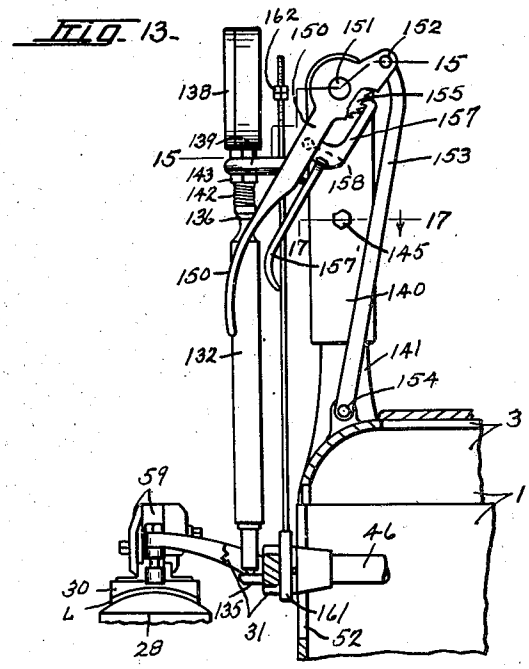


FIG. 14.

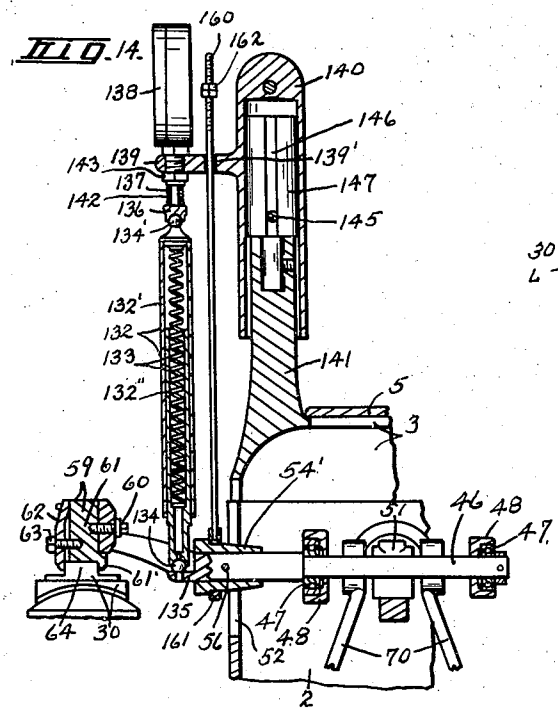


FIG. 15.

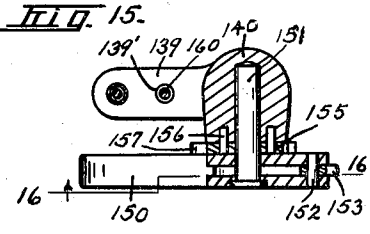


FIG. 16.

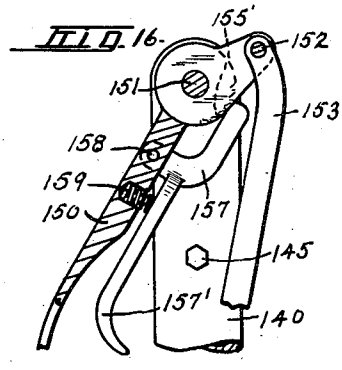
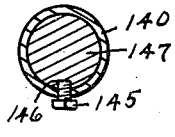


FIG. 17.



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FIG. 19.

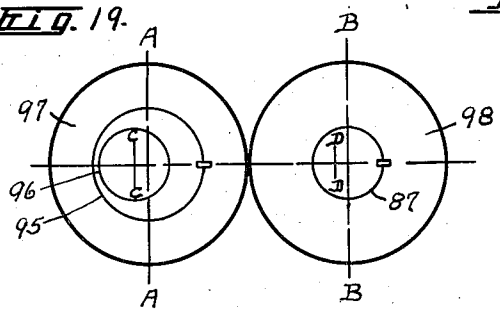


FIG. 20.

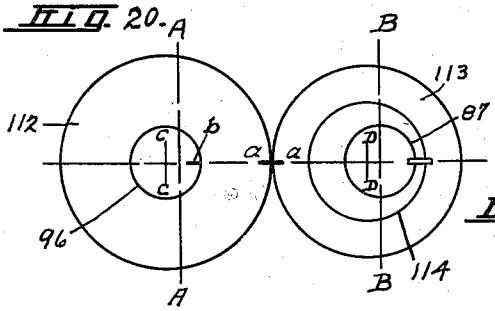


FIG. 21-A

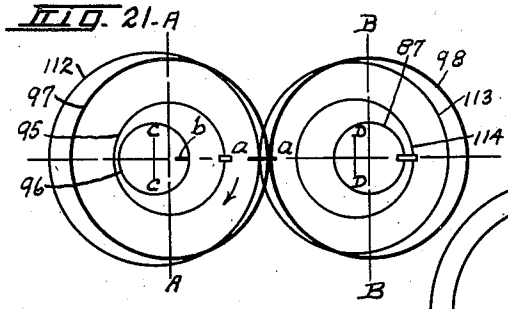


FIG. 22.

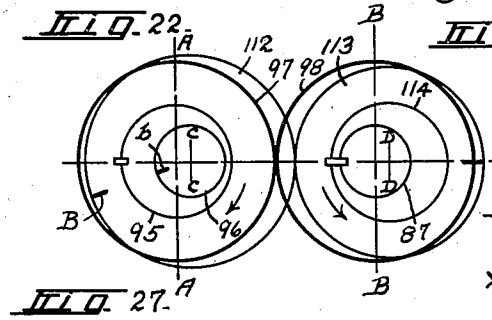


FIG. 27.

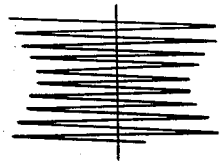


FIG. 23.

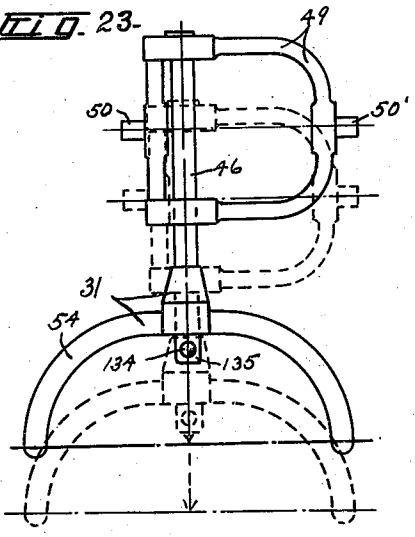


FIG. 24.

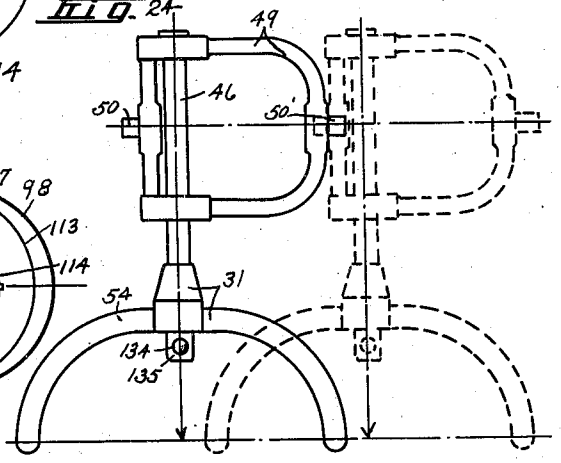


FIG. 25.

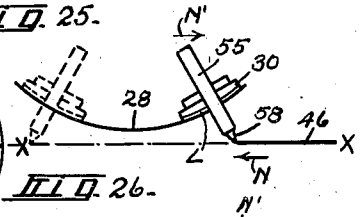
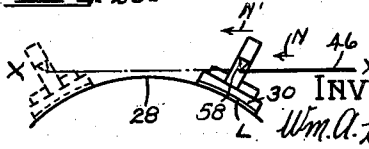


FIG. 26.



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FIG. 28.

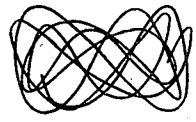


FIG. 29.

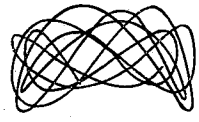


FIG. 30.

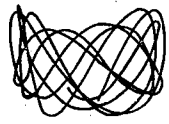
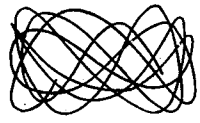


FIG. 31.



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Patented Mar. 5, 1940 2,192,486

UNITED STATES PATENT OFFICE

2,192,486

LENS GRINDING AND POLISHING MACHINE

William A. Lockhart, Waterloo, N. Y., assignor to Shuron Optical Company, Inc., Geneva, N. Y., a corporation of New York

Application September 1, 1937, Serial No. 161,985

14 Claims. (Cl. 51—160)

This invention relates to improvements in a surface or lens grinding and polishing machine, in which a plurality of (in this instance two) grinding and polishing couples, each consisting of a lens holder and grinding lap, are operated in synchronism by a combination of two reciprocative movements and two variations or break-up movements. The two reciprocative movements operate in different directions, preferably at right angles to each other, and the two continuous variation or break-up movements operate in conjunction with the reciprocative movements; whereby the paths of travel of the movable elements of the grinding and polishing couples are changed during successive strokes so that each lens will be moved relative to the grinding surface of the couple through a series of curvilinear strokes to thereby produce surfaces which are free from deformations and waves. This invention is an improvement on the structure shown in Patent No. 1,709,943, issued to E. M. Long, April 23, 1929, and also on my co-pending application, now Patent No. 2,168,843, issued August 8, 1939.

An object of this invention is to provide a machine, which is of improved simplified construction, for grinding and polishing the surfaces of lenses or analogous objects; that is, a machine wherein the various movable parts thereof will operate more efficaciously than heretofore, and thereby more expeditiously and accurately grind or polish such surfaces to the desired contour and finish.

A more specific object of the invention is to provide a grinding and polishing machine of the above mentioned class with improved mechanisms associated with the two major or reciprocative movements for producing a break-up in the strokes thereof whereby the path of transversing movement of the movable elements of each grinding and polishing couple will be caused to vary throughout successive strokes of a cycle of operation, and particularly to produce alterations in the positions of reversal at the ends of successive strokes of the relative movement of the lens, or other object, and the grinding surface or lap, and thereby to greatly increase the duration of each cycle of operation or the period between the operation of the lens, or other object, a second time through a given path; so that the lens or object will not be moved twice through the same path or a portion thereof during the time ordinarily required to grind or polish a surface thereof, and therefore any minute inaccuracies occurring in the surface of the lap will not be reproduced on the surface being ground.

Other specific objects of the invention are: First, to provide a connecting rod associated with one of the major or reciprocative movements of the grinding and polishing couples which is of improved, simplified construction and which is arranged to operate in an improved, more direct manner than the corresponding connecting rod shown in the above mentioned patent; second, to provide an improved structure connecting the main drive element or shaft with the reciprocating members or rock frame 3, associated with the two reciprocative movements to break up or alter the normal movements thereof, so that a slow, continuous change in the path of the relative movement of a lens and the grinding or polishing surface, and particularly in the reversing points thereof throughout successive strokes of the cycle of operation over an extended or indefinite period and thus eliminate the formation of lines, waves or other defects in the lens surface which may cause a zone or aberration; third, to provide the drive mechanism with a simply constructed clutch means whereby the movable elements of the grinding and polishing couples may be selectively operated at either of two speeds,—a relatively slow speed for wax polishing and when grinding high or complex curved surfaces, or a relatively high speed for grinding surfaces of relatively low pitch or curves, depending upon the operation to be performed; fourth, to provide a removable rouge feed whereby the same may be used only when a surface is being polished; fifth, to provide the drive elements or arms for transmitting motion from the reciprocating members or rock frames to the work or lens holders which are of improved structure. In carrying out this object, the drive arms or elements are so constructed that the weight thereof is arranged as close to the axis of movement or rotation of the elements as possible, whereby said elements will operate with a minimum amount of vibration and power and the pressure between the works and grinding lap or surface will be maintained more nearly uniform, particularly at the point of reversal of the drive elements or arms at the end of one stroke and the beginning of the next stroke; sixth, to provide an improved selective tension means whereby the work may be readily moved into and maintained in operative relation with the grinding and polishing surface under a predetermined pressure, that is, a pressure most advantageous to the form or type of the work surface being ground or polished; seventh, to so construct this machine

that the various moving parts thereof will be adequately lubricated for an extended or indefinite period so that the machine will successfully operate without a continuous flow of lubricating fluid to the various bearing members thereof and the mechanism for producing such flow.

Other objects and advantages relating to the specific construction of the parts of the machine will more fully appear from the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a front elevation of a lens grinding and polishing machine embodying the various features of this invention.

Figure 2 is a top plan, partly broken away and in sections, of the machine shown in Figure 1 with the top removed to illustrate the interior construction.

Figure 3 is a detail longitudinal vertical sectional view taken substantially on line 3—3, Figure 2.

Figure 4 is a detail vertical sectional view taken on line 4—4, Figure 3.

Figure 5 is a detail horizontal sectional view taken substantially on line 5—5, Figure 3, illustrating the greater portion of the gear case or housing and the bearing bracket in elevation.

Figure 6 is a detail horizontal sectional view on an enlarged scale, taken substantially on line 6—6, Figure 3.

Figure 7 is a vertical sectional view taken on line 7—7, Figure 3.

Figure 8 is a longitudinal vertical sectional view taken on line 8—8, Figure 2.

Figure 9 is a detail vertical sectional view taken substantially in the plane of the line 9—9, Figure 8, an outer end portion of the lens driving member or arm and the lens holder connected thereto being broken away.

Figure 10 is a longitudinal vertical sectional view, partly in elevation, taken substantially in the plane of the line 10—10, Figure 2.

Figure 11 is a detail sectional view taken on line 11—11, Figure 10.

Figure 12 is a detail horizontal sectional view taken on line 12—12, Figure 10.

Figure 13 is a detail vertical sectional view of the upper portion of the supporting frame illustrating my novel mechanism for producing a predetermined pressure between the lens and the grinding surface or lap, in side elevation, as viewed from line 13—13, Figure 1.

Figure 14 is a detail vertical sectional view through the pressure producing mechanism taken substantially on line 14—14, Figure 1.

Figure 15 is a horizontal sectional view taken substantially on line 15—15, Figure 13.

Figure 16 is a detail vertical sectional view of the upper end portion of the pressure producing mechanism shown in Figure 13 taken substantially on line 16—16, Figure 15.

Figure 17 is a horizontal sectional view through the guide post and sleeve taken substantially on line 17—17, Figure 13.

Figure 18 is a sectional view taken on line 18—18, Figure 6.

Figures 19 to 22 inclusive are diagrammatic views illustrating the operation of my novel motion break-up mechanism associated with the reciprocative movement operating substantially parallel with the base axis of the lens.

Figure 23 is a diagrammatic plan view of one of the lens holder drive elements illustrating the reciprocative movement thereof operating substantially parallel with the cylinder axis of the lens being ground and which is usually called the cross stroke.

Figure 24 is a view similar to Figure 23 illustrating the reciprocative movement of a lens holding drive element operating substantially parallel with the base axis of the lens being ground and which is usually called the lengthwise stroke.

Figure 25 is a diagrammatic view illustrating the action of the drive element upon the lens holder when grinding or polishing a convex surface.

Figure 26 is a view similar to Figure 25 illustrating the action of the drive element upon the lens holder when grinding a concave surface.

Figure 27 is a diagrammatic view illustrating succeeding strokes of a lens over the grinding surface of a lap produced either by the cross stroke or the lengthwise stroke of the drive element.

Figures 28, 29, 30 and 31 are diagrammatic views illustrating the path of travel of a given point on the lens, for instance the center, over the grinding surface of the lap, each figure showing the movement of the lens through ten consecutive revolutions of the drive shaft.

The construction illustrated in the drawings comprises a main supporting frame 1 consisting of a substantially rectangular housing section 2 and a top section or cover 3 removably secured to the housing 2 by any suitable means. The housing 2 in this instance has the lower side thereof open and is provided with a pair of ribs 4 extending transversely therethrough adjacent the bottom or lower edge in spaced relation to each other. The top section 3 may, as indicate in Figures 1 and 3, have an opening 3' in the upper side thereof which is closed by a lid 5. A main drive shaft 6 is journaled in suitable bearings 7 and 7' to revolve about a horizontal axis. The bearing 7 is mounted in one of the end walls of the housing section 2, while the bearing 7' is mounted in a bracket 8 secured to the rear side wall of said housing intermediate the ends thereof. One end of the shaft 6 extends some distance outwardly beyond the adjacent end wall of the housing 2 and has secured thereto a hand wheel 9 by which the shaft may be manually rotated.

Mounted upon the shaft 6 intermediate the hand wheel 9 and housing 2 is a simple drive mechanism adapted to be connected with any suitable source of power, not shown, as by a belt 10 whereby the shaft may be rotated at either of two speeds. This drive mechanism comprises a pair of grooved pulleys 11 and 12 mounted upon the shaft 6 in axial spaced relation to each other and a pair of flat faced pulleys 13 and 14 positioned intermediate the pulleys 10 and 11. The grooved pulley 11 is fixed to the shaft 6 by any suitable means, as a pin 15, while the other grooved pulley 12 is loosely mounted on said shaft to rotate relatively thereto. The pulleys 11 and 12 are connected by belts 16 and 17 to similar pulleys 18 and 19 rotatably mounted upon a shaft 20 secured to the housing 2 in front of the shaft 6, pulleys 18 and 19 being connected to each other, as shown in Figure 2, to rotate in unison. The pulley 11 is preferably of greater diameter than the pulley 12, while the pulley 18, connected by the belt 16 to pulley 11, is of smaller diameter than the pulley 19 which is connected by belt 17 to pulley 12, as clearly illustrated in Figure 2. The pulleys 13 and 14, which are adapted to be operated by the belt 10 are loosely

mounted upon the shaft 16 to rotate relative thereto. The pulley 14 is an idler pulley and, as shown, is mounted upon a roller bearing 21 mounted upon the hub portions 12' and 13' of pulleys 12 and 13 respectively.

The pulley 13 is adapted to be connected with either pulley 11 or 12 by a simple clutch mechanism which, as shown, consists of clutch pins 22 mounted in the hub portions 11' and 12' of pulleys 11 and 12 respectively and a clutch pin 23 mounted in the hub portion 13' of the pulley 13. The clutch pins 22 are fixedly secured to the respective hub portions 11' and 12' to extend inwardly toward each other beyond the adjacent surfaces of said hub portions into corresponding recesses 24 provided between the pulleys 13 and pulleys 11 and 12, as shown in Figure 3. The clutch pin 23 is slidably mounted in the hub portion 13' of pulley 13 for movement into and out of engagement with the pins 22. The clutch pin 23 is moved axially relative to the pulley 13 by a cam rod 25 which extends inwardly from the outer face of the pulley 13 through a suitable hole provided in the pulley and has the inner end thereof provided with an eccentric portion or extension 25' received in a suitable aperture provided in the pin 23 intermediate the ends thereof. The cam rod 25 is maintained against outward axial movement by a pin 26 which extends diametrically through the rod adjacent the outer wall of a slot 27 formed in the web portion of the pulley 13.

It will now be observed that when the belt 10 is shifted from the idle pulley 14 onto the drive pulley 13, motion from the pulley 13 may be transmitted either directly to the pulley 11 and shaft 6 through the medium of clutch pin 23 and one of the clutch pins 22 connected with pulley 11 so that the shaft 6 will be operated at the same speed as the pulley 13. If, on the other hand, it is desired to operate the shaft at a slower rate of speed than that of the pulley 13, the clutch pin 23 may be moved by rotating the cam rod 25 out of engagement with the clutch pins 22 associated with the pulley 11 into operative engagement with clutch pins 22 associated with the pulley 12. Rotation of the pulley 13 will now transmit motion through the pulley 12 and belt 17 to pulleys 19 and 18 and then through belt 16 to pulley 11 and shaft 6.

The shaft 6 is adapted to operate the movable elements of the two lens surface grinding and polishing couples which comprise a grinding lap 28 mounted on a relatively stationary lap supporting element 29 and a work or lens supporting block 30 operatively connected to a lens driving element for moving the work or lens as L, Figures 10, 13, 14, across and upon the upper surface of a lap 28. The laps 28 are of course of various contours and must be interchanged from time to time upon the supporting element 29. For this reason each lap is releasably held in operative position on a support 29 by a plate 33 arranged at the front side of a supporting block 34 and a second plate 35 positioned at the rear side of said block, as illustrated in Figure 9, said plates being clamped to the supporting block by a screw 36. The blocks 34 are each provided with a pendant hollow hub 34' which is adapted to removably receive the upper end portion of a bolt 37 mounted on a boss 38' provided in the bottom wall 38 of a catch basin 39, see Figure 10. The supporting elements 29 are removably mounted on the bolts 37, and in order that these elements may be releasably maintained in operative position, the upper end portion of each bolt 37 is provided with a pin 40 which is adapted to be received in an elongated slot 41 extending upwardly from the lower end of each hub portion 34' as shown in Figure 10. The supporting elements 29 are constructed with hubs 34' of different lengths so as to adapt them for maintaining the grinding lap 28 at different elevations with respect to the driving elements 31, so as to adapt the machine for grinding and polishing different forms of lens; for instance, when grinding a plus or convex lens the lap is maintained at a relatively high level and therefore the hub 34' is a relatively long member, as illustrated at the left hand side of Figure 10. If, on the other hand, a minus or concave lens is being ground or polished, the same is maintained at a relatively low level and the hub 34' is a relatively short member, as illustrated at the right hand side of Figure 10. Also, if a substantially flat lens is to be ground or polished, the lap 28 will be maintained at an intermediate position and the hub 34' will be of intermediate length.

The catch basin 39 is removably secured to the housing 2 by a pair of bolts 43 extending through corresponding holes or apertures at opposite ends of the catch basin 39, and are screw-threaded in the front wall of the housing 2. Each of these bolts 43, as shown more particularly in Figure 11, are of substantially uniform diameter throughout the length thereof, and is provided with an annular recess or groove 43' in the periphery thereof a short distance from the outer end. A slotted washer 44 extends into the groove 43' for maintaining the catch basin against outward movement axially from the screws 43. The washers 44 are clamped in the grooves 43' when the screws 43 are tightly screw-threaded in the housing 2; and when it is desired to remove the catch basin, it is only necessary to rotate the screws 43 to move them axially outwardly a short distance relatively to the housing 2 to release the washers 44. Then by removing the washers from their respective grooves 43', the catch basin may be drawn outwardly over the screws and thus removed from the housing 2. Likewise, the catch basin may be readily mounted on the housing 2 by sliding them onto the screws 43, inserting the washers 44 in the grooves 43' and then tightening the screws.

Lens drive element

The lens driving elements 31 are of novel construction and, as shown in Figures 2 and 14, each comprises a spindle 46 journaled in suitable ball bearings 47 mounted in the outer end portions 48 of a D-shaped frame 49 which is rotatably supported by stub shafts or studs 50 carried by a substantially horizontally disposed floating member or beam 51 mounted in the housing 2 in front of shaft 6. Each spindle 46 extends outwardly from the interior of the housing 2 through an opening 52 provided in the front wall of the housing 2 and has connected to the outer end thereof a drive frame 53 for the lens holder or supporting block 31. Each drive frame 53 comprises a substantially U-shaped bracket 54 and a saddle member 55. The bracket member 54 has the center thereof provided with a hollow hub 54' which is adapted to removably receive the outer end of the spindle 46 therein. The bracket 54 is secured to the spindle 46 by means of a pin 56 which extends through the hub 54' and said spindle. The outer ends of the arms 54'' of the bracket 54 are provided with hardened

bearings 57 adapted to be engaged by pointed pins 58 mounted on the opposite ends of the saddle member 55 which, in turn, is adapted to receive a supporting lens block holder 59 which is secured to the central portion of the saddle 55 by a screw 60, as shown in Figures 2 and 14.

The lens block holder 59 comprises a body portion 61 provided with a shoulder 61' at the lower, inner or rear edge thereof. A clamp plate 62 is secured by a screw 63 to the outer face of the body portion 61 for firmly clamping the rib 64 of the lens holder 30 between the lower edge thereof and the shoulder 61'. The bearing members 57 are tightly secured in the opposite ends of the bracket member 54 and are provided with conical sockets in their lower faces for receiving the upper tapered ends of the pins 58 which engage the sockets in about the horizontal plane of the axis of rotation of the corresponding spindle 46, as illustrated in Figures 10 and 13. As shown in Figure 10, the central portion of each saddle member 55 extends across and some distance above the upper surface of the lap 28 and with the opposite side portions 55' of the saddle extending downwardly in diverging planes to a position below the adjacent ends of the bracket 54 to support the bearing pins 58 and to allow free lateral rocking movement of the saddle and its lens block holder 59 without liability of contact with the lap or its supporting means.

In order that lenses of various curvatures, whether concave or convex, may move across the surface of the lap 28 with a minimum amount of power and with a substantially uniform pressure maintained between the lens and the grinding surface of the lap, the side portions 55' may vary materially in length in different saddle members 55. The reason for this is to maintain the lens at one or the other side of the horizontal plane passing through the axis of rotation of the spindle 46, depending upon the curvature of the surface being ground. That is, when the surface to be ground is of convex curvature, the side portions 55' are of relatively long length so as to hold the lens above the horizontal plane passing through the axis of rotation of the spindle 46, as shown at the left hand side of Figure 10.

On the other hand, if the surface to be ground is of concave form, then the side portions 55' of the saddle are of relatively short length so as to maintain the lens, and particularly the surface thereof to be ground, below the horizontal plane passing through said spindle 46, as illustrated at the right hand side of Figure 10. Again, if the surface of the lens, or other object to be ground, is substantially flat the side portions 55' of the saddle are of medium length so as to maintain said surface to be ground in substantially a horizontal plane passing through the axis of rotation of the spindle 46.

To explain more explicitly, the co-action of the various members of a lens drive element 31 and the lap 28 when polishing lenses or other objects with surfaces of different curvatures, let it be assumed, first, that a plus or convex lens as illustrated at the left hand side of Figure 10 and in Figure 25 is to be ground. This lens L is positioned, as shown, with the surface thereof to be ground above the axis X—X of rotation of the spindle 46 by the selection of a saddle member 55 having relatively long side portions 55' and a lap support having a relatively long hub 34'.

It will now be apparent that inasmuch as the longitudinal thrust of the spindle 46 upon the lens holder 30 is applied at the points of contact of the pins 58 with bearings 57 below the connection of the lens with the surface of the lap 28, the frictional resistance to the movement of the lens over the lap will tend to rotate the holder 30 and saddle 55 in a direction opposite to that of the movement of the spindle 46, as indicated by arrows N and N', Figure 25. The forward edge of the lens will therefore tend to move away from the curved portion of the lap surface coincident therewith at the beginning of each stroke of the drive element 31, so that the lens will tend to rock about the center of curvature of the grinding surface of the lap and thus prevent excessive or uneven friction between the lap and lens.

If, on the other hand, a minus or concave lens is to be ground, a saddle 55 and lap support will be chosen having relatively short side portions 55' and a relatively short hub 34' respectively, as illustrated on the right hand side of Figure 10 and in Figure 26 so as to position the lens surface to be ground below the axis X—X of rotation of spindle 46 and therefore below the point of contact of pins 58 with bearings 57. In this arrangement of the parts, the thrust of the spindle 46 during the axial movement thereof upon the lens holder 30 will be applied to said holder at the same side of said lens surface as the connection of the lens with the lens holder. It therefore follows that the force produced by the thrust of the lens upon the upwardly inclined central portion of the said lap at the beginning of each stroke will be applied to the lens holder radially outward from the surface of the lens contacting with the lap. This will tend to rock the lens holder forwardly or in the direction of movement of the spindle 46 as indicated by arrows N and N', Figure 26 and thereby tend to rock the lens holder 20 and the lens carried thereby about the center of curvature of the lap surface or in the direction of curvature of the grinding surface of the lap, so that the lens will move smoothly along said surface of the lap in substantially coincidental contact therewith and therefore with a minimum amount of lateral thrust upon the surface of the lap, particularly at the beginning of each stroke.

When a lens with a substantially flat surface is to be ground, a saddle member 55 and lap holder 29 will be chosen which will maintain such surface of the lens substantially in the plane of the axis X—X of rotation of the spindle 46. When the surface to be ground is in this position, the line of thrust of the spindle 46 during an axial movement thereof upon the lens holder is substantially coincident to the line of thrust of lens upon the grinding surface of the lap so that the tendency of the lens holder to be rotated upon the axis extending through the points of the pin 58 is reduced to a minimum, and the surface of the lens will be maintained in substantially coincidental contact with the grinding surface of the lap.

It will therefore be seen that it will be necessary to frequently change the saddle members in order to successfully grind surfaces of different curvatures, and this is readily accomplished due to the fact that the pins 58 have merely a bearing engagement with the bearings 57 so that the sadole members may be readily removed from the corresponding bracket 54 by merely separating the bearing members 57 from the pins 58.

The term "coincidental contact" is used in the specifications and claims to designate that rela-

tion between the lens and lap whereby all portions of the surface of the lens being ground will engage, in so far as possible, the grinding surface of the lap and with a substantially uniform pressure throughout the area thereof in common distinction to any inequality in the engagement of such surface that would occur if they were caused to assume a more or less angular relation with respect to each other.

The hereinbefore mentioned stub shafts 50 and 50' which rotatably support the D frames 49 have the outer end portions and the central portion thereof respectively secured to the floating beam or member 51, while the opposite end portions of the shaft 50 and the outer end portions of the shaft 50' are each journaled in a respective roller bearing 66 secured in enlarged housing portions 67 formed in each D frame 49 at opposite ends thereof. The stub shafts 50 and 50' are arranged in co-axial alignment with each other and with the common axis thereof intersecting the axes of rotation of the spindles 46. It will therefore be understood that inasmuch as the bracket members 54 are arranged substantially in a diametrical plane passing through the axis of the corresponding spindle 46 each lens driving element 31 will be in nearly a balanced condition and will therefore rotate with a minimum amount of power and vibration about the axis of the spindle 46 as the lens is moved back and forth across the grinding surface of the lap.

Reciprocating rock frames or carriers

The axial movement of spindle 46 for moving the lens carried thereby through the cross strokes, that is, transversely of the grinding surface of a lap, and the lateral movements of the spindle for producing the lengthwise strokes of the lens longitudinally of the grinding surface of the lap are produced by the operation of the floating beam 51 which has secured thereto a pair of studs or pivot shafts 69 extending transversely of the beam intermediate shafts 50 and shaft 50', as illustrated in Figure 8. The shafts 69 are arranged with the axes thereof intersecting the common axis of the shafts 50 and 50'. The shafts 69 have the ends thereof extending outwardly from the opposite sides of the beam 51 and journaled in corresponding bearings 66 mounted in the upper end portions of a pair of supporting inverted V-frames 70 at opposite sides thereof and through which the beam 51 extends, as shown in Figures 8 and 9. These frames 70 extend downwardly from the beam 51 to near the bottom of the housing 2 and have secured to opposite sides of the lower ends thereof a pair of stub shafts 71 arranged in co-axial alignment with each other. These shafts 71 extend inwardly from adjacent sides of the corresponding frame 70 and have their ends mounted in bearings 66 secured in the opposite sides of an oscillating frame 72 mounted in a vertical plane beneath the floating beam 51 and in spaced relation thereto.

This oscillating frame 72 is provided with a pair of bearing members 66 arranged in the ends thereof, as shown in Figure 8, and which receive the respective ends of a pair of stub shafts 73 which are secured to the hereinbefore mentioned ribs 4 provided in the housing 2. The shafts 73 are arranged in axial alignment with each other with the common axis thereof intersecting the common axes of each pair of stub shafts 71. It will therefore be obvious that the frame 72, the beam 51 and the lens driving elements 31 connected thereto are free to rock about the common axis of the shafts 73 extending longitudinally of the housing 2 in substantially parallel relation with the minor or lateral axes of the laps 28. Furthermore, it will be obvious that the beam 51 and the lens driving elements 31 connected thereto may reciprocate in a direction longitudinal of the housing 2 and in substantially parallel relation with the major or longitudinal axes of the laps 28, due to the rocking action of the frames 70 about the axes of the shafts 71 extending transversely of the housing 2. The mechanism for producing these rocking or oscillating movements of the frame 72 and beam 51 will now be described.

Lengthwise reciprocating movement

Mounted upon the drive shaft 6 intermediate the bearings 7 and 7' is a spiral gear 75 which is positioned within a gear housing or case 76 having bearings 77 arranged in opposite ends thereof, as shown in Figure 3, for receiving the shaft 6 therethrough and supporting a case 76 on said shaft. The case 76 is maintained against rotation during the rotation of shaft 6 by a pin 78 secured in the hereinbefore mentioned bearing bracket 8 and which extends into a suitable aperture 79 formed in one side of the case 76, pin 78 being secured to said case by a pin or screw 80, as illustrated in Figures 2 and 5. The gear 75 is in meshing engagement with a spiral gear 81 secured to a stub shaft 82 which is arranged beneath the shaft 6 and is journaled in bearings 83 mounted in the case 76 to rotate about an axis extending in right angular relation to the axis of rotation of shaft 6, as shown in Figure 4. The shaft 82 extends beyond the outer side of the case 76 and has secured to the outer end thereof a grooved pulley 84 which is connected by a belt 85 to a grooved pulley 86 secured to one end of a drive shaft 87 comprising a portion of one of my novel power transmission and motion breakup mechanism 88.

This mechanism 88 comprises a case 89 which is secured to one end wall of the housing 2 as by screws 90 or their equivalent. The upper side of the case 89 is provided with a cover 89' removably secured thereto by screws 91, as indicated in Figures 2 and 3. The case 89 is provided with a pair of bearings 93 and 93' arranged in axial spaced relation to each other in one side thereof, which rotatably supports the shaft 87, as shown in Figure 6, whereby said shaft may be rotated about a fixed axis extending at substantially right angles to the axis of rotation of the drive shaft 6. The case 89 also has a pair of axially spaced bearing members 94 mounted therein at one side of the bearings 93 and 93' for rotatably supporting an eccentric sleeve 95 arranged in parallel spaced relation to the shaft 87. A shaft 96 is journaled in the sleeve 95 to rotate about an axis arranged in spaced substantially parallel relation with the axis of rotation of said sleeve. The sleeve 95 has secured to the one end thereof a gear 97 which is in meshing engagement with a similar gear 98 splined or otherwise secured to the shaft 87 to rotate in unison with said shaft. The gears 97 and 98 are of the same pitch diameter so that the sleeve 95 will be rotated at the same rate of speed as the shaft 87.

The shaft 96 has one end thereof extending forwardly beyond the case 89 and supports an eccentric crank pin 100 which is journaled therein for angular adjustment at one side of and

parallel with the axis of rotation of said shaft 96. The crank pin 100 is held in different positions of angular adjustment by means of a clamping screw 101 engaged in a diametrically extending threaded aperture in the crank pin 100 and which extends outwardly from the crank pin through an elongated slot 102 provided in the adjacent end portion 96' of the shaft 96 which is enlarged to receive the pin 100 therein. The crank pin 100 is provided with an eccentric extension 100' which is arranged at one side of the axis of the crank pin.

Mounted upon the extension 100' is a ball bearing member 102 which rotatably supports one end of my novel connecting rod 103. This rod 103 comprises a head 104 and a flexible shaft or rod 105. The head 104 is provided with a bore 104' extending transversely therethrough for the reception of the bearing 102 and outer end portion of the crank pin extension 100'. The rod 105 is comprised of a flexible metal core 106 which in this instance is in the form of a coil spring having one end thereof secured in a bore 104'' provided in the head 104 in right angular relation to the bore 104'. The head 104 may, as shown in Figures 2, 6 and 8, be slotted to form opposed sections at opposite sides of the bore 104'' and which are provided with screws or bolts 107 whereby the sections may be clamped to the core 106 for securing the core to the head 104. The core 106 is provided with a flexible cover 108 composed of rubber, or the like, for providing the rod with a smooth outer surface and for maintaining the core free from dirt, grease or other foreign elements. The sleeve 108 extends from the head 104 to within a short distance of the opposite end of the core which is clamped in a split hollow boss 109 by a screw 110, said boss being shown integral with the end of the floating beam 51 opposite the transmission mechanism 88, as illustrated in Figures 2 and 8.

The boss 109 is arranged, when the beam 51 is substantially midway between the extreme ends of the transverse stroke thereof, in a plane extending substantially at right angles to the end portion 100' of the crank pin 100 to which the connecting rod 103 is attached. It will, therefore, be seen that the connecting rod 103, during the rotation of the crank pin, will extend in substantially a straight line from the crank pin portion 100' to the boss 109 and will therefore have substantially a direct thrust upon the floating beam 51. It will also be observed by referring to Figure 8 that owing to the particular construction of the beam 51 and rock frames 70 and 72 the connecting rod 103 may freely extend between the floating beam and rock frame 72 and through the interior of the rock frame 70. It is, therefore, evident that this structure is an improvement over the structure shown in the hereinbefore mentioned Patent 1,709,943 wherein the connecting rod corresponding to applicant's connecting rod 103 is necessarily a more or less arcuate member to enable the same to extend around the rock frames associated therewith.

The read end of shaft 96 extends a short distance beyond the sleeve 95 and has secured thereto a gear member 112 which is in meshing engagement with a similar gear member 113 keyed to an eccentric sleeve 114 which in turn is keyed to the shaft 87 adjacent the gear 98, as shown in Figure 6. As hereinbefore mentioned and as illustrated diagrammatically in Figure 19, the gears 97 and 98 are of substantially the same size while the gears 112 and 113, as illustrated diagrammatically in Figure 20, are of unequal pitch diameter. The gear 113, which is the smaller of the two, is mounted concentrically upon the sleeve 114 and is therefore eccentric to the shaft 87 as indicated in Figures 6 and 20.

It will now be evident that when the crank pin 100 is adjusted relative to the shaft 96 to obtain the maximum degree of travel of the crank pin extension 100' about the axis of the shaft 96, as shown in Figure 6, any point on the lens, as the center thereof, will be moved a maximum distance over the grinding surface of the lap 28 as the crank pin 100 revolves with the shaft 96 during the rotation of said shaft as produced by the gears 113 and 112.

It will also be obvious that inasmuch as the eccentric sleeve 95 is being continuously rotated at the same rate of speed as the shaft 87, the shaft 96, which is eccentrically mounted in said sleeve, will be revolved about the longitudinal center or axis of rotation of the sleeve at the same rate of speed that the shaft 87 is operated, while the speed of rotation of the shaft 96 about its own axis will be slightly slower than the speed of rotation of the sleeve 95 and shaft 87.

It therefore follows that the distance between the axis of the crank pin extension 100' and the axis of rotation of sleeve 95 are constantly changing during the operation of the machine and, therefore, the effective throw of the crank pin will be constantly varying and causing the beam 51 and each lens driving element 31 to move through gradually varying distances within certain limits. In other words, each driving element 31 will move between the positions obtained by the maximum degree of throw produced by the combined action of the crank pin 100, shaft 96 and sleeve 95 and the minimum degree of throw produced by the combined action of these members.

To explain more explicitly, in Figures 19 to 22 inclusive of the drawings, circles 97 and 98 represent the gears 97 and 98 and circles 112 and 113 represent the corresponding gears. The lines A—A and B—B represent the axis of rotation of eccentric sleeve 95 and shaft 87 respectively. These axes, it will be observed, are in fixed relation with each other and lines C—C and D—D representing the axes of shaft 96 and eccentric sleeve 114 which are mounted eccentrically to and adapted to be revolved around the fixed axes A—A and B—B respectively. As hereinbefore stated, Figure 19 illustrates the shaft 87 and eccentric sleeve 95 with the gears 98 and 97 mounted thereon in cooperative relation with each other. Figure 20 illustrates the shaft 87 and shaft 96 and the gears 113 and 112 associated therewith mounted in cooperative relation with each other. The teeth of the gears 112 and 113 engaging each other are illustrated by the line *a—a*, while the side of the shaft 96 adjacent the line *a—a* is represented by the line *b*. Figures 21 and 22 are each a combination of Figures 19 and 20.

It will now be readily understood that during a revolution of the shaft 87 the eccentric sleeve 95 will operate through a complete revolution due to the gears 98 and 97 being of the same pitch diameter. Furthermore, it will be observed that inasmuch as the eccentric sleeve 114 is keyed to the shaft 87 and gear 113 is keyed to the sleeve 114, the gear 113 will rotate one complete revolution during each revolution of the shaft 87. The gear 112, however, will be rotated slightly

less than a revolution during each revolution of the shaft 87 and gear 113 inasmuch as the gear 113 is of smaller pitch diameter than the gear 112. It therefore follows that during each rotation of the shaft 87 the shaft 96 will be rotated slightly less than one complete revolution.

In other words, let it be considered that gears 98 and 97 are each provided with twenty-four teeth, that gear 113 is provided with twenty-three teeth and gear 112 is provided with twenty-five teeth, and also that the eccentric sleeves 95 and 114 are arranged so that the axes C—C and D—D of the shaft 96 and gear 113 are at one and the same side of the axes A—A and B—B respectively of eccentric sleeve 95 and shaft 87, as indicated in Figure 21. It will now be obvious that during one-half revolution of the shaft 87 and gears 98 and 113 connected therewith from the position shown in Figure 21 to the position shown in Figure 22, the eccentric sleeve 95 will be driven one-half revolution while the shaft 96 will be driven slightly less than one-half revolution or to position *b* and, therefore, the crank pin 100 will be rotated slightly less than one-half revolution. It therefore follows that the throw of the crank pin 100 will be slightly less than the maximum, which will produce a corresponding shortening in the stroke of reciprocation of the floating beam 51 connected to said crank pin by the connecting rod 103. This shortening in the length of succeeding strokes of the floating beam will continue during the rotation of the shafts 87 and 96 until the minimum length stroke has been reduced, and then these strokes will gradually increase in length until the maximum length stroke is again reached.

During continued rotation of the shafts 87 and 96 the axes of rotation of gears 113 and 112 will be constantly varied with respect to each other in synchronism with the operation of said gears due to the rotation of the eccentric sleeve 95 at the same rate of speed as the shaft 87 for maintaining the gears 113 and 112 in constant mesh with each other, as illustrated in Figures 21 and 22.

The setting of the crank pin 100 to a maximum degree of movement of the lens driving element 29 longitudinally of the grinding surface of the lap is utilized with a lens having a substantially flat surface or one in which the curve of the surface being ground has a relatively long radius. When the surface of the lens being ground has a relatively short radius, the crank pin 100 is adjusted relative to the end of the shaft 96 to bring the axis of the extension 100' thereof into relatively close relation with the axis of the shaft 96. When the crank pin 100 is thus adjusted to obtain the minimum degree of action produced by the crank pin, the lens driving element 31 will obviously have a much less degree of movement than with the previously described adjustment of the crank pin.

It will be observed, however, that owing to the particular driving connection shown between the drive shaft 6 and the crank pin 100 the lens driving element will not only be caused to travel through continuously changing paths or fields of action, but the ends of succeeding strokes thereof are continuously changing positions which reduces to a minimum the liability of scoring or otherwise injuring the lens, as the lens is moved longitudinally of the base curve of the lap 28, by any errors or imperfections in the grinding surface of the lap. This is due not only to the positive action of the transmission mechanism 88 above described, but also to the more or less indefinite action of the belt 85 connecting the shaft 6 with the transmission mechanism 88 due to the creeping action of said belt with respect to the pulleys 84 and 86.

Transverse or cross reciprocative movement

The mechanism producing reciprocative movement of the beam 51 at substantially right angles to the reciprocative movement thereof produced by the driving mechanism 88 above described for reciprocating the lens driving element 31 through the cross strokes, that is to say, in strokes substantially parallel with the cylinder axis of the lens is shown more particularly in Figures 2, 3, 7, 8, and 9. This construction comprises an eccentric collar 116 which is secured to the inner end of the drive shaft 6 adjacent the bearing members 7'. In this collar 116 is adjustably mounted an eccentric crank pin 117. The pin 117 is secured in the adjusted position by a screw 118 which extends through an elongated slot 119 formed in the collar 116 and screw-threaded into the pin 117 in the same manner as the screw 101 shown in Figure 18 for the crank pin 100. The crank pin 117 is provided with an extension 117' arranged in eccentric substantially parallel relation with the axis of the crank pin. Mounted on the extension 117' is a bearing 120 which is also mounted in one end of a connecting rod 121 extending downwardly from the crank pin. The connecting rod has the lower end thereof provided with a bearing 120' in which is mounted one portion of an eccentric crank pin 122 which is maintained in fixed spaced relation to crank pin extension 117' by said connecting rod, as shown in Figure 3. The crank pin 122 is provided with an extension 122' arranged in eccentric substantially parallel relation to the axis of the crank pin 122. Upon extension 122' is mounted a bearing 120'' which is also mounted in one end of a drive link 123 having the opposite end thereof secured, as by a pin 124 or other suitable means, to one end of a tubular sleeve 125. The sleeve 125 is secured by a screw 126 in the boss 72' connected with the rock frame 72 to extend outwardly from one end of the frame in a plane over the adjacent stub shaft 73, as illustrated in Figure 8.

It will now be observed that when the crank pin 117 is secured in the collar 116, rotation of the shaft 6 will produce a vertical reciprocating movement of the connecting rod 121 and the rear end of the drive link 123 which in turn will produce a corresponding rocking or oscillating movement of the frame 72. This rocking of the frame 72 will produce a similar rocking or reciprocating movement of the floating beam 51 through the medium of the supporting rock frames 70, which in turn produces reciprocative movement of the lens driving elements 31 connected therewith in a direction substantially parallel with the minor or cylinder axis of the lap 28.

In order that the transverse or cross strokes of the lens driving elements 31 thus produced may be varied so that a variation in the point of reversal of the lens driving elements, and therefore of the lens carried thereby, at the ends of the strokes may be produced, I have provided a simple mechanism for rotating the eccentric crank pin 122 about the axis of bearing 120 mounted in the lower end of connecting rod 121. This mechanism comprises a drive pulley 128 secured, as shown in Figure 3, to the outer end

of the extension 117' of the crank pin 117. The pulley 128 may be secured to said extension in any suitable manner so as to rotate in unison therewith. The pulley 128 is connected by a belt 129 to a similar pulley 130 secured to the crank pin 122, so that said pulley and crank pin will rotate in unison. Pulleys 128 and 130 are thus maintained in fixed spaced relation with respect to each other and the pulley 130, as shown, is of slightly greater diameter than the pulley 128 so that the crank pin 122 will be rotated at a slightly slower rate of speed than the crank pin 117.

It will now be seen that this continuous rotation of the crank pin 122 will vary the distance between the axis of the extension 122' of said pin and the axis of rotation of the crank pin 117, that is, of shaft 6, and will therefore vary the effective length of the connecting rod 121. It therefore follows that a continual change will be produced in the cross stroke of each lens driving element due to a continual change in the lengths of succeeding strokes of the beam 51 and that the movement of the lens across the grinding surface of the lap will be correspondingly affected thereby. It will be seen from the foregoing description that the two reciprocative movements when combined with the two break-up movements will be synchronous and simultaneous, resulting in the travel of the lens across the face of the lap in serpentine paths and also in the gradual and continuous changing of these paths during successive lengthwise and transverse strokes of the lens driving elements, as clearly illustrated in Figures 28, 29, 30 and 31.

It will now be noted that inasmuch as all the co-acting relatively movable members of the mechanism mounted within the frame 1 are supported by bearings of the roller bearing type arranged in suitable housings to protect them from dust and other foreign material, the machine may be successfully operated without the use of an oil pump or a liquid lubricant being supplied to said bearings.

Pressure means

Each lens is yieldingly held against the surface of a lap 28 partially by the weight of the front end of the lens driving element 31 and saddle 55 and partly by means of an upright pressure rod 132 and a coil spring 133 mounted in said rod. The rod 132 is composed of two telescoping tubular sections 132' and 132'' and the spring 133 is mounted within said sections between opposite ends thereof. The inner section, as 132'', has the lower end thereof provided with a ball 134 which is adapted to releasably engage a seat 135 connected with the spindle 46 and which is formed by extending a portion of the outer end of said spindle, as shown in Figure 14. The upper end of the outer tubular section 132' is provided with a ball 134' which is seated in a socket 136 provided in the lower end of a stem 137 of a pressure gauge 138. The ball 134' is preferably secured in the socket 136 so that the pressure rod 132 will be secured to the pressure gauge 138. The pressure gauge is mounted upon an outwardly extending arm 139 formed integral with a supporting slide or bracket 140 mounted on a standard 141 secured to or made integral with the upper section 3 of the frame 1. The stem 137 is yieldingly urged downwardly to its lowermost position by a spring 142 coiled about said stem between the lower end thereof and a nut 143 engaging the threaded sleeve connected to the gauge 138 and which serves to clamp the gauge to the arm 139.

The bracket 140 is a tubular member which is mounted for vertical reciprocative movement upon the standard 141. The bracket 140 is maintained with the arm 139 in predetermined aligned relation with the corresponding spindle 46 of the respective lens driving element 31 by means of a screw 145 screw-threaded in the side of the bracket and which has the inner end thereof slidably received in a vertically disposed slot 146 provided in a guide post or a stud 147 secured to the upper end of the standard 141, as shown in Figure 14.

The vertical movement of the slide or bracket 140, and therefore the gauge 138, is controlled by a lever 150 which is rotatably mounted intermediate the ends upon a pin 151 secured to the upper end of the bracket 140. The upper or rear end of the lever 150 extends a short distance beyond the pin 151 and is pivotally connected, as at 152, to one end of a link 153 which has the other end pivotally connected at 154 to the upper section 3 of the frame 1, as shown in Figure 13. Mounted upon the pin 151 intermediate the lever 150 and bracket 140 is a ratchet wheel 155 which is secured by pins 156 to the bracket 140 to maintain said ratchet wheel against rotation. A ratchet pawl 157 is pivotally connected at 158 to the lever 150 at the lower or forward side of the pin 151. The pawl 157 is provided with a finger piece 157' which extends outwardly therefrom in close cooperative relation with the outer end of the lever 150 which is curved, as shown in Figure 13, to provide a finger piece 150'. The pawl 157 is urged into engagement with the ratchet wheel 155 by a spring 159 mounted in the lever 150 and which is adapted to engage the finger piece 157', as shown in Figure 16. The teeth, as 155', and the ratchet wheel 155 are arranged in one side portion thereof only so as to be engaged by the pawl 157 when pressure is being exerted by the spring 133 upon the lens driving element, or, in other words, when the bracket 140 is in a lowered position. When the action of the spring 133 upon the spindle 46 is to be discontinued, the bracket 140 and rod 132 are raised to an upper inoperative position by swinging the lever 150 about the pin 151 until the pivot 152 has passed downwardly and through the straight line extending between the pivot 151 and the pivot 154, whereupon the weight of the bracket 140, gauge 138 and rod 132 will counter-balance the action of the upper or inner end of the lever 150 and link 153 for releasably securing said bracket, gauge and rod in the upper position.

The rod 132 is maintained in cooperative engagement with the spindle 46 during the upward movement of the bracket 140 by a rod 160 which has the upper end portion extending through an aperture 139' formed in the arm 139 intermediate the bracket 140 and the gauge 138. The lower end of the rod 160 is secured in a ring 161 mounted upon the boss or hub portion 54' of the bracket 54 as shown in Figures 2 and 14. This ring 161 is removably mounted on the hub so that the bracket 54 may readily be removed from the spindle 46 and from said ring during the substitution of one bracket 54 for another. The upper end of the rod 160 is provided with a pair of nuts 162 so related to the ring 161 and arm 139 that prior to the rod 132 being moved out of engagement with the seat 135 as the bracket 140 is moved upwardly, said nuts will engage the arm

139 and subsequently cause the outer end of the spindle 46 to move upwardly in unison with the bracket 140. This upward movement of the spindle 46 is permitted by rotation of said spindle about the axes of the stub shafts 50 and 50' associated with the D frame 49 with which said spindle is connected.

It will be understood that there is one of these pressure devices for each of the lens driving elements, and the operation of each of these pressure devices will now be understood to be substantially as follows: After a lens secured to one of the saddles 55 has been placed upon a lap 28 the lens driving element 31 will be moved from the upper inoperative position downwardly by the operator swinging the lever 150 about the pin 151 to move the bracket 140 downwardly. It will be obvious that during this downward movement of the bracket the spindle 46 will move in unison with the arm 139 until the downward movement of the spindle is limited by the engagement of the pins 58 with the bearing members 57 provided on the saddle 55. During this downward movement of the bracket and spindle there will be no appreciable pressure inserted by the spring 133 upon the spindle. In other words, the pressure gauge 138 will have a zero reading. As soon, however, as the spindle 46 is maintained against downward movement by the engagement of the pins 58 with the bearings 57 when the saddle is supported by the engagement of the lens with the lap, any further downward movement of the arm 139 will tension the spring 133 by decreasing the over-all length of the rod 132. This pressure tension of the spring 133 will be registered in the gauge 138, so that the operator may readily determine the pressure being exerted by the spring upon the spindle 46 which will more or less accurately indicate the pressure between the lens and the grinding surface of the lap. When the downward movement of the bracket 140 is sufficient to produce the required tension of the spring, the bracket may be secured in that position by the engagement of the ratchet pawl 157 with the ratchet wheel 155. When the lens is again to be released from the lens driving element, this may be readily accomplished by the operator using the finger pieces 150' and 157' to move the pawl 157 out of engagement with the ratchet wheel 155 against the action of the spring 159, after which the lever 150 may be readily moved to its uppermost position and thus move and maintain the lens driving element in its uppermost inoperative position.

Rouge pump

In order that rouge may be applied to the grinding surface of the lap during the polishing of lenses, I have provided a simply constructed pump attached to the catch basin 39. This pump comprises a pump case 165 which is secured to one end of the catch basin 39 by one or more screws 166. This pump case is provided with a pump chamber 167 in which is rotatably mounted a rotary pump 168 which is secured to the lower end of a motor shaft 169 as shown in Figures 10 and 12. The shaft 169 extends upwardly from the pump chamber and case 165 through a vertically disposed standard 170 connected at its lower end to the case 165. The upper end of the standard is connected with and supports an electric motor 171 connected with the opposite or upper end of the shaft 169. The standard 170 is provided with suitable bearings 172 in which the shaft 169 is journaled.

The intake side of the pump chamber 167 is connected by an inlet passage 174 provided in the case 165 with the adjacent end of the interior of the catch basin 39 which has the bottom wall 38 thereof inclined upwardly from the inlet opening 174 to the opposite end of the catch basin, as illustrated in Figure 10. The case 165 is also provided with an outlet or discharge passage 175 which has the outer end thereof registering with the interior of the catch basin 139 adjacent the outer or front wall thereof, as illustrated in Figure 12. The end wall of the catch basin adjacent the pump case 165 is provided with an opening 174' registered with the inlet opening 174 in said case and a second opening 175' in registration with the exhaust passage 175.

A distribution tube 176 is positioned in the catch basin 139 to extend from within the opening 175' along the front side wall of the catch basin and then inwardly along the end wall of said basin opposite the pump case, as illustrated in Figure 2. The tube 176 has the outer end thereof adjacent the rear wall of the catch basin closed and is provided with a pair of laterally projecting tubes 177, one for each lap 30. These lateral tubes 177 extend upwardly and inwardly from the distribution tube 176 to a position adjacent to and slightly above the corresponding lap 28 for continually supplying said lap and the lens surface being ground thereon with rouge. The excess rouge deposited upon the lens and lap flows downwardly to the inclined wall 38 of the catch basin and then down said wall to the opening 174' and inlet passage 174 back to the pump 168. The distribution tube 176 merely rests upon the bottom wall 38 of the catch basin when the inlet end thereof is inserted in the discharge opening 175' of the catch basin, so that said tube may be readily removed for the purpose of cleaning or for any other reason, by simply lifting the tube out of the catch basin. It is obvious that the tube may as readily be placed in operative position within the catch basin by inserting the inlet end thereof in the opening 174' and positioning the laterally disposed opposite end of the tube along the end of the catch basin opposite the pump.

As hereinbefore stated, the rouge pump 168 and distribution tube 176 are used to supply rouge to the grinding surface of the laps when polishing lenses. When it is desired to use a grinding compound such as emery dust or the like, in grinding a lens, the catch basin 39 together with the pump 168 and motor 171 are removed from the supporting frame 1 by the manipulation of the bolts 43 and washers 44 in the manner hereinbefore described, and another catch basin of suitable structure and design for collecting the dust and excess grinding compound may be secured to the supporting frame by the screws 43 and washers 44 in the same manner in which the catch basin 39 is secured to said frame.

Although I have shown and particularly described the preferred embodiment of my invention, I do not wish to be limited to the exact construction shown, as various changes, both in the form and relation of the parts thereof, may readily be made without departing from the spirit of the invention as set forth in the appended claims.

I claim:

1. In a surface grinding and polishing machine having a grinding member and a work

holding member, operating mechanism for producing relative movement of said members comprising a rotary drive shaft having an eccentric, a connecting rod journaled on said eccentric, a driven element journaled on the connecting rod having an eccentric operatively connected with one of said members for producing reciprocative movement thereof, means for transmitting rotary movement from the drive shaft to the driven element comprising a pulley secured to the eccentric of the drive shaft, a second pulley connected to the driven element to rotate therewith, and a flexible friction belt connecting said pulleys.

2. In combination, an actuating member mounted for reciprocative movement in two directions, means for reciprocating the member in one of said directions, and additional means for reciprocating the member in a second of said directions comprising a drive element mounted to revolve about a fixed axis, means including a head journaled on the drive element and a connecting rod fixedly secured to said head and to the actuating member operatively connecting the drive element with the actuating member, said connecting rod being adapted to flex laterally during the reciprocative movement of the actuating member in the first of said directions.

3. The combination with an actuating member mounted for reciprocative movement, of a drive mechanism for producing reciprocation of the actuating member through strokes of varying lengths comprising a driven shaft mounted to rotate about a fixed axis, a second shaft having an eccentric and mounted in spaced relation to the driven shaft, means operatively connecting the eccentric with the actuating member, means including a pair of gears one secured to the second shaft and the other secured to the driven shaft and meshing with said first mentioned gear operatively connecting the second shaft with the driven shaft whereby the second shaft will be rotated by the driven shaft at a different rate of speed than that of said driven shaft, and separate means connecting said shafts whereby the second shaft will be revolved by the driven shaft about an axis arranged in eccentric relation with the axes of rotation of both of said shafts including a rotatable sleeve rotatably supporting said second shaft in eccentric relation with the axis of rotation of said sleeve, and a second pair of intermeshing gears secured to said sleeve and driven shaft respectively.

4. The combination with a rotary drive shaft and an actuating member mounted for reciprocative movement, of two drive mechanisms operatively connecting the shaft with the actuating member for producing two reciprocative movements thereof operating in directions at substantially right angles to each other and through strokes of varying lengths, one of said drive mechanisms comprising a driven shaft mounted to rotate about a fixed axis, a second shaft having an eccentric and mounted in spaced relation to the driven shaft, means operatively connecting the eccentric with the actuating member, means operatively connecting the second shaft with the driven shaft whereby the second shaft will be rotated by the driven shaft at a different rate of speed than that of the driven shaft, separate means connecting said shafts whereby the second shaft will be revolved by the driven shaft about an axis arranged in eccentric relation with the axes of rotation of both of said shafts, and means including a belt operatively connecting the driven shaft with said drive shaft independently of the other one of said drive mechanisms.

5. The combination with an actuating member mounted for reciprocative movement, of a drive mechanism for producing reciprocation of said member through strokes of varying lengths comprising a driven shaft mounted to rotate about a fixed axis, an eccentric sleeve mounted to rotate about a fixed axis arranged in predetermined spaced substantially parallel relation with said axis of rotation of said driven shaft, a second shaft journaled in said sleeve in eccentric relation therewith having an eccentric, means operatively connecting said shaft eccentric with the actuating member for producing reciprocation of said member, and means including two pairs of intermeshing gears rotatably connecting the driven shaft with the sleeve and with said second shaft, one pair of said gears being secured to the driven shaft and to the second shaft respectively, the gear on said driven shaft being eccentrically mounted with respect thereto, and the other pair of said gears being secured to the driven shaft and to the eccentric sleeve respectively, two of the gears of said pairs of gears being of different pitch diameter than the other two gears so that said second shaft and sleeve will be simultaneously rotated at different speeds.

6. The combination with an actuating member mounted for reciprocative movement, of a drive mechanism for producing reciprocation of said member through strokes of varying lengths comprising a driven shaft mounted to rotate about a fixed axis, an eccentric sleeve mounted to rotate about a fixed axis arranged in predetermined spaced relation to said axis of rotation of said driven shaft, a second shaft journaled in said sleeve in eccentric relation therewith having an eccentric, means operatively connecting said shaft eccentric with the actuating member for producing reciprocation of said member, means rotatably connecting the driven shaft with the eccentric sleeve and with said second shaft whereby said second shaft will be simultaneously rotated at different speeds, a drive shaft, means operatively connecting the drive shaft with the actuating member for producing reciprocative movement thereof in directions at substantially right angles to the direction of the first mentioned reciprocating movement, and means including a belt operatively connecting the drive shaft with said driven shaft.

7. In a surface grinding and polishing machine having a grinding element and a work holding element arranged in cooperative relation with each other, operating mechanism for producing relative movement of said elements comprising a rock frame mounted to swing about a fixed axis, a supporting floating member mounted in a plane above the rock frame, means including hollow frame members pivotally connecting the floating member to the rock frame whereby said floating member may be reciprocated in a direction extending substantially parallel with the axis of rotation of the rock frame, means connected with the rock frame for producing swinging movement thereof and the floating member about said axis, means operatively connecting the floating member with one of said elements, means for producing reciprocative movement of the floating member independently of said swinging movement thereof including a flexible substantially straight connecting rod extending through the hollow frame intermediate the rock frame and said floating member and fixedly

connected with the floating member, and means connected with the connecting rod for producing reciprocative movement thereof in a direction substantially parallel with said axis of rotation of the rock frame.

8. In a surface grinding and polishing machine having a grinding member and a work holding member, in combination, operating mechanism for producing reciprocative movement of one of said members with respect to the other member including a supporting floating element pivotally mounted to reciprocate in two directions substantially at right angles to each other, a D-frame arranged in substantially parallel relation with the floating element and pivotally connected to said element in coaxial relation therewith and to rotate about an axis extending substantially parallel with one of said directions of reciprocation of said floating element, a spindle journaled in said D-frame with the longitudinal axis thereof intersecting said axis of rotation of said D-frame substantially normal thereto, a saddle connected with said one of the members to extend to opposite sides thereof, means including a forked bracket connected with the spindle, and pivotal bearing means associated with the bracket and saddle arranged substantially in a plane extending diametrically through said spindle for operatively connecting the spindle with the ends of said saddle.

9. A structure as in claim 8 having means operatively engaging the spindle for maintaining the work carried by the work holding member in pressure engagement with the grinding member.

10. In a surface grinding and polishing machine having a grinding member and a work holding member mounted in cooperative relation with each other, means including a driving element operatively connected with one of said members for producing relative movement of the members with respect to each other, and means for maintaining the work carried by the work holding member in pressure engagement with the surface of the grinding member including a spring, a support for said spring having engagement with the driving element, manually operated means connected with said driving element and spring support for moving the same and the member connected therewith toward and from the other member, means connected with the manually operated means and spring support for tensioning the spring carried by said support after the work is brought into engagement with the grinding member, and a pressure gauge carried by the manually operated means and connected with the spring for indicating the amount of pressure between the work and the grinding member.

11. A structure as in claim 10 having means including a ratchet wheel and pawl associated with the manually operated means and spring support for releasably maintaining the spring at a selected one of a plurality of predetermined tensions.

12. In a grinding and polishing machine of the class having a supporting frame, a grinding member mounted on said frame, a work holding member arranged in cooperative relation with said grinding member, and operating means including a driving element connected with the work holding member for producing movement thereof with respect to the grinding member to effect grinding of the surface of the work carried by said work holding member, the combination with said frame and operating means of means for maintaining the work in predetermined pressure engagement with the grinding member comprising a pressure rod composed of telescoping sections, having engagement at one end with the driving element, means including a supporting member connected with the frame for movement toward and from the driving element and supportably engaging said pressure rod, additional means connected with the driving element and engaging the supporting member at a predetermined position of said member for causing the driving element to move toward and from the grinding member during a portion of the movement of the supporting element, and means including a spring mounted in the pressure rod rendered effective after the work carried by the work holding member is brought into engagement with the grinding member for producing a predetermined pressure between said work and grinding members.

13. In a surface grinding and polishing machine having a grinding member and a work supporting member arranged in cooperative relation with each other, a catch basin mounted beneath said members and provided with a pair of fluid passages in communication with the interior thereof, a pump secured to the catch basin with the inlet port in communication with one of said fluid passages and the exhaust port thereof in communication with the other one of said fluid passages, and a conduit removably connected with the catch basin in communication with the last mentioned fluid passage adapted to supply rouge between the work carried by the work supporting member and the grinding member.

14. In a precision surface grinding and polishing machine of the character described wherein a grinding member and a work holding member are mounted in cooperative relation with each other, in combination, operating mechanism for producing relative movement of said members comprising a rotary drive shaft having an eccentric, a connecting rod journaled on said eccentric, said connecting rod having a bearing member mounted in spaced relation to the shaft eccentric, a rotary driven element rotatably mounted in said bearing member to be carried by the connecting rod, means for transmitting rotary motion from the drive shaft to said driven element including a pulley secured to the eccentric of the drive shaft, a second pulley secured to the driven element in coaxial relation with the bearing member, a flexible belt connecting said pulleys, and a second connecting rod rotatably connected with the driven element in eccentric relation to said bearing member operatively connecting the driven element with one of said members.

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