

Feb. 18, 1969

R. K. LANMAN

3,427,751

DIE FINISHING MACHINE

Filed June 29, 1965

Sheet 1 of 2

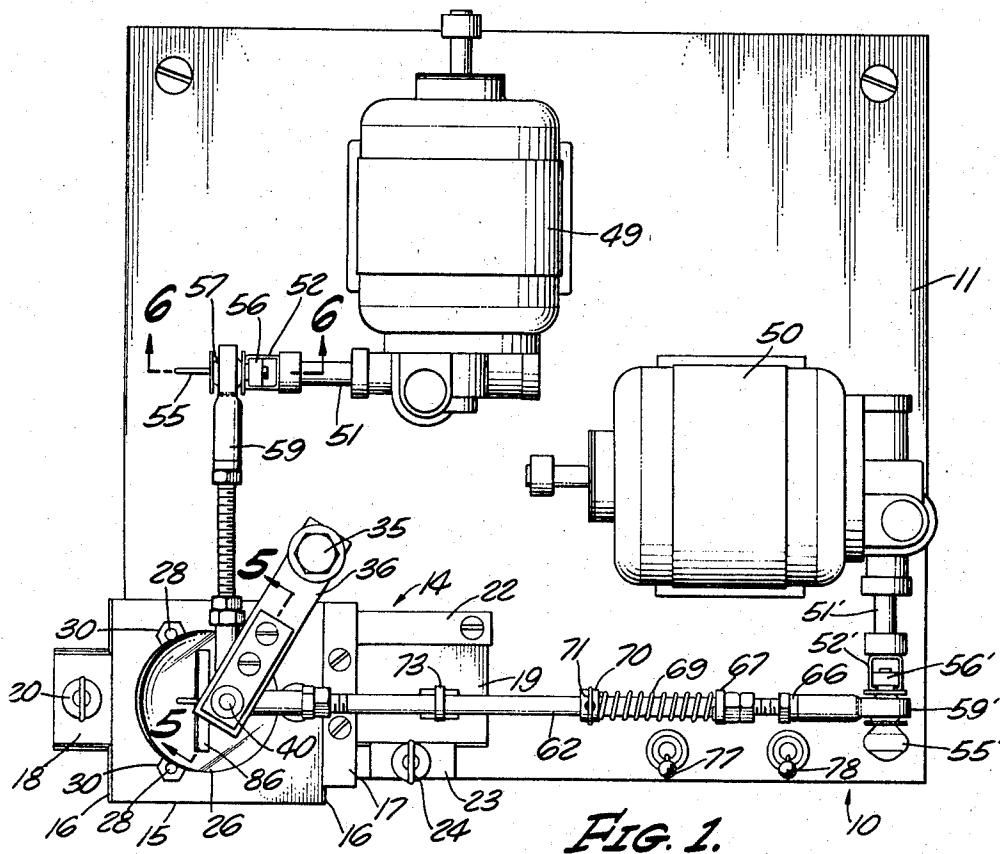


FIG. 1.

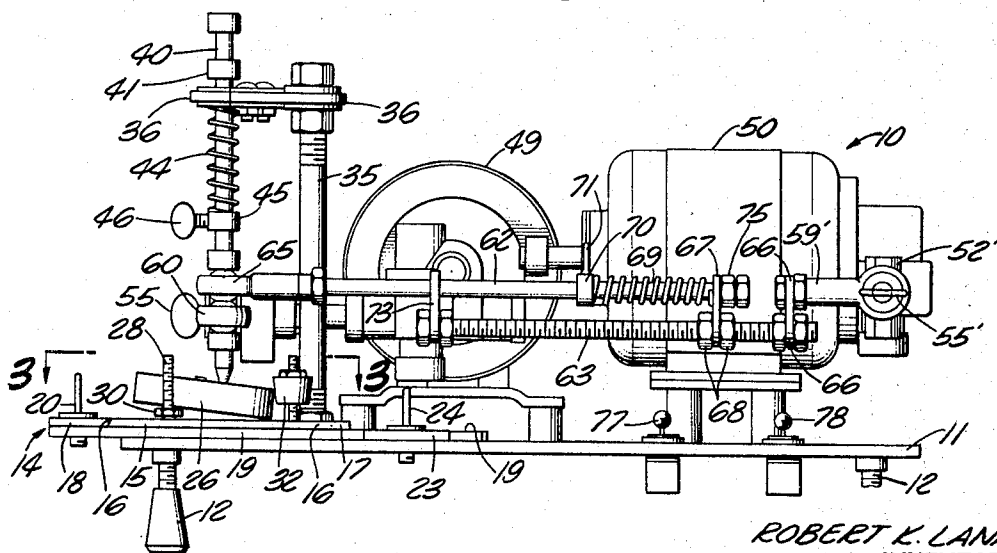


FIG. 2.

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Sheet 2 of 2

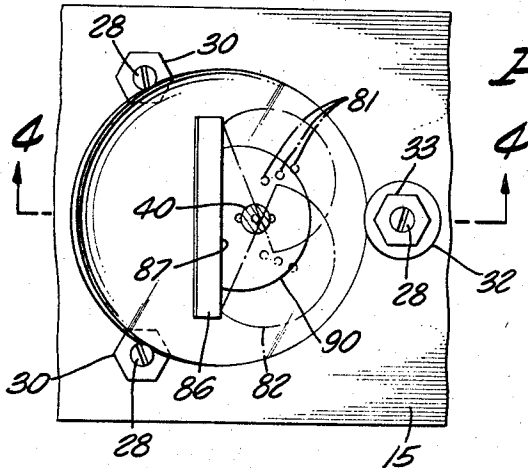


FIG. 3.

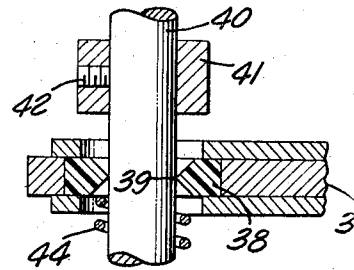


FIG. 5.

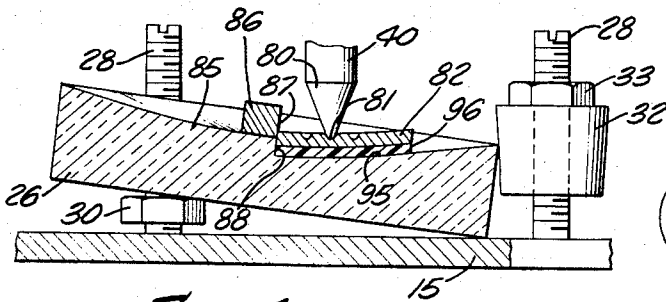


FIG. 4.

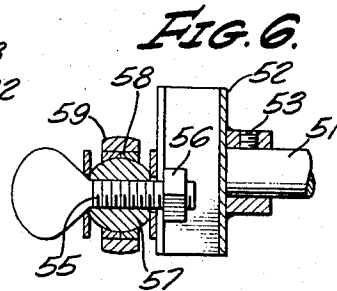


FIG. 6.

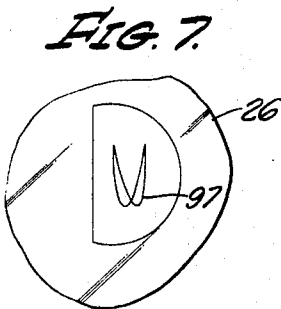


FIG. 7.

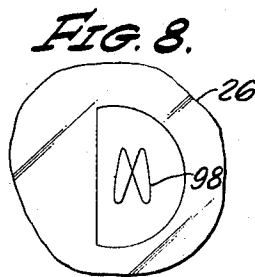


FIG. 8.



FIG. 9.

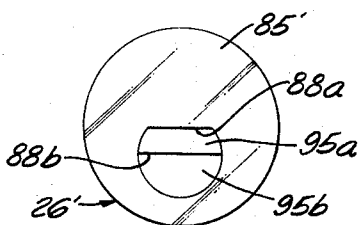


FIG. 10.

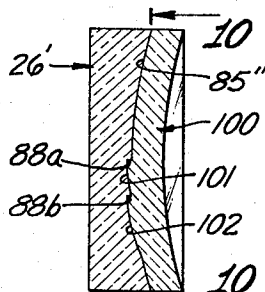
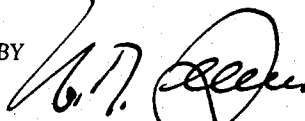


FIG. 11.

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3,427,751

DIE FINISHING MACHINE

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U.S. Cl. 51—57

17 Claims

Int. Cl. B24b 7/00, 9/00

ABSTRACT OF THE DISCLOSURE

A high precision machine for shaping and polishing the surfaces of dies for use in casting optical elements with bifocal and trifocal finished surfaces. The machine includes means for grinding and polishing surfaces of different local lengths in the principal non-planar surface of a die with one portion of the depression merging smoothly and imperceptibly with the surrounding die surface and another portion connected to an adjacent die surface by a long narrow polished surface generally normal to both the die and the depression surfaces. The driving means for the grinding and polishing subassembly is arranged to move through a continually changing excursion path.

This invention relates to lapping and polishing apparatus and more particularly to a high precision apparatus for grinding, lapping and polishing a lens casting die member having a flat top reading segment offset from the center of a distance segment and all peripheral edges of which merge with the reading segment in a precise manner.

Casting optically precise bifocal plastic lenses has presented serious problems because of difficulties encountered in making the die members with the requisite preciseness. In particular it is most desirable that the reading portion of the bifocal lens merge with the distance section along a generally straight line located along or closely offset from the center of the distance section. Satisfying this desirable objective requires that the surface of the relatively long radius distance segment be connected with the relatively short radius reading segment along a low-height wall normal to the two curved surfaces. This vertical wall must be lapped and polished with the same preciseness as the other surfaces and must merge with the differently curved distance and reading segments sharply and precisely.

Accordingly it is a primary purpose of this invention to provide a machine suitable for grinding, lapping and polishing a wide range of sizes of die members suitable for casting optical quality plastic lenses having finished bifocal surfaces and featuring a flat top junction between the distance and reading segments. The invention apparatus meeting these requirements has chucking means for supporting the die member being processed in any desired position. Overlying the center of the area being treated is a pressure applying spindle mounted for universal movement and bearing against a pressure pad having a radius corresponding to that of the surface being treated. Arranged to drive the pad over an intricate lapping path are a pair of motors having driving connections to the pressure spindle lying at right angles to one another. The two motors operate at different speeds and cooperate with other components in providing an ever-changing lapping path. The straight upright wall junction desired between the distance and reading segments is obtained with the aid of a rigid stop providing a limiting abutment cooperating with the adjacent similarly-shaped edge of the pressure pad. A lost motion connection in the drive means of one motor makes it possible to hold this edge of the pad against the abutment while the other motor, at times,

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reciprocates the pad back and forth parallel to the abutment during a portion of certain lapping excursions.

It is therefore a primary object of the present invention to provide a novel grinding, lapping and polishing apparatus for making dies suitable for casting optically finished plastic lenses.

Another object of the invention is the provision of apparatus for lapping and polishing a lens die with segments of different radius and merging with one another along precisely shaped lines and more particularly one line of which comprises a vertical wall located closely adjacent the center of the distance segment.

Another object of the invention is the provision of an apparatus for making lens casting die members to different specifications and each having a distance segment surrounding a reading segment with one edge of the line of merger between the two segments comprising a straight wall interconnecting and lying normal to these two segments.

Another object of the invention is the provision of precision lapping and polishing apparatus for making adjacent optical surfaces of different radius merging with one another with optical preciseness.

Another object of the invention is the provision of lapping and polishing apparatus for making die members having optical surfaces of different radius and which apparatus utilizes a pivoting pressure applying surface finishing member arranged to be driven in an intricate ever-changing path and driven by the conjoint action of a pair of motors arranged to drive the spindle in a different path and at different speeds.

These and other more specific objects will appear upon reading the following specification and claims and upon considering in connection therewith the attached drawings to which they relate.

Referring now to the drawings in which a preferred embodiment of the invention is illustrated.

FIGURE 1 is a top plan view of a preferred embodiment of the grinding and polishing apparatus;

FIGURE 2 is a front elevational view of FIGURE 1; FIGURE 3 is a fragmentary top plan view on an enlarged scale taken along line 3—3 on FIGURE 2;

FIGURE 4 is a fragmentary view on an enlarged scale taken along line 4—4 on FIGURE 3;

FIGURE 5 is a fragmentary view on an enlarged scale taken along line 5—5 on FIGURE 1;

FIGURE 6 is a fragmentary view on an enlarged scale taken along line 6—6 on FIGURE 1; and

FIGURES 7, 8 and 9 are fragmentary top plan views indicating diagrammatically typical ones of the ever-changing lapping excursions obtained with the invention apparatus;

FIGURE 10 is a top plan view of a die member formed to cast a trifocal plastic lens; and

FIGURE 11 is a sectional view of the FIGURE 10 die member and a plastic lens blank cast therefrom before being separated.

Referring initially to FIGURES 1 to 2, there is shown a preferred embodiment of the invention apparatus designated generally 10 having a rigid base 11 suitably supported on feet 12. A clamping facility 14 for the die member undergoing processing is secured to one corner of base 11. This facility includes a supporting chuck 15 for the die member having beveled opposite lateral edges 16 which edges are slidable lengthwise between a fixed clamping jaw 17 and a movable clamping jaw 18 both mounted on a carrier plate 19. Movable jaw 18 can be clamped against chuck 15 by manipulation of a thumb screw 20. Carrier plate 19 is similar to chuck base plate 15 except that it is slidable along a path at right angles to the movement of the chuck between a fixed clamping jaw 22 and an adjustable jaw 23. The latter can be tightened

by a thumb screw 24 to lock slide 19 firmly and immovably in place. From the foregoing it will be clear that chuck 15 can be shifted in any horizontal direction and as necessary to center the die member being processed precisely in the position desired.

Usually the die member to be ground and polished comprises a circular disc 26 of suitable material, such as glass, having a flat bottom surface and a concave upper surface. This die member must be rigidly and fixedly supported in chuck 15 throughout the grinding and lapping operation. For this purpose the chuck here shown has three rigidly supported threaded posts 28 arranged equidistantly from one another and suitably secured to the chuck. It is important that the spherical surface undergoing processing be located in a level position directly beneath the pressure applying spindle for the pressure pad. This requirement usually necessitates supporting die member 26 in a canted position with one rim edge, as its right hand edge as viewed in FIGURE 1, resting against the top surface of chuck plate 15 and with its bottom surface supported at a proper angle relative to the horizontal. As herein shown this is accomplished by providing the two left-hand posts 28 with resting pads 30, 30 adjustable therealong and underlying the left-hand edge of the die member. These pads are so adjusted along the posts as to support die 26 with the spherical reading segment surface being processed directly underlying the pivot axis for the pressure applying polishing spindle. The die is firmly clamped in this position by a wedge member 32 loosely mounted on the third post and arranged to be clamped against the adjacent upper rim corner of the die by nut 33.

Rigidly secured to the apparatus base plate 11 is a bracket 35 having an arm 36 clamped to its upper end with its free end overlying the above-described chucking assembly for the die member. Suitably secured in an opening at the outer end of arm 36 is a universal pivot bearing 38 preferably formed of nylon, Teflon, or the like suitable bearing material. Bearing ring 38 has an inwardly facing annular knife edge 39 having a loose sliding fit with the upper end of a spindle 40. A collar 41 secured to this spindle above arm 36 by a set screw 42 is normally adjusted to be out of contact with bracket arm 36 so long as a die member is undergoing processing in the chucking device. However when a die is not present in the chuck, collar 41 bears against the upper side of arm 36 and supports the spindle with its lower pointed end out of contact with chuck 15. A light compression spring 44 encircles spindle 40 below arm 36 with its lower end bearing against a collar 45 adjustably secured to the spindle by thumb nut 46 and enables the operator to adjust the downward pressure applied to the spindle by spring 44.

The means for driving spindle 40 through an intricate ever-changing excursion path comprises a pair of electric motors 49, 50 secured to base 11 with their axes lying at right angles to one another. Each motor is provided with speed reduction gearing of different ratio with motor 49 operating at approximately double the speed of motor 50. Output speeds found satisfactory are 288 r.p.m. for motor 49 and 150 r.p.m. for motor 50. Each motor has an adjustable crank secured to its output shaft. For example, referring to FIGURE 6, it will be seen that shaft 51 of motor 49 has a channel-shaped crank member 52 secured crosswise of its end by set screw 53. A crank pin adjustable along channel member 52 is here shown as comprising a thumb nut 55 having its shank extending through the slotted face of member 52 and into a nut 56. Mounted on the shank of the thumb screw is a sphere 57 which is journaled in a complementally shaped bearing 58 carried on the adjacent end of connecting rod 59. It will be appreciated from the foregoing that members 58 and 57 form a universal bearing. A similar universal bearing 60 is provided between the other end of the connecting rod and spindle 40.

The adjustable crank and coupling assembly between

the shaft of motor 50 and its connecting rod is the same as that just described and, for this reason, the corresponding components of that crank have been given the same reference characters distinguished by the addition of a prime. However for reasons which will become evident below the connecting rod between motor 50 and spindle 40 preferably includes a suitable lost motion connection since its effective stroke differs from time to time. A suitable construction meeting these requirements is shown in FIGURES 1 and 2 and will now be described.

Basically this connecting rod comprises two main portions 62, 63 lying closely parallel to one another, portion 62 being connected to spindle 40 through a universal coupling 65, and portion 63 being connected to the driving crank by rigid bracket 66. A second bracket 67 is rigidly but adjustably connected to section 63 by lock nuts 68 and its upper free end having a close sliding fit lengthwise of rod 62 and supporting the right hand end of a light compression spring 69. The other end of spring 69 bears against a collar 70 held adjustably clamped along rod 62 by thumb nut 71. If desired a further guide support for the left hand end of rod 63 is provided by a bracket 73 clamped to rod 63 and having a loose fit with rod 62.

From the foregoing it will be understood that motor 50 and its crank assembly is effective to drive spindle 40 so long as there is no interference with its full stroke in a left-hand direction. However, if resistance is encountered in excess of the strength of spring 69 then portion 63 of the compound rod assembly continues to move to the left as spring 69 undergoes compression but without producing any movement of rod 62. Spring 69 continues to hold rod 62 pressed to the left until rod 63 moves to the right sufficiently for bracket 67 to contact stop nuts 75 whereupon portion 62 of the rod then moves to the right in unison with rod 63. Each motor is controlled by its own switch, as by the snap action switches indicated at 77 and 78.

Referring now more particularly to FIGURES 3 and 4 it is pointed out that spindle 40 is provided with a hardened and pointed lower end 80 which seats in a cooperating depression 81 formed in the upper surface of a suitable shaped pressure pad 82. Usually the reading segment of the die surface being processed is spherical with one rim edge straight. In this event pressure plate 82 is of similar shape and substantially larger in area. As herein shown, the upper surface of die member 26 has been previously processed with a concave surface 85 coextensive with the upper face of the die member. This distance segment has a relatively long radius as compared with that of the reading segment. After the distance surface has been lapped and polished to the fineness and accuracy required for casting an optically finished plastic lens, there is suitably fixed thereto a rigid abutment block 86. A suitable adhesive may be used to hold stop 86 firmly in a desired position with its face 87 directly overlying the vertical wall 88 to be formed, lapped and polished in preparing the mold cavity for the reading segment of the lens, the semi-spherical contour of the reading segment being indicated at 90 in FIGURE 3.

OPERATION

The operation of the apparatus described above will be understood in general from the foregoing detailed description of its components and their structural and functional relationship to one another. In preparing the apparatus for use, the operator places a die member 26 having its cavity 85 already finished and having an abutment block 86 already mounted thereon in chuck 15 in the manner described above. The clamping nut 33 on the right hand clamping post is loosened and nuts 30, 30 of the other two posts are properly adjusted to support the die member at an appropriate angle with the focal point of the reading segment surface directly beneath the center of universal bearing 38 for spindle 40. When this position has been ascertained by technique well known to those familiar with the grinding and lapping of spherical die surfaces,

nut 33 for the wedge clamping member is tightened to anchor member 26 firmly in chucked position.

Thereafter, a pressure pad 82 having a spherical lower surface of the focal length desired for surface 95 of the reading segment is inserted beneath the tip 80 of spindle 40. Usually, at the start of the grinding operation the spindle tip is placed in the depression 81 closest to the straight edge of the pressure pad since the major portion of the material must be removed from the area closest to the vertical wall 88. An appropriate slurry is applied beneath the pad and the throw of crank 52' for motor 50 is adjusted to provide a relatively short stroke as compared to the stroke of the crank for motor 49. Additional slurry is added from time to time as necessary and the operator may find it desirable to increase the throw of crank 52' slightly by appropriate adjustment of thumb screw 55'. It may also be desirable to shift the position of the spindle into one of the other depressions 81 as grinding progresses.

After the reading segment has been ground to a desired size and depth, the operator will wish to proceed with the polishing and lapping operation. Desirably this is performed using the same size pressure pad 82 but with its lower surface accurately coated with a thick layer 96 of pitch or the like. Care is taken to provide a layer of uniform thickness and, in particular, to have its straight edge coplanar with the straight edge of the pad and parallel to the straight wall of abutment 86. The pressure pad is now reassembled beneath the pointed end of the spindle and a suitable polishing powder well known to those skilled in this art is applied between the surface of the pitch and reading segment 95. Normally, the center one of the depressions 81 is used to seat the spindle. It will be understood that all of depressions 81 are so located as to lie appreciably inside rim 90 (FIGURE 3) of the reading segment in all positions of the pressure pad during the grinding and finishing operations.

It will be understood that the operator usually makes frequent checks of the various adjustments including the throw of cranks 52, 52', the pressure exerted by spindle spring 44, the amount of lost motion between the two parts 62, 63 of the connecting rod for motor 50. It may also be desirable to adjust the bias on spring 69 by changing the position of collar 70 along rod 62. Initiation of either the grinding or polishing operation occurs by closing the two motor switches 77, 78. These motors then cooperate in driving spindle 40 through an intricate, ever-changing excursion path. FIGURES 7, 8 and 9 indicate in a general way the nature of this lapping circuit. Thus the closed loops 97, 98 and 99 represent three radically different illustrative excursions or paths traversed by the pointed end 80 of spindle 40. Owing to the different lengths of the strokes, the intervention of the lost motion connection in rod 62, 63 and the materially different operating speeds of the two motors it will be quite apparent that the route taken by the tip of the spindle is constantly and everlastingly changing as is highly important in high accuracy lapping operations. Under certain conditions pressure pad 82 moves strictly in a straight line parallel to face 87 of the fixed stop 86. When so operating the juxtaposed surface of the resin layer 96 and its film of polishing compound are effective to polish and lap the vertical wall 88. During other parts of the operating cycle pressure pad 82 may have only point contact with stop 86, the straight edge of the pressure pad then being canted at an angle to the stop with one or the other of its ends in contact with the stop. Both of these momentary positions are illustrated in dot and dash lines in FIGURE 3.

It is pointed out and emphasized that irrespective of whether the apparatus is being used for grinding, lapping or polishing, the general mode of operation is the same with the exception that a different working compound may be applied to the surface undergoing processing. It will also be apparent from the foregoing that the pressure

applied to the pressure pad is always applied along the axis of spindle 40 which always is positioned within the confines of the reading segment with the result that there is no tendency to round off the line of merger between the reading and distance segments. On the contrary, a very sharp and circular merger line exists between these two segments.

It will be equally apparent that the flat top wall portion 88 of the reading segment cavity is truly flat and coincident with the accurately finished surface 87 of stop member 86. The merger of straight wall 88 with the bottom of the reading segment cavity and with the distance segment is also truly optically sharp and coincident with the spherical surfaces of the respective segments.

The same general procedure is employed in preparing a die member for casting trifocal lenses, thus referring to FIGURE 10, there is shown a die member 26' for casting such a lens. The distance segment 85' differs in no important particular from the corresponding surface of die member 26. However, the cavity for the reading segment is formed with two reading segments of different radii and herein designated 95a and 95b. Segment 95a merges with a straight wall 88a corresponding with wall 88 of the first described bifocal die member; a second vertical wall 88b parallel to wall 88a is formed between the two reading segments.

The above described apparatus is used to grind and polish each of these reading segments in the same general manner described above. Usually, the fixed abutment 86 is first applied in a position for grinding and polishing wall 88a and reading segment 95a. After these surfaces have been properly finished, abutment 86 is moved to lie opposite the position desired for the optically finished surface for wall 88b following which the operator proceeds as before to grind and to polish reading segment 95b.

FIGURE 11 shows a trifocal lens 100 cast in a mold using die member 26'. The second and conventional die member used in casting the concave face of the lens blank is not shown since it is well known. It will be understood that all surfaces of lens blank 100 in contact with die member 26' are fully finished optical surfaces and that the only finishing operation required is that customarily employed in finishing the right-hand or concave face with the desired prescription surface prescribed for use by the purchaser of the lens. Distance segment 85'' and each of the slightly different reading segments 101 and 102 are completely finished and ready for use as soon as removed from die member 26', and this is equally true of the flat polished surfaces formed by die member surfaces 88a and 88b. It will, therefore, be understood that the cast multifocal lens of either bifocal or trifocal design forms a novel feature of the present invention.

While the particular high precision machine for grinding, lapping and polishing dies for casting optical lenses herein shown and disclosed in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiment of the invention and that no limitations are intended to the details of construction or design herein shown other than as defined in the appended claims.

I claim:

1. Apparatus for grinding and lapping a die for casting on a lens a first precision optical surface merging at its rim with at least a second optical surface of different radius, said apparatus comprising clamping means for a precision casting die having a first finished casting surface facing outwardly, grinding and lapping pad means having a spherical lower surface having a radius corresponding to that desired for a second casting surface corresponding to a reading segment of the lens, fixed stop means securable in a fixed position on said first casting surface and engageable with an adjacent edge of said pad means to limit movement thereof in one direction while

grinding and lapping said second casting surface, movably supported pressure means for holding said pad means against said second casting surface and including means for moving said pad means through a continually changing excursion path including repeated intermittent contact of said pad means with said fixed stop means and cooperating therewith to control movement of said pad means thereby to form an elongated casting surface generally normal to said first and second casting surfaces and merging along its opposite longer edges with said first and second casting surfaces.

2. Apparatus as defined in claim 1 characterized in that said means for moving said pad means over said second casting surface includes a plurality of separate motion-imparting drive means for said pad means each operating at a different speed and in a different direction from the other and mutually cooperating to determine the excursion path of said pad means.

3. Apparatus as defined in claim 1 characterized in that said movably supported pressure means comprises elongated rigid means having a pointed end bearing against said pad means and a second end having a universal connection with fixed support means therefor, and spring means urging said pointed end against said pad means with a desired pressure.

4. Apparatus as defined in claim 2 characterized in that at least one of said drive means for said pad means includes a spring-biased lost-motion connection operating to drive said pad means against said fixed stop means and to hold it thereagainst as another of said drive means continues to move said pad means in a different direction.

5. Apparatus as defined in claim 2 characterized in that said plurality of drive means for said pad means includes a pair of prime movers having separate reciprocating drive connections to said movably supported pressure means and arranged generally at right angles to one another.

6. Apparatus for grinding a die for casting a plastic lens which die has a bifocal optical surface including a reading segment within the confines of a distance segment, rigid stop means having a straight edge adapted to be secured temporarily to said distance segment with its straight edge parallel to a straight edge portion to be formed along one rim of said reading segment, rigid pad means coated on one surface with cutting compound and shaped to correspond with the shape of said reading segment, pressurized means bearing against said pad means opposite the side bearing said coating and supported for limited universal movement transversely of said reading segment, and driving means connected to said pressurized means and operating to move said pad means in a continuously changing excursion path to grind and lap a flat top reading segment and having a side wall parallel to the straight edge of said stop means and wherein said side wall lies generally normal to the adjacent portions of said distance and reading segments.

7. Apparatus for forming a die member suitable for casting optical quality bifocal lenses and which die member has finished polished surfaces including a reading segment and a distance segment merging with a flat surfaced side wall between the reading and distance segments, said apparatus comprising chuck means for holding a lens casting die member, rigid stop means having a straight edge fixedly supported close to and parallel with the side wall between said reading and distance segments, pad means coated on its underside with cutting compound and shaped complementally to the surface of said reading segment and having a straight edge engageable at times with the straight edge of said stop means, and motor driven means for pressing said pad means against said reading segment and cooperating with the straight edge of said rigid stop means while moving said pad means in an ever changing excursion path restricted to said reading segment while grinding and finishing said reading segment to provide a reading segment having a long narrow polished surface lying generally normal to the surface of said reading segment.

8. Apparatus as defined in claim 7 characterized in that said motor driven means includes a first and a second motor having first and second reciprocating drive connections to said pad means, said first drive connection being arranged to shift said pad means generally parallel to the straight edge of said stop means and the second drive means being arranged to reciprocate said pad means toward and away from said stop means.

9. Apparatus as defined in claim 7 characterized in that said motor driven means includes a pair of independent motors operating at different speeds and including separate reciprocable drive connections coupled to means having a universal coupling with the central area of said pad means and cooperating to move the same in a changing path of intricate configuration.

10. Apparatus as defined in claim 9 characterized in that said universal coupling with said pad means is located inwardly of the rim edges of said reading segment in all operating positions of said pad means thereby to form a sharp-edged junction between said reading and distance segments.

11. Apparatus as defined in claim 8 characterized in the provision of a spring-biased lost-motion coupling in said second drive connection.

12. Apparatus as defined in claim 8 characterized in that said first and second drive connections each include a connecting rod having universal couplings at their ends.

13. Die grinding and polishing apparatus for use in grinding and finishing a female flat-top reading segment in a die member suitable for casting optical-quality bifocal lens from uncured plastic monomer, said apparatus having a main frame, chuck means thereon for supporting and gripping a die member therein and having a spherical concavity facing upwardly, bracket means overlying said chuck means and supporting a vertically disposed operating spindle means through a universal connection to said bracket, pad means coated with cutting compound on its underside and seated against the area of the die member to be formed with a reading segment, the lower end of said operating spindle means being pointed and seated in a depression in the upper side of said pad means, means applying pressure to said pad means, power-driven means including a plurality of individually controllable separate drive connections to the lower portion of said operating spindle means each operating at a substantially different speed and cooperating to move said pad means in a closed circuit of ever-changing configuration to form a reading segment having an arcuate rim merging sharply with the adjacent areas of the distance segment and a low-height straight wall lying normal to the reading and distance segments and merging sharply and generally at right angles with said reading and distance segments.

14. Apparatus as defined in claim 13 characterized in that said drive connections include a plurality of connecting arms connected to a crank arm of adjustable length to vary the effective throw of each connecting arm.

15. Apparatus as defined in claim 14 characterized in that one of said connecting arms includes a spring-biased lost motion connection.

16. Apparatus as defined in claim 13 characterized in the provision of rigid stop means having a straight edge, and means temporarily securing said stop means to said die member with said straight edge contiguous to the straight side wall portion of said reading segment but outside the confines of said reading segment.

17. Apparatus for grinding and polishing a die member for casting optical quality plastic lenses and which die member has a pair of merging optical surfaces of different radius interconnected by a polished wall lying normal to said pair of optical surfaces, said apparatus comprising clamping means for clamping a die member in a fixed position, spindle means lying normal to said pair of optical surfaces with one end facing toward said die member and having universal pivot means supporting the other end thereof for universal movement of said one end transversely of said optical surfaces, pressure pad means hav-

ing a spherical surface corresponding to that desired for a reading segment of the lens to be cast from said die member, said spindle being engageable in seating recess means in the outer surface of said pressure pad means, a pair of motors operating at different speeds and operably connected with said spindle means to pivot the same about said universal pivot means through a continually changing looped excursion path to grind and polish a reading segment surface in said die member and including a spherical surface and a long narrow surface generally normal to said spherical surface.

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LESTER M. SWINGLE, *Primary Examiner.*