

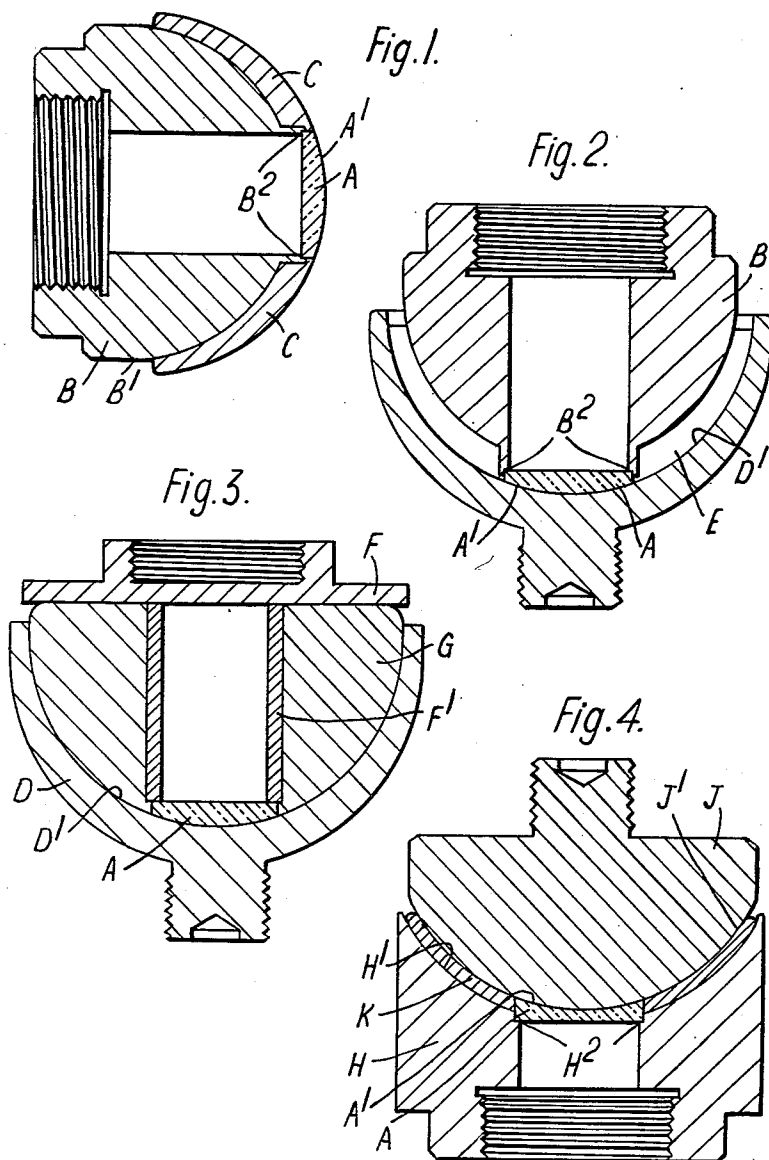
March 5, 1963

G. O. RAWSTRON
METHOD AND APPARATUS FOR POSITIONING
A WORKPIECE FOR POLISHING

3,079,739

Filed Feb. 16, 1960

3 Sheets-Sheet 1



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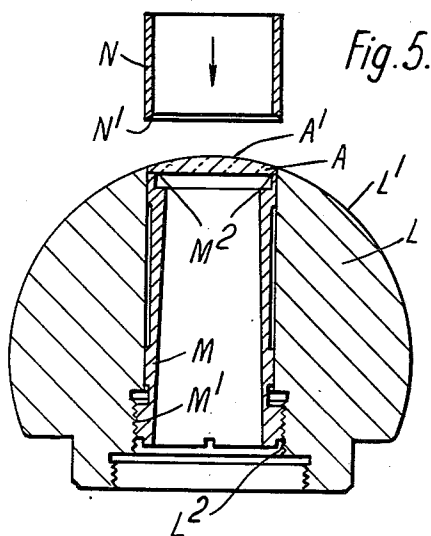


Fig. 5.

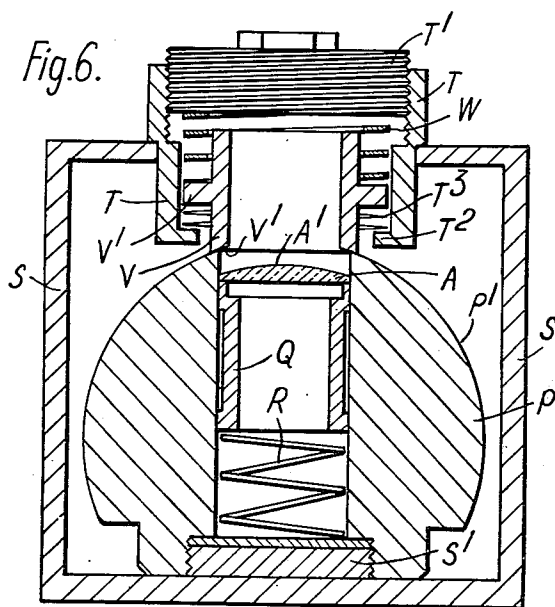


Fig. 6.

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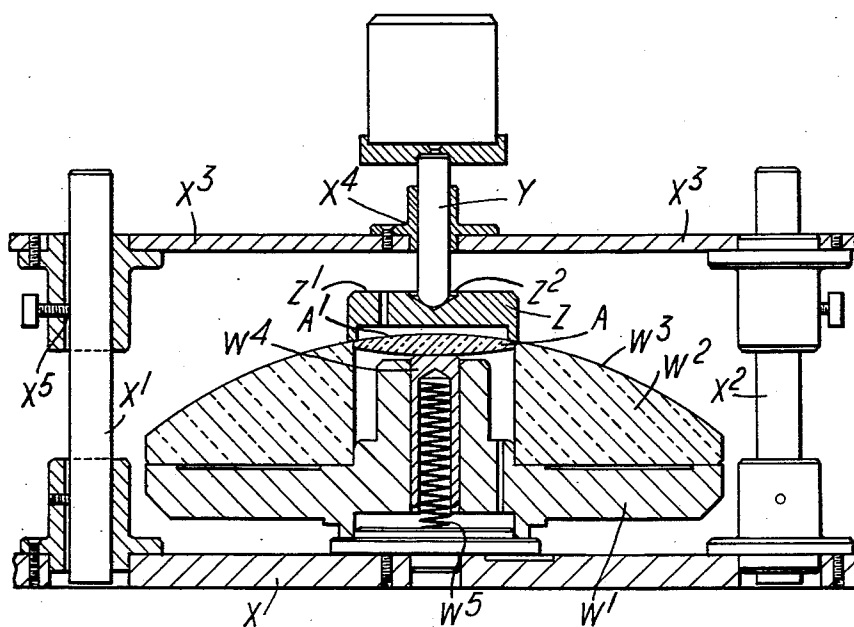
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Fig. 7.



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METHOD AND APPARATUS FOR POSITIONING A WORKPIECE FOR POLISHING

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Filed Feb. 16, 1960, Ser. No. 9,085

Claims priority, application Great Britain Feb. 18, 1959
5 Claims. (Cl. 51-277)

This invention relates to a workholder for a workpiece, such for example as an optical lens element, having a surface of revolution to be polished and also to the production of such a workholder. The surface to be polished may be constituted for example by a spherical surface or by an aspheric surface which deviates by only small amounts from a basic spherical surface.

In the polishing of a spherical surface or an approximately spherical surface or other surface of revolution, it is often found difficult to polish such surface near its periphery either as evenly or to such an adequate extent as the central portion of such surface.

The object of the present invention is to provide a workholder for the workpiece having the surface of revolution to be polished whereby the above-mentioned difficulty is satisfactorily overcome.

The workholder according to the invention comprises a main workholder body, means for supporting the workpiece on the workholder body, and an annular surround for the workpiece carried by or constituted by part of the workholder body, the inner edge of the surface of such annular surround coming very close at all points to the circular edge of the surface to be polished and such surface of the surround being so shaped that, in any plane through the axis of the surface to be polished, the adjacent portions of such two surfaces have at least approximately the same curvature.

In one arrangement the annular surround for the workpiece is constituted by a mass of resinous material on which is formed the shaped surrounding surface for the surface to be polished. Conveniently, such mass of resinous material may be constituted by a moulded annulus thereof on the workholder body.

Thus, in the case of an approximately spherical surface to be polished and which deviates by only small amounts from a basic spherical surface and does not intersect such basic spherical surface, the shaped surface of the resinous annular surround may conveniently at least approximate to an extension of the basic spherical surface associated with the surface to be polished. The annular surround will thus be formed with a mould having, in the case of a generally convex surface to be polished, a concave spherical surface of the largest radius, and in the case of a generally concave surface to be polished, a convex spherical surface of the smallest radius, which will contact the surface to be polished at its circular edge only.

However, the present workholder may also be applied to a workpiece having a surface of revolution to be polished other than an at least approximately spherical surface, such for example as a paraboloidal surface, and in the arrangement employing a moulded resinous surround, it is necessary to use a mould suited to such surface of revolution.

In an alternative arrangement, means are provided for adjusting the relative positions of the workpiece supporting means and the annular surround for the workpiece along the axis of such annular surround. For this purpose for example, the main workholder body may be formed in two parts, an outer annular part constituting the annular surround and an inner part adjustably movable relatively to the outer part along the axis thereof,

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the workpiece supporting means being carried by or constituted by part of the inner part of the workholder body. In this case, the two parts of the workholder body are preferably in screwthreaded cooperation for adjustment purposes.

The main workholder body may alternatively be formed in two parts however in an arrangement in which the outer annular part constituting the annular surround is employed to carry the workpiece. In this case, the two parts of the workholder are relatively adjusted correctly to position the workpiece relative to the annular surround, whereafter the workpiece is fixed in such correct position to such annular surround.

The above-described workholder having a workpiece accurately located therein may be produced in a variety of ways. Thus, in one method of producing the workholder according to the invention, the workpiece is attached to a main workholder body so that the surface to be polished is left exposed, a mould is located in position adjacent to the workpiece, such mould having a surface generally corresponding to a surface of revolution and which will contact the surface to be polished at its circular edge, whereby an annular space is formed between such mould and the workholder body around the workpiece, and such annular space is filled with a mass of resinous material which is allowed to set, whereafter the mould is removed.

Conveniently in this method, the workpiece may be attached to the workholder body by means of a wax material and the resinous material may be constituted by a cold-setting resin.

In an alternative method of producing the workholder having a workpiece accurately located therein according to the present invention, the workpiece is located within an outer annular part of a main workholder body having an inner workholder part axially movable within the outer part and for engagement with the workpiece, the outer workholder part being of a size just to receive the workpiece with the axis thereof collinear with the axis of such outer part and being formed with an annular surface so shaped that, in any plane through the common axis of the workpiece and such outer part, the inner edge portion of such shaped annular surface and the outer edge portion of the surface to be polished have substantially the same curvature, a stop effectively having a shaped annular positioning surface is located in engagement with the outer workholder part so that the outer edge portion of the shaped positioning surface abuts against the inner edge portion of the shaped annular surface of such outer workholder part, axial movement of the inner workholder part is effected to move the workpiece so that the outer edge portion of the surface to be polished abuts against the inner edge portion of the shaped positioning surface, and the stop is withdrawn to leave the workpiece correctly located in the workholder.

In this method, the workpiece may be secured by means of wax or other suitable securing material to the inner workholder part, or alternatively, after correctly positioning the workpiece by effecting axial movement of the inner workholder part within the outer workholder part, the workpiece may be secured by means of wax or other suitable securing material to the outer workholder part.

In the latter case, axial movement of the inner workholder part is preferably effected by means of a spring acting to urge the workpiece into its correct position, such workpiece then being secured to the outer workholder part before the stop is withdrawn. Thus, in one convenient method, the workpiece is initially located within the outer workholder part and secured thereto by means of a meltable securing material, heat is applied to melt

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such securing material so as to permit movement of the workpiece into its correct position under the action of the spring-pressed inner workholder part, and the securing material is allowed to cool so as to resecure the workpiece to the outer workholder part before the stop is withdrawn.

The invention may be carried into practice in various ways, but some convenient practical arrangements of workholder and methods of production thereof will now be described by way of example with reference to the accompanying drawings, in which

FIGURE 1 shows one convenient arrangement of workholder,

FIGURE 2 indicates a convenient method of producing the workholder of FIGURE 1,

FIGURE 3 shows a modified workholder arrangement during production thereof,

FIGURE 4 shows another modified workholder arrangement during production thereof,

FIGURE 5 shows a further workholder arrangement, FIGURE 6 indicates a method of producing yet another workholder arrangement, and

FIGURE 7 shows a modification of the method of production of FIGURE 6.

According to the arrangement of FIGURE 1, the workholder, for a workpiece A having a convex spherical surface A^1 to be polished, comprises a main body B for example of metal or of glass having a generally hemispherical surface B^1 whose curvature is approximately equal to that of the surface to be polished. At the centre of its generally spherical surface B^1 , the main workholder body B is provided with a cylindrical recess B^2 of just sufficient diameter to receive the workpiece A, which may for example be constituted by an optical lens element, and of depth less than the thickness of such workpiece. The lens element A is located in such recess B^2 with the surface A^1 to be polished exposed and standing out from the generally spherical surface B^1 of the main body B owing to the relatively small depth of the recess B^2 , which may conveniently be equal to about one half of the thickness of the lens element A. Over its generally spherical surface B^1 , the main workholder body B carries a moulded annular layer C of resinous material closely surrounding the workpiece A and having a surface C^1 flush with the surface A^1 to be polished, the spherical curvature of such surface C^1 of the resinous layer C being substantially equal to that of the surface A^1 to be polished. It will be appreciated that the thickness of the resinous layer C will be of the order of one half of the thickness of the lens element A but that such thickness may not be uniform, the degree of uniformity depending on the difference between the curvature of the generally spherical surface B^1 of the main holder body B and the curvature of the surface A^1 to be polished.

Using the above-described workholder, polishing may be effected in the known manner by imparting suitable relative movement to the element to be polished and a polishing pad. However, in order to avoid edge effects at the periphery of the actual surface to be polished, the area over which the polishing pad moves during polishing is increased to include a portion of the spherical surface of the workholder around the workpiece, whereby the actual surface of the workpiece to be polished constitutes only the central portion of the whole area polished, which portion is polished both adequately and substantially evenly.

The above-described workholder is conveniently produced, as indicated in FIGURE 2, by moulding the layer of resinous material after the lens element A has been secured in the recess B^2 in the main body B of the workholder by means of a suitable wax material. Thus, in the case shown of a workpiece A having a convex surface A^1 to be polished, the main workholder body B together with the workpiece A waxed therein is placed in an inverted mould D having an internal spherical sur-

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face D^1 of the appropriate curvature and the annular space E between such mould D and the workholder main body B around the lens element A is filled with a cold setting resin, constituted for example by an epoxy resin or a polyester resin. After such resinous mass has set, the mould D is removed.

It will be appreciated that it is not essential in the above-described arrangement for the workholder body to have a generally hemispherical shape, although this is most convenient. For example as shown in FIGURE 3, the workholder may consist of a generally flat plate F having a central boss F^1 to which the workpiece A is attached, in which case a somewhat larger quantity of resinous material is required to form the annular surround G for the workpiece. As before, a mould D having an internal spherical surface D^1 of appropriate curvature may be used to produce the annular surround G. It will also be clear that the above-described workholder and method of production thereof may be modified to suit a workpiece having a concave spherical surface to be polished. Thus, in this case (see FIGURE 4) the main body H of the workholder is provided with a generally hemispherical internal surface H^1 having a central recess H^2 for receiving the workpiece A whilst the mould J has an external spherical surface J^1 of curvature substantially equal to that of the concave surface A^1 to be polished. The mould J in this case is placed over the workpiece A and the annular space thus formed around such workpiece is filled with resinous material to form the annular surround K.

The above-described workholder is especially convenient for a workpiece having a surface of revolution to be polished constituted by an approximately spherical surface, e.g. an aspheric surface deviating on one side only of a basic spherical surface by only small amounts. In this case, the spherical curvature of the annular surround will be arranged to be substantially equal or approximately equal to the curvature of the basic spherical surface, this being the spherical surface, of smallest curvature in the case of a convex surface and of largest curvature in the case of a concave surface, which will contact the surface to be polished around its circular edge only. In the production of such workholder, the curvature of the generally spherical surface of the mould will of course be appropriately chosen for this purpose.

Furthermore, the above-described workholder may also be employed for a workpiece having a surface of revolution other than a spherical or approximately spherical surface of revolution to be polished, such for example as a paraboloidal surface or any other standard surface of revolution or surface deviating by only small amounts from such standard surface. Thus, in the production of such a workholder, the surface of the mould is appropriately shaped to suit the surface of revolution to be polished i.e. such mould is formed with a standard surface of revolution corresponding to that of the surface to be polished or from which such surface to be polished deviates by only small amounts.

An alternative arrangement of workholder shown in FIGURE 5 comprises a main workholder body formed in two parts, one within the other. The workholder outer part consists of an annular member for example of metal, having a convex hemispherical surface L, whose curvature is substantially equal to the curvature of a convex spherical surface A^1 to be polished on a workpiece A, the inner diameter of such annular member L being just greater than the diameter of such workpiece A. The interior wall of such annular member L is cut with a screwthread L^2 cooperating with an external screwthread M^1 on the workholder inner part which is in the form of a tube M, for example of metal, which fits within such annular member L. The two members L and M can thus be relatively moved for adjustment purposes along the axis of the annular member L by relatively rotating such two members. During production of the workholder, the

two members L and M are adjusted so that when the workpiece A is attached to the appropriate end face M² of the workholder inner part M by means of suitable wax material, such workpiece A is received within the annular member L with its surface A¹ to be polished flush with the spherical surface L¹ of such annular member L.

In the production of the last-described workholder, the workholder outer part L is first provided with the surround surface L¹ suited to the surface A¹ to be polished and the workpiece A is then waxed in position to the end face M² of the workholder inner part M, which at this stage is retracted into the outer part L so that the surface A¹ to be polished is retracted below the surround surface L¹. A cylinder N (see FIGURE 5), axially aligned with the annular member L, is then moved axially towards such annular member L so that its annular end face N¹ engages the surround surface L¹. The end face N¹ of the cylinder N is accurately shaped to match that of the surround surface L¹, i.e. such end face N¹ forms an annular part of a concave spherical surface having a curvature equal to the curvature of such convex spherical surround surface L¹. Further, the size of the cylinder N is chosen so that its outer and inner diameters are respectively greater than and less than the inner diameter of the annular member L, so that such cylinder N constitutes a stop for the workpiece A when the workholder inner part M is adjusted relatively to the workholder outer part to move the workpiece A towards such cylinder N. The accurate shaping of the annular end face N¹ of the cylinder N thus ensures that, when the two workholder parts L and M have been relatively adjusted, the surface A¹ to be polished is positioned precisely flush with the surround surface L¹. The cylinder N is withdrawn when the accurate positioning of the workpiece A has been effected.

The above-described workholder can clearly be modified for a workpiece having a concave surface to be polished by forming the outer workholder part with a concave generally hemispherical surround surface of curvature substantially equal to that of the surface to be polished. In this case, the positioning surface of the cylinder employed in the production of the workholder will constitute an annular part of a convex spherical surface of curvature substantially equal to that of the concave surround surface.

The workholder may also be modified for an aspheric surface to be polished, i.e. a surface deviating by only small amounts from a basic spherical surface, by providing the workholder outer part with a surround surface having curvature substantially equal to that of the basic spherical surface. Furthermore, the workholder may also be modified for use with a workpiece having a surface of revolution to be polished other than a generally spherical surface, e.g. a paraboloidal surface, the workholder outer part being provided with a surface of revolution corresponding to that of the surface to be polished.

Another alternative workholder is shown in FIGURE 6, the main workholder body again being formed in two parts P and Q, one within the other. The outer part P is again constituted by an annular member, for example formed of metal or glass, carrying a surround surface P¹ suited to the surface A¹ to be polished on the workpiece A, and the workholder inner part Q is again constituted by a tube, for example of metal or glass, axially movable within the annular member P. However, instead of being in screwthreaded cooperation with the outer workholder part P, the tube Q is urged outwardly of the annular member P towards the surface P¹ by means of a spring R. In the finished workholder, the workpiece A is again positioned with the surface A¹ to be polished precisely flush with the surround surface P¹, but is waxed in this position to the outer workholder part P.

In the production of such workholder (see FIGURE 6)

an oven S is employed having on its base an externally screwthreaded boss S¹ on which can be mounted the workholder outer part P, which is provided with a screwthreaded central recess in its generally flat base surface for this purpose. Such screwthreaded recess will in any case usually be provided in such workholder base to enable the workholder to be mounted on a suitable work support during polishing. In axial alignment with the screw-threaded boss S¹, the roof of the oven S carries a cylindrical fitting T for receiving a stop cylinder V of a size suited to the diameter of the workpiece and having an annular end face V¹ shaped to match that of the surround surface P¹. The fitting T constitutes a guide for a peripheral flange V² provided on the cylinder V, which is urged downwardly to engage the surround surface P¹ by means of a spring W. The guide preferably allows sufficient freedom of lateral movement for the cylinder V to ensure that it seats itself correctly on the surround surface P¹ under the pressure of the spring W. The abutment for the spring W is constituted by a plug T¹ which can be screwed downwardly into the upper end of the fitting T. Preferably, as shown, the lower end of the fitting T carries an inward projection T² for preventing the cylinder V passing right through such fitting T into the oven S when no workholder is in position, and a light spring T³ is provided to press the cylinder V upwardly out of engagement with the workholder when the plug T¹ is unscrewed upwardly to reduce the downward pressure of the spring W.

The workpiece A is first waxed within the workholder outer part P so that the surface A¹ to be polished lies below the surround surface P¹. The production of the workholder is shown in this stage in FIGURE 6. The spring R presses the workholder inner part Q against the underside of the workpiece so that when operation of the oven S is effected to melt the wax securing the workpiece A to the workholder outer part P, the workpiece A is urged upwardly until the surface A¹ to be polished engages the shaped annular positioning surface V¹ on the lower end of the cylinder V. The spring W is arranged to exert a considerably stronger downward pressure than the upward pressure of the spring R, so that further upward movement of the workpiece is prevented when the surface A¹ to be polished has been moved into a position in which it is flush with the surround surface P¹. The oven S is then allowed to cool so that the wax resolidifies to resecure the workpiece A to the workholder outer part P, whereafter the plug T¹ is unscrewed to release the downward pressure of the spring W on the stop cylinder V and thus to permit the workholder to be removed from the oven S.

A modified method of production shown in FIGURE 7 conveniently also shows a modified workholder outer part consisting of a metal base element W¹ and rigidly secured thereto an annular glass element W² carrying the surround surface W³. Within the workholder outer part W¹W² is a workholder inner part again in the form of a tube W⁴ pressed outwardly of the outer part W¹W² by means of a spring W⁵. The base element W¹ of the workholder outer part is secured to a base plate X carrying on opposite sides of the workholder two supporting posts X¹X² for a cross-piece X³ passing above the workholder. In accurate vertical alignment with the axis of the workholder, the cross-piece X³ carries a cylindrical fitting X⁴ for a weighted plunger Y withdrawable upwardly through such fitting X⁴. The stop cylinder Z has a closing end wall Z¹ at its upper end and the upper face of such end wall Z¹ is provided with a central shallow recess Z² with which the lower end of the plunger Y cooperates. Means are provided, as indicated at X⁵, for adjusting the height of the cross-piece X³ to suit the height above the base plate X of the inner periphery of the surround surface W³, since this height may vary considerably from one workpiece and workholder therefor to another workpiece and workholder therefor,

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both according to whether the surface to be polished is convex or concave and to the size of such workpiece.

As before, the workpiece A is initially waxed within the outer workholder part W^1W^2 with the surface A^1 to be polished below the level of the surround surface W^3 . The plunger Y is at this stage withdrawn so that the stop cylinder Z can be placed approximately in its correct position on the workholder. The plunger is then lowered through the fitting X^4 into engagement with the stop cylinder Z exactly to position such cylinder with its axis collinear with the axis of the workholder, the recess Z^2 in the top wall Z^1 of the cylinder Z being so shaped that the cooperation thereof with the lower end of the downwardly urged plunger Y ensures the correct seating of the shaped lower annular face of the cylinder Z on the surround surface W^3 . The whole assembly is then placed in an oven for the purpose of axially displacing the workpiece A to its correct position in the manner previously described, the plunger Y being so weighted that the downward pressure on the cylinder Z considerably exceeds the upward pressure on the workpiece A due to the spring W^5 .

In the last described method of producing the workholder, it is not essential to employ an oven, for if for example at least the workholder outer part is made of metal, heat may be applied to such workholder part to cause the wax securing the workpiece to melt. Further, instead of a complete cylinder, the stop may be constituted by two or more cylindrical segments having suitably shaped end faces. Clearly, as above-mentioned with reference to the workholder of FIGURE 5, the last-described workholder may be modified to suit a workpiece having a concave spherical surface or an aspheric surface or any other surface of revolution to be polished.

It should also be mentioned that a workholder of the kind shown in FIGURE 5 or FIGURE 6 or FIGURE 7 is preferred when it is desired to polish many workpieces of the same size and shape, whilst a workholder having a moulded resinous surround is preferred when only one workpiece or only a smaller number of similar workpieces are to be polished.

What I claim as my invention and desire to secure by Letters Patent is:

1. A method of accurately securing a workpiece in position to be polished on a workholder, said workpiece having an aspheric surface of revolution which deviates by only small amounts from a basic spherical surface, and said workholder being of the type comprising an outer workholder part having a spherical end surface substantially conforming to said basic spherical surface and encircling a cylindrical hole dimensioned to closely encircle said workpiece, the axis of said hole being collinear with a radius of such spherical end surface, and an axially movable inner workholder part which fits closely into said hole, said method comprising the steps of retracting the inner workholder part within the outer workholder part, inserting the workpiece in the outer workholder part, supporting said workpiece therein on the inner workholder part with its axis collinear with the axis of the cylindrical hole and its aspheric surface exposed towards the opening of the cylindrical hole, locating a removable stop member having a rigid abutment surface curved to match the spherical end surface on the outer workholder part in a position in engagement with the edge portion of said spherical end surface surrounding said cylindrical hole in which a portion of said abutment surface substantially smaller than said aspheric workpiece surface overlies said hole, applying an adjusting force to effect axial movement of the inner workholder part within the outer workholder part to bring the workpiece into an operative position with a small portion of its aspheric surface in engagement with the stop member, securing the workpiece in such operative position against further movement relative to the outer workholder part, and removing the stop member.

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2. A method of accurately securing a workpiece in position to be polished on a workholder, said workpiece having an aspheric surface of revolution which deviates by only small amounts from a basic spherical surface, and said workholder being of the type having an outer workholder part having a spherical end surface substantially conforming to said basic spherical surface and a cylindrical hole whose axis is collinear with a radius of such spherical end surface and within which an axially movable inner workholder part and said workpiece each closely fit, said method comprising the steps of retracting the inner workholder part within the outer workholder part, inserting the workpiece in the outer workholder part, fixing said workpiece therein with its axis collinear with the axis of the cylindrical hole and its aspheric surface exposed towards the opening of the cylindrical hole by means of a heat-softenable material, locating in engagement with the spherical end surface a removable stop member having a rigid spherically curved abutment face matched to such spherical end surface and having a small contact area therewith, said step of locating such stop member consisting in engaging the abutment surface with the edge portion of the spherical end surface surrounding the cylindrical hole in a position such that a portion of such abutment surface substantially smaller than said aspheric workpiece surface overlies the opening of such cylindrical hole, heating the heat softenable material to permit axial movement of the inner workholder part within the outer workholder part to bring the workpiece into an operative position with a small portion of its aspheric surface in engagement with the stop member, resecuring the workpiece against movement relative to the outer workholder part by allowing the heat-softenable material to cool, and removing the stop member.

3. A method of accurately securing a workpiece in position to be polished on a workholder, said workpiece having an aspheric surface of revolution which deviates by only small amounts from a basic spherical surface, and said workholder being of the type having an inner workholder part and an annular outer workholder part provided with a central hole dimensioned to fit closely about said workpiece and within which said inner workholder part fits closely and is axially movable, said outer workholder having a spherical end surface substantially conforming to said basic spherical surface, said method comprising the steps of retracting the inner workholder part within the outer workholder part, inserting the workpiece in the outer workholder part and supporting said workpiece therein on the inner workholder part with its axis collinear with the axis of the cylindrical hole and its aspheric surface exposed towards the opening of the central hole, locating in engagement with the spherical end surface a removable annular stop member having a rigid annular abutment face spherically curved to match the spherical end surface, said step of locating such stop member consisting in engaging the outer zone of the abutment face with the inner edge portion of the spherical end surface on the outer workholder part with a portion of said abutment face substantially smaller than said aspheric workpiece surface overlapping the opening of the central hole, applying an adjusting force to effect relative axial movement between the inner and outer workholder parts to bring the workpiece into an operative position with a small portion of its aspheric surface in engagement with the stop member, securing the workpiece in such operative position against further movement relative to the outer workholder part, and removing the stop member.

4. A method of accurately securing a workpiece in a workholder as claimed in claim 3, including the steps of initially securing the workpiece against movement relative to the outer workholder part by means of a heat-softenable material, heating such heat softenable material to permit the workpiece to be moved to its operative position, and resecuring the workpiece against movement

relative to the outer workholder part by allowing the heat-softenable material to cool.

5. Apparatus for accurately securing a workpiece in position to be polished on a workholder, said workpiece having an aspheric surface of revolution which deviates by only small amounts from a basic spherical surface, and said workholder being of the type having an outer workholder part having a spherical end surface substantially conforming to said basic spherical surface and a cylindrical hole whose axis is collinear with a radius of such spherical end surface and wherein closely fits an axially movable inner workholder part, said apparatus comprising a support for the outer workholder part, means for effecting relative axial movement between the inner and outer workholder parts, thereby enabling the inner part to be retracted within the outer part to permit insertion of the workpiece into such outer part to be supported therein on the inner part with its axis collinear with the axis of the cylindrical hole and its aspheric surface facing the opening of such cylindrical hole, a removable stop member having for engagement with the spherical end surface a rigid abutment face spherically curved to match such spherical end surface, means carried by the support for holding the stop member in a position in which its abutment surface engages the edge portion of the spherical end surface sur-

rounding the cylindrical hole with a portion of such abutment surface having an area substantially less than the cross-sectional area of the cylindrical hole overlying the opening of such cylindrical hole, thereby enabling the two workholder parts to be axially moved relatively to one another to bring the workpiece into an operative position in which a small portion of its aspheric surface engages the stop member, means for securing the workpiece in such operative position relative to the outer workholder part, and means for releasing the holding means for the stop member to permit such stop member to be removed.

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