

## Description

The invention relates to supports, particularly for workpieces or machining parts, allowing limited movement about a central point or axis, in particular in the form of a rubbing or wobbling motion. Such a support is used in lens smoothing or polishing where a shaft supporting a lapping tool is required to perform limited movements away from a rest position so as to smooth or polish a lens, resting on the tool, to the desired surface finish by means of a smoothing or polishing powder.

In a prior proposal a gimbal mount was used to provide a supporting shaft with the appropriate freedom of movement. This was, however, seen to be unsatisfactory because the bearings would wear out very quickly and, even with repeated replacement of the bearings every few weeks, the apparatus had an average life span of about six months.

The wearing down of the bearings was attributed to two main causes, the first being that the motion of the apparatus required the bearings to rotate by angles rarely exceeding  $15^\circ$ , causing very uneven wear, and the second being that emery powder washed down from the grinding surface was able to get into the bearings, rapidly rendering them unusable.

Although the bearings can be shielded to a certain extent from the grinding powder by rubber sheets and washers such protection has never been completely effective and in any case makes replacement of the bearings more difficult.

According to the present invention there is provided a device for supporting an article so as to allow limited motion of the article, comprising a base; a mount; a bearing in the form of a ball-and-socket-type joint between the base and the mount allowing the said motion of the article when in place on the mount, the mount having a part by which the said motion can be imparted; and a restraining means provided between the mount and the base in such a manner as to allow the said limited motion while at the same time preventing the mount from rotating about its own axis; characterised in that the restraining means comprises spring means being relatively stiff with respect to twisting about the axis of the mount but relatively yielding about axes perpendicular to the axis of the mount.

By "limited motion" is meant in particular motion with only two degrees of freedom, such as over the surface of a spheroid or cylinder, for instance. The apparatus of the invention is particularly suitable for supporting tools or workpieces for lens smoothing or polishing, where the allowable motion required is usually over a spherical surface subtending a small angle at the centre of the sphere (i.e. at the bearing), such as about  $15^\circ$ .

Ball-and-socket joints are known for grinding applications, as see DE-B-24 54 961 and US-A-1 260 872, the latter forming the base for the preamble of claim 1.

Since with support devices made in accordance with the invention the number of parts having surfaces moving relative to each other is reduced to two, the amount

of maintenance necessary may be greatly reduced. Ball-and-socket-type joints are in any case less prone to malfunction caused by limited bearing movement such as occurs in lens grinding apparatus since considerably more wear can be tolerated before the bearing is no longer usable than in, say, a bearing incorporating a ball race.

Preferably the ball member is generally spherical and the cup or socket likewise spherical, though advantageously with a slightly greater radius than that of the ball to prevent jamming, at their respective bearing surfaces. This allows wobbling movement in all directions.

In an advantageous configuration the ball member is mounted on the upper end of a vertically extending stem of the base, and the socket is set facing downwards in the mount. In this case there is substantial built-in protection for the bearing from abrasive powder since the orientation of the socket member acts as a shield against contamination, rendering rubber washers and similar measures largely unnecessary.

The ball and socket members are preferably replaceably mounted in the base and workpiece mount so that when they finally do need replacing this involves the minimum of effort and expenditure. This may be realised by providing the ball member with a stem, as mentioned above, which can be attached to the base by a screw, for instance, and incorporating the socket into a rod-shaped insert which can slide into and be fastened to the workpiece mount.

For smoothing or polishing of an aspheric lens it is essential that the mount for the lapping or polishing tool does not rotate about its own axis. In the invention, therefore, a restraint is provided which is so shaped and positioned as substantially to prevent the mount, and hence the workpiece, from rotating about its own axis, whilst at the same time allowing it sufficient freedom to rotate in the direction or directions allowed by the bearing, namely about any axis perpendicular to the bearing axis, which is generally vertical. The amount of rotation allowed should be about  $15^\circ$  to provide a rubbing or wobbling motion.

The restraining means should thus be relatively easily movable or deformable about horizontal axes, i.e. axes perpendicular to the axis of the mount in its resting position, while being relatively stiff with respect to twisting about the vertical axis. To this end the restraining means may consist of one or more flat springs with their plane perpendicular to the axis of the bearing, connected between the base and the mount. In a preferred embodiment there are two springs each extending to an attachment point in the mount from a bracket on the base, the brackets being arranged one on each side of the mount; preferably the springs have a hook shape so as to extend from their brackets round each side of the mount respectively to attachment points on the far side of the mount. This allows the use of a longer spring for a given bracket spacing and facilitates the bending and twisting necessary to follow the motion of the mount. The use of springs has the further advantage that the springs also have a

restoring function, which makes the device easy to handle.

The base advantageously comprises two side brackets as mentioned above for attaching the restoring means, and a central arm generally parallel to the brackets, for supporting the ball or socket member; in the particularly simple arrangement where the ball has an integral stem, as discussed above, this stem can be inserted and secured into the arm, allowing easy replacement when necessary.

The mount is preferably in the form of a shaft on one end of which the workpiece or tool can be located, the shaft having an enlarged hollow central portion defining a recess for accommodating the end of the arm with the ball or socket piece. The socket or ball member, as the case may be, is located correspondingly in the recess. Advantageously the shaft is at least partly tubular so that a socket insert can be fitted in the shaft between one end and the central recess, as mentioned above, again so as to allow replacement of the socket in a simple fashion.

For a better understanding of the invention reference will now be made, by way of example, to the accompanying drawings in which:-

Fig. 1 shows an exploded view of a lens-smoothing or polishing apparatus in accordance with the invention;

Fig. 2 shows an exploded view of the lapping tool support of the above apparatus; and

Fig. 3 shows the support shaft in elevation.

Figure 1 is an exploded view of a support unit for a lens smoothing or polishing machine. The main component of the support unit, namely the support or "wobble unit" 20, comprises two relatively movable parts 1 and 2 and is described in detail below. The fixed part or base 1 is bolted to the machine frame and the movable mount in the form of a shaft 2 is driven by a motor (not shown). The motor rotates a driving plate 21 with an offset pin 22 engaging in a self-aligning bearing fitted to the underside of the shaft adapter 23 so as to rotate the lower end of the shaft 2 around the central vertical axis. In Fig. 1 the shaft is shown in its rest position, aligned with the central axis; in use, however, the pin 22 would engage the adapter 23 so as to hold it inclined to the central axis.

The shaft 2 is mounted on the base 1, in a way described more fully in connection with Fig. 2, so as to allow the axis of the shaft to tilt about any horizontal axis. Thus, rotation of the lower end of the shaft about the central, vertical axis causes the upper end to rotate ("wobble") correspondingly. The lapping tool 27 mounted on the upper end of the shaft 2 via clamp 26 therefore performs a generally rotary movement, the inclination of the axis of the shaft to the central axis about which it precesses or wobbles being about 15°.

The support device 20 in accordance with the invention is shown in an exploded view in Fig. 2. It can be seen that the base 1 consists of two brackets 1a, 1b and an arm 1c attached to a backplate 1d. The base 1 supports

the shaft 2, which is mounted on the arm 1c of the base via a single bearing located within an enlarged central portion 16 of the shaft 2 as described below.

The support device 20 includes two flat, hook-shaped springs 3 lying in the horizontal plane, used to attach the shaft resiliently to the brackets 1a and 1b of the base. The springs are fastened to the brackets by means of screws 12 and similarly to the enlarged central portion 16 of the shaft 2.

The springs are designed as a restraining means so as substantially to prevent the shaft rotating about its own axis whilst permitting a tilting or rotating motion about axes perpendicular to this axis, i.e. horizontal axes. To this end it is advantageous to make the length of the springs relatively large; hence the hook shape clearly shown in Figure 2. This reduces stress in the springs and helps to increase the lifetime of the article.

The bearing between the shaft 2 and the base 1 is of particularly simple construction and consists essentially of a ball member 9 fixed to the base and a socket member 14 fixed to the shaft. The ball 9 is fastened to a stem 10, which in turn is secured to the end of the arm 1c by means of a locking screw 11. The arrangement allows easy replacement of the ball when worn. Likewise the socket member 14, in the form of a cup having a generally spherical recess, fits into an insert 13 itself secured by an axis alignment pin 15 into a cylindrical recess in the upper part of the shaft 2, as best seen in Fig. 3. The thickened central portion 16 has a central recess 17 large enough to allow the end of the arm 1c with the ball to be inserted into the recess 17 of the shaft so that the shaft can be lowered on to the arm until the ball locates into the socket member 14 inside the shaft 2 so enabling the shaft to be freely rotatably mounted on the arm about the centre of the ball. The recess 17 must be of suitable size and shape to allow the desired limited movement of the shaft.

In use, a pre-ground lens 30 (Fig. 1) is held rigidly to a holder 31 by way of a suitable adhesive. The lens is held firmly against the lapping tool (27) by introducing the desired downward pressure to the lens holder 31, and smoothing or polishing powder in suspension can then be supplied to the interface between the lens and the lapping tool, so that the smoothing or polishing of the lens can be performed.

The downward pressure on the lens holder 31 is applied by a biasing arrangement, not shown, with two downwardly projecting pins engaging in the two off-axis indentations shown in the holder. The holder can thus tilt about the horizontal axis defined by the indentations, and in addition the pin arrangement can itself tilt about the other horizontal axis. In this way the lens can be pressed conformally against the lapping tool 27 as the latter moves, while at the same time being prevented from rotating about the vertical by virtue of the two-pin arrangement. This is essential for aspherical lenses, i.e. lenses where the radii of curvature are different in the two orthogonal directions, as indicated in Fig. 1.

During operation the bottom of the shaft 2 is rotated in a horizontal plane via the pin 22 at a relatively high speed. Simultaneously the axis of rotation of the driving plate 21 is itself rotated at a consistently lower speed so that the shaft in fact follows a convoluted path. This ensures a uniform rubbing effect over the surface of the lens.

The bearing of the shaft on the base comprises only one pair of sliding or rolling surfaces, namely the surfaces of the ball member and socket member. This itself reduces the amount of maintenance necessary. In addition, as can be seen from Fig. 3 in particular, the bearing is itself concealed within a void, namely the recess 17, so that it is further shielded from the abrasive powders necessarily given off in the lens smoothing or polishing process, which are particularly harmful to moving parts in this type of apparatus.

Furthermore, a ball-and-socket joint is less prone to failure as a result of wearing than is a gimbal mount as constant motion tends to wear the ball and socket evenly in any case. With carbide steel bearing members the bearing can be expected to last many months, if not years - far longer than the traditional bearings - and it is a simple operation to replace the ball and socket parts.

Whilst the present invention has been described in terms of its use for lens smoothing and polishing, especially in ophthalmological applications, it is by no means restricted to these uses and applications may be found in many areas where restricted motion about a plurality of axes, in particular motion over a part-spherical surface, is required.

## Claims

1. A device for supporting an article (27) so as to allow limited motion of the article, comprising a base (1); a mount (2); a bearing in the form of a ball-and-socket-type joint (9,14) between the base and the mount allowing the said motion of the article when in place on the mount, the mount (2) having a part by which the said motion can be imparted; and a restraining means (3) provided between the mount and the base in such a manner as to allow the said limited motion while at the same time preventing the mount from rotating about its own axis;  
characterised in that the restraining means comprises spring means being relatively stiff with respect to twisting about the axis of the mount but relatively yielding about axes perpendicular to the axis of the mount.
2. A device according to claim 1, in which the base includes a stem (10), the ball member (9) is mounted on the upper end of this stem (10) and the socket is set in the mount (2) so as to face the ball member.
3. A device according to claim 1 or 2, in which the ball and socket members are replaceably mounted in the base (1) and the mount (2).

4. A device according to claim 3, in which the socket member (14) is located on a rod-shaped insert (13) slidably fastened in the mount (2).
5. A device according to any preceding claim, in which the base (1) includes a projecting arm (1c) the projecting end of which supports the ball member (9), and the mount is formed as a shaft (2) the central portion (16) of which has a recess (17) accommodating the said end of the arm and the ball member, the socket member (14) being located in the recess (17) and engaging in use with the ball member (9).
6. A device according to any preceding claim, in which the spring means (3) comprises one or more flat springs, the or each plane of which is generally perpendicular to the axis (24) of the bearing.
7. A device according to claim 6 when appendant to claim 5, in which the base includes two side brackets (1a, 1b) either side of and generally parallel to the central arm (1c), the springs (3) each being fixed at one end respectively to the brackets.
8. An apparatus for polishing lenses, comprising a lens holder (31), a lapping tool (27) mounted on a support device according to any preceding claim, a drive means (21) for moving the mount (2) so as, in use, to rub the lapping tool (27) against a lens, and a means for supplying abrasive.

## Patentansprüche

1. Vorrichtung zum Unterstützen eines Gegenstands (27), um eine begrenzte Bewegung des Gegenstands zu gestatten, wobei die Vorrichtung umfaßt: eine Basis (1); eine Halterung (2); ein Lager in der Form eines kugelpfannenartigen Gelenks (9, 14) zwischen der Basis und der Halterung, das die besagte Bewegung des Gegenstands erlaubt, wenn er sich auf der Halterung befindet, wobei die Halterung (2) ein Teil hat, durch das die besagte Bewegung übertragen werden kann; und ein Hemmungsmittel (3), das zwischen der Halterung und der Basis auf eine solche Weise vorgesehen ist, daß die besagte begrenzte Bewegung gestattet wird, während gleichzeitig verhindert wird, daß die Halterung um ihre eigene Achse rotiert;  
dadurch gekennzeichnet, daß das Hemmungsmittel ein Federmittel aufweist, das relativ steif bezüglich Verdrehen um die Achse der Halterung, jedoch relativ biegsam um Achsen senkrecht zur Achse der Halterung ist.
2. Vorrichtung nach Anspruch 1, in der die Basis einen Fuß (10) umfaßt, wobei das Kugelteil (9) am oberen Ende dieses Fußes (10) angebracht ist und die Pfanne so in der Halterung (2) angeordnet ist, daß sie dem Kugelteil gegenüberliegt.

During operation the bottom of the shaft 2 is rotated in a horizontal plane via the pin 22 at a relatively high speed. Simultaneously the axis of rotation of the driving plate 21 is itself rotated at a consistently lower speed so that the shaft in fact follows a convoluted path. This ensures a uniform rubbing effect over the surface of the lens.

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3. Vorrichtung nach Anspruch 1 oder 2, in der die Kugel- und Pfannenteile austauschbar in der Basis (1) und der Halterung (2) angebracht sind.
4. Vorrichtung nach Anspruch 3, in der das Pfannenteil (14) auf einem stabförmigen Einsatz (13) angeordnet ist, der verschiebbar in der Halterung (2) befestigt ist.
5. Vorrichtung nach einem der vorangehenden Ansprüche, in der die Basis (1) einen vorstehenden Arm (1c) umfaßt, dessen vorstehendes Ende das Kugelteil (9) unterstützt, und die Halterung als ein Schaft (2) ausgebildet ist, dessen zentraler Abschnitt (16) eine Ausnehmung (17) hat, die das besagte Ende des Arms und das Kugelteil aufnimmt, wobei das Pfannenteil (14) in der Ausnehmung (17) angeordnet ist und beim Gebrauch in das Kugelteil (9) eingreift.
6. Anordnung nach einem der vorangehenden Ansprüche, in der das Federmittel (3) eine oder mehr Flachfedern aufweist, deren Ebene oder jede von deren Ebenen im allgemeinen senkrecht zur Achse (24) des Lagers ist.
7. Vorrichtung nach Anspruch 6 und nach Anspruch 5, in der die Basis zwei Seitenklammern (1a, 1b) umfaßt, von denen jede Seite und die im allgemeinen parallel zum zentralen Arm (1c) sind, wobei jede der Federn (3) an jeweils einem Ende an den Klammern befestigt ist.
8. Apparat zum Polieren von Linsen, der einen Linsenhalter (31), ein auf einer Unterstützungsvorrichtung nach einem der vorangehenden Ansprüche angebrachtes Läppwerkzeug (27), ein Antriebsmittel (21) zum Bewegen der Halterung (2), so daß beim Gebrauch das Läppwerkzeug (27) an einer Linse gerieben wird, und ein Mittel zum Versorgen mit Schleifmittel umfaßt.

#### Revendications

1. Dispositif de support d'un objet (27) afin de permettre un mouvement limité de l'objet, comprenant une base (1) ; une monture (2) ; un palier se présentant sous la forme d'un joint du type à bille (9, 14) entre la base et la monture, permettant le mouvement de l'objet lorsqu'il est en place dans la monture, la monture (2) possédant une partie au moyen de laquelle le mouvement peut être communiqué ; et des moyens d'entrave (3) prévus entre la monture et la base pour permettre le mouvement limité tout en empêchant, simultanément, la monture de tourner autour de son propre axe ;  
caractérisé en ce que les moyens d'entrave comprennent des moyens élastiques qui sont relativement rigides quand il s'agit de tourner autour de

l'axe de la monture mais relativement souples autour d'axes perpendiculaires à l'axe de la monture.

2. Dispositif selon la revendication 1, dans lequel la base comprend une tige (10), la bille (9) est montée sur l'extrémité supérieure de cette tige (10) et la partie femelle est montée dans la monture (2) afin de faire face à la bille.
3. Dispositif selon la revendication 1 ou 2, dans lequel la bille et la partie femelle sont montés de façon interchangeable dans la base (1) et la monture (2).
4. Dispositif selon la revendication 3, dans lequel la partie femelle (14) est située sur un insert en forme de tige (13) fixé de façon coulissante dans la monture (2).
5. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la base (1) comprend un bras dépassant (1c) dont l'extrémité dépassante supporte la bille (9), et la monture a la forme d'un arbre (2) dont la partie centrale (16) présente un évidement (17) logeant l'extrémité du bras et la bille, la partie femelle (14) étant située dans le logement (17) et coopérant, en cours d'utilisation, avec la bille (9).
6. Dispositif selon l'une quelconque des revendications précédentes, dans lequel les moyens élastiques (3) comprennent un ou plusieurs ressorts plats, dont le ou chaque plane est globalement perpendiculaire à l'axe (24) du palier.
7. Dispositif selon la revendication 6 lorsqu'elle est dépendante de la revendication 5, dans lequel la base comprend deux appliques (1a, 1b) de part et d'autre et globalement parallèles au bras central (1c), les ressorts (3) étant chacun fixés à une extrémité, par rapport aux appliques.
8. Appareil pour polir les lentilles, comprenant un support de lentille (31), un outil de rodage (27) monté sur un dispositif de support selon l'une quelconque des revendications précédentes, des moyens d'entraînement (21) destinés à déplacer la monture (2) afin, en cours d'utilisation, de frotter l'outil de rodage (27) contre une lentille, et des moyens d'alimentation en abrasif.

