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(54) **Tool for polishing conventional and free-form optical surfaces**

(57) The invention relates to a tool (10) for polishing optical surfaces (21) comprising a rigid base (11) which has a spherical surface (14) which carries a resilient cushion (12) which has a polishing face (16), characterised in that the diameter of the rigid base (11) is between 50 and 65 mm, the radius of curvature of the spherical surface (14) is between 54 and 60 mm, the thickness of

the resilient cushion (12) is between 13 and 16 mm and the resistance to compression of the resilient cushion (12) is substantially between 0.08 and 0.15 bar at 10% compression and substantially between 0.55 and 0.8 bar at 70% compression. The invention also relates to the use of such a tool for polishing an optical surface, particularly an ophthalmic lens, and more particularly a free-form lens.

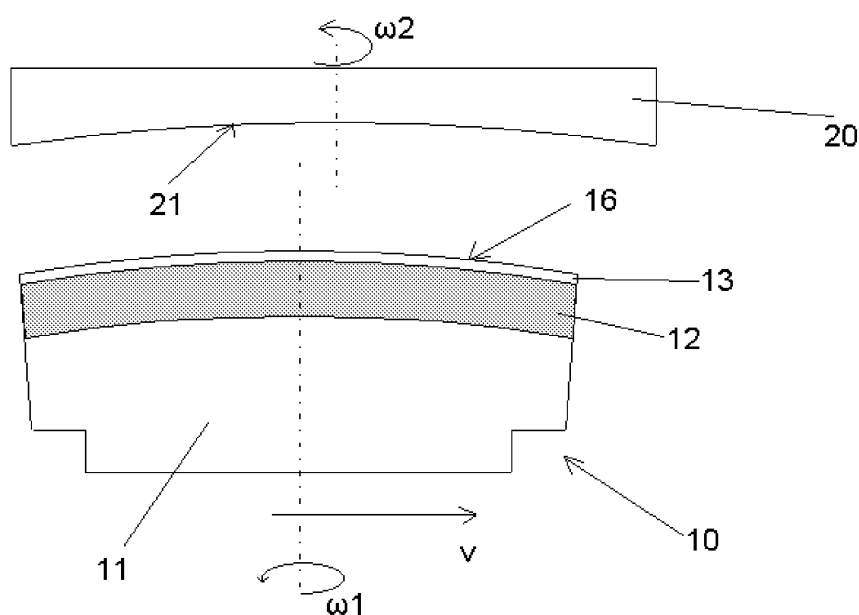


Figure 2

Description

[0001] The present invention relates to a tool for polishing optical surfaces and to the use of such a tool when polishing optical surfaces. More specifically it relates to a tool for polishing optical surfaces comprising a rigid body carrying a resilient cushion which has a polishing face and to the use of such a tool for polishing optical surfaces.

[0002] In the manufacture of optical lenses, it is known to polish a previously machined lens surface by means of a polishing tool. A conventional type of polishing tool comprises a support which to a certain extent has a similar surface as the lens to be polished and on which a polishing pad is mounted. The tool is brought into contact with the lens, and the lens surface is polished by the combined effect of a pressure between the tool and the lens and a relative angular velocity between them and with the aid of abrasive slurry. The goal of the polishing process is reduce the roughness of the lens to under 10 nanometres.

[0003] Lenses of largely varying surfaces are known. Firstly, the surface of a lens may be spherical, aspherical, toric or atoric. Additionally, lenses with more irregular surfaces have been developed, so called free-forms. Free-form lenses can have largely varying surfaces containing local curvatures from 13 dioptres to 0 dioptres (a locally flat surface). When polishing these free-form lenses, the goal is not to reduce the thickness of the lens by more than 20 micrometers and at the same time obtain a surface roughness under 10 nanometers.

[0004] Traditionally, a manufacturer has a large number of different polishing tools at his disposal, which can all be mounted in the same polishing machine. Each of these tools is more or less adapted to the surface of the lens that is to be polished.

[0005] EP 1 655 102 describes using polishing tools with a rigid surface upon which an elastic body is mounted. The diameter of the elastic body is between 20 and 60 mm. It is described to prepare five to ten types of elastic bodies with a radius of curvature ranging between 5 and 50 mm and several elastic bodies with a radius of curvature between 100 and 200 mm to be able to polish lenses of most lens prescriptions.

[0006] US 2008/0047301 describes using polishing tools which also comprise a rigid body carrying a resilient pad which has a polishing face. It also describes using 108 different devices to be able to polish a variety free-form lenses.

[0007] A variety of different polishing tools is needed to be able to polish the lenses of different prescriptions. So, to polish one lens after another, the polishing tool needs to be changed. This is cumbersome and slows down the polishing process. Additionally, it is expensive to have a high number of different tools.

[0008] The present invention therefore aims at establishing a single polishing tool which can be used to polish a large variety of all lenses. Specifically, the invention

aims at providing a single polishing tool that can be used for polishing conventional and free-form surfaces, which are made from any of the organic materials normally used in ophthalmological lenses and with curvatures within the following curvature ranges: between 0 and -11 dioptres sphere, between 0 and -4 dioptres cylinder and additions up to 3.5 dioptres, with a maximum allowable (combined) local concave curvature along the surface of -11 dioptres. When they are being polished, the lenses have a round or elliptical shape. The diameter of the lenses is between 50 and 70 mm. The maximum difference between the diameters of the elliptical lenses is 15 mm.

[0009] This goal is achieved with a polishing tool according to claim 1. Namely, with a tool for polishing optical surfaces comprising a rigid base which has a spherical surface which carries a resilient cushion which has a polishing face, **characterised in that** the diameter of the rigid base is between 50 and 65 mm, the radius of curvature of the spherical surface is between 54 and 60 mm, the thickness of the resilient cushion is between 13 and 16 mm and the resistance to compression of the resilient cushion is substantially between 0.08 and 0.15 bar at 10% compression and substantially between 0.55 and 0.8 bar at 70% compression.

[0010] The tool for polishing is mounted in a polishing machine and the lens is polished through a combined effect of a pressure between the tool and the lens and a relative angular velocity between them and with the aid of abrasive slurry. For each lens, the polishing machine may be programmed differently, i.e. the force between lens and polisher, the speed of rotation, translation etc. may be varied. With the described tool, a large variety of lenses may be polished with the same tool. The polishing machine may be preprogrammed to automatically change the values of the polishing parameters (velocities, pressure etc.) depending on the curvature of the surface to be polished.

[0011] Preferably, the resistance to compression of the resilient cushion is substantially between 0.10 and 0.16 bar at 15% compression and between 0.20 and 0.30 bar at 50% compression. During polishing, the resilient cushion deforms to redistribute the pressure and forces on the lens surface. The resistance to compression is the parameter that describes how much the cushion deforms under pressure and thus to what extent the cushion can redistribute forces and pressures. The resistance to compression is particularly relevant in the range of 15 - 50% compression, since this is a compression that the resilient cushion experiences mostly during polishing. A small increase in the pressure should lead to a relatively large increase in deformation (or percentage of compression). This ensures a good redistribution of forces over the lens surface.

[0012] Preferably, the thickness of the resilient cushion is between 14 and 15 mm. The resilient cushion, which deforms slightly during polishing redistributes the pressure and forces on the lens surface. For this, it needs to have a certain thickness. On the other hand, if the resilient

cushion is too thick, it is more likely to bend and break during polishing. With a thickness between 14 and 15 mm, a good balance of redistribution of forces and probability of breaking is achieved.

[0013] Preferably, the radius of curvature of the spherical surface of the rigid base is between 54 and 56 mm. During polishing, the resilient cushion deforms to redistribute pressure and forces on the lens surface. This way, the polishing is more equal over the entire lens surface and one can ensure that the required surface roughness has been achieved while at the same time the stock removal is uniformly distributed over the surface of the lens. The resilient cushion can partly redistribute forces and pressure, but this effect naturally is limited. If the curvature of the rigid base corresponds more closely to the curvature of the lens surface that is to be polished, the forces do not need to be redistributed as much. But a large variety of lenses with varying radius of curvature needs to be polished with this single tool and it has been found, that the optimum form for the polishing tool is obtained with a radius of curvature of the spherical surface of the rigid body between 54 and 56 mm.

[0014] Preferably, the diameter of the rigid base is between 55 and 65 mm. The larger the diameter of the tool, the higher the velocity at its extremity in rotation and this leads to more material removed in the polishing process. On the other hand, with a larger diameter, the necessary linear movement of the tool in polishing is reduced, since with a small movement it already covers the entire surface of the lens. This reduces polishing time. With a diameter between 50 and 65 mm, satisfactory results are achieved, but improved results are achieved with diameters between 55 and 65 mm.

[0015] Preferably, the resilient cushion is a sponge, commercially available as Eurocell 130™ from Recticel. This sponge is made from polyether, has the required resistance to compression and a specific density between 110 kg/m³ and 130 kg/m³.

[0016] Preferably, the polishing face of the resilient cushion is formed by a separate polishing pad which can be attached to the resilient cushion. The separate polishing pad may be attached to the resilient cushion using an adhesive. The polishing pads and resilient cushions can thus be manufactured separately which is easier.

[0017] Preferably, the polishing pad comprises a top layer and a bottom layer, the top layer being a nap layer adapted to carry an abrasive slurry. More preferably, the bottom layer of the polishing pad is of a polyurethane impregnated non-woven fabric. The function of the polishing pad is to hold the abrasive slurry and bring it into contact with the lens. The pad with these characteristics has been shown to function properly and also to last long. With other polishing pads, the pad needs to be changed more frequently, which is costly and slows down the polishing process.

[0018] A number of commercially available polishing pads have the desired characteristics. For example, suitable pads are: Bellatrix Polishing PAD K0034™ com-

mercially available from Filwel Co., Ltd. and Politex™ Supreme finishing pad, commercially available from EM-INESS technologies Inc. The abrasive slurry used may be an aluminium oxide water solution.

[0019] Particular embodiments of the present invention will be described in the following, only by way of non-limiting example, with reference to the appended drawings, in which:

figure 1 is a cross section showing a polishing tool according to a preferred embodiment of the present invention, with its components shown separately; figure 2 is a cross section showing a polishing tool according to a preferred embodiment of the present invention in use; figure 3 is a perspective view of a polishing pad which might be used in the invention; figure 4a shows a graph of the resistance to compression of a resilient cushion which may be used in the present invention; figure 4b shows a detail of the graph shown in figure 4a.

[0020] In figure 1, it is shown how a polishing tool according to a preferred embodiment of the present invention is built up from its separate components. A first component is the rigid body (11). Rigid body (11) comprises a surface (14), upon which resilient cushion (12) is to be mounted. In this preferred embodiment, the polishing face of the resilient cushion is formed by a polishing pad (13). Reference sign (15) is used to indicate the side of the rigid body (11) which is to be mounted in the polishing machine.

[0021] According to the invention, the surface (14) is spherical and has a radius of curvature between 54 and 60 mm. The diameter of the tool is between 50 and 65 mm, and the thickness of resilient cushion (12) is between 13 and 16 mm. The resilient cushion has a resistance to compression between 0.14 and 0.4 bar when compressed between 15% and 60%.

[0022] Figure 2 shows a schematic cross section of polishing tool (10) completely assembled with rigid body (11), resilient cushion (12) and polishing pad (13). The top surface (16) of the polishing pad is used to polish the surface (21) of a lens (20) and can be regarded as the polishing face of the tool.

[0023] The lens surface that is to be polished (21) does not exactly correspond to the surface (16) of the polishing tool. In fact, it can be quite different, since a wide range of lenses (between 0 and -11 dioptres sphere, between 0 and -4 dioptres cylinder and additions up to 3.5 dioptres, but with a maximum allowable combined local concave curvature along the surface of -11 dioptres) is polished with the same tool. The resilient cushion (12) deforms when in contact with the lens. This ensures a redistribution of forces over the surface (16) of the lens. This ensures that the desired roughness and an even stock removal can be obtained over the entire surface.

[0024] The tool is the same for the whole range of lenses, but the program that the polishing machine performs can vary. Some parameters of the polishing program may be e.g. rotational velocity (ω_1) of the tool, rotational velocity (ω_2) of the lens, lateral displacement and velocity (v) of the tool, inclination between the axis of the tool and the axis of the lens, force between lens and polisher and polishing time.

[0025] Figure 3 shows a perspective view of a polishing pad (13) which might form the polishing surface (16) of a tool according to the invention. The bottom surface (19) may carry an adhesive to easily attach it to the resilient cushion. The polishing pad shown has two layers. A top layer (17) is designed to hold an abrasive slurry. For this purpose, it preferably has vertical pores. The abrasive slurry used may be an aluminium oxide water suspension. The bottom layer (18) is preferably of a non-woven fabric.

[0026] Figure 4a shows a graph of the resistance to compression of a resilient cushion which may be used in the present invention. The graph shows the resistance to compression of the cushion Eurocell 130™ commercially available from Recticel. The resistance to compression is particularly relevant in the range of 15 - 50% compression, since this is a compression that the resilient cushion might ordinarily experience during polishing. As can be seen in the graph, in this range, a small increase in the pressure leads to a relatively large increase in deformation (or percentage of compression). This ensures a good redistribution of forces over the lens surface. Figure 4b shows a more detailed view of the lower range of compression.

Claims

1. A tool (10) for polishing optical surfaces (21) comprising a rigid base (11) which has a spherical surface (14) which carries a resilient cushion (12) which has a polishing face (16), **characterised in that** the diameter of the rigid base (11) is between 50 and 65 mm,
the radius of curvature of the spherical surface (14) is between 54 and 60 mm,
the thickness of the resilient cushion (12) is between 13 and 16 mm and
the resistance to compression of the resilient cushion (12) is substantially between 0.08 and 0.15 bar at 10% compression and substantially between 0.55 and 0.8 bar at 70% compression.
2. A tool for polishing optical surfaces according to claim 1, **characterised in that** the resistance to compression of the resilient cushion (12) is substantially between 0.10 and 0.16 bar at 15% compression and between 0.20 and 0.30 bar at 50% compression.
3. A tool for polishing optical surfaces according to any

previous claim, **characterised in that** the thickness of the resilient cushion (12) is between 14 and 15 mm.

4. A tool for polishing optical surfaces according to any previous claim, further **characterised in that** the radius of curvature of the spherical surface of the rigid base (11) is between 54 and 56 mm.
5. A tool for polishing optical surfaces according to any previous claim, **characterised in that** the diameter of the rigid base (11) is between 55 and 65 mm.
6. A tool for polishing optical surface according to any previous claim, **characterised in that** the resilient cushion is Eurocell 130™.
7. A tool for polishing optical surfaces according to any previous claim, **characterised in that** the polishing face of the resilient cushion is formed by a separate polishing pad (13) which can be attached to said resilient cushion (12).
8. A tool for polishing optical surfaces according claim 7, **characterised in that** the polishing pad (13) comprises a top layer (17) and a bottom layer (18), the top layer being a nap layer adapted to carry an abrasive slurry.
9. A tool for polishing optical surfaces according to claim 8, further **characterised in that** the bottom layer (18) of the polishing pad is of a polyurethane impregnated non-woven fabric.
10. The use of a tool according to any previous claim for polishing an optical surface, particularly an ophthalmic lens, and more particularly a free-form lens.

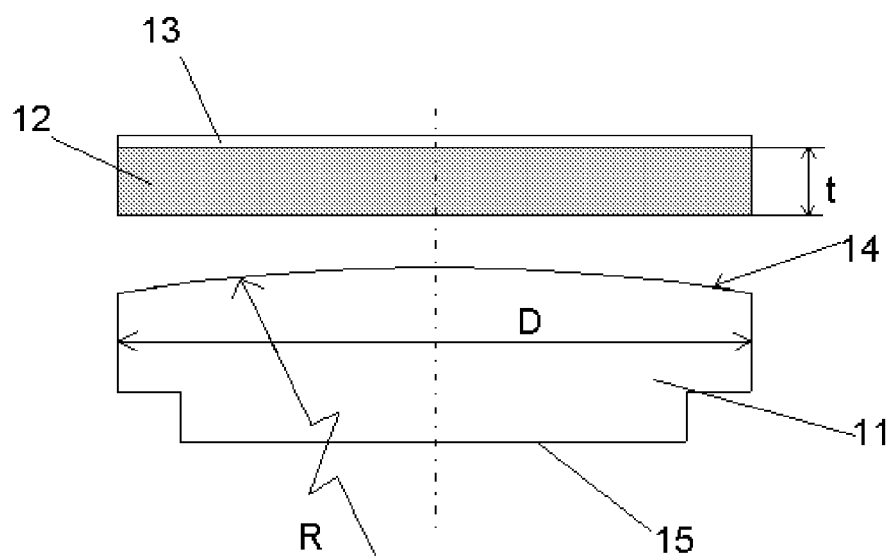


Figure 1

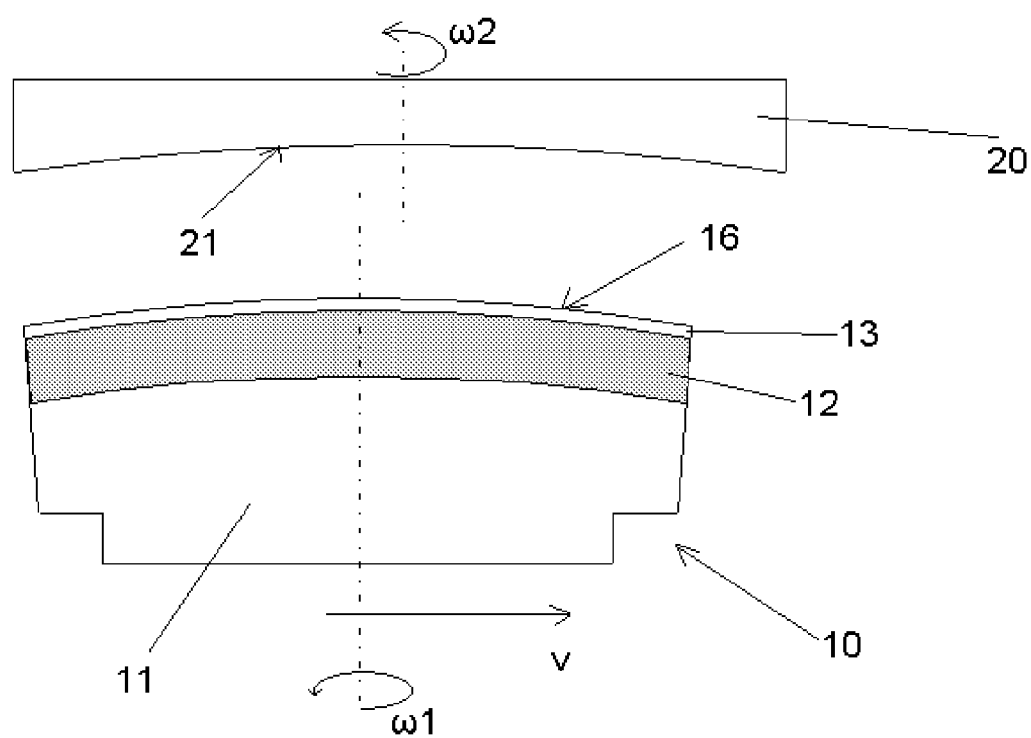


Figure 2

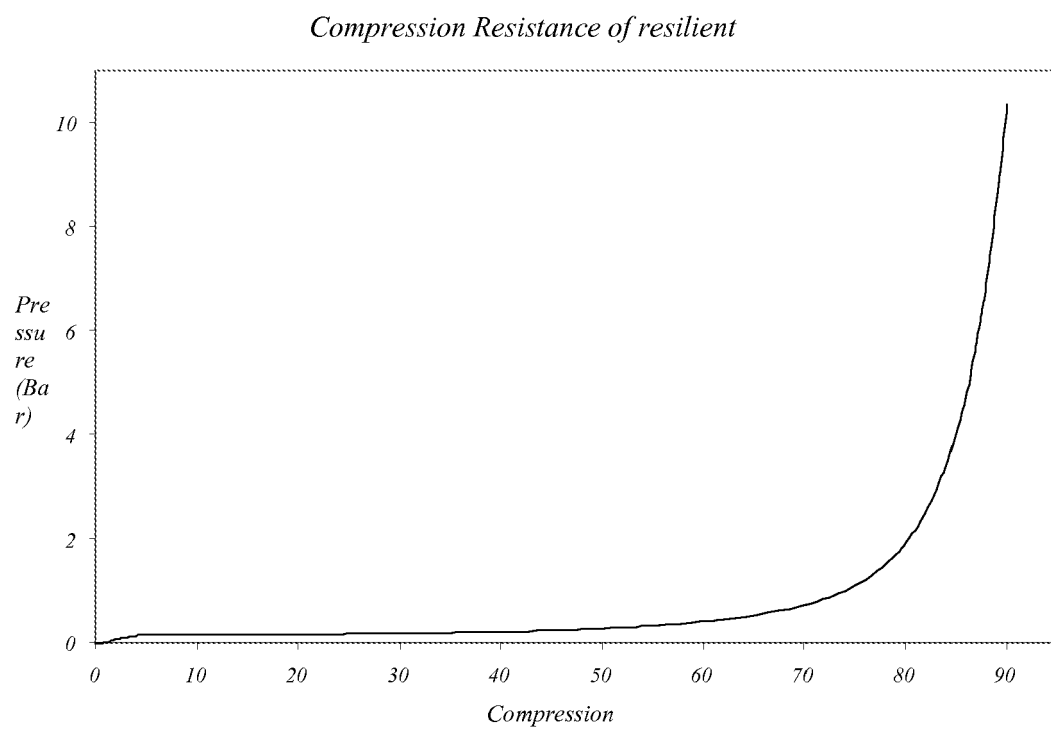
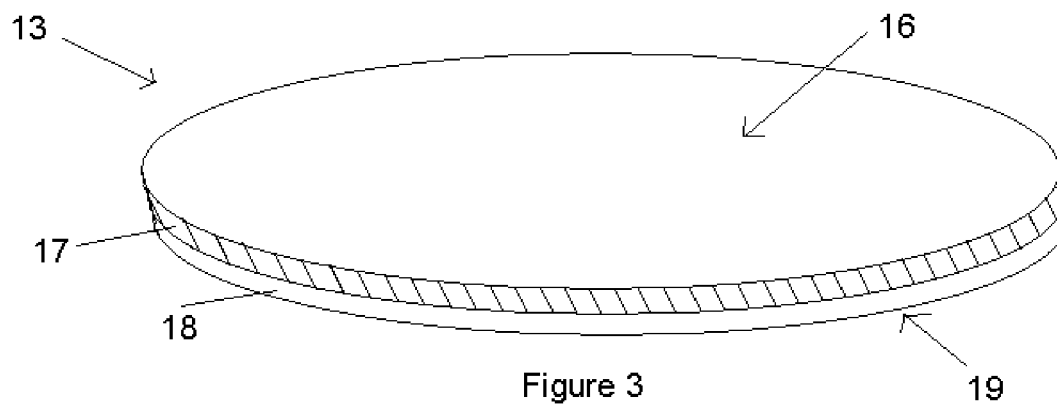


Figure 4a

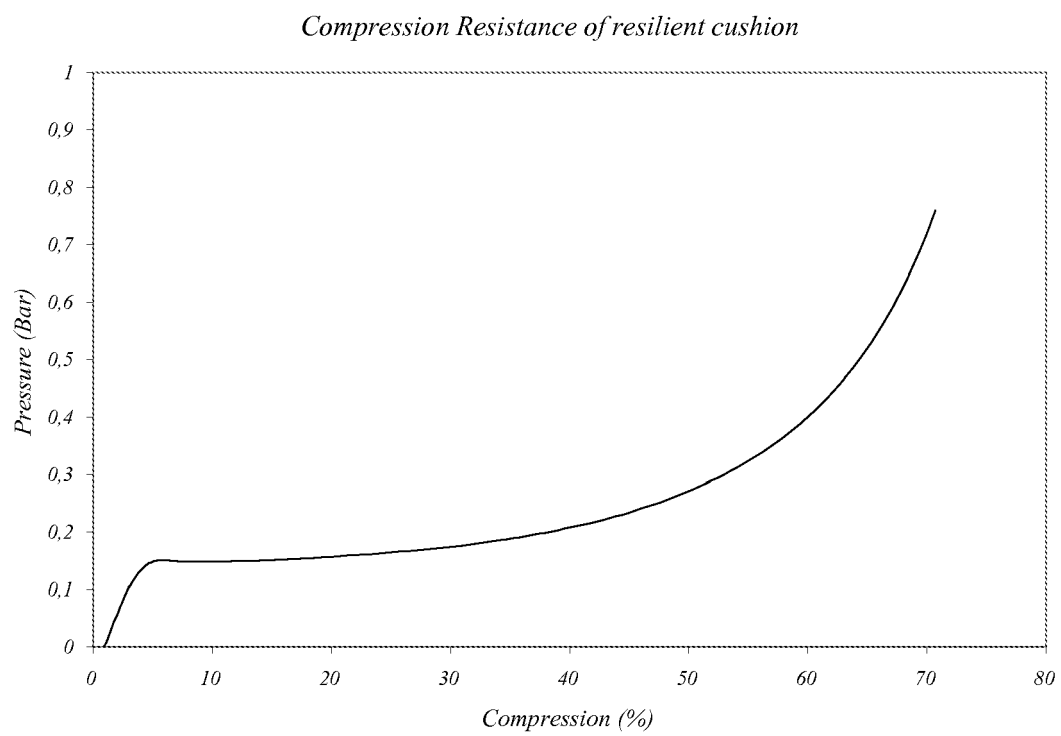


Figure 4b



EUROPEAN SEARCH REPORT

Application Number
EP 08 38 2026

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 3 November 2008	Examiner Eder, Raimund
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

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EP 08 38 2026

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