P/00/001 28/5/91
Section 29

AUSTRALIA 644723
Patents Act 1990

PATENT REQUEST: STANDARD PATENT/PATENT OF ADDITION

I/We, being the person(s) identified below as the Applicant, request the grant of a patent to the person identified below as the Nominated Person, for an invention described in the accompanying standard complete specification.

Full application details follow.

[71] Applicant: ESSILOR INTERNATIONAL CIE GENERALE D'OPTIQUE

Address: 1 Rue Thomas Edison, Echat 902, 94028 Creteil Cedex, France

[70] Nominated Person: ESSILOR INTERNATIONAL CIE GENERALE D'OPTIQUE

Address: 1 Rue Thomas Edison, Echat 902, 94028 Creteil Cedex, France

[54] Invention Title: METHOD OF MANUFACTURING A TRANSPARENT POLYMER MATERIAL ARTICLE WITH A REFRACTIVE INDEX GRADIENT

[72] Name(s) of actual inventor(s): LEANIRITH YEAN, GEORGES WAJS, GERARD MARTIN and PATRICK GUERRERO

[74] Address for service in Australia: c/o WATERMARK PATENT & TRADEMARK ATTORNEYS, of The Atrium, 290 Burwood Road, Hawthorn, Victoria 3122, Australia Attorney Code: WM

BASIC CONVENTION APPLICATION(S) DETAILS

[31] Application Number	[33] Country	Country Code	[32] Date of Application
9102827	France	FR	8th March 1991

Drawing number recommended to accompany the abstract ....

By my/our Patent Attorneys,
WATERMARK PATENT & TRADEMARK ATTORNEYS

....
Ian A. Scott

..........5th March 1992..........
(Date)

Registered Patent Attorney

P/00/008b 12/11/91
Section 29 (1)
Regulation 3.1 (2)

AUSTRALIA

Patents Act 1990

NOTICE OF ENTITLEMENT

(To be filed before acceptance)

We, **ESSILOR INTERNATIONAL Cie Générale d'Optique** of 1 Rue Thomas Edison, Echat 902, 94028, Creteil, Cedex, France, being the applicant in respect of Application No. 11460/92 state the following:-

The Person nominated for the grant of the patent has entitlement from the actual inventors named on the Patent Request by virtue of the employment of the inventors by the person nominated.

The person nominated for the grant of the patent is the applicant of the basic application listed on the patent request form.

The basic application listed on the request form is the first application made in a Convention country in respect of the invention.

ESSILOR INTERNATIONAL Cie Générale d'Optique

By our Patent Attorneys,
WATERMARK PATENT & TRADEMARK ATTORNEYS

.... 13 October 1993

Ian A. Scott (Date)
Registered Patent Attorney

AU9211460

(12) PATENT ABRIDGMENT (11) Document No. AU-B-11460/92
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 644723

(54) Title
METHOD OF MANUFACTURING A TRANSPARENT POLYMER MATERIAL ARTICLE WITH A REFRACTIVE INDEX GRADIENT

International Patent Classification(s)
(51)[5] C08J 005/00 B29C 039/10 B29D 011/00 G02B 001/04 G02C 007/04

(21) Application No. : 11460/92 (22) Application Date : 06.03.92

(30) Priority Data

(31) Number (32) Date (33) Country
91 02827 08.03.91 FR FRANCE

(43) Publication Date : 10.09.92

(44) Publication Date of Accepted Application : 16.12.93

(71) Applicant(s)
ESSILOR INTERNATIONAL CIE GENERALE D'OPTIQUE

(72) Inventor(s)
LEANIRITH YEAN; GEORGES WAJS; GERARD MARTIN; PATRICK GUERRERO

(74) Attorney or Agent
WATERMARK PATENT & TRADEMARK ATTORNEYS , Locked Bag 5, HAWTHORN VIC 3122

(56) Prior Art Documents
US 4208362

(57) Claim

1. Method of manufacturing a transparent polymer material article having a refractive index gradient in which the polymer base material is caused to absorb a swelling agent including at least a monomer adapted to yield a polymer having a refractive index different than that of the polymer base material wherein a first preform having a first geometry is formed from said polymer base material sufficiently polymerized for said first preform to be self-supporting, a confinement space is defined between said first preform and an abutment member having facing it a second geometry at least partly different than said first geometry and having a greater volume than said first geometry, said first preform is brought into contact in said confinement space with a sufficient quantity of swelling agent for the swelling to which it is then subject to cause it to be urged actively into contact with all points of said second geometry, the resulting polymer material is polymerized and the second preform thus obtained is machined, if necessary, to the required final geometry of the required article.

.../2

3. Method according to claim 1 or claim 2 wherein said polymer base material and said swelling agent are selected so that the difference between the refractive indices of said polymer base material and the polymer produced by said swelling agent is equal to 0.005 at least.

P/00/011 28/5/91
Regulation 3.2(2)

AUSTRALIA

Patents Act 1990

644723

ORIGINAL

COMPLETE SPECIFICATION

STANDARD PATENT

Application Number:

Lodged:

Invention Title: METHOD OF MANUFACTURING A TRANSPARENT POLYMER MATERIAL ARTICLE WITH A REFRACTIVE INDEX GRADIENT

The following statement is a full description of this invention, including the best method of performing it known to :- us

Method of manufacturing a transparent polymer material article with a refractive index gradient

The present invention concerns the manufacture of a transparent polymer material article with a refractive index gradient whereby the refractive index varies continuously in at least one direction.

It is more particularly, although not necessarily exclusively, directed to the situation in which the article can be used to manufacture an ophthalmic lens.

It is known that varying the refractive index of an ophthalmic lens makes it possible to reduce the maximum thickness and therefore the weight so that the same correction can be achieved with greater comfort for the user, for example.

Various methods have already been proposed for obtaining a refractive index gradient in a polymer material.

As disclosed in American patent US-A-3.718.383, for example, an additive composition, in practise a dilutant, can be absorbed into the polymer material, a hardened polymer material in this instance, in practise by diffusion.

Alternatively, as disclosed in the Japanese patent document No 60-175009 a gel can be treated with a monomer adapted to produce a polymer whose index of refraction is different than that of the base material, after which the combination is finally polymerized to set the geometry of the refractive index gradient which is then obtained.

However, this geometry depends directly on the concentration profile of the monomer within the polymer base material.

It therefore depends on the polymer/monomer interaction and can therefore be affected by changes of temperature that may occur during the diffusion process.

Under these conditions, it is difficult to control accurately the spatial distribution of the refractive index gradient obtained.

In either case, a refractive index gradient can be achieved only over a limited distance, this being the distance over which the monomer diffuses into the polymer base material.

To obtain accurate control of the spatial distribution of the refractive index gradient it has been proposed to diffuse a mixture of monomers into a gel, to vary the composition of the mixture during the diffusion process until a relative concentration profile is obtained which matches the required refractive index gradient profile and then to complete the polymerization of the whole to fix the resulting refractive index gradient geometry.

Although satisfactory in other respects, this method is unable to increase significantly the distance over which a refractive index gradient can be obtained, this distance being still limited by the diffusion process.

A general object of the present invention is a method enabling this difficulty to be overcome and the spatial distribution of the refractive index gradient obtained to be monitored and controlled.

The invention consists in a method of manufacturing a transparent polymer material article having a refractive index gradient in which the polymer base material is caused to absorb a swelling agent including at least a monomer adapted to yield a polymer having a refractive index different than that of the polymer base material wherein a first preform having a first geometry is formed from said polymer base material sufficiently polymerized for said first preform to be self-supporting, a confinement space is defined between said first preform and an abutment member having facing it a second geometry at least partly different than said first geometry and having a greater volume than said first geometry, said first preform is brought into contact in said confinement space with a sufficient quantity of swelling agent for the swelling to which it is then subject to cause it to be urged actively into contact with all points of said second geometry, the resulting polymer material is polymerized and the second preform thus obtained is machined, if necessary, to the required final geometry of the required article.

By confining the swelling of the treated polymer material there is produced in the relevant part thereof a swelling gradient responsible for most of the required refractive index gradient.

The swelling gradient itself depends only on the difference between the two geometries between which the swelling develops one preform from the other.

In this way the spatial distribution of the refractive index gradient obtained in the second preform depends only on the geometry differences.

It is therefore possible to obtain any refractive index gradient profile over all or part of the article concerned.

All that is required is to choose appropriately the two geometries to be used.

With the swelling gradient achieved in accordance with the invention, and unlike the prior art diffusion processes previously described, the refractive index gradient is advantageously developed in a transverse direction to that in which the swelling is obtained.

In practise this direction is a radial direction of the article concerned.

Be this as it may, there is therefore no longer any limit as to the distance over which the refractive index gradient obtained can effectively extend.

As previously, all that is required is to choose appropriately the two geometries employed.

It is theoretically possible, and tests have confirmed this, to obtain the refractive index gradient with a single swelling.

The refractive index is then advantageously constant along any straight line parallel to the direction in which the swelling gradient is developed.

In all cases the maximum difference in refractive index that can be achieved with the method in accordance with the invention depends firstly on the refractive indices of the polymer base material and the swelling agent and secondly on the maximum swelling of the polymer base material relative to the swelling agent.

All that is required is therefore to choose these materials appropriately.

The features and advantages of the invention will emerge from the following description given by way of example with reference to the appended diagrammatic drawings, in which:

- figure 1 is a perspective view of a transparent polymer material article having a refractive index gradient to the manufacture of which the invention may be applied,

- figure 2 is a view in cross-section relating to the prior manufacture of a first preform of this article,

- figure 3 is a view in cross-section of this preform,

- figure 4 is a view in cross-section relating to the manufacture of a second preform of the required article,

- figure 5 is a view in cross-section of the second preform assumed to have been polymerized in situ before swelling is complete,

- figure 6 is a view in cross-section of the required article as obtained after appropriate machining of the second preform,

- figures 7 and 8 are diagrams relating to this article,

- figures 9, 10, 11 and 12 are views in axial cross-section analogous to that of figure 5 and each relating to a respective preform having a different spatial distribution of the refractive index gradient than the preform shown in figure 5,

- figure 13 is a diagram summarizing these spatial distributions of the refractive index gradient,

- figure 14 is a view in cross-section analogous to that of figure 4 relating to an alternative embodiment.

Figures 1 through 14 show by way of example the application of the invention to the manufacture of an ophthalmic lens 10 shown separately in figures 1 and 6.

A transparent polymer base material is caused to absorb, by methods to be described in more detail later, an additive composition comprising at least one monomer adapted to yield a polymer having a refractive index different than that of the polymer base material.

According to the invention, the additive composition is a swelling agent.

The combination of the polymer base material and the swelling agent including at least one monomer must in practise preferably meet the following requirements:

Firstly, and by definition, it must be possible for the polymer base material to swell due to the action of the swelling agent at least sufficiently to implement the method in accordance with the invention.

The polymer base material and the swelling agent are preferably, but not necessarily obligatorily, chosen so that the polymer base material swells by at least 100% in the presence of the swelling agent.

Also, the final polymer material must be transparent.

Finally, to obtain a meaningful refractive index gradient there must be a ~~minimal~~ difference of refractive index between the polymer base material and the polymer produced by the swelling agent.

The polymer base material and the swelling agent are preferably selected so that this difference in refractive index is equal to 0.005 at least.

The polymer base material may comprise a polyolefin, for example.

It may be a polyolefin, for example.

It is then mostly styrene and the appropriate swelling agent essentially comprises methyl methacrylate.

The resulting swelling coefficient G is 100% and the maximal refractive index difference Dmax is in the order of 0.05.

A reticulating agent is preferably added to the polymer base material, for example divinylbenzene or triethylene glycol dimethacrylate (TEGDM), in this case in the proportion of 0.5%.

A reticulating agent such as TEGDM, for example, is likewise preferably added to the swelling agent.

The polymer base material preferably includes a product such as allylmethacrylate, for example, in the proportion of 10% in this case, adapted to have its matrix link up with that of the additive composition so that the final polymer material obtained has a semi-IPM type matrix, in other words a matrix which, whilst being similar to interpenetrated polymer matrices, contains chemical bonds between the constituent polymers.

Table I gives a specific example for a combination of polymer base material and swelling agent and the results obtained.

Table I

Polymer base material	Swelling agent	Results
Styrene	Methyl methacrylate	G = 100% Dmax = 0.05
Allylmethacrylate (10%)		
Divinylbenzene or TEGDM (0.5%)	TEGDM	

The percentages in brackets in table I are percentages by weight relative to 100% for the styrene.

Alternatively, the polymer base material may comprise a polyurethane.

It may be a polyurethane, for example.

For example, it then results for the most part from the reaction of a substance comprising at least one isocyanate and at least one polyol and the swelling agent then essentially comprises styrene.

Table II gives a specific example for a combination of polymer base material and swelling agent and the results obtained.

Table II

Polymer base material	Swelling agent	Results
IPDI (1) U 1004 (0.6) [catalyst : DBLE] T 301 (0.3) HEMA (0.1)	Styrene + 1% TEGDM	G = 100% Dmax = 0.05
HDT (1) CAPA 200 (0.9) HEMA (0.1)	Styrene + 1% TEGDM	G = 400% Dmax = 0.07
DESMODUR N 100 (1) CAPA 200 (0.9) HEMA (0.1)	Styrene + 1% TEGDM	G = 250% Dmax = 0.06
HDT (0.5) DESMODUR W (0.4) Isocyanatoethyl methacrylate (0.1) CAPA 200 (1)	Styrene + 1% TEGDM	G = 150% Dmax = 0.05

The abbreviations used in table II have the following meanings:

IPDI : isophorone diisocyanate manufactured by HULS,

U 1004 * : polyetherdiol manufactured by UGINE-KUHLMANN,

T 301 * : polyester triol manufactured by UNION CARBIDE,

HEMA : hydroxy ethyl methacrylate,

HDT * : triisocyanathohexyl isocyanurate manufactured by RHONE-POULENC,

DBLE : dibutyldilaurate of tin,

CAP 200 * : polyesterdiol manufactured by SOLVAY,

DESMODUR W * : diisocyanate of dicyclohexylmethane manufactured by BASF,

DESMODUR N 100 * : triisocyanatohexyl biuret manufactured by BASF.

* : Registered trademark.

The figures in brackets in table II are the proportions of the isocyanate and alcohol reactive functions.

Finally, in table II and as with the previously referred to allylmethacrylate, the hydroxy ethyl methacrylate (HEMA) or the isocyanatoethyl methacrylate are products adapted to link the matrix of the polymer base material to that of the swelling agent [V. NEVISSAS, J.M. WIDMAYER and G.C. MEYER (STRASBOURG CRM), Journal of Applied Polymer Science, vol. 36, 1467-1473 (1988)].

In another embodiment the polymer base material may comprise both a polyurethane and an allyl type monomer which is unpolymerized at this stage.

The swelling agent then essentially comprises styrene.

Table III gives a specific example of such materials and the result obtained in the same conditions as previously.

Table III

Polymer base material	Swelling agent	Results
HDT (1) CAPA 200 (0.9) [catalyst: DBLE] 99% to 70% HEMA (0.1) XR80 + TBPIN : 1% to 30%	Styrene + 1% TEGDM	G = 150% Dmax = 0.05

The abbreviations used in table III have the following meanings:

TBPIN : terbutylperoxy trimethylhexanoate manufactured by SCPO,

XR80 * : diethylene glycol diallylcarbonate manufactured by RHONE-POULENC.

* : Registered trademark.

It should be emphasized that because the polymer base material comprises an allyl monomer in addition to a polyurethane the polyurethane matrix is formed in a first stage, the allyl monomer present being intended to react during final polymerization after swelling.

In this case the first preform is therefore a polyurethane matrix impregnated with allyl monomer.

After it is polymerized the allyl monomer improves the mechanical properties of the second preform and therefore of the final article obtained.

It should also be emphasized that the refractive indices mentioned in this application are those of the polymers in their final state, that is to say after the final polymerization producing the .uired article, and that the expression "polymer base material" as used in the present application must be interpreted in a broad sense.

In another embodiment the polymer base material comprises a polyurethane and an acrylic or methacrylic monomer with the same function as the allyl monomer of the previous embodiment.

Table IV shows this possibility subject to the same conditions as above.

Table IV

Polymer base material		Swelling agent	Results
HDT (1) CAPA 200 (0.9) [catalyst : DBLE] HEMA (0.11)	99% to 70%	Styrene + 1% TEGDM	G = 150% Dmax = 0.05
Methyl methacrylate TEGDM (1%)	1% to 30%		

Practical methods of executing the invention will now be described with reference to figures 1 through 6.

The first stage (figures 2 and 3) is to produce a first preform P1 of the polymer base material which is sufficiently polymerized to be self-supporting.

The following composition from table II:

HDT (1),
CAPA 200 (0.9),
HEMA (0.1),

is reacted in a mold 11 comprising two molding shells 12, 12′ and an O-ring seal 13 holding them apart.

There is no a priori connection between the geometry G1 required for the first preform P1 and the geometry G0 required for the final ophthalmic lens 10 except that it must be possible to obtain the latter from the former, of course.

In the application shown the ophthalmic lens 10 is a concave-convex lens with an optical axis XY and a geometry G0 formed essentially by a convex surface S0 and a concave surface S′0.

As shown (Example 1), the first preform P1 then required is biconvex with a geometry G1 formed by two convex surfaces S1, S′1.

For example, the thickness E1 at the centre of the preform P1 is 10 mm, its thickness E2 at the edge is 5 mm, its diameter 2R is 80 mm and the radius of the convex surfaces S1, S′1 is 254 mm.

The mold 11 is constructed accordingly.

Its interior geometry is therefore the geometry G1.

0.1% DBLE is preferably added to the mixture placed in the mold 11 to act as a catalyst and the whole is heated from 42°C to 80°C in ten hours after which it is maintained at 80°C for four hours.

In the polymer base material then constituting the first preform P1 obtained in this way the degree of polymerization is in the order of 100%.

Alternatively, it could be between at least the degree of polymerization for the gel form and 100%.

Generally speaking, it is sufficient that it should render the first preform P1 obtained self-supporting.

Be this as it may, the refractive index of the transparent polymer material is 1.5.

According to the invention, a confinement space 14 is then defined between the first preform P1 and at least one abutment member 16, 16′ having a second geometry G2 which differs at least in part from the first geometry G1 and has a greater volume than the latter.

As in the embodiment specifically shown in figure 4, for example, the first preform P1 is placed in a confinement enclosure 15.

Like the mold 11, the confinement enclosure 15 comprises two walls 16, 16′ each of which constitutes one abutment member 16, 16′ and an O-ring seal 17 holding the walls 16, 16′ apart.

In this specific embodiment both the walls 16, 16′ are flat plates whose inside surfaces S2, S′2 are perpendicular to the optical axis XY and separated by a distance equal to the thickness E1 at the center of the first preform P1, which is 10 mm.

As symbolically shown by arrows F, F′, the walls 16, 16′ are appropriately braced, for example by means of a clamp (not shown).

The first preform P1 is brought into contact with the selected swelling agent in the confinement space 14 delimited in the confinement enclosure 15 by a method that will not be described here as it will be obvious to the man skilled in the art.

This substance is styrene to which 1% TEGDM and 0.5% azobisisobutyronitrile catalyst have been added.

The refractive index of the polymer produced by this swelling agent is 1.59.

The swelling of the first preform P1 at ambient temperature in contact with this swelling agent takes four days in practise.

The quantity of swelling agent used is in practise sufficient for this swelling to cause the first preform

P1 to be urged actively into contact with all points of the second geometry G2 defined by the abutment members 16, 16′ formed by the walls 16, 16′ of the confinement enclosure 15. The result is as if its convex surfaces S1, S′1 were brought into contact at all points with the plane surfaces S2, S′2.

The resulting polymer material is then polymerized by carrying out a heating cycle during which the temperature is raised to 100°C.

This polymerization is carried out in situ and must of course take place before swelling is complete, so that a swelling gradient is obtained within the treated material.

It is in this sense that the required second preform P2 is said to be urged actively into contact with all points of the abutment members 16, 16′.

Because of this, the second preform P2 obtained (see figure 5) has a second geometry G2 which is a mirror image of that defined by the abutment members 16, 16′.

In this embodiment it is therefore a disk-shape blank with plane surfaces and a circular contour, the O-ring seal 17 also acting as an abutment member.

To explain the invention more clearly, figure 5 shows the geometry G1 of the original preform P1 in chain-dotted outline inside this blank.

Figure 7 is a graph showing the swelling G between the first preform P1 and the second preform P2 as a function of the radius R.

Because of the methodology employed, there is no swelling on the optical axis XY and the swelling then increases in the radial direction away from this axis to a maximum at the edge.

Given the original thickness E1 of the first preform P1 at its edge, this maximum swelling is 100%.

Figure 8 is a graph showing the refractive index N profile obtained after swelling and polymerization as a function of the radius R.

The refractive index is in the order of 1.5 on the optical axis XY.

At the edge it is in the order of 1.55.

If required, as is the case in this embodiment, the second preform P2 obtained is machined to yield the final geometry G0 required for the ophthalmic lens 10.

Figures 9 through 12 relate to examples of preforms P2 which all have the same geometry G2 as the previous preform P2 but different spatial distributions of the refractive index. The preforms P1 from which they are obtained, shown in chain-dotted outline, have different geometries G1 but the same diameter 2R equal to 80 mm.

In figure 9 (Example 2) the preform P1 is biconvex but its convex surfaces S1, S'1 have a different radius than the previous convex surfaces S1, S'1.

This radius is 321.25 mm, the thickness at the center is 10 mm and the thickness at the edge is 5 mm, for example.

In figure 10 (Example 3) the preform P1 is biconcave.

The concave surfaces have the same radius 321.25 mm, the thickness at the center is 5 mm and the thickness at the edge is 10 mm, for example.

In figure 11 (Example 4) the preform P1 is plano-convex.

The radius of the convex surface is 110.41 mm and the thickness at the edge is 2.5 mm, for example.

Finally, in figure 12 (Example 5) the profile of the surfaces S1, S'1 of the preform P1 features a point of inflexion.

The surfaces S1, S'1 have the same profile, for example. They are convex at the center and their radius in this central area is 134.08 mm while the radius in the concave area of their profile is 81.25 mm, the thickness at the center is 10 mm and the thickness at the edge is 2 mm, for example.

Figure 13 is a graph showing the profile of the refractive indices N obtained after swelling and polymerization.

In this diagram the curve N2 relates to Example 2, the curve N3 to Example 3, the curve N4 to Example 4 and the curve N5 to Example 5.

In the embodiment shown in figure 14 the confinement space 14 is operative in a localized area because of a localized depression provided to this end in the surface S1 of the preform P1.

The confinement volume 14 is in practise defined between the preform P1 and a molding shell 16 constituting the abutment member 16 and espousing the shape of the surface S1 outside the confinement space 14.

The molding shell 16 must of course be braced as previously or, more generally, fixed relative to the part of the surface S1 of the preform P1 that is not part of the surface of the confinement space 14.

The present invention is obviously not limited to the examples described and shown, either with regard to the geometries employed or with regard to the materials used.

Nor is the invention limited to the specific methodologies described, but encompasses any variant thereof.

Specifically, to homogenize the mechanical properties of the final polymer some swelling may also be developed along the optical axis.

All that is required to achieve this is to space away from the first preform P1 the abutment members 16, 16′ constituting the walls 16, 16′ of the confinement enclosure 15 by providing spacer means for the first preform P1 adapted to hold it between the walls 16, 16'.

The swelling along the optical axis XY may then be 100% and that along the edge in the order of 200%, for example.

What is more, the swelling could be applied to only one surface of the first preform rather than both surfaces.

This might apply in particular to the manufacture of a semi-finished ophthalmic lens already having the required geometry on one surface.

Similarly, although in the foregoing description swelling occurs in all of the polymer base material, swelling may equally well occur in only part of this material.

Finally, the first and/or the second preform need not necessarily be symmetrical about an axis of revolution.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

~~CLAIMS~~

1. Method of manufacturing a transparent polymer material article having a refractive index gradient in which the polymer base material is caused to absorb a swelling agent including at least a monomer adapted to yield a polymer having a refractive index different than that of the polymer base material wherein a first preform having a first geometry is formed from said polymer base material sufficiently polymerized for said first preform to be self-supporting, a confinement space is defined between said first preform and an abutment member having facing it a second geometry at least partly different than said first geometry and having a greater volume than said first geometry, said first preform is brought into contact in said confinement space with a sufficient quantity of swelling agent for the swelling to which it is then subject to cause it to be urged actively into contact with all points of said second geometry, the resulting polymer material is polymerized and the second preform thus obtained is machined, if necessary, to the required final geometry of the required article.

2. Method according to claim 1 wherein to define said confinement space said first preform is placed in a confinement enclosure at least one wall of which constitutes an abutment member.

3. Method according to claim 1 or claim 2 wherein said polymer base material and said swelling agent are selected so that the difference between the refractive indices of said polymer base material and the polymer produced by said swelling agent is equal to 0.005 at least.

4. Method according to any one of claims 1 to 3 wherein said polymer base material comprises a polyolefin.

5. Method according to claim 4 wherein said

polymer base material is mainly styrene and said swelling agent essentially comprises methyl methacrylate.

6. Method according to any one of claims 1 to 5 wherein said polymer base material comprises a polyurethane.

7. Method according to claim 6 wherein said polymer base material results for the most part from the reaction of a composition comprising at least an isocyanate and at least a polyol and said swelling agent essentially comprises styrene.

8. Method according to claim 6 or claim 7 wherein said polymer base material comprises a polyurethane and a monomer such as an allyl, acrylic or methacrylic monomer.

9. Method according to any one of claims 1 to 8 wherein said polymer base material also comprises a product adapted to link its matrix to that of said swelling agent.

DATED this 5th day of March 1992.

ESSILOR INTERNATIONAL CIE GENERALE D'OPTIQUE

WATERMARK PATENT & TRADEMARK ATTORNEYS
"THE ATRIUM"
290 BURWOOD ROAD
HAWTHORN. VIC. 3122.

ABSTRACT

In a method of manufacturing a transparent polymer material article having a refractive index gradient the polymer base material is caused to absorb a swelling agent including at least a monomer adapted to yield a polymer having a refractive index different than that of the polymer base material. A first preform having a first geometry is formed from the polymer base material sufficiently polymerized for the first preform to be self-supporting. A confinement space is defined between the first preform and an abutment member having facing it a second geometry at least partly different than the first geometry and having a greater volume than the latter. The first preform is brought into contact in the confinement space with a sufficient quantity of swelling agent for the swelling to which it is then subject to cause it to be urged actively into contact with all points of the second geometry. The resulting polymer material is polymerized and the second preform thus obtained is machined, if necessary, to the required final geometry of the required article. The method finds an application in the manufacture of ophthalmic lenses.

FIG.1

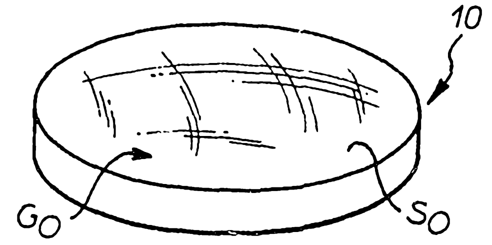


FIG.2

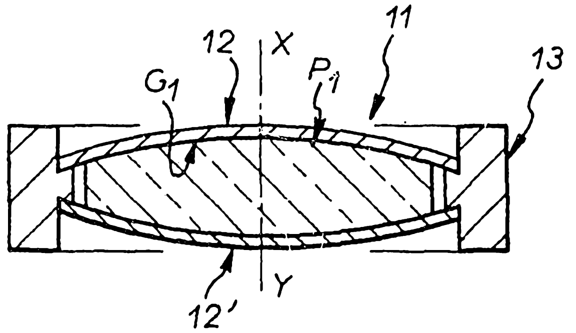


FIG.3

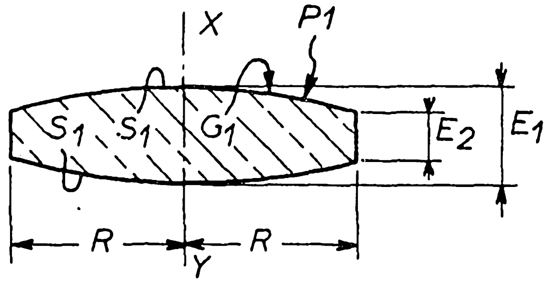


FIG.4

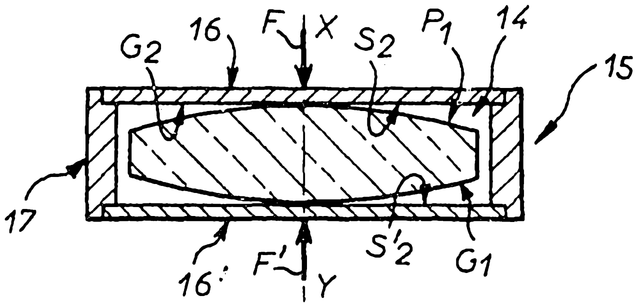


FIG.5

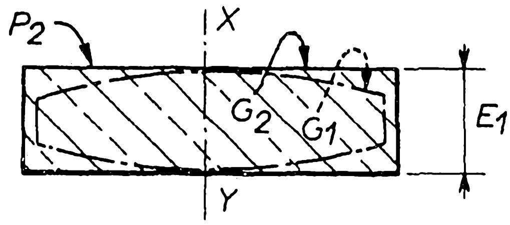


FIG.6

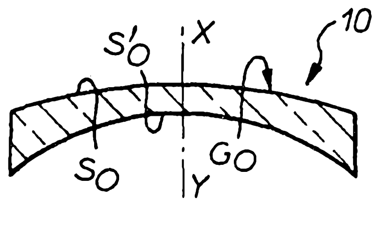


FIG.7

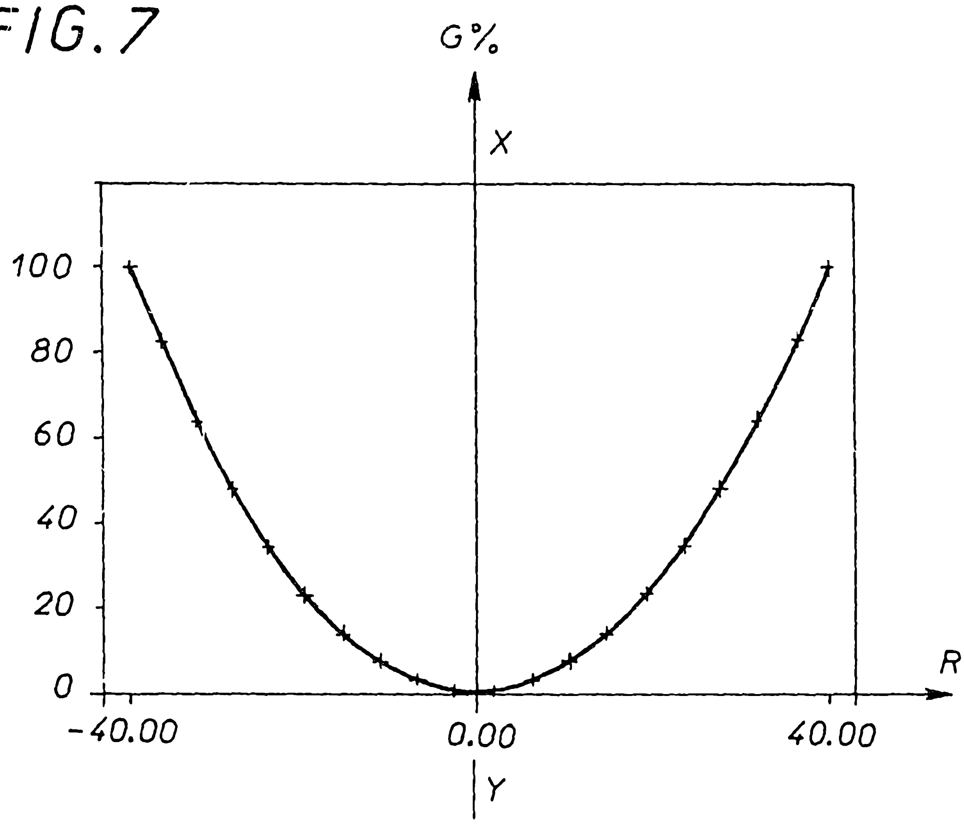

G%
X
100
80
60
40
20
0
-40.00
0.00
40.00
R
Y

FIG.8

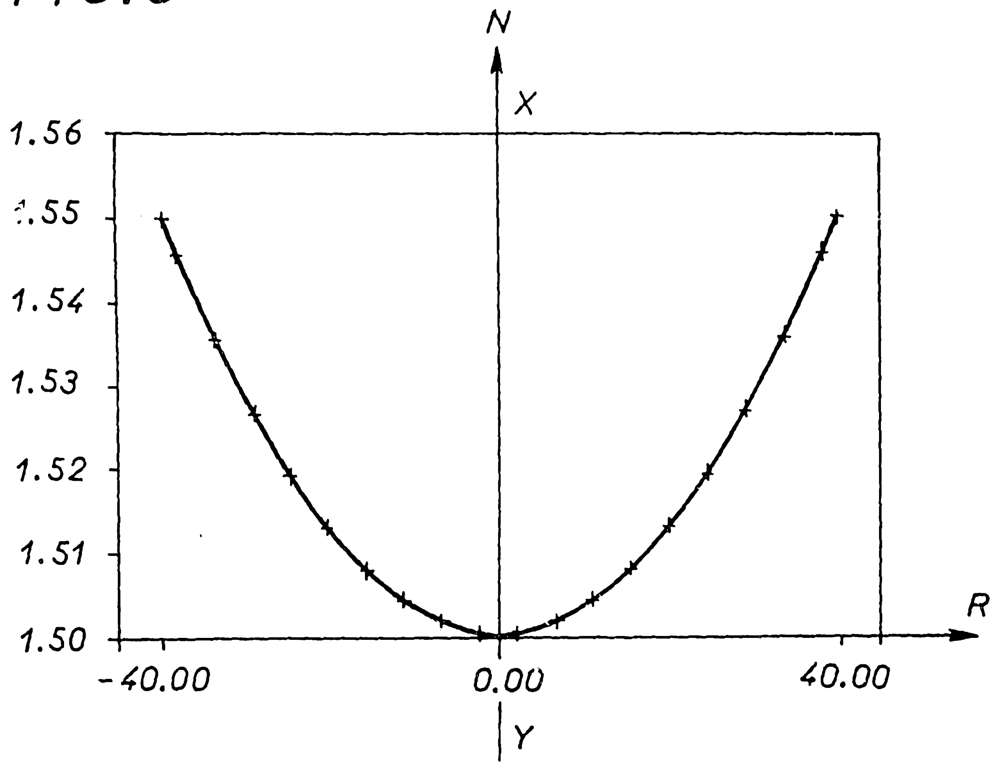

N
X
1.56
1.55
1.54
1.53
1.52
1.51
1.50
-40.00
0.00
40.00
R
Y

FIG. 9

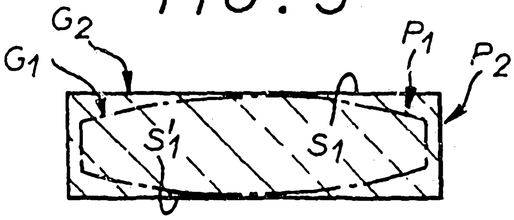


FIG. 11

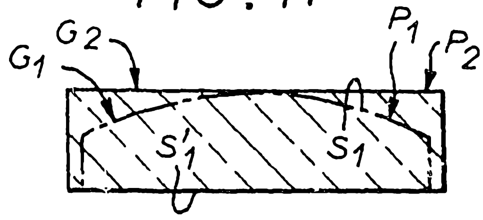


FIG. 10

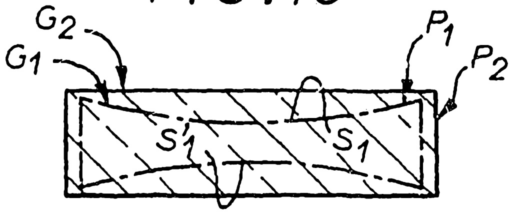


FIG. 12

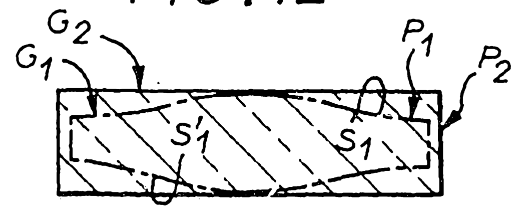
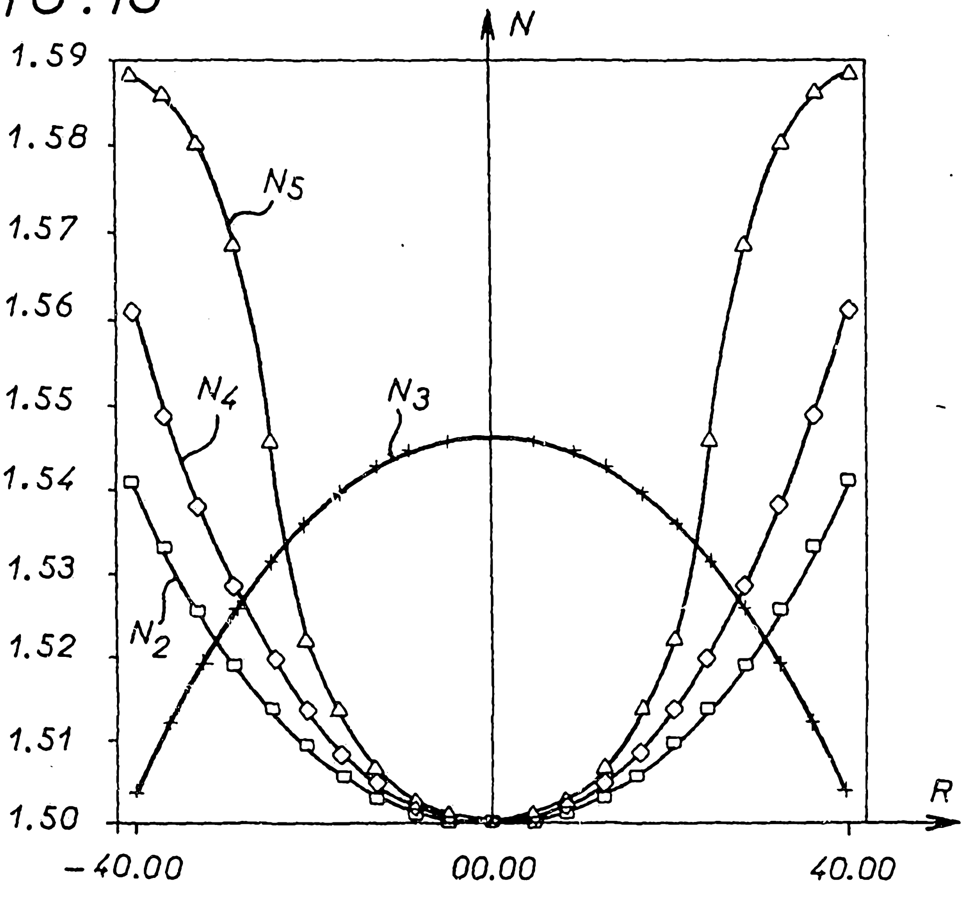


FIG. 13



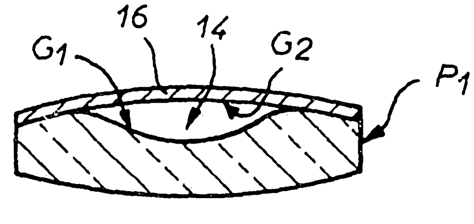


FIG. 14