INTRAOCULAR AND EXTRAOCULAR LENS CONSTRUCTION AND METHOD OF MAKING THE SAME

This application is a division of copending application Ser. No. 288,217, filed July 29, 1981 and now U.S. Pat. No. 4,402,579.

BACKGROUND OF THE INVENTION

This invention relates to lens and haptic structures having application as intraocular lens implants, or as extraocular devices for contact application to the cornea, for wear in place of spectacles.

As intraocular devices, such structures and methods of making the same are illustratively treated in my U.S. Pat. No. 4,080,709, and as extraocular devices, such structures are illustratively treated in my copending application, Ser. No. 124,941, filed Feb. 26, 1980.

Design philosophy behind intraocular and extraocular devices of the character indicated holds that the lens element shall be an optically finished unitary part, and that associated haptic structure shall be a separate thin flexible part or parts devised for central support of the lens element and for suitably compatible stabilized referencing engagement with adjacent body features.

There is another category of intraocular lens, exemplified by Choyce, et al., U.S. Pat. No. 4,087,866, wherein lens and haptic structure are the integral product of plastic-molding. But such products do not lend themselves to fabrication with glass, nor to known glass-lens finishing techniques. Moreover, injection-molded plastic materials are inherently incapable of providing the optical quality and uniformity that is available from certain plastic materials which are available in flat-sheet form.

BRIEF STATEMENT OF THE INVENTION

It is an object to provide improved integrally formed lens and haptic structures of the character indicated.

Another object is to provide methods of manufacture of such structures which are inherently applicable to fabrication from glass or from a plastic, as the starting and the only material of the ultimate product.

A specific object is to meet the above object with structures and techniques which utilize flat sheet material as the starting and only material of the ultimate product.

The invention achieves these objects and certain further features by employing suitably coordinated masking and etching steps to determine the peripheral contour of the ultimate central lens as well as the thickness and fenestration detail of the ultimate thin flexible haptic formations which are integral with and extend radially outward of the lens blank. In all cases, the starting material is flat sheet stock, of thickness to provide for the overall ultimate axial extent of the lens. Lens-surface curvature may be developed prior to but is preferably developed after haptic formation. The masking and fenestration detail are provided via photo-etch techniques and are applicable to mass production of plural duplicates of the identical lens-and-haptic structures from a single sheet through formative operations performed concurrently and in common on all structures of a given sheet.

DETAILED DESCRIPTION

Illustrative structures and techniques of the invention will be described in detail in conjunction with the accompanying drawings, in which:

FIG. **1** is a plan view of a single-piece integrally formed lens and haptic construction of the invention;

FIG. **2** is a sectional view, taken at 2—2 in FIG. **1**;

FIG. **3** is an enlarged schematic sectional representation of sheet starting material, for the aspect depicted in FIG. **2**, i.e., what begins as shown in FIG. **3** ultimately becomes what is shown in FIG. **2**;

FIG. **4** is a diagram similar to FIG. **3**, to show the result of an intermediate step in proceeding from the material of FIG. **3** to the product of FIG. **2**;

FIGS. **4A** and **4B**, are diagrammatic representations of different masks used to create the intermediate stage of FIG. **4**;

FIG. **5** is a view similar to FIG. **4**, to illustrate a finishing step, for the product of FIGS. **1** and **2**;

FIGS. **6** and **7** are views similar and respectively corresponding to FIGS. **4** and **5**, to illustrate a modification;

FIGS. **8** and **9** are views similar and respectively corresponding to FIGS. **6** and **7**, to illustrate a further modification;

FIGS. **10** and **11** are similar fragmentary plan views of two alternative multiple-structure layouts on a single sheet of starting material, for mass-production purposes;

FIGS. **12** and **13** are sectional views to the scale of FIGS. **3**, **4** and **5**, to illustrate a modified technique;

FIGS. **14** and **15** are sectional views, to the scale of FIGS. **4** and **5**, to illustrate successive finishing steps for simultaneously finishing the convex surface of each of a plurality of lens elements of optical glass;

FIG. **16** is a diagram similar to FIG. **14**, to show a set-up for simultaneously finishing the concave surface of each of a plurality of lens elements of optical glass;

FIG. **17** is a plan view of a modified integral lens and haptic construction; and

FIG. **18** is a view in side elevation of a construction as in FIG. **17**.

In the form of FIGS. **1** and **2**, the invention is shown in application to an extraocular or contact-lens assembly, strongly resembling multiple-component structure as disclosed in my said copending application, Ser. No. 124,941, but in reality comprising a central lens **10** and haptic structure **11** which are integral with each other, being the product of selectively etched reduction from starting material in the form of flat sheet stock **12**, of thickness T_1, as shown in FIG. **3**. As will later appear, the sheet stock **12** may be suitable plastic or glass, and inert to body fluids. For convenience, dimensional symbols have been applied to identify: lens diameter at D_1, which may be in the range of 6 to 9 mm; an inner circumferential haptic band or ledge **13**, which is preferably at least 0.25-mm wide, to account for its outer diameter D_2 in the range of 6.5 to 9.5 mm; and haptic outer diameter D_3 which may be in the range up to 20 mm, and thus in excess of the 12 to 14 mm diameter of the iris of an eye. It will be understood that haptic **11** may be characterized by very substantial fenestration, meaning that the structure is primarily "open", for normal air or "breathing" exposure of the surface of the cornea to which it is applied. Such substantial fenestration is shown and described in said copending application Ser. No. 124,941, and is therefore not repeated here. It suffices to note that the detail of fenestration and the vari-