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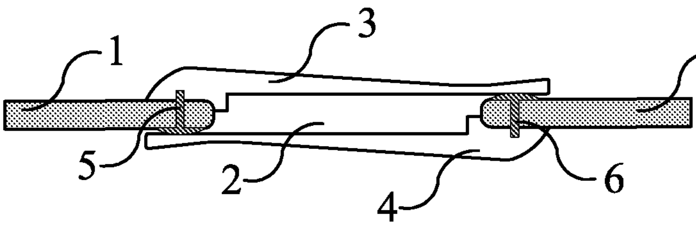
(54) Title: INTRA-OCULAR ARTIFICIAL LENS FOR IRIS-DRIVEN ACCOMMODATION



(57) Abstract: The invention relates to an intra-ocular artificial lens with variable optical strength, wherein the artificial lens comprises two optical elements which are movable relative to each other in a direction extending transversely of the optical axis, wherein the optical elements have a form such that in different relative positions they together have different optical strengths, wherein the movable optical elements are connected to positioning means which are adapted for coupling to the iris of the eye for the purpose of driving. This measure makes use of the fact that one or both of the optical elements can be displaced relative to each other through the driving of the natural orbicularis muscle of the his in order to obtain an accommodating function.

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Intra-ocular artificial lens for iris-driven accommodation

The present invention relates to an intra-ocular artificial lens with variable optical strength, wherein the artificial lens comprises at least two optical elements, at least two of which are movable relative to each other in a direction extending transversely of the optical axis, wherein the optical elements have a form such that in different relative positions of the optical elements the artificial lens has different optical strengths. The optical elements comprise positioning means for positioning the optical elements in the eye and on the iris for the purpose of driving at least one of the optical elements in order to perform a movement relative to the other optical element.

Such intra-ocular artificial lenses for implantation in the eye form the subject-matter of the non-prepublished Netherlands patent applications 1028496, 1029041 and PCT/NL 2005/000153.

In these documents the intra-ocular artificial lens is driven by the orbicularis oculi muscle, which in the natural situation drives the accommodating function of the natural eye lens.

The eye lens lies quite deeply in the eye however, so that according to the prior art replacing of the eye lens by the accommodating eye lens requires an operation wherein it is necessary to operate quite deeply in the eye. The object of the present invention is to provide such an intra-ocular artificial lens, wherein the arranging thereof requires operating less deeply in the eye.

An artificial lens according to the present invention functions generally in combination with a fixed lens in the lens capsule. This fixed lens can be either a natural, inelastic and presbyopic lens or a non-accommodating artificial lens placed as a consequence of for instance cataracts. An artificial lens according to the present invention could also function without a fixed lens in the lens capsule, although the optical properties will then of course be different compared to the previous example.

This object is achieved by such an intra-ocular eye lens which is characterized in that at least one of the movable optical elements is connected to positioning means which are adapted for coupling to the iris of the eye for the purpose of driving.
This measure makes use of the fact that one or both of the optical elements can be displaced relative to each other through the driving of the natural orbicularis muscle of the iris in order to obtain an accommodating function.

The natural lens will in practice often be inelastic due to presbyopia (long-sightedness), and the artificial lens will often be a lens which has been implanted by an ophthalmic surgeon to replace the natural lens which has become opaque as a result of cataracts.

In the natural eye lens accommodation of the eye takes place as follows. The orbicularis oculi muscle is contracted for near vision; the lens capsule, the natural casing of the natural eye lens, hereby dilates, whereby the natural eye lens, as a result of its elasticity, takes on its natural convex form. For distance vision the orbicularis muscle dilates, the lens capsule is contracted and the natural eye lens is pulled flatter. The natural rest position of the natural eye lens is therefore near vision, and the natural rest position of the orbicularis muscle is, conversely, distance vision. In the case of presbyopic patients (long-sighted people; people with reading glasses; practically anyone older than 35 years of age) the natural lens has hardened, still transmits light but no longer accommodates - these people can generally focus on distant objects but not on near objects. In the case of patients with cataracts the natural lens is opaque and will have to be removed by the ophthalmic surgeon and replaced by an artificial lens.

The iris has a natural central opening, the pupil, which becomes smaller or larger depending on the amount of light reaching the eye from outside. The pupil becomes small at a high light intensity, and the pupil enlarges at a low light intensity. The amount of light finally incident upon the retina can thus be kept relatively constant for optimum functioning of the retina. The iris is built up from an elastic tissue extending in radial direction and consisting of fibres. Situated in this fibrous tissue are melanocytes which produce melanosomes. These melanosomes are in turn filled with melanin which determines the colour of the iris and which makes the iris largely opaque to light. The patterns in which these melanosomes are deposited largely determine the colour of the iris. Situated centrally in the iris is an orbicularis muscle which controls the change in pupil size.

Experience has shown that the iris of the eye takes on a small diameter in the case of near vision, for instance during reading, and a large diameter in the case of distance vision, for instance during driving at night. This effect of the iris can therefore also be used to drive the accommodation of the eye. This principle is already being applied now in several existing lenses, particularly for patients with cataracts, where the natural lens is replaced by a special, non-accommodating artificial lens.

According to a first embodiment, the positioning means are adapted to cause the optical elements to make a translating movement relative to each other during movement of the iris. A simple construction of the positioning means is hereby obtained.

According to another embodiment, the positioning means are adapted to cause the optical elements to make a rotating movement relative to each other during movement of the iris. The construction of the positioning means hereby also becomes relatively simple. It is otherwise also possible to make use of a composite form of movement. In the above embodiments the two optical elements usually shift relative to each other over equal distances during the change in diameter of the iris.

Yet another preferred embodiment provides the measure that the positioning means are adapted to fix one of the optical elements relative to the eyeball and to drive one of the other optical elements during movement of the iris. This latter movable element, in combination with the fixed element, provides for the variation in focal distance of the whole construction driven by the iris. This principle can be embodied by combining one of the optical elements with a construction which supports in the corners of the anterior chamber (a chamber corner-supported construction).

A variant of the above embodiments provides the measure that the positioning means are connected to mechanical arresting means for limiting the stroke of the optical elements. These arresting means can be placed at random, structurally attractive locations on or around the optical elements. The arresting means define the rest position of the intra-ocular artificial lens. They can be placed so as to be active on both sides of the working area, so that they serve to define an area over which the optical elements can be moved. These arresting protrusions can be of a light construction since the iris and the intra-ocular lens are driven only by a weak orbicularis muscle. Arresting protrusions can be applied in all the above and subsequent embodiments.

The positioning means are preferably adapted for forming by the optical elements at a small pupil diameter of a lens with a high dioptric value and for forming by the optical elements at a large pupil diameter of a lens with a low dioptric value. The optical elements are herein adapted to have the optical strength for near vision, i.e. a high dioptric strength, at a high light intensity, and so a small opening of the pupil. The optical elements are also adapted to have the optical strength for distance vision, i.e. a low dioptric strength, at a low light intensity and so a large opening of the pupil.

One or more optical elements can be adapted so as to also have negative optical strength in order to compensate a myopia (near-sightedness) in a patient.

Other optical modifications can also be made to compensate other aberrations, such as astigmatic aberrations and other order aberrations of the individual eye.

The optical elements are preferably arranged at a distance from each other, each on one side or both on one side of the iris.

The invention provides the measure that the optical elements are drivable by the iris. Use is preferably made for this purpose of the measure that the positioning means of at least one of the optical elements is connected to the iris. This does after all represent an easy way to couple the optical elements to the driving member, the iris.

It is structurally simple when the optical elements are connected to the iris on one side. The configuration hereby becomes simpler, particularly when the positioning means can be connected to the iris only on the front side by a surgical treatment. It is possible here to apply a configuration wherein the optical elements are placed on either side of the iris. The positioning means of one of the optical elements then extend through the opening of the iris and are connected to the iris on the other side.

A plurality of connections per optical element can herein ensure that the optical elements can move reciprocally in only one direction and cannot rotate radially. The tissue from which the iris is built up is well suited to such a construction, since this tissue also consists of elastic fibres extending in radial direction. The advantage of such a construction is that the optical elements can move completely freely of each other and can thus be set into motion by the weak orbicularis muscle of the iris.

The positioning means are preferably connected to the iris by means of a nail, clamp or (claw) hook connection. Other connections engaging on or form-fitting on the iris are by no means precluded.

The heads of the nails are preferably situated on the rear side (inner side) of the iris. The heads are hereby less visible, this being important from a cosmetic viewpoint.

A specific preferred embodiment provides the measure that the nail or nails have a form such that they are elastically adaptable to a change in the diameter of the pupil. The iris is a dynamic whole. Its diameter deforms as a result of contracting and dilating of the orbicularis muscle. It should however be noted that when one of the elements is fixed to the rear side of the iris it must be ensured that this element is separate from the lens capsule if the natural lens is still present therein.

Another alternative provides an embodiment wherein the optical elements are clamped via a clamp connection to the edge of the pupil, being the opening in the iris, this on or around the muscle which brings about the contraction of the pupil, with optionally a light supporting construction extending to the inner side of the iris and the outer side of the pupil. The clamp connection must be sufficiently wide to prevent rotation of the optical elements in radial direction. In this embodiment the optical elements can also move completely freely of each other.

Yet another alternative provides an embodiment wherein the optical elements are hooked into the fibrous tissue of the iris via a (claw) hook connection close to the edge of the pupil, this on or outside the muscle which brings about contraction of the pupil. In this embodiment both optical elements can be constructed such that they both hook on the front side of the iris. This clamp connection must be sufficiently wide to prevent rotation in radial direction. In this embodiment too the optical elements can displace completely freely of each other. Both optical elements can also be joined together in a construction, which construction provides for individual displacement of the optical elements via a spring connection. This construction is comparable to the accommodating intra-ocular lens described in the non-prepublished Netherlands patent applications 1029037, 1029041 and PCT/NL 2005/000153. Here only one element of the accommodating artificial lens can be fixed to the iris, while another optical element independently occupies a fixed position relative thereto.

As already stated above, the invention requires the presence of a connection between the connecting elements and the part of the iris co-displacing with the central orbicularis muscle. It is therefore important to limit extending of connections in radial direction in all embodiments since the central part, the inner side, of the iris moves through a considerably greater distance than the outer side of the iris.

The claws or hooks of the connections to the optical elements are preferably situated on the front side of the iris; this results in a better accessibility, and thereby placeability, of the auxiliary means.

A single element of such a construction can also be used in combination with a fixed element of any form whatever for the present application of an iris-driven accommodating intra-ocular lens. This fixed element can be formed by an optical element with a fixed position between cornea and iris. It is the case for all embodiments that the intra-ocular artificial lens must be placed during a surgical operation. The pupil has a maximum diameter during the operation. The above stated embodiments of an intra-ocular lens can all be inserted via the anterior chamber. This makes implanting of such an iris-driven intra-ocular artificial lens a relatively simple surgical treatment.

It is however also possible to place the element with a fixed position between the iris and the lens capsule. With the correct choice of materials for the artificial lens, this latter can then come into contact with the lens capsule without medical drawbacks worthy of mention.

It is however also possible to make use of existing transparent structures in the eye in order to provide the function of one of the optical elements. This requires arranging a surface on these structures in order to have the optical properties of the structure fulfil the desired function. It is thus possible to use the easily accessible cornea for this purpose. So-called laser eye surgery is in general use. Lasek and femtosecond laser equipment in particular can be precisely programmed on the basis of wave-front analysis in order to also arrange on the cornea Alvarez surfaces and corrections of aberrations of the individual eye. Due to this additional procedure the elements for implanting are reduced to an element in the simplest embodiment. This provides the preferred embodiment wherein the optical element with a fixed position is formed by the cornea and the optical properties are arranged in the cornea by a laser in the form of a relief surface. It is noted here that it is likewise possible to arrange such a structure on the natural eye lens by means of a laser treatment. The application of this measure is usually precluded however, because in situations where an intra-ocular eye lens is placed the natural eye lens has usually been removed.

It is also possible to implant into patients a cataract lens provided with an arcuate Alvarez surface which provides accommodation in combination with a second Alvarez component which is fixed to the iris.

The invention also relates to a method for arranging an accommodating intra-ocular artificial lens, wherein an optical element is arranged on the cornea via a laser treatment.

Performing of such a laser treatment applies a relief in the external surface of the cornea. This is less desirable from a hygienic and practical viewpoint. A specific preferred embodiment therefore provides the measure that the relief surface is located inside the cornea.

In order to arrange such a structure a preferred embodiment provides the measure wherein a disc-shaped outer layer of the cornea is lifted, the relief surface is then formed at the position of the removed layer, and that finally the removed layer is folded back again. This lifting of a layer of the cornea is a standard surgical procedure. The arranging of an arcuate Alvarez surface on the cornea is new here.

Modern techniques and materials provide the option of giving the intra-ocular artificial lens according to the invention a thin form. This creates the problem that the lens is limp and the optical surface is deformed by forces exerted on the eye during the accommodation process. This does of course result in a deterioration of the optical quality of the lens formed by the optical elements. This is prevented by the measure that the optical elements are provided with strengthening elements which extend on their periphery and with which they acquire the necessary firmness.

The present invention provides means which function as substitute for glasses or contact lenses. People who wear glasses and contact lenses in the armed forces are confronted with challenges in performing their activities. Improvement of eyesight and minimizing the number of people wearing glasses and contact lenses is an important point for defence forces worldwide. The intra-ocular artificial lenses as described in the present patent application and previous patent applications are highly suitable for this purpose. According to a preferred embodiment, at least one of the optical elements comprises an optical filter with transmission characteristics dependent on the wavelength of the light. Intra-ocular lenses with filters for ultraviolet light (UV) are now in general use, but other specific wavelengths can also be extinguished. It is noted here that this measure is not only applicable in intra-ocular eye lenses of the type described in the present patent application, but is also applicable in intra-ocular eye lenses generally.

According to a specific preferred embodiment, intra-ocular eye lenses can generally be equipped with light filters with extinguishing peaks in the infrared range. High light intensities of military lasers can hereby be blocked; frequencies of these lasers vary in the range of 742-1550 nm for directional and offensive lasers.

It is also possible to apply special transparent photochromes which block all light briefly and within a number of milliseconds at the high light intensities in the visible (400-700 nm) and UV range (300-360 nm) during explosions.

The principle forming the basis of the invention requires the use of at least two optical elements. The inventor has found that, when two optical elements are used, they can be given an identical form. From a production engineering viewpoint this brings advantages. It is noted here that this measure is not only applicable to the optical elements themselves but also to the elements connected to the optical elements. The two optical elements are of course here positioned rotated relative to each other over two different axes.

A further reduction in costs occurs when the optical elements, the flexible and the rigid connecting elements and the anchors are manufactured from the same material. This measure does after all provide the option of manufacturing all these elements in the same forming process, such as for instance turning and cutting or injection moulding. It is however also possible to manufacture the optical elements and the other components from different materials. The choice of material can hereby be optimized for any function.

Cell growth-inhibiting agents for inhibiting the activity of fibrogenic cells and thus preventing PCO are not yet applied in combination with intra-ocular lenses. Rapamycin for instance (also known as sirolimus) is a generally known cell growth-inhibiting pharmaceutical product in use in organ transplantation and treatment of different disorders of the eye (melanoma, uveitis and infections of the cornea). For ophthalmic applications we refer here to WO-A-2005027906, US-A-2005064010, WO 2005011813 and JP-A-5194212.

Rapamycin is suitable for preventing PCO and hardening of the lens capsule by inhibiting general cell growth close to an intra-ocular lens, inhibiting transformation of epithelial cells to fibroblasts and inhibiting further fibrogenic activity. Rapamycin is approved for use in the eye. Other possible candidates for such a therapeutic are mitomycin, cyclosporin and toramycin preparations. Mitomycin is already applied as an inhibitor of fibroblast growth elsewhere in the eye. Corticosteroids and even specific cytostatic preparations could also be suitable for such an application.

According to a further preferred embodiment of the invention, the intra-ocular artificial lens is coupled to a therapeutic. This therapeutic can be formed by rapamycin, but equally by another therapeutic.

The therapeutic is preferably arranged in a carrier, which simplifies administering. This carrier can take the form of an encapsulation of the therapeutic, but the carrier can likewise be formed by a matrix incorporating the therapeutic.
The therapeutic is preferably received in its carrier such that the therapeutic is released slowly.

The carrier can be received in an element of the intra-ocular artificial lens. This results in a simple procedure for placing of the combination of artificial lens and therapeutic. In this case the carrier can be formed by the polymer mass of at least one of the parts of the artificial lens.

It is however also possible for the carrier to be accommodated on one of the surfaces of the intra-ocular artificial lens. Surfaces with an optical function must be avoided as much as possible here.

It is however also possible for the carrier to be formed by a separate element which is adapted for placing simultaneously with the placing of the intra-ocular artificial lens. This embodiment provides the option of adapting the nature and dosage of the therapeutic to the situation encountered during placing of the intra-ocular artificial lens.

According to a more specific embodiment, the therapeutic is formed by rapamycin. Rapamycin can also be incorporated in the above stated manner in all other existing intra-ocular lenses and related products. The effect of rapamycin has advantages for the mechanical operation of the present lenses, and PCO can be prevented in all ophthalmic products.

The therapeutic can also be inserted, independently of the artificial lens but during the surgical treatment, particularly on this rear side of the artificial lens.

The present invention will be elucidated hereinbelow with reference to the accompanying figures, in which:

Figure 1a shows a cross-sectional view of a first embodiment of the invention in the case of a large pupil;

Figure 1b shows a view corresponding with figure 1a in the case of a small pupil;

Figure 1c is a schematic front view of the embodiment shown in figures 1a and 1b;

Figure 2a shows a cross-sectional view corresponding with figure 1a of a first variant;

Figure 2b shows a cross-sectional view corresponding with figure 1b of a first variant;

Figure 3a shows a cross-sectional view corresponding with figures 1a and 2a of a second variant;

Figure 3b shows a cross-sectional view corresponding with figures 1b and 2b of a second variant;

Figure 4a shows a cross-sectional view corresponding with figures 1a and 2a of a third variant;

Figure 4b shows a cross-sectional view corresponding with figures 1b and 2b of a third variant;

Figure 5 is a perspective view of the optical element shown in figures 3a and 3b;

Figure 6 shows a perspective view of an embodiment wherein both optical elements are combined in a construction for implantation on the front side of the iris;

Figure 7 shows a cross-sectional view of an embodiment with a fixed optical element and a displacing element; and

Figure 8 is a cross-sectional view of a variant of the embodiment shown in figure 7 with a fixed optical element and a displacing optical element.

Figure 1a shows a cross-sectional view of an iris 1 which encloses pupil 2. The intra-ocular lens according to the invention comprises two optical elements 3, 4 which are preferably, though not necessarily, identical. The first optical element 3 is connected by means of a nail 5 to one side of iris 1, while the second optical element 4 is connected by means of a nail 6 to the other side of the iris. Nails 5,6 are herein arranged on the front side and rear side respectively of the iris. Figure 1a shows a relatively dark situation with a large pupil 2 and a wide open iris 1. The optical elements are preferably formed here for near vision.

Figure 1b shows the same device but in a light situation, wherein pupil 2 is small and iris 1 is contracted. Optical elements 3,4 are then preferably adapted for distance vision. This latter situation is shown in a front view in figure 1c. It is otherwise possible to place nails 5,6 with their heads on the same side, for instance the rear or front side, of the iris.

Figure 2a shows a situation corresponding to figure 1a, wherein optical elements 3, 4 are connected to iris 1 not by a nail but by a clamp 7, 8 respectively. This shows the relatively dark situation. The relevant light situation is shown in figure 2b.

It is possible in principle to apply other types of attachment between iris 1 and optical elements 3, 4. Figures 3a, 3b, 4a, 4b and 5 thus show a situation in which fixation is obtained between optical elements and 3, 4 and iris 1 with a claw-like hook 9, 10 respectively. These claw-like hooks 9, 10 make it possible to give clamps 7, 8 a smaller form. An advantage of this configuration is that the transmission of forces between iris 1 and the optical elements is distributed over different parts of the iris, which is formed by a delicate tissue.

Figures 3a,b show perhaps the simplest embodiment of this concept. Figures 4a,b show an embodiment wherein the hooks of both optical elements are situated on the front side of the iris, which simplifies the implantation, and perhaps the removal, of the optical elements by the surgeon.

The same situation is shown in figure 5 in the form of a perspective view. The orbicularis muscle 1a for driving the movements of iris 1 is moreover shown here in the form of a torus. Figure 5 only shows an element on the upper side of the iris. The other element is not shown but is situated on the underside of the orbicularis muscle (torus).

It is pointed out that in the above shown configuration optical elements 3, 4 are each placed on one side of the iris in all cases. It is of course likewise possible to place both optical elements on the same side of the iris, i.e. in front of or behind the iris.

Figure 6 shows a perspective view of a configuration wherein use is made of positioning means as described earlier in the Netherlands patent application 1028496. In this earlier patent application these positioning means are arranged in the lens capsule. In the situation shown in figure 4 however, the entity of optical elements and positioning means is arranged in the anterior chamber, i.e. on the front side of the iris. Optical elements 3, 4 are mutually connected here on one side via resilient constructions 11 and on another side with a rigid connection 12. This enables a relative displacement of the optical elements. On both sides of the overall construction a claw or hook connection is arranged for fixing to the iris.

Figure 7 shows a cross-section of an embodiment wherein an optical element 3 occupies a fixed position, in this example supported by chamber corners 13 of the anterior chamber and behind cornea 15. The other element 4 is fixed to the iris, in this example with a nail connection 5.

Figure 8 shows a variant of the embodiment depicted in figure 7, wherein fixed element 3 is combined with a moving element 4 fixed to two sides of iris 1 with, in this example, a claw connection 14. The resilient connection 11 and the rigid connection 12 enable displacement of element 4, driven by iris 1, relative to element 3.

Claims

1. Intra-ocular artificial lens with variable optical strength, wherein the artificial lens comprises at least two optical elements, at least two of which are movable relative to each other in a direction extending transversely of the optical axis, wherein the optical elements have a form such that in different relative positions of the optical elements the artificial lens has different optical strengths, **characterized in that** at least one of the movable optical elements is connected to positioning means which are adapted for coupling to the iris of the eye for the purpose of driving .

2. Intra-ocular artificial lens as claimed in claim 1, **characterized in that** the movable optical elements are dimensioned for co-action with a lens present in the eye.

3. Intra-ocular artificial lens as claimed in claim 1 or 2, **characterized in that** the positioning means are adapted to cause the optical elements to make a translating movement relative to each other during movement of the iris.

4. Intra-ocular artificial lens as claimed in claim 1, 2 or 3, **characterized in that** the positioning means are adapted to cause the optical elements to make a rotating movement relative to each other during movement of the iris.

5. Intra-ocular artificial lens as claimed in claim 1, 2, 3 or 4, **characterized in that** the positioning means are adapted to fix one of the optical elements relative to the eyeball and to drive at least another optical element during movement of the iris.

6. Intra-ocular artificial lens as claimed in any of the foregoing claims, **characterized in that** the positioning means are connected to mechanical arresting means for limiting the stroke of the movable optical elements.

7. Intra-ocular artificial lens as claimed in any of the foregoing claims, **characterized in that** the positioning means are adapted for forming by the optical elements at a small pupil diameter of a lens with a strong dioptric value and for forming by the optical elements at a large pupil diameter of a lens with a weak dioptric value.

8. Intra-ocular artificial lens as claimed in claim 7, **characterized in that** the optical elements are adapted to form a lens with a negative dioptric value at a large diameter of the pupil.

9. Intra-ocular artificial lens as claimed in any of the foregoing claims, **characterized in that** the optical elements are adapted to correct aberrations of the eye.

10. Intra-ocular artificial lens as claimed in claim 9, **characterized in that** the optical elements are adapted to correct astigmatic aberrations of the eye.

11. Intra-ocular artificial lens as claimed in any of the foregoing claims, **characterized in that** the optical elements are arranged at a distance from each other.

12. Intra-ocular artificial lens as claimed in any of the foregoing claims, **characterized in that** one of the optical elements is positioned on the front side of the iris and the other optical element on the rear side of the iris.

13. Intra-ocular artificial lens as claimed in any of the foregoing claims, **characterized in that** the positioning means of each of the optical elements are connected to the iris.

14. Intra-ocular artificial lens as claimed in claim 13, **characterized in that** the optical elements are connected to the iris on one of their sides.

15. Intra-ocular artificial lens as claimed in claim 13 or 14, **characterized in that** the optical elements are connected to the iris at more than one location around the pupil.

16. Intra-ocular artificial lens as claimed in claim 13, 14 or 15, **characterized in that** the optical elements are coupled to the iris with a nail connection.

17. Intra-ocular artificial lens as claimed in claim 16, **characterized in that** the heads of the nail connections of both optical elements are situated on the rear side of the iris.

18. Intra-ocular artificial lens as claimed in claim 13, 14 or 15, **characterized in that** the optical elements are coupled to the iris with a clamp connection.

19. Intra-ocular artificial lens as claimed in claim 13, 14 or 15, **characterized in that** the optical elements are coupled to the tissue of the iris with a (claw) hook connection.

20. Intra-ocular artificial lens as claimed in claim 19, **characterized in that** the (claw) hooks of the connections of both optical elements are situated on the front side of the iris.

21. Intra-ocular artificial lens as claimed in claim 5, **characterized in that** the optical element with a fixed position is situated between the iris and the cornea.

22. Intra-ocular artificial lens as claimed in claim 5, **characterized in that** the optical element with a fixed position is situated between the iris and the lens capsule.

23. Intra-ocular artificial lens as claimed in claim 5, **characterized in that** the optical element with a fixed position is formed by the cornea and that the optical properties are arranged in the cornea in the form of a relief surface by a laser treatment.

24. Intra-ocular artificial lens as claimed in claim 23, **characterized in that** the relief surface is located inside the cornea.

25. Method for providing an accommodating intra-ocular artificial lens, **characterized in that** an optical element is arranged on the cornea via a laser treatment.

26. Method as claimed in claim 25, **characterized in that** an outer layer of the cornea is removed, the relief surface is then formed at the position of the removed layer, and that finally the removed layer is re-placed again.

27. Intra-ocular artificial lens as claimed in any of the foregoing claims, **characterized in that** at least one of the optical elements comprises an optical filter with transmission characteristics dependent on the wavelength of the light.

28. Intra-ocular artificial lens as claimed in claim 27, **characterized in that** the optics comprise optical filters with extinguishing peaks in the infrared (700-1550 nm) range.

29. Intra-ocular artificial lens as claimed in claim 27, **characterized in that** the optics comprise optical photochrome filters with extinguishing peaks in the visible and ultraviolet range (UV; 300-700 nm) range.

30. Intra-ocular artificial lens as claimed in any of the foregoing claims, **characterized in that** the intra-ocular artificial lens is coupled to a therapeutic.

31. Intra-ocular artificial lens as claimed in claim 30, **characterized in that** the therapeutic is arranged in a carrier.

32. Intra-ocular artificial lens as claimed in claim 31, **characterized in that** the therapeutic is received in its carrier such that the therapeutic is released slowly.

33. Intra-ocular artificial lens as claimed in claim 31 or 32, **characterized in that** the carrier is received in an element of the intra-ocular artificial lens.

34. Intra-ocular artificial lens as claimed in claim 31 or 32, **characterized in that** the carrier is arranged on at least one of the surfaces of the intra-ocular artificial lens.

35. Intra-ocular artificial lens as claimed in claim 31 or 32, **characterized in that** the carrier forms a separate element which is adapted for placing simultaneously with the placing of the intra-ocular artificial lens in the eye.

36. Intra-ocular artificial lens as claimed in any of the claims 30-35, **characterized in that** the therapeutic is formed by an inhibitor of fibrogenic cell growth.

37. Intra-ocular artificial lens as claimed in claim 36, **characterized in that** the therapeutic comprises one of the substances chosen from the group of mitomycin, cyclosporin, rapamycin, toramycin or a corticosteroid.

FIG. 1A

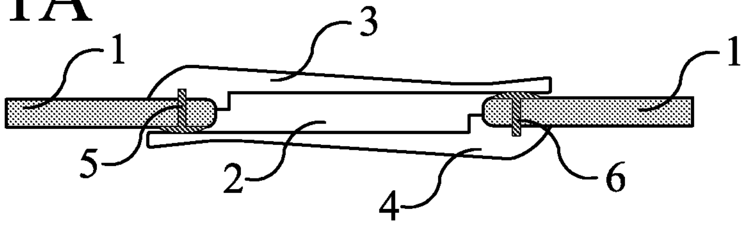


FIG. 1B

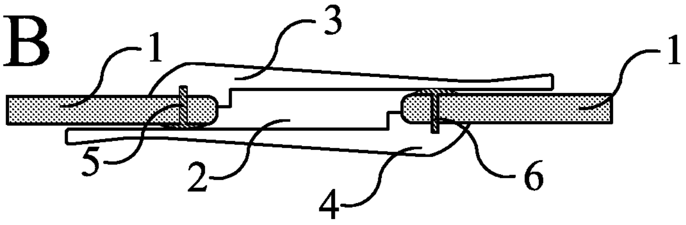


FIG. 1C

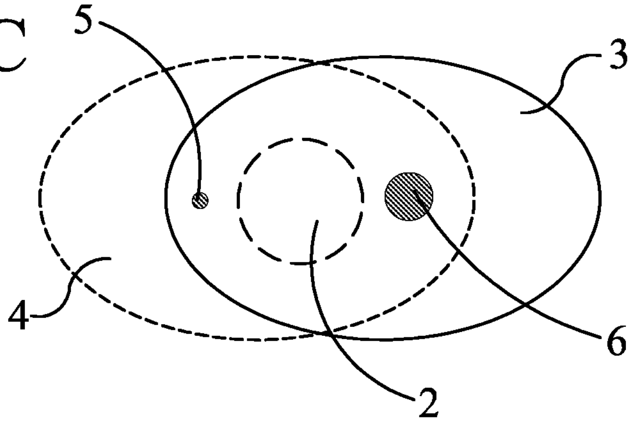


FIG. 2A

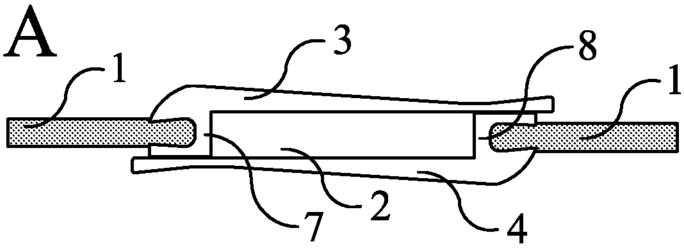


FIG. 2B

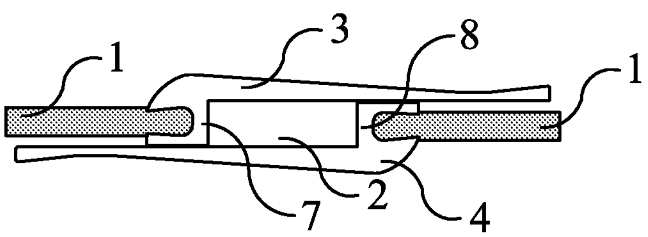


FIG. 3A

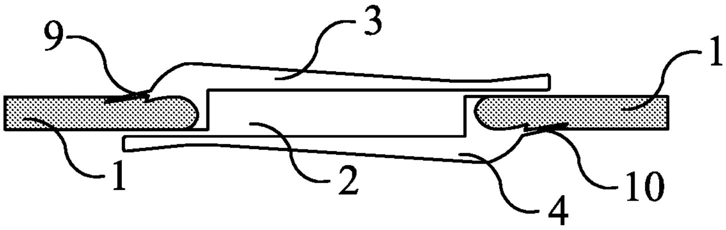


FIG. 3B

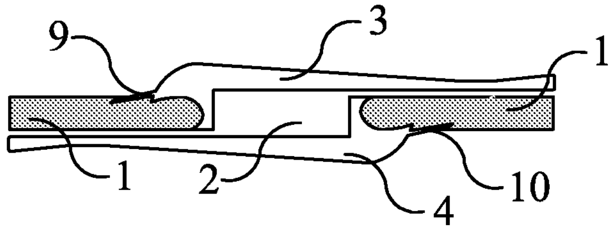


FIG. 4A

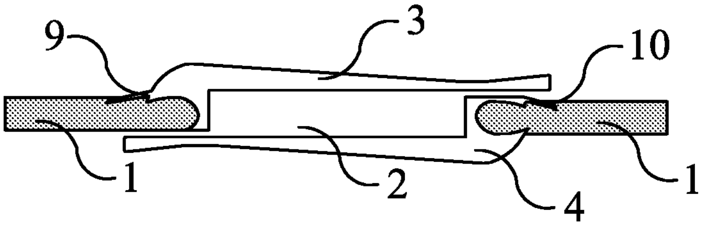


FIG. 4B

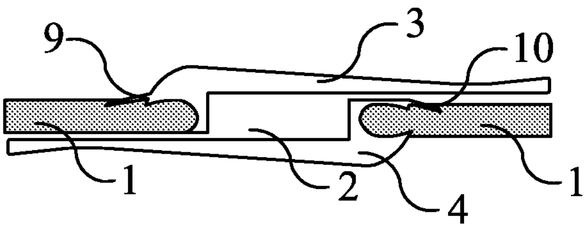
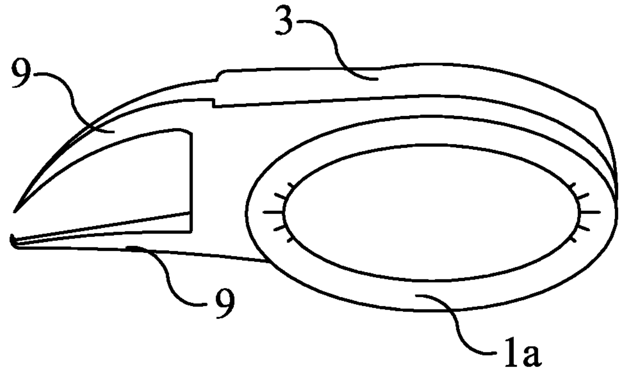


FIG. 5



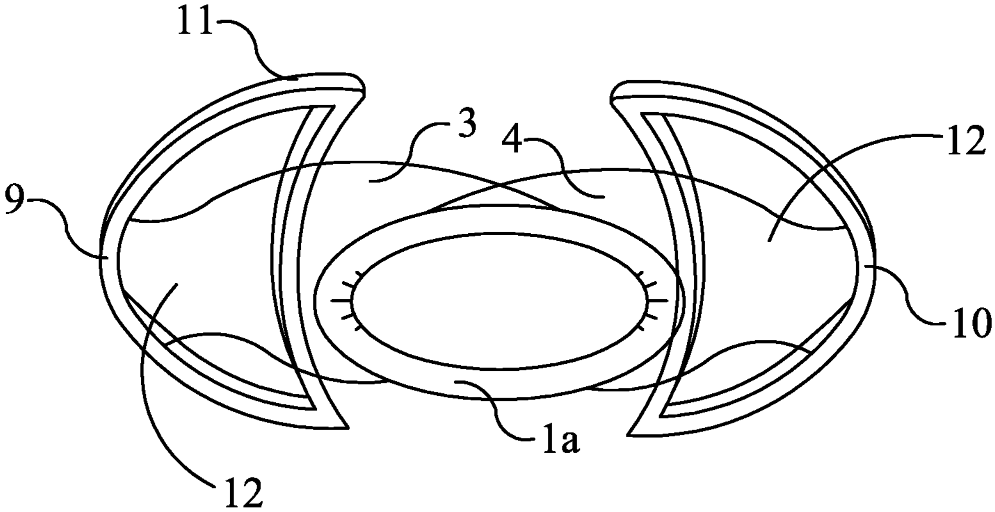
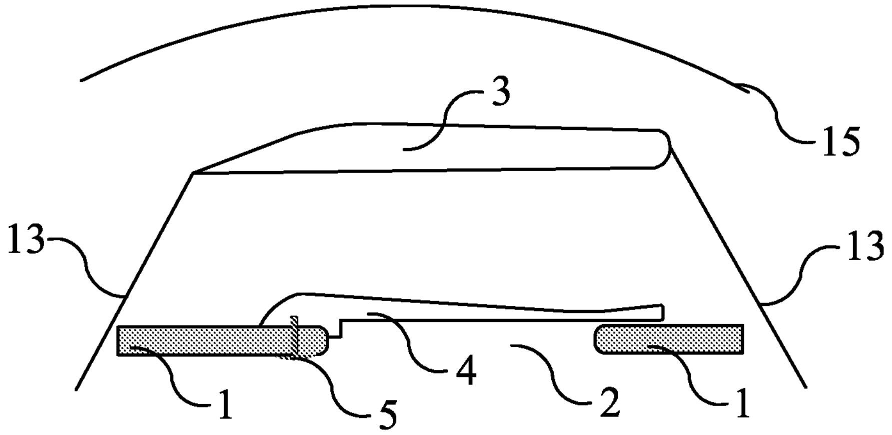


FIG. 6

FIG. 7



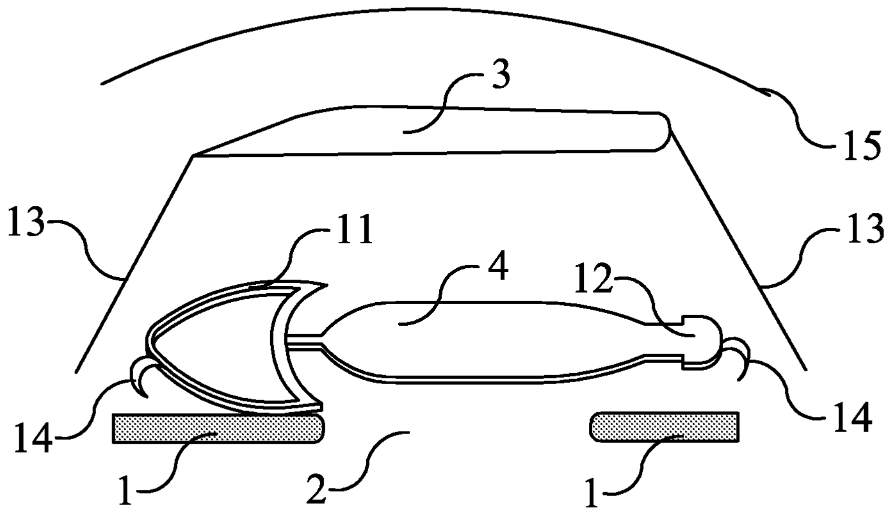


FIG. 8