AUSTRALIA
Patents Act 1990

PATENT REQUEST : STANDARD PATENT

We, being the person 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.

Applicant: JOHNSON & JOHNSON VISION PRODUCTS, INC.
Address: 4500 Salisbury Road, Jacksonville, Florida 32216-0995, United States of America

Nominated Person: As above
Address: As above

Invention Title: CONCENTRIC ANNULAR RING LENS DESIGNS FOR ASTIGMATIC PRESBYOPES

Names of actual Inventors: Jeffrey H. ROFFMAN and Edgar V. MENEZES

BASIC CONVENTION APPLICATION DETAILS

Applicants Names: Jeffrey H. ROFFMAN and Edgar V. MENEZES
Application Number: 08/433,844
Country: UNITED STATES OF AMERICA
Code: US
Date of Application: 4 MAY 1995

Address for service in Australia: CARTER SMITH & BEADLE, 2 Railway Parade, Camberwell, Victoria, 3124, Australia. (Attorney Code CD)

Dated: 2 May 1996

CARTER SMITH & BEADLE
Patent Attorneys for the Applicant

TO: The Commissioner of Patents
Fee: $280.00
Our Ref: #20574 PRS: JL9
NOTICE OF ENTITLEMENT

We, JOHNSON & JOHNSON VISION PRODUCTS, INC.
of 4500 Salisbury Road, Jacksonville, Florida 32216-0995, United States of America,
being the Applicant and Nominated Person in respect of the accompanying application
entitled: CONCENTRIC ANNULAR RING LENS DESIGNS FOR
ASTIGMATICA PREGBYTOPES

state the following:-

(a) The Applicant and Nominated Person is the assignee of the invention from the actual
    inventors.

(b) The Applicant and Nominated Person is entitled to claim priority from the
    basic application listed in the Patent Request form because the Nominated
    Person is the assignee of the Applicants in respect of the basic application.

(c) The basic application listed on the Patent Request Form is the first application
    made in a Convention country in respect of the invention.

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CARTER SMITH & BEADLE
Patent Attorneys for the Applicant

TO: The Commissioner of Patents
Our Ref: #20574 PRS:JL:9
Claim

1. A multifocus, concentric annular ring lens for astigmatic presbyopes comprising:
   a. said lens having a front surface and an opposite back surface, wherein one of the front and back surfaces defines a central area comprising a circular disc having a surface corresponding to a basic prescription distance optical power; and
   b. a plurality of annular rings surrounding the central area and comprising at least one near optical power annular ring and at least one optical power annular ring which corresponds to the cylindrical optical power prescription of the patient, to provide visual acuity for astigmatic presbyopes.

20. A method of designing a multifocus, concentric annular ring lens for astigmatic presbyopes comprising:
   a. said lens having a front surface and an opposite back surface, wherein one of the front and back surfaces defines a central area comprising a circular disc having a surface corresponding to a basic prescription distance optical power;
   b. a plurality of annular rings surrounding the central area and comprising at least one near optical power annular ring and at least one optical power annular ring which corresponds to the cylindrical optical power prescription of the patient, to provide visual acuity for astigmatic presbyopes;
c. performing an in vivo image quality analysis, with an in vivo quality analysis instrument, of the lens on the eye to measure any residual aberrations;

d. reducing the measured residual aberrations by redesigning the lens to improve visual acuity and performance.
AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

Name of Applicant: JOHNSON & JOHNSON VISION PRODUCTS, INC.

Actual Inventors: Jeffrey H. ROFFMAN and Edgar V. MENEZES

Address for service in Australia: CARTER SMITH & BEADLE
2 Railway Parade
Camberwell Victoria 3124
Australia

Invention Title: CONCENTRIC LENS DESIGNS FOR ASTIGMATIC PRESBYOPES

The following statement is a full description of this invention, including the best method of performing it known to us.
CONCENTRIC ANNULAR RING LENS DESIGNS
FOR ASTIGMATIC PRESBYOPES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to concentric annular ring lens designs for astigmatic presbyopes. More particularly, the subject invention pertains to such concentric annular ring lens designs wherein at least one surface of the lens has a circular central portion and a plurality of annular rings with at least three separate spherical optical powers corresponding to a prescription for the astigmatic presbyopic patient. The three separate spherical optical powers correspond to 1) a basic distance spherical prescription Rx, 2) a near add spherical prescription Rx, and 3) a spherical prescription corresponding to the full, or preferably a fraction of the, cylindrical prescription Rx.

2. Discussion of the Prior Art

The present invention pertains to ophthalmic lenses, and in particular to contact lenses such as soft hydrogel contact lenses, and intraocular lenses, designed particularly for astigmatic presbyopes.

It is well known that as an individual ages, the eye is less able to accommodate, i.e. bend the natural lens in the eye, in order to focus on objects that are relatively near to the observer. This condition is referred to as presbyopia, and presbyopes have in the past relied upon spectacles or other lenses having a number of different regions with different optical powers to which the wearer can shift his vision in order to find the appropriate optical power for the object or objects upon which the observer wishes to focus.

Similarly, for a person who has had the natural lens of the eye removed because of a cataract condition and an intraocular lens inserted as a replacement, the ability to adjust the lens (accommodate) to the distance of the object being viewed is totally absent. In this case, the lens provided is usually set at a single infinite distance focal power, and spectacles are worn to provide the additional positive
optical power needed for in-focus closer vision. For such a patient, a functional multifocal lens would be particularly useful.

It is known that for astigmatic subjects, the astigmatic eye forms an image which contains three main regions:

1. The spherical power focuses as a line;
2. The cylindrical power also focuses as a line, perpendicular to the spherical image line;
3. In between the two, a circular image is formed, known as the "circle of least confusion."

It is also known in the art that under certain circumstances the brain can effectively discriminate between separate competing images by accepting an in-focus image and rejecting an out-of-focus image.

Toric contact lenses are normally prescribed for astigmatic patients with either corneal or lenticular astigmatism, and have a cylindrical optical surface/power which is used to correct for astigmatism in a wearer. Statistically, astigmatism usually occurs in people primarily around either the horizontal axis or the vertical axis, but also at varying axial locations with respect thereto. In the prior art a separate type of toric contact lens is required for each different toric optical power and also for each different orientation of the toric cylindrical axis of the contact lens, which are required to accommodate different patients with differing amounts of astigmatism along different axes.

Accordingly, an inventory of toric contact lenses, or plastic molding parts for molding the toric contact lenses, include a number of different combinations of toric axis location and toric optical power. One significant advantage of the present invention is a resultant substantial reduction in the number of stock keeping units maintained in inventory (different possible prescriptions maintained in inventory).

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide concentric lens designs for astigmatic presbyopes.

Another object of the present invention is the provision of concentric annular
ring lens designs for astigmatic presbyopes which results in a substantial reduction in the number of stock keeping units maintained in inventory.

A further object of the subject invention is the provision of concentric lens designs for astigmatic presbyopes which comprise at least one surface which has a circular central portion and a plurality of concentric annular rings with at least three separate optical powers corresponding to a prescription for a patient and corresponding to 1) a basic distance spherical prescription Rx, 2) a near add spherical prescription Rx, and 3) a spherical prescription corresponding to the full, or preferably a fraction of the, cylindrical prescription Rx.

A presbyope requires a lens with a basic distance spherical prescription for focusing on distant objects and a near spherical prescription (add) for focusing on near objects. In addition thereto, an astigmatic presbyope requires an astigmatic correction, normally in the nature of a cylindrical prescription which specifies both the cylindrical optical power and the orientation of the cylindrical axis. The present invention takes the cylindrical prescription into account in the design of the lens, but does not use a cylindrical optical surface. Instead, the present invention recognizes that the brain can effectively discriminate between separate competing images by accepting an in-focus image and rejecting an out-of-focus image. Accordingly, the present invention provides a portion of the lens with a spherical surface corresponding to the cylindrical prescription, or more preferably a fraction of the full cylindrical prescription, and relies upon the brain to discriminate and accept an in-focus image to compensate for the patient's astigmatism. The spherical surface corresponding to the cylindrical prescription provides a lens with an improved depth-of-field for low cylindrical astigmats.

The present invention is directed to concentric lens designs for astigmatic presbyopes which provide:

(i) the ability to address the visual prescription requirements of approximately 25% of the vision correction market;

(ii) the ability to provide high volume/low cost contact lenses with a minimal number of stock keeping units in inventory, comparable to current spherical contact
lenses;

(iii) the ability to eliminate the requirement for cylindrical axis stabilization features for astigmatic patients, thereby providing for greater patient comfort and ease of fit; and

(iv) the ability to provide lens designs that are finely tunable to the individual needs of a patient.

In accordance with the teachings herein, the present invention provides a multifocus, concentric annular ring lens for astigmatic presbyopes, wherein one of the front and back surfaces of the lens defines a central area comprising a circular disc having a spherical surface corresponding to a basic prescription distance optical power. A plurality of annular rings surround the central area and comprise at least one spherical near optical power annular ring and at least one spherical optical power annular ring which corresponds to the cylindrical optical power prescription of the patient, to provide visual acuity for astigmatic presbyopes.

In greater detail, the spherical optical power annular ring which corresponds to the cylindrical optical power prescription of the patient can correspond to the full cylindrical power prescription or a fraction of the full cylindrical power prescription. The plurality of annular rings also comprise at least one spherical distance optical power annular ring. The plurality of annular rings can comprise alternating spherical near optical power annular rings, spherical distance optical power annular rings, and spherical optical power annular rings which correspond to the cylindrical optical power prescription of the patient. The innermost annular ring is preferably a spherical near optical power annular ring, and the second innermost annular ring can be a spherical optical power annular ring which corresponds to the cylindrical optical power prescription of the patient, and the third innermost annular ring is a spherical distance optical power annular ring. Alternatively, the second innermost annular ring is a spherical distance optical power annular ring, and the third innermost annular ring is a spherical optical power annular ring which corresponds to the cylindrical optical power prescription of the patient. The lens can comprise a contact lens to be worn on the cornea of the eye, such as a soft hydrogel contact lens, or an
intraocular lens. For a contact lens, the central area and the plurality of annular rings are preferably formed on the back surface of the lens to minimize flare and glare problems. Moreover, the widths of the individual annular rings can be different to generate a power profile which varies to generate different ratios of distance optical power to cylindrical correction optical power and near optical power.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The foregoing objects and advantages of the present invention for concentric lens designs for astigmatic presbyopes may be more readily understood by one skilled in the art with reference being had to the following detailed description of several preferred embodiments thereof, taken in conjunction with the accompanying drawings wherein like elements are designated by identical reference numerals throughout the several views, and in which:

Figure 1 is a plan view of the back surface of one designed embodiment of a preferred type of contact lens pursuant to the teachings of the present invention which has a central area with a circular disc having a basic prescription Rx spherical distance optical power, surrounded by a plurality of alternating concentric spherical near optical power, concentric spherical distance optical power, and spherical annular rings which correspond to the cylindrical power prescription of the patient.

**DETAILED DESCRIPTION OF THE DRAWINGS**

The present invention provides a lens design for astigmatic presbyopes. A presbyope requires a lens with a basic distance spherical prescription for focusing on distant objects and a near spherical prescription (add) for focusing on near objects. In addition thereto, an astigmatic presbyope requires an astigmatic correction, normally in the nature of a cylindrical prescription which specifies both the cylindrical optical power and the orientation of the cylindrical axis. The present invention takes the cylindrical prescription into account in the design of the lens, but does not use a cylindrical optical surface. Instead, the present invention recognizes that the brain can effectively discriminate between separate competing images by accepting an in-focus image and rejecting an out-of-focus image. Accordingly, the present invention provides a portion of the lens with a spherical surface having the
cylindrical optical power prescription, or more preferably a fraction of the full
cylindrical prescription, and relies upon the brain to discriminate and accept an in-
focus image to compensate for the patient's astigmatism. The spherical surface
which corresponds to the cylindrical prescription provides a lens with an improved
depth-of-field for low cylindrical astigmats.

Referring to the drawings in detail, Figure 1 is a plan view of the back
surface of one designed embodiment of a preferred type of contact lens 10 pursuant
to the teachings of the present invention. The lens 10 has a central area with a
circular disc 12 containing a basic prescription Rx spherical distance optical power
which is surrounded by a plurality of alternating concentric annular rings 14, 16, 18,
20 and 22. The plurality of alternating concentric annular rings includes a spherical
near optical power annular ring 14, spherical distance optical power annular rings
18 and 22, and spherical power annular rings 16 and 20 which correspond to the
cylindrical power prescription of the patient. The spherical power which corresponds
to the cylindrical power prescription of the patient can be the sum of the basic
spherical distance optical power and the cylindrical prescription optical power or the
sum of the basic spherical distance optical power and a portion (25% to 100%) of
the cylindrical prescription optical power.

Preferably the back surface of the lens is provided with the multiplicity of
concentric rings shown in Figure 1, although the front surface is also suitable,
particularly in intraocular lenses.

For example, consider an astigmatic presbyopic patient prescription of: -2.00/
-1.00 x 180 with 1.25D add. In this prescription, -2.00 diopters is the basic
spherical distance prescription Rx, -1.00 diopters is the astigmatic cylindrical optical
power prescription Rx correction and 180 specifies a horizontal cylindrical axis, and
1.25 diopters is the near spherical prescription Rx add. In this exemplary
embodiment, the powers chosen for the concentric annular rings can be SPHERE (S)
= -2.00D (diopters), CYLINDER (C) = -3.00D (which is the sum of the spherical
distance prescription Rx -2.00 and the cylindrical prescription Rx -1.00) and NEAR
(N) = -0.75D (which is the sum of the spherical distance prescription Rx -200 and
the near spherical prescription Rx add +1.25).

Some patients may not require the full cylindrical and add powers in these designs. For these cases, the cylindrical and near powers can be made a fraction (preferably 50%) of the full cylinder or add power. The cylindrical power can be the full cylindrical difference or any portion thereof, ranging from 25% to 100% of the full refractive cylindrical power. The specified position for the cylindrical axis is ignored since a spherical surface is substituted therefor. It is not expected that the visual acuity of the patient will deteriorate significantly for low cylindrical astigmats because of the increased depth-of-focus provided by the concentric annular ring designs of the present invention.

Alternately, the near add optical power could be a non-constant function across the concentric annular rings.

The present invention functions by alternating spherical power with cylindrical equivalent spherical power in such a way as to provide adequate levels of images from both optical powers to the retina of the observer.

In general, the powers in the zones may be arranged in a manner determined to be suitable to the visual needs of the patient. Some examples of possible arrangements are shown below, wherein the central disc 12 is listed as the first ring:

<table>
<thead>
<tr>
<th>ARRANGEMENT OF RINGS FROM CENTER OF LENS</th>
<th>% OF RINGS FOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># RINGS</td>
</tr>
<tr>
<td>SNCS</td>
<td>4</td>
</tr>
<tr>
<td>SNSCS</td>
<td>5</td>
</tr>
<tr>
<td>SNCSNNSCNS</td>
<td>7</td>
</tr>
<tr>
<td>SNCSNSNNSCS</td>
<td>11</td>
</tr>
<tr>
<td>SNCNSNCSNCSNNSNSCSNS</td>
<td>13</td>
</tr>
<tr>
<td>SNCNSCSNCSNCSNCNS</td>
<td>13</td>
</tr>
</tbody>
</table>

(Where S = SPHERE, C = CYLINDER AND N = NEAR)
In alternative embodiments, the positions of C and N can be reversed, and clearly, many other combinations than those specifically shown are possible.

The combined areas of the center spherical disc 12 and the surrounding annular rings 14 through 22 comprise the active optical area of the lens, which is surrounded by a lenticular (nonoptical) area 24 which is beveled at its outer circumference to an outer circumferential edge 26 of the lens.

The lens can be a contact lens to be worn on the cornea of the eye, such as a soft hydrogel contact lens, or can be an intraocular lens. The central area and the plurality of annular rings are preferably formed on the rear surface of a contact lens to minimize flare and glare problems.

A person's pupil size is a function which is dependent upon light intensity, and is an important parameter in the design of ophthalmic lenses, particularly contact lenses and intraocular lenses.

Moreover, the widths of the individual annular rings can be different to adjust the area of the optic zone devoted to each power, to generate a power profile which varies to generate different ratios of distance optical power to cylindrical correction and near optical power.

Moreover, in order to provide a depth-of-focus effect, asphericity can be incorporated into either of the S, C and/or N rings, or the surface not containing the concentric rings can be made aspherical.

Moreover, ocular in vivo image quality measurement devices can be used to optimize the ocular image quality in the concentric annular ring lens designs to produce even more improved designs. This is accomplished by using an in vivo image quality measurement device to measure and decrease the sum of the aberrations of a first design of a lens on the patient's eye to measure residual aberrations, and then redesigning the lens to reduce the measured residual aberrations and improve visual acuity and performance. The redesign of the lens can include aspherizing the surface opposite the surface defining the central area and the plurality of annular rings, or aspherizing the concentric annular ring surface. An aberroscope or MTF point spread device is preferably utilized to measure the
modulation transfer function of the combination of the lens and eye.

Obviously, many different embodiments of the present invention are possible, with alterations of the number of annular rings, the widths and arrangement of the annular rings, and the optical powers assigned to each of the annular rings.

While several embodiments and variations of the present invention for concentric annular ring lens designs for astigmatic presbyopes are described in detail herein, it should be apparent that the disclosure and teachings of the present invention will suggest many alternative designs to those skilled in the art.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A multifocus, concentric annular ring lens for astigmatic presbyopes comprising:
   a. said lens having a front surface and an opposite back surface, wherein one of the front and back surfaces defines a central area comprising a circular disc having a surface corresponding to a basic prescription distance optical power; and
   b. a plurality of annular rings surrounding the central area and comprising at least one near optical power annular ring and at least one optical power annular ring which corresponds to the cylindrical optical power prescription of the patient, to provide visual acuity for astigmatic presbyopes.

2. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 1, wherein the circular disc defines a spheric curve.

3. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 2 wherein the annular rings define spheric curves.

4. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 1, wherein the circular disc defines an aspheric curve.

5. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 4, wherein the annular rings define aspheric curves.

6. A multifocus, concentric annular ring lends for astigmatic presbyopes as claimed in claim 3, wherein the spherical optical power annular ring which corresponds to the cylindrical optical power prescription of the patient corresponds to the full cylindrical power prescription.

7. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the spherical optical power annular ring which corresponds to the cylindrical optical power prescription of the patient corresponds to a fraction of the full cylindrical power prescription.

8. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the plurality of annular rings also comprise at least one spherical distance optical power annular ring.

9. A multifocus, concentric annular ring lens for astigmatic presbyopes as
claimed in claim 3, wherein the plurality of annular rings comprise alternating spherical near optical power annular rings, spherical distance optical power annular rings, and spherical optical power annular rings which correspond to the cylindrical optical power prescription of the patient.

10. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the innermost annular ring is a spherical prescription near optical power annular ring and the second innermost annular ring is a spherical optical power annular ring which corresponds to the cylindrical optical power prescription of the patient.

11. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 10, wherein the third innermost annular ring is a spherical distance optical power annular ring.

12. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the innermost annular ring is a spherical prescription near optical power annular ring and the second innermost annular ring is a spherical distance optical power annular ring.

13. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 12, wherein the third innermost annular ring is a spherical optical power annular ring which corresponds to the cylindrical optical power prescription of the patient.

14. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the lens comprises a contact lens to be worn on the cornea of the eye.

15. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 14, wherein the contact lens comprises a soft hydrogel contact lens.

16. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the lens comprises an intraocular lens.

17. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the widths of individual annular rings are different to generate a power profile which varies to generate different ratios of distance optical
power to cylindrical correction optical power and near optical power.

18. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the central area and the plurality of annular rings are formed on the back surface of the lens to minimize flare and glare problems.

19. A multifocus, concentric annular ring lens for astigmatic presbyopes as claimed in claim 3, wherein the other of the front and back surfaces comprises a booster aspheric curve.

20. A method of designing a multifocus, concentric annular ring lens for astigmatic presbyopes comprising:

a. said lens having a front surface and an opposite back surface, wherein one of the front and back surfaces defines a central area comprising a circular disc having a surface corresponding to a basic prescription distance optical power;

b. a plurality of annular rings surrounding the central area and comprising at least one near optical power annular ring and at least one optical power annular ring which corresponds to the cylindrical optical power prescription of the patient, to provide visual acuity for astigmatic presbyopes;

c. performing an in vivo image quality analysis, with an in vivo quality analysis instrument, of the lens on the eye to measure any residual aberrations;

d. reducing the measured residual aberrations by redesigning the lens to improve visual acuity and performance.

21. A method of designing a concentric annular ring, single vision lens as claimed in claim 20, wherein redesigning the lens includes aspherizing the surface opposite the surface defining the central area and the plurality of annular rings.

22. A multifocus, concentric annular ring lens substantially as hereinbefore described with reference to the accompanying drawings incorporating any one or more of the novel features herein disclosed.
23. A method of designing a multifocus concentric annular ring lens substantially as hereinbefore described with reference to the accompanying drawings incorporating any one or more of the novel features herein disclosed.

DATED: 29 August 1996

CARTER SMITH & BEADLE
Patent Attorneys for the Applicant:
Johnson & Johnson Vision Products, Inc.
ABSTRACT

Concentric lens (10) designs are disclosed for astigmatic presbyopes which comprise at least one surface which has a circular central portion (12) and a plurality of concentric annular rings (14,16,18,20,22) with at least three separate optical powers corresponding to a prescription for a patient and corresponding to 1) a basic distance spherical prescription Rx, 2) a near add spherical prescription Rx, and 3) a spherical prescription corresponding to the full, or preferably a fraction of the, cylindrical prescription Rx. An astigmatic presbyopic prescription contains an astigmatic correction, normally in the nature of a cylindrical prescription which specifies both the cylindrical optical power and the orientation of the cylindrical axis. The cylindrical prescription is taken into account in the design of the lens, but not with a cylindrical optical surface. Instead, the present invention recognizes that the brain can effectively discriminate between separate competing images by accepting an in-focus image and rejecting an out-of-focus image. Accordingly, a portion of the lens is provided with a spherical surface corresponding to the cylindrical prescription, or more preferably a fraction of the full cylindrical prescription, and the brain is relied upon to discriminate and accept an in-focus image to compensate for the patient's astigmatism.
C = CYLINDRICAL POWER
N = NEAR POWER
S = SPHERICAL DISTANCE RX POWER

FIG. 1

S2066/46
END