

Description

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The prior art has shown progressive addition lenses characterized by mainly four areas. The distance portion of the lens, the reading portion, the transition corridor and the areas peripheral to the transition zone, i.e. at the sides of the transition corridor between the reading zone and the distance area. These zones are usually achieved by shaping one of the two surfaces of the lens. The convex surface is normally chosen for this, although the opposite surface of the spectacle lens can be chosen as well. In the description, it is assumed that the progressive addition correction is on the convex surface. The ophthalmic lens can either be a finished or a semi finished progressive addition lens.

A finished lens (either cut to fit a frame or uncut) has on the convex surface the shape that defines the progressive addition lens behaviour. It has on the concave surface the shape governed by the cylindrical or spherical correction required to compensate these refractive aberrations of the wearer. On the convex side the surface refractive power causes in combination with the refractive power of the concave surface the required lens power to comply with the prescription of the wearer. The center thickness of the lens is dependent on the distance portion lens power and the lens power addition to reach the reading portion lens power. A minimum center thickness is required to give the lens sufficient mechanical strength.

Normally, a lens of the present invention would be sold to a manufacturing optician as a semi finished ophthalmic lens, consisting of two surfaces. One surface (convex) would contain the refractive power typifying the progressive addition lens properties of the present invention and the other surface would be generally spherical (concave); the lens has a thickness in excess of that required for a finished progressive addition lens. This excess material permits the optician to grind and polish the concave surface to the refractive power to suit the wearer's prescription, resulting in a finished lens as described above.

Within the above four areas, the aberrations influencing the visual acuity (mainly astigmatism) and the distortion aberration contribute to the quality of the lens. A certain state of balancing of these aberrations has led to lenses which either have too much distortion when good acuity is obtained, or relative low acuity when low distortion is achieved. Typically, a lens with very low distortion and a distribution of astigmatism of rather high value in the distance portion has been described in UA—A—3,687,582 to Maitenaz. On the other hand, a lens with very low astigmatism in the distance portion and relatively high distortion in the periphery has been described in US—A—4,056,311 to Winthrop. In both cases the usable width of the progression zone has been limited to cause a small width-of-field in this zone.

The object of this invention is to provide a symmetrical progressive addition lens with a substantially wider width of field in the progression zone, a substantially improved balance between astigmatism and distortion in the field of peripheral vision to render a clear distortion free, wide view when looking through the lens. This is achieved by a novel formulation of the progression corridor and a blending of the transition corridor with the peripheral area, using a cosine function as defined in the attached claims.

Figure 1 is a front view of the surface from which a lens of the present invention is cut out showing the various zones referred to in the specification.

Figure 2 is a graph of the calculated power law for a 2 addition lens.

Figure 3 is a graph of the calculated astigmatism of the progression zone of a lens of the present invention for a 2 addition.

Figure 4 is a graph of the measured values of the power law for 10 lenses having a 2 diopter addition.

Figure 5 is a graph of the measured astigmatism for the progression zone of 2 diopter lens.

Figure 6 is a front view of a lens showing some permanent marks thereon.

For purposes of explanation, the convex surface of the lens is chosen as the progressive addition surface.

Referring now to Figure 1, the zones are described as follows:

- A Distance Zone
- B Progressive zone
- C Upper blending zone
- D Reading zone
- E Lower blending zone
- F Upper peripheral zone — outside C
- G Lower peripheral zone — outside E

The new points of the embodiment described below are the formulae relating the zones B, C, E, F, and G, and particularly B, C and E on the convex side of the lens.

The formula in zone B, the central corridor is

$$X_2 = C[p(Z - 3)^3 + qy^2(z - 3)^2 + ry^2(Z - 3)] + \& + t$$

where X is the coordinate perpendicular to the paper, and & = the formula for the distance portion. This could be the formula for a sphere, a hyperbola, a parabola or any formula relevant to good distance vision.

C is a constant connected with the addition of power from the distance to the reading portion in diopters =

$$\frac{\text{add}}{324 \times 10^3}$$

$$0 < p \leq 14$$

Z = coordinate Z

$$q \cong 0$$

y = coordinate y

$$r \cong 8$$

t = correction term to satisfy boundary conditions with distance portion =

$$-(t_2 + d_1 Z) + \frac{500}{A_1} - \sqrt{\frac{500}{A_1}^2 - y^2 - Z^2}$$

$$A_1 = (A_2)_{\substack{y=0 \\ Z=0}}$$

$$A_2 = \frac{1000(n-1)}{2} \left[\frac{1}{\rho_1} + \frac{1}{\rho_2} \right], \text{ wherein}$$

n = refractive index of the lens material, and

$$\frac{1}{\rho_1} = \frac{1}{2(1+d^2+e^2)^{3/2}} \left[\frac{(1+d^2)g + (1+e^2)f - 2deh + \sqrt{\{(1+d^2)g + (1+e^2)f - 2deh\}^2 - 4(fg - h^2)(1+d^2+e^2)}}{2} \right]$$

$$\frac{1}{\rho_2} = \frac{1}{2(1+d^2+e^2)^{3/2}} \left[\frac{(1+d^2)g + (1+e^2)f - 2deh - \sqrt{\{(1+d^2)g + (1+e^2)f - 2deh\}^2 - 4(fg - h^2)(1+d^2+e^2)}}{2} \right]$$

$$d_1 = \left(\frac{\partial t_1}{\partial Z} \right)_{\substack{y=0 \\ Z=0}}$$

$$t_2 = (t_1)_{\substack{y=0 \\ Z=0}}$$

$$d = \frac{\partial t_1}{\partial Z}$$

$$e = \frac{\partial t_1}{\partial y}$$

$$f = \frac{\partial^2 t_1}{\partial Z^2}$$

$$g = \frac{\partial^2 t_1}{\partial y^2}$$

$$h = \frac{\partial^2 t_1}{\partial Z \partial y}$$

$$t_1 = C[p(Z-3)^3 + qy^2(Z-3)^2 + ry^2(Z-3)]$$

The formula in zone C:

$$X_2' = f_1 X_2 + f_2 X_2''$$

where X_2'' = formulation in F

5 X_2 = formula in central corridor B

$$f_1 = \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_a}{y_b - y_a} \right) \right]$$

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For $Z_0 \leq Z \leq Z_1$

$$f_2 = \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_b}{y_a - y_b} \right) \right]$$

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The formula in zone F:

$$X_2'' = \frac{M}{6} Z^3 + \frac{NZ^4}{12} + \& + V$$

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M and N are coefficients chosen to optimize the distortion properties.

& = the same as before

25 v = is a correction term to further influence the distortion properties.

The formulation for zone D:

The equation for a sphere

$$X_3 = X_R - \sqrt{R_R^2 - y^2 - (Z - Z_R)^2}$$

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X_R = X coordinate of the center of this sphere

Z_R = Z coordinate of the center of this sphere

R_R = radius of this sphere

X_R and Z_R are chosen such that in the $y = 0$ meridian the circular intersection of this sphere with this meridian is tangent with $(X_2)_{y=0}$ at $Z = Z_1$.

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The preferred embodiment of this invention is a case characterized by preferred constants p, q, r, M, N, y_1 , y_2 , y_3 , y_4 , y_5 , y_6 , Z_0 , Z_1 , Z_2 and k. The constants C and R_R are connected with the addition of power between the distance portion A and reading portion D. They are not critical for this invention but more for the different additions. The formula & is not critical for the invention, but relates to the base curve of the distance portion, giving it a certain value. These base curves are standardized in the common lenses now available.

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In the case where a sphere is chosen for the distance portion, the formula for & is

$$X_1 - R_D - \sqrt{R_D^2 - y^2 - Z^2}$$

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Where R_D is the radius of curvature of the distance portion surface (convex). This is the preferred embodiment for the distance portion. In the preferred embodiment the constants take the following values:

$$p \cong 11$$

$$q \cong 1$$

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$$r \cong 15$$

$$M \cong \frac{1.22 \times \text{addition in progression corridor}}{n - 1}$$

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$$\times \frac{2}{(Z_1 - Z_0) \times 1000}$$

$$N \cong 0$$

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$$y_1 \cong 2.1 \text{ mm}$$

$$y_2 \cong 50 \text{ mm}$$

$$y_3 \cong 4.2 \text{ mm}$$

$$y_4 \cong 7 \text{ mm}$$

$$y_5 \cong 50 \text{ mm}$$

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$$y_6 \cong 14.5 \text{ mm}$$

$$\begin{aligned} Z_0 &\equiv 0 \text{ mm} \\ Z_1 &\equiv 12 \text{ mm} \\ Z_2 &\equiv 18 \text{ mm} \\ k &\equiv 0 \end{aligned}$$

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The formula for zone E:

$$X'_3 = G_1 X_3 + G_2 X'_3''$$

10 $X'_3'' = \text{formula for zone G}$

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$$\left. \begin{aligned} G_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_e}{y_d - y_e} \right) \right] \\ G_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_d}{y_e - y_d} \right) \right] \end{aligned} \right\} \text{For } Z_1 < Z < Z_2$$

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$$\left. \begin{aligned} G_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_c}{y_d - y_c} \right) \right] \\ G_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_d}{y_c - y_d} \right) \right] \end{aligned} \right\} \text{For } Z \geq Z_2$$

30 The formula of zone G:

$$X'_3'' = X'_2'' + W$$

W = is a constant

The boundaries:

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These are defined by the plane $Z = Z_0$ delineating the distance portion from the intermediate zone.
The plane $Z = Z_1$ defining the boundary between the intermediate zone and the near portion.
The plane perpendicular to the paper containing the line

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$$y_a = \frac{y_3 - y_1}{Z_1 - Z_0} Z + y_1$$

The plane $y_b = y_2$ The plane perpendicular to the paper containing the line $y_c = y_6 + k(Z - Z_2)$

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The plane $y_d = y_5$.

The plane perpendicular to the paper containing the line

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$$y_e = \frac{y_6 - y_4}{Z_2 - Z_1} (Z - Z_1) + y_4$$

All the powers are in diopters and lengths in mm.

The factor

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$$C = \frac{\text{add}}{324 \times 10^3}$$

The addition takes place between $Z = 0$ and $Z = 12$ and is expressed in diopters.

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The blending formula having the general form of

$$\frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_a}{y_b - y_a} \right) \right]$$

65 results in distortion properties, best described as follows.

A horizontal line distorts into a cosine shaped line with a certain amplitude. The advantage of the cosine distortion is that approaching the center of the eye's field of view of distortion decreases rapidly. As long as the amplitude of the distortion is kept within limits of human tolerance, the total field can be considered optimized. The cosine distortion adds to the optimization by insuring less distortion closer to the center of attenuation of the observer. This feature gives the wearer a feeling as if there were no distortion at all. This feature enhances the dynamic use of the lens.

In prior art lenses the distortions in the periphery are either a fanning of straight lines or by practically extending the distance portion into the periphery while making the blending zone very narrow and abrupt. The fanning leaves in the vicinity of the area of attention some distortion even though small. This distortion exceeds the distortion of a cosine blending. The extension of the distance portion into the periphery with an abrupt blending zone makes the blending zone very obvious at all times. The blending is further influenced by the choice of M , N , y_a , y_b , y_c , y_d and y_e . When $N = 0$ and $M \neq 0$ the blending in the far periphery causes distortion akin to that of a linear power law surface. When $M = 0$ and $N \neq 0$, a quadratic power law governs the distortions in the far periphery.

In Figure 2, the calculated power law for a 2 addition lens is shown.

In Figure 3, the calculated astigmatism of the progression zone for a 2 addition lens is shown.

Figure 4 is a graph showing the measured values of the power law for 10 lenses, having a 2 diopter addition.

In Figure 5, the measured astigmatism for a 2 diopter addition lens' progression zone is given.

For the explanation of the invention, the convex lens surface was described as having the progressive addition properties. The same teaching applies for the concave surface, but in this case allowance should be made for some signs in the formulations, such that concave surfaces are expressed rather than convex.

The state of the art lenses of the present invention may provide permanent marks on the progressive addition surface in order to enable the orientation of the progressive surface relative to the wearer's eyes.

Figure 6 shows the relative placement of typical permanent marks on the lens. Thus the marks 10 and 12 enable the practitioner to properly position lens relative to the wearer's eye.

Claims

1. A progressive power lens having a distance portion (A) at the top and a reading portion (D) at the bottom connected by a central corridor (B) wherein the power varies and merges smoothly into said distance (A) and reading portions (D) characterized in that said central corridor (B) is defined by X_2 as the height measured from the reference plane (y , Z) in mm as follows:

$$X_2 = t_1 + \& + t$$

$$t_1 = C[p(Z - 3)^3 + qy^2(Z - 3)^2 + ry^2(Z - 3)]$$

& formula of the distance portion

t correction term to satisfy boundary conditions with distance portion =

$$-(t_2 + d_1 Z) + \frac{500}{A_1} - \sqrt{\frac{500^2}{A_1} - y^2 - Z^2}$$

$$t_2 = (t_1)_{\substack{y=0 \\ Z=0}}$$

$$d_1 = \left(\frac{\partial t_1}{\partial Z} \right)_{\substack{y=0 \\ Z=0}}$$

$$A_1 = (A_2)_{\substack{y=0 \\ Z=0}}$$

$$A_2 = \frac{1000(n - 1)}{2} \left(\frac{1}{\rho_1} + \frac{1}{\rho_2} \right)$$

n = refractive index of lens material

ρ_1 and ρ_2 are principal radii of the surface defined by t_1

y = coordinate of y

Z = coordinate of Z



A horizontal line distorts into a cosine shaped line with a certain amplitude. The advantage of the cosine distortion is that approaching the center of the eye's field of view of distortion decreases rapidly. As long as the amplitude of the distortion is kept within limits of human tolerance, the total field can be considered optimized. The cosine distortion adds to the optimization by insuring less distortion closer to the center of attenuation of the observer. This feature gives the wearer a feeling as if there were no distortion at all. This feature enhances the dynamic use of the lens.

In prior art lenses the distortions in the periphery are either a fanning of straight lines or by practically extending the distance portion into the periphery while making the blending zone very narrow and abrupt. The fanning leaves in the vicinity of the area of attention some distortion even though small. This distortion exceeds the distortion of a cosine blending. The extension of the distance portion into the periphery with an abrupt blending zone makes the blending zone very obvious at all times. The blending is further influenced by the choice of M, N, y_a , y_b , y_c , y_d and y_e . When $N = 0$ and $M \neq 0$ the blending in the far periphery causes distortion akin to that of a linear power law surface. When $M = 0$ and $N \neq 0$, a quadratic power law governs the distortions in the far periphery.

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1. A progressive power lens having a distance portion (A) at the top and a reading portion (D) at the bottom connected by a central corridor (B) wherein the power varies and merges smoothly into said distance (A) and reading portions (D) characterized in that said central corridor (B) is defined by X_2 as the height measured from the reference plane (y, Z) in mm as follows:

$$X_2 = t_1 + \& + t$$

$$t_1 = C[p(Z - 3)^3 + qy^2(Z - 3)^2 + ry^2(Z - 3)]$$

& formula of the distance portion

t correction term to satisfy boundary conditions with distance portion =

$$-(t_2 + d_1 Z) + \frac{500}{A_1} - \sqrt{\frac{500^2}{A_1} - y^2 - Z^2}$$

$$t_2 = (t_1)_{\substack{y=0 \\ Z=0}}$$

$$d_1 = \left(\frac{\partial t_1}{\partial Z} \right)_{\substack{y=0 \\ Z=0}}$$

$$A_1 = (A_2)_{\substack{y=0 \\ Z=0}}$$

$$A_2 = \frac{1.300(n - 1)}{2} \left(\frac{1}{p_1} + \frac{1}{p_2} \right)$$

n = refractive index of lens material

p_1 and p_2 are principal radii of the surface defined by t_1

y = coordinate of y

Z = coordinate of Z



C is a constant connected with the addition of power from the distance to the reading portion in diopters.

$$0 < p \leq 14$$

$$q \geq 0$$

$$r \geq 8$$

2. A lens according to claim 1 wherein the values are as follows (all other values as in claim 1):

$$C = \frac{\text{add}}{324 \times 10^3}$$

add = the addition of power from the distance to the reading portion in diopters.

$$p \approx 11$$

$$q \approx 1$$

$$r \approx 15$$

$$\& \approx R_D - \sqrt{R_D^2 - y^2 - Z^2}$$

R_D = radius of the spherical surface in the distance portion.

3. A lens according to claim 1 or 2 having a blending zone (C) on each side of a central corridor and horizontally spaced therefrom a peripheral zone (F), said blending zone (C) having the formula $X'_2 = f_1 X_2 + f_2 X'_2$ wherein X'_2 is defined as the height measured from the reference plane (y, Z) in mm where X_2 = formula in the central corridor in mm, X'_2 = formula in the peripheral zone in mm

$$f_1 = \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_a}{y_b - y_a} \right) \right]$$

For $Z_0 \leq Z \leq Z_1$

$$f_2 = \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_b}{y_a - y_b} \right) \right]$$

y = coordinate y

Z = coordinate Z

$$y_a = \frac{y_3 - y_1}{Z_1 - Z_0} Z + y_1$$

$$y_b = y_2$$

$$0 \leq y_1 \leq 15$$

$$y_2 \geq 15$$

$$2 \leq y_3 \leq 30$$

$$-2 \leq Z_0 \leq 5$$

$$8 \leq Z_1 \leq 18$$

$$X'_2 = \frac{M}{6} Z^3 + \frac{N}{12} Z^4 + \& + V$$

$$M = \frac{C_2 \times \text{addition in progression corridor}}{\frac{n-1}{2} \times (Z_1 - Z_0) \times 1000}$$

n = refractive index of lens material

$$0 \leq C_2 \leq 5$$

$$N \geq 0$$

& formula of the distance portion



v is a correction term to further influence the distortion properties.

4. A lens according to claim 3 wherein the values are as follows (all other values as in claim 3):

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- $y_1 \cong 2.1$
 - $y_2 \cong 50$
 - $y_3 \cong 4.2$
 - $Z_0 \cong 0$
 - $Z_1 \cong 12$
 - $C_2 \cong 1.22$
 - $N \cong 0$

5. A lens according to any preceding claim having a blending zone (E) on each side of the reading portion (D) and a peripheral zone (G) horizontally spaced therefrom, said blending zone on each side of the reading portion having the formula $X'_3 = G_1 X_3 + G_2 X'_3$ wherein X'_3 is defined as the height measure from the reference plane (y, Z) in mm

X_3 = formula in the reading portion in mm
 X'_3 = formula in the peripheral zone in mm

$$\left. \begin{aligned} G_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_e}{y_d - y_e} \right) \right] \\ G_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_d}{y_e - y_d} \right) \right] \end{aligned} \right\} \text{For } Z_1 < Z < Z_2$$

$$\left. \begin{aligned} G_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_e}{y_d - y_e} \right) \right] \\ G_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_d}{y_e - y_d} \right) \right] \end{aligned} \right\} \text{For } Z \geq Z_2$$

y = coordinate y
 Z = coordinate Z
 $y_e = y_6 + k(Z - Z_2)$
 $y_d = y_5$

$$y_e = \frac{y_6 - y_4}{Z_2 - Z_1} (Z - Z_1) + y_4$$

$0 \leq k \leq 5$
 $2 \leq y_4 \leq 30$
 $y_5 \geq 15$
 $y_6 \geq 2$
 $8 \leq Z_1 \leq 18$
 $Z_2 \geq 8$

$$X'_3 = \frac{M}{6} Z^3 + \frac{N}{12} Z^4 + V + \& + W$$

$$M = \frac{C_2 \times \text{addition in progression corridor}}{\frac{n - 1}{2} \times (Z_1 - Z_0) \times 1000}$$

n = refractive index of lens material
 $-2 \leq Z_0 \leq 5$
 $0 \leq C_2 \leq 5$
 $N \geq 0$



& formula of the distance portion

V is a correction term to further influence the distortion properties.

W = constant

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6. A lens according to claim 5 wherein the values are as follows (all other values as in claim 5):

- $k \cong 0$
 $y_4 \cong 7$
 $y_5 \cong 50$
 $y_6 \cong 14.5$
 $z_1 \cong 12$
 $z_2 \cong 18$
 $C_2 \cong 1.22$
 $z_0 \cong 0$
 $N \cong 0$

Patentansprüche

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1. Brillenglas mit stufenloser Brechkraftänderung, mit einem oben angeordneten Fernteil (A) und einem unten angeordneten Leseteil (D), die miteinander durch einen in der Mitte angeordneten Zwischenteil (B) getrennt sind, in dem sich die Brechkraft verändert und der glatt in den Fernteil (A) und den Leseteil (D) übergeht, dadurch gekennzeichnet, daß der in der Mitte angeordnete Zwischenteil (B) durch die von der Bezugsebene (y, Z) aus in mm gemessene Höhe X_2 wie folgt definiert ist:

$$X_2 = t_1 + \delta + t$$

$$t_1 = C[p(Z - 3)^3 + qy^2(Z - 3)^2 + ry^2(Z - 3)]$$

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δ die Formel für den Fernteil ist,
t ein Korrekturterm zur Erfüllung der Bedingungen am Rand des Fernteils und =

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$$- (t_2 + d_1 Z) + \frac{500}{A_1} - \sqrt{\frac{500^2}{A_1} - y^2 - Z^2}$$

ist,

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$$t_2 = (t_1)_{\substack{y=0 \\ Z=0}}$$

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$$d_1 = \left(\frac{\partial t_1}{\partial Z} \right)_{\substack{y=0 \\ Z=0}}$$

$$A_1 = (A_2)_{\substack{y=0 \\ Z=0}}$$

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$$A_2 = \frac{1000(n - 1)}{2} \quad \frac{1}{\rho_1} + \frac{1}{\rho_2}$$

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n = die Brechzahl des Brillenglasswerkstoffes ist,
 ρ_1 und ρ_2 Haupttradien der durch t_1 definierten Fläche sind,
y die y-Koordinate ist,
Z die Z-Koordinate ist,
C eine in Dioptrien angegebene Konstante ist, die mit der Zunahme der Brechkraft von dem Fernteil zu dem Leseteil in Beziehung steht,

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$$0 < p \leq 14$$

$$q \geq 0$$

$$r \geq 8.$$

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2. Brillenglas nach Anspruch 1, dadurch gekennzeichnet, daß die Werte wie folgt sind (alle anderen Werte wie im Anspruch 1):

$$C = \frac{\text{add}}{324 \times 10^3}$$

add = die Zunahme der Brechkraft von dem Fernteil zu dem Leseteil in Dioptrien

$$\begin{aligned} p &\cong 11 \\ q &\cong 1 \\ r &\cong 15 \\ \delta &\cong R_0 - \sqrt{R_0^2 - y^2 - Z^2} \\ R_0 &= \text{Radius der Kugelfläche des Fernteils.} \end{aligned}$$

3. Brillenglas nach Anspruch 1 oder 2, in dem auf jeder Seite des Zwischenteils eine Mischzone (C) und im Horizontalabstand von ihr eine Umfangszone (F) vorgesehen ist, die Mischzone (C) die Formel $X_2' = f_1 X_2 + f_2 X_2''$ hat, in der X_2' die von der Bezugsebene (y, Z) aus gemessene Höhe in mm ist, X_2 die Formel für den zentralen Zwischenteil in mm ist, X_2'' die Formel für die Umfangszone in mm ist.,

$$\begin{aligned} f_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_a}{y_b - y_a} \right) \right] \\ f_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_b}{y_a - y_b} \right) \right] \end{aligned} \quad \left. \vphantom{\begin{aligned} f_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_a}{y_b - y_a} \right) \right] \\ f_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_b}{y_a - y_b} \right) \right] \right\} \text{Für } Z_0 \leq Z \leq Z_1$$

y die y-Koordinate ist,
Z die Z-Koordinate ist

$$y_a = \frac{y_3 - y_1}{Z_1 - Z_0} Z + y_1$$

$$\begin{aligned} y_b &= y_2 \\ 0 &\leq y_1 \leq 15 \\ y_2 &\leq 15 \\ 2 &\leq y_3 \leq 30 \\ -2 &\leq Z_0 \leq 5 \\ 8 &\leq Z_1 \leq 18 \end{aligned}$$

$$X_2'' = -\frac{M}{6} Z^3 + \frac{N}{12} Z^4 + \delta + V$$

$$M = \frac{C_2 \times \text{Brechkraftzunahme im Zwischenteil}}{\frac{n-1}{2} \times (Z_1 - Z_0) \times 1000}$$

n = Brechzahl des Brillenglaswerkstoffes
 $0 \leq C_2 \leq 5$
 $N \geq 0$
 δ = Formel für den Fernteil
 V = ein Korrekturterm für die weitere Beeinflussung der Verzeichnungseigenschaften.

4. Linse nach Anspruch 3, dadurch gekennzeichnet, daß die Werte wie folgt sind (alle anderen Werte wie im Ansprüche 3);

$$\begin{aligned} y_1 &\cong 2,1 \\ y_2 &\cong 50 \\ y_3 &\cong 4,2 \\ Z_0 &\cong 0 \end{aligned}$$



$$\begin{aligned} Z_1 &\cong 12 \\ C_2 &\cong 1,22 \\ N &\cong 0 \end{aligned}$$

- 5 5. Brillenglas nach einem der vorhergehenden Ansprüche, in dem auf jeder Zeite des Leseteils (D) eine Mischzone (E) und im Horizontalabstand von ihr eine Umfangszone vorgesehen ist, die Mischzone auf jeder Seite des Leseteils die Formel $X'_3 = G_1 X_3 + G_2 X'_3$ hat, in der X'_3 die von der Bezugsebene (y , Z) aus gemessene Höhe in mm ist,

X_3 die Formel für den Leseteil in mm ist,

- 10 X'_3 die Formel für die Umfangszone in mm ist,

$$\left. \begin{aligned} G_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_e}{y_d - y_e} \right) \right] \\ G_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_d}{y_e - y_d} \right) \right] \end{aligned} \right\} \text{Für } Z_1 < Z < Z_2$$

$$\left. \begin{aligned} G_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_e}{y_d - y_e} \right) \right] \\ G_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_d}{y_e - y_d} \right) \right] \end{aligned} \right\} \text{Für } Z \geq Z_2$$

- 30 y die y -Koordinate ist,
 Z die Z -Koordinate ist,
 $y_e = y_6 + k(Z - Z_2)$
 $y_d = y_5$

$$35 \quad y_e = \frac{y_6 - y_4}{Z_2 - Z_1} (Z - Z_1) + y_4$$

- 40 $0 \cong k \cong 5$
 $2 \cong y_4 \cong 30$
 $y_5 \cong 15$
 $y_6 \cong 2$
 $8 \cong Z_1 \cong 18$
 $Z_2 \cong 8$

$$45 \quad X'_3 = \frac{M}{6} Z^3 + \frac{N}{12} Z^4 + V + \delta + W$$

$$50 \quad M = \frac{C_2 \times \text{Brechkraftzunahme im Zwischenteil}}{\frac{n - 1}{2} \times (Z_1 - Z_0) \times 1000}$$

- 55 n = Brechzahl des Brillenglaswerkstoffes
 $-2 \cong Z_0 \cong 5$
 $0 \cong C_2 \cong 5$
 $N \cong 0$

- 60 δ = die Formel für den Fernteil,

V ein Korrekturterm für eine weitere Beeinflussung der Verzweigungseigenschaften und W eine Konstante ist.

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6. Brillenglas nach Anspruch 5, dadurch gekennzeichnet, daß die Werte wie folgt sind (alle anderen Werte wie im Anspruch 5):

- 5 $k \cong 0$
 $y_4 \cong 7$
 $y_5 \cong 50$
 $y_6 \cong 14.5$
 $Z_1 \cong 12$
 $Z_2 \cong 18$
 10 $C_2 \cong 1.22$
 $Z_0 \cong 0$
 $N \cong 0$

Revendications

15

1. Lentille à puissance variant progressivement ayant une partie (A) de vision éloignée en haut et une partie de lecture (D) en bas reliées par un couloir central (B) dans lequel la puissance varie et qui se raccorde progressivement à la partie de vision éloignée (A) et à la partie de lecture (D), caractérisée en ce que le couloir central (B) est défini par X_2 qui constitue la hauteur mesurée à partir du plan de référence (y , Z) en mm de la manière suivante:

$$X_2 = t_1 + \& + t$$

$$t_1 = C[p(Z-3)^3 + qy^2(Z-3)^2 + ry^2(Z-3)]$$

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& est la formule de la partie de vision éloignée

t est un terme de correction destiné à la satisfaction des conditions aux limites avec la partie de vision éloignée

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$$t = -(t_2 + d_1 Z) + \frac{500}{A_1} - \sqrt{\frac{500^2}{A_1} - y^2 - Z^2}$$

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$$t_2 = (t_1)_{\substack{y=0 \\ Z=0}}$$

$$d_1 = \frac{\partial t_1}{\partial Z} \quad \substack{y=0 \\ Z=0}$$

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$$A_1 = (A_2)_{\substack{y=0 \\ Z=0}}$$

45

$$A_2 = \frac{1000(n-1)}{2} \quad \frac{1}{p_1} + \frac{1}{p_2}$$

n est l'indice de réfraction du matériau de la lentille

p_1 et p_2 sont les rayons principaux de la surface définis par t_1

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y = coordonnée de y
 Z = coordonnée de Z

C est une constante reliée à l'addition de puissance de la partie de vision éloignée à la partie de lecture, en dioptries:

$$0 < p \leq 14$$

$$q \geq 0$$

$$r \geq 8.$$

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2. Lentille selon la revendication 1, dans laquelle les valeurs sont les suivantes (toutes les autres valeurs étant celles de la revendications 1):

$$C = \frac{ad}{324 \times 10^3}$$

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ad = addition de puissance en dioptries de la partie de vision éloignée à la partie de lecture

$$p \cong 11$$

$$q \cong 1$$

$$r \cong 15$$

$$5 \quad \& \cong R_D - \sqrt{R_D^2 - y^2 - Z^2}$$

R_D = rayon de la surface sphérique dans la partie de vision éloignée.

3. Lentille selon l'une des revendications 1 et 2, ayant une zone de jonction (C) de chaque côté d'un couloir central et une zone périphérique (F) que en est distante horizontalement, la zone de jonction (C) ayant la formule $X_2' = f_1 X_2 = f_2 X_2''$ dans laquelle X_2' est défini comme étant la hauteur mesurée à partir du plan de référence (y, Z) en mm, avec X_2 = formule dans le couloir central en mm, X_2'' = formule dans la zone périphérique en mm,

$$15 \quad f_1 = \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_a}{y_b - y_a} \right) \right] \quad \text{pour } Z_0 \leq Z \leq Z_1$$

$$20 \quad f_2 = \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_b}{y_a - y_b} \right) \right]$$

y = coordonnée y,
Z = coordonnée Z

$$25 \quad y_a = \frac{y_3 - y_1}{Z_1 - Z_0} Z + y_1$$

$$30 \quad \begin{aligned} y_b &= y_2 \\ 0 &\leq y_1 \leq 15 \\ y_2 &\geq 15 \\ 2 &\leq y_3 \leq 30 \\ -2 &\leq Z_0 \leq 5 \\ 8 &\leq Z_1 \leq 18 \end{aligned}$$

$$35 \quad X_2'' = -\frac{M}{6} Z^3 + \frac{N}{12} Z^4 + \& + V$$

$$40 \quad M = \frac{C_2 \times \text{addition dans le couloir de progression}}{\frac{n-1}{2} \times (Z_1 - Z_0) \times 1000}$$

$$45 \quad \begin{aligned} n &= \text{indice de réfraction du matériau de la lentille} \\ 0 &\leq C_2 \leq 5 \\ N &\geq 0 \end{aligned}$$

& formule de la partie de vision éloignée

v terme de correction influençant en outre les propriétés de distorsion.

- 50 4. Lentille selon la revendication 3, dans laquelle les valeurs sont les suivantes (toutes les autres valeurs étant telles que dans la revendication 3);

$$55 \quad \begin{aligned} y_1 &\cong 2,1 \\ y_2 &\cong 50 \\ y_3 &\cong 4,2 \\ Z_0 &\cong 0 \\ Z_1 &\cong 12 \\ C_2 &\cong 1,22 \\ 60 \quad N &\cong 0 \end{aligned}$$

5. Lentille selon l'une quelconque des revendications précédentes ayant une zone (E) de jonction de chaque côté de la partie de lecture (D) et une zone périphérique (G) qui en est espacée horizontalement, la zone de jonction, de chaque côté de la partie de lecture, ayant la formule: $X_3' = G_1 X_3 + G_2 X_3''$ dans laquelle



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X_3' est défini comme la hauteur mesurée à partir du plan de référence (y, Z), en mm X_3 = formule de la partie de lecture en mm, X_3'' = formule dans la zone périphérique en mm

$$\left. \begin{aligned} G_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_e}{y_d - y_e} \right) \right] \\ G_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_d}{y_e - y_d} \right) \right] \end{aligned} \right\} \text{ pour } Z_1 < Z < Z_2$$

$$\left. \begin{aligned} G_1 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_e}{y_d - y_e} \right) \right] \\ G_2 &= \frac{1}{2} \left[1 + \cos \left(\pi \frac{y - y_d}{y_e - y_d} \right) \right] \end{aligned} \right\} \text{ pour } Z \geq Z_2$$

y = coordonnée y
Z = coordonnée Z
 $y_e = y_6 + k(Z - Z_2)$
 $y_d = y_5$

$$y_e = \frac{y_6 - y_4}{Z_2 - Z_1} (Z - Z_1) + y_4$$

$0 \leq k \leq 5$
 $2 \leq y_4 \leq 30$
 $y_5 \geq 15$
 $y_6 \geq 2$
 $8 \leq Z_1 \leq 18$
 $Z_2 \geq 8$

$$X_3'' = \frac{M}{6} Z^3 + \frac{N}{12} Z^4 + V + \& + W$$

$$M = \frac{C_2 \times \text{addition dans le couloir de progression}}{\frac{n-1}{2} \times (Z_1 - Z_0) \times 1000}$$

n = indice de réfraction du matériau de la lentille
 $-2 \leq Z_0 \leq 5$
 $0 \leq C_2 \leq 5$
 $N \geq 0$

& formule de la partie de vision éloignée
V terme de correction influençant en outre les propriétés de distortion

W = constante

6. Lentille selon la revendication 5, dans laquelle les valeurs sont les suivantes (toutes les autres valeurs étant comme indiqué dans la revdication 5):

$k \approx 0$
 $y_4 \approx 7$
 $y_5 \approx 50$
 $y_6 \approx 14.5$
 $Z_1 \approx 12$
 $Z_2 \approx 18$
 $C_2 \approx 1.22$
 $Z_0 \approx 0$
 $N \approx 0$