shown in the astigmatic difference diagram of FIG. 8. The isoastigmatic difference lines in FIG. 8 are plotted in units of 0.5 diopters. As a comparison with this embodiment, isoastigmatic difference lines of a conventional ophthalmic lens having a progressively variable refracting power are shown in FIG. 9. These isoastigmatic difference lines are obtained in units of 0.5 diopters.

Since the conventional ophthalmic lens having a progressively variable focal power does not have the above arrangement of the present invention, an astigmatic difference density is increased, and the astigmatic difference values and the gradient of the astigmatic differences are increased, as shown in FIG. 9. As a result, image distortion is undesirably increased, and the user may feel image shift when he or she moves lines of sight. Aberration by the astigmatic difference from the side area of the intermediate portion adversely affects side areas at a lower position in the portion F of each lens. When eyes are directed toward these areas, image distortion and shift in addition to blurring typically occur in these areas.

To the contrary, in this embodiment, the astigmatic difference density of the surface refracting powers is decreased, the gradient of the astigmatic differences is moderate, and image distortion and shift are apparently suppressed, as shown in FIG. 8.

The major points of the ophthalmic lens having a progressively variable refracting power according to the present invention will be described with reference to FIG. 7 which shows the additional power curve g of this embodiment.

The center O_F is located on the principal meridional curve having a predetermined average refracting power in the portion F and serves as the measuring reference point for the portion F in practice. The center O_N is located on the principal meridional curve having a predetermined refracting power at the portion N and serves as the measuring reference point for the portion N in practice. The eye point E for the portion F serves as a reference point when lenses are fitted in a frame. The eye point E serves as a distance vision correction reference point which coincides with a distance vision correction position where the line of sight passes when the user wears lenses. The position of the eye point E is determined independently of the geometric center (FIG. 2A) of the lens, as indicated by the average refracting power distribution curve on the principal meridional curve in FIG. 7. The eye point E is defined as follows. That is, a straight line b which is tangent to a portion F side of the additional power curve g and parallel to a straight line a which connects the center O_F of the portion F and the center O_N of the portion N crosses a straight line c representing an average refracting power at the center O_F to form an intersection. This intersection is defined as the distance vision correction eye point. In this case, the additional power curve g as shown in FIG. 7 is obtained by plotting the average of the surface refracting powers of the respective points on the principal meridional curve.

In general, since ophthalmic lenses having a progressively variable refracting power are worked to match the frame, the sizes of the respective areas, i.e., the portions F, P, and N, and especially the sizes of the areas of the portions F and N including the peripheral portions vary depending on shapes of frames. However, before working of the ophthalmic lens having a progressively variable refracting power, it is a circular lens having a diameter of about 60 mm or more. The circular lenses are delivered to retail shops and are worked to match desired frame sizes at the retail shops. Therefore, the surface shape of the ophthalmic lens having a progressively variable refracting power according to the present invention is defined as a shape prior to working. In design of an optimal surface shape of the ophthalmic lens having a progressively variable refracting power, it is important to balance aberration in consideration of the surface shape in a larger area including an effective area to be used in addition to the central area which is frequently used.

Conventional ophthalmic lenses having a progressively variable refracting power have a surface shape with a so-called umbilical line in which microscopically spherical surfaces continue along the entire principal meridional curve, and a surface shape which is not umbilical in part of the principal meridional curve, but in which two radii of curvature perpendicular to each other are different in this part of the curve. In other words, surface shapes on the principal meridional curve are classified into two shapes, i.e., a surface shape which is umbilical along the entire principal meridional curve; and a surface shape which is not umbilical on at least part of the principal meridional curve, but in which a radius of curvature along the principal meridional curve is different from that in a direction perpendicular to the principal meridional curve. The present invention is effective in both surface shapes.

In addition, conditions (1) and (2) are valid for an entirely umbilical surface shape on the principal meridional curve, or a surface shape including a portion which is not umbilical.

According to the present invention, there is provided an ophthalmic lens having a progressively variable refracting power, in which a wide field of view can be assured at a lower position in the portion for distance vision, the intermediate portion and the portion for near vision have wide bright fields which can be sufficient in practice, image distortion and shift in the peripheral areas of the intermediate portion and the portion for near vision can be minimized, a good aberrational balance can be obtained, and the user who wears this lens for the first time will not feel discomfort.

According to the present invention, there is provided an ophthalmic lens having a progressively variable refracting power, in which the curvature of the lens surface is not monotonous but a moderate refracting power gradient within allowable ranges of the above conditions is provided, thereby minimizing the astigmatic difference throughout the refracting surface of the lens. The maximum value of the astigmatic difference can be minimized, and its gradient can be moderate so that the aberration density in the aberration concentration area in the side areas of the principal meridional curve from the lower position in the portion for distance vision to the portion for near vision is reduced, image shift and distortion of the areas of the intermediate portion and the portion for near vision can be suppressed, and the user who wears the lenses of this type for the first time will not experience discomfort. In addition, a design standard for improving the visual characteristics can be established on the basis of the parameters of the present invention. Therefore, the design standard is very useful as a reference for evaluating characteristics of the lens.

What is claimed is:

1. An ophthalmic lens having a progressively variable refracting power, including: