The Science of Optics.

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Elementary Anatomy of the Eye.

A convex lens increases in strength when held further away from the eye, but a concave decreases; so that although a positive and a negative lens of the same curvature will neutralize each other when placed close together, they will not do so if separated a few inches. If you take a No. 5 convex and a No. 5 concave, and separate them, holding the former further away, the light passing through the two is converged considerably, because the convex lens acts as one that is stronger than No. 5. If the concave is placed further away it acts as one that is somewhat weaker than No. 5, so that the light passing through the two is converged slightly. The difference when the lenses are held together is slight; but, as the one or the other must of necessity be further away, it is sufficient to prevent an absolute neutralization.

If a convex lens, say, No. 10, and a concave of the same number be held in front of the eye, they act practically as a plain glass. If the concave be gradually moved further out, the convex being left in its original position, the concave neutralizes less of the convex power, until, if it be removed to a certain distance, the former has no influence on the latter, as practically all the rays of light diverged by the concave pass to the outside of the convex lens.

To learn whether a convex or a concave sphere is properly centred, look through it at the cross on the analyzing card. If it be centred, the junction of the two lines will be exactly in the centre of the lens, while, if it be decentred, the junction of the two lines will be seen somewhere not in the exact centre of the lens. To complete the test the lens must be rotated on its axis while being looked through, and the cross should not move if it be a properly centred spherical.

The optical centre lies in the thickest part of a convex, and the thinnest part of a concave lens.

The geometrical centre of a lens is that which is midway between the edges—that is, the middle point of the glass.

A lens is said to be centred when the optical and geometrical centres coincide, and is said to be decentred when they do not.

The test of noting whether the cross moves when the lens is rotated on its geometrical centre is also that which is used for distinguishing between spherical and cylindrical lenses.

A meridian is any line encircling a globe and passing through the two poles. It is, therefore, as regards lenses, any line across it passing through the centre.

Spherical lenses, being segments of or hollowed out on spheres, have the same curvature, and, therefore, the same refractive power in every meridian.

Cylindrical lenses are segments of or hollows made on a cylinder or column which is perfectly straight in one direction, that is the axis, and has a varying degree of curvature in each meridian, the greatest being in that direction which is at right angles to the axis. A convex cylindric lens is a segment of a cylinder on one side, and is flat on the other. A concave cylindric lens is a hollow curved out by a cylinder on one side and is flat on the other. As a cylindrical lens has no curvature in the line of its axis, it has there no refractive power; the greatest amount of refractive power is in the meridian of greatest curvature at right angles to the axis, and on the curvature of this meridian of greatest refraction depends the number of the lens.

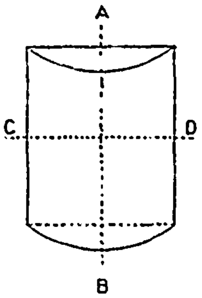

FIG. 23.

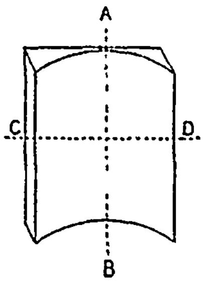

FIG. 24.

Fig. 23 represents a convex cylinder, and Fig. 24 a concave cylinder. The line AB in either shows the axis where there is no refractive power, and CD in either shows the meridian at right angles to the axis, where there is the most curvature, and therefore the greatest refracting power.

In discussing or fitting cylinder lenses it is necessary to consider only these two principal meridians, the axis and the meridian at right angles to it.

We always talk of a cylinder as being with its axis in a certain direction, and it is well to grasp the fact that the defect which the cylinder has to correct is at right angles to the axis of the lens; that is to say, it is in the same direction as the meridian of greatest curvature. I consider it a pity that the position of a cylinder should be marked by its axis. It would be far more rational to mark it by the meridian of greatest power, but such is the custom.

Vertical is that direction running straight up and down, perpendicular to the horizon. Horizontal is that direction running straight across, parallel to the horizon.

Two cylinders of the same number, both convex or both concave, placed together with their axes crossing one another, make a spherical lens of the same number. For example, a +4D cylinder axis vertical and a +4D cylinder axis horizontal are together exactly the same as a +4D sphere. The greatest power of the one coincides with the axis of the other, and *vice versa*, and at the intermediate meridians what is wanting in curvature to make a +4D in the one lens is supplied in the other, so that there is a refractive power of 4D in every meridian, and this constitutes a 4D spherical.

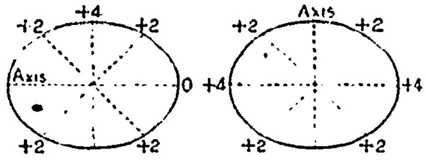

FIG. 25.

In Fig. 25, if the lens A be placed over the lens B it will be seen that the total refracting power of the two lenses is 4D in every meridian.

A 2D cylinder may therefore be considered as a lens that has half the refractive of a 2D sphere, not half of its refractive power in every meridian, that would constitute a 1D sphere, but one that has the full amount of refractive power in one meridian and none at all in the opposite meridian, the intermediate ones having a curvature that gradually descends from that of 2D to *nil*.

If two cylinders, say, +1.50D, be placed with their axes parallel, they make a +3D cylinder; if the axes are at right angles to each other, they make a +1.50 sphere. At any intermediate position they make a certain compound cylindric lens, the same as a sphere and a cylinder.

As rays of light passing through a cylinder suffer refraction to a different in every meridian and none in that of the axis, it is not possible to get a complete image of a luminous object on a screen with such a lens. If, however, a convex cylinder be held in front of a screen at the focal distance of the meridian of greatest curvature, with the axis either horizontal or vertical, certain bright lines will be seen. For instance, if a +4D cylinder be held with its axis horizontal at 10 in. distance from a screen and facing a bright light, some lines will be seen on the screen running horizontally, so that a number of a simple convex cylinder might be learnt in this way, although it is not very certain or satisfactory.

It should be noticed that if the axis be held vertical the bright lines are vertical; the greatest power of the lens being horizontal the rays of light are refracted in that meridian, and brought to a focus point by point, so that they form lines that run vertically.

When a cylinder is combined with a sphere the cylindric power is ground on one side, the spherical power on the other, and it is called a compound cylindric lens. The refraction of such a lens is very complicated. There is refractive power in every meridian, the least being in the meridian of the axis of the cylinder, and the greatest in the meridian at right