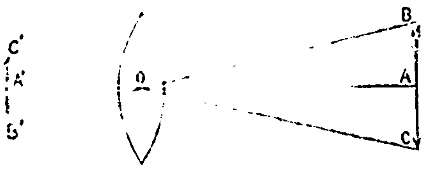

Fig. 20.

little, deviation. In Fig. 20 the secondary axes *BB* and *CC* cross the principal axis *AA* at *O*, the optical centre of the lens.

The principal focus only is considered in calculating the refractive power of a lens.

Convex lenses converge rays transmitted by them; they are called positive because they have a real focus, and are also called plus (sign +), because they increase the refractive power of the eye.

Concave lenses diverge rays transmitted by them; they are called negative because they have no real, but only a negative focus, and are also called minus (sign —) because they decrease the refractive power of the eye.

In order to know the number of a convex lens, it is merely necessary to measure with a yard stick the distance at which a focus is obtained of light entering a doorway or window that is situated twenty feet or more away. On a piece of white paper fastened to the wall a clear inverted image of the view outside the door or window can be obtained if the number of the lens be not higher than 24. Weaker lenses are difficult to focus, especially if the light be dull. The stronger the lens the more the rays will be refracted, and therefore the sooner they will meet, and so the shorter is the focal length. The weaker the lens the greater the focal distance. The picture thrown on to the screen will be sharp only at the exact focal distance of the lens; when it is held nearer or further away than this exact distance the image is indistinct. The stronger the lens, the smaller and sharper is the picture.

The inch or old system of numeration is based on the fact that a double convex lens formed of two segments of a sphere of 1 inch radius refracts parallel rays of light so as to bring them to a focus at one inch; this lens is the unit or standard of the inch system. A lens that has one-half this power refracts rays only to one-half this extent, and so brings them to a focus at two inches. A lens with $\frac{1}{10}$ the power of the unit bends the rays only enough to bring them to a focus at ten inches. Oculists and opticians mark such lenses as $\frac{1}{2}$ or $\frac{1}{10}$, but in the trade they are called No. 2 convex or No. 20 convex, and so with all the other numbers.

The concaves are similarly numbered according to the radius of their curvature. The amount of refraction outwards in any concave lens is sufficient to render parallel the inwardly refracted rays of the corresponding convex No. (see Fig. 13). A No. 20 concave bends the rays outwards to exactly the same extent as No. 20 convex bends them inwards; so, together, their united refraction amounts to nothing.

To add together, that is, to find the strength of, two convex lenses, say, Nos. 24 and 10, as the refractive power of the one has to be added to the refractive power of the other, proceed thus:

$$(+\tfrac{1}{24})+(+\tfrac{1}{10})=\tfrac{10}{240}+\tfrac{24}{240}=\tfrac{34}{240}=\tfrac{1}{7}$$
(about),

so these two lenses together make a $\frac{1}{7}$, or, as generally called, a No. 7 convex. The small fraction need not be considered.

To add together two lenses of opposite refraction, for instance, No. 12 concave and No. 15 convex (here the concave is the stronger, so the result must be concave), proceed thus:

$$(+\tfrac{1}{15})+(-\tfrac{1}{12})=\tfrac{12}{180}-\tfrac{15}{180}=-\tfrac{3}{180}=-\tfrac{1}{60},$$

and the two together are therefore equal to a No. 60 concave.

To add, say, No. 20 concave and No. 10 convex, here the convex is the stronger, so the result is convex:

$$(+\tfrac{1}{10})+(-\tfrac{1}{20})=\tfrac{20}{200}-\tfrac{10}{200}=+\tfrac{10}{200}=+\tfrac{1}{20},$$

therefore the two combined equal No. 20 convex.

For quick working all that is necessary is, when both lenses are convex or both concave, to divide the multiple by the sum of the two numbers.

For instance, Nos. 20 and 10, then

20 × 10 = 200
20 + 10 = 30
30)200(7

If one number is convex and the other is concave, then divide the multiple by the difference. For instance, Nos. 30 concave and 10 convex:

30 × 10 = 300
30 − 10 = 20
20)300(15 convex,

as of the original numbers the convex was the stronger.

The new scale of numeration is very much more simple. It is called the dioptric (dia, through; opto, to see), which means refractive. In this system, instead of measuring the focal length, which is the result of the refraction of a lens, the refraction itself is measured, and the unit is a diopter (sign D). The diopter of refraction is the quantity of converging power in a convex lens that is sufficient to bend rays of light that are parallel before entering the lens to a focus one metre behind it.

A metre (sign M) is a French measure of length equal to 39.337 inches English or American. For general purposes, it is sufficiently close to calculate forty inches as equal to one metre. If 1D of refraction makes a focus of parallel rays at forty inches, then 2D will refract just double as much, and the focus will be found at twenty inches; a 4D convex lens having four times the refractive power of 1D will retract the light sufficiently to make the focus ten inches, and so on through the scale.

In connection with diopters it is customary to use the sign + for convex and − for concave, and this should be noted, as often oculists merely put the sign + or −, and the number of the lens without adding the sign D; therefore, when you read +4 it should be taken as meaning four diopters, whereas 4 Cx should be understood as representing a four-inch convex lens.

To find the strength of two or more lenses combined by the dioptric system is particularly easy. It is merely necessary to add or subtract, and the result is + or −, according to which is the higher or stronger number. For example:

+2 and +4 = +6
+4 and −3 = +1
−5 and +3 = −2
−5 and −2 = −7
+3 and −3 = 0

Now as +1D refracts parallel rays so that they focus at 40 inches, it is plain that it is equal to a No. 40 convex lens of the old system; a +2D equals a No. 20, and a +40D lens is the same as a 1 inch convex lens.

To translate the number of a lens of the one scale into that of the other, the rules are as follows:

To turn inches into diopters multiply the refractive power by 40; thus a No. 5 equals 8D, as

$$\tfrac{1}{5}\times\tfrac{40}{1}=\tfrac{40}{5}=8.$$

To turn diopters into inches: Divide the refractive power by 40; thus, 10D equals a No. 4, as

$$\tfrac{10}{1}\times\tfrac{1}{40}=\tfrac{10}{40}=\tfrac{1}{4},$$ or a No. 4.

But a more simple method of converting lenses of either scale into that of the other is to divide 40 by the known number. For instance, you wish to know what is the equivalent of a 5D lens in the inch system; then 5)40(8, so 5D is the same as an 8-inch lens, or an 8D equals a 5-inch. In making this division there is often a small fraction left over, as many numbers will not divide evenly into 40; these fractions need not be considered, but the next nearest number must be taken; thus 3D equals No. 13 inch. The rule is that if the number will not go exactly into 40, divide it into 39, or the nearest possible number to the one or the other. For instance, 3.50D = No. 11, 3.25D = No. 12, 4.50 = No. 9.

In the same way, if the inch number be known, divide it into 40 to get the dioptric measurement; thus No. 16 equals 2.50D, as 40 ÷ 16 goes 2.50 times; No. 12 equals 3.25D, as 40 ÷ 12 gives 3.25 (about); a No. 2½-inch goes 16 times into 40, so that it is equal to a 16D.

It must be noted also that the fractions of inches are always expressed as vulgar fractions, as 2½ inch, while fractions of diopters are invariably expressed in decimals, as 6.50D. The mere putting of a decimal fraction denotes that the lens required is of the dioptric scale, this system being entirely based on decimal calculations.

By dividing into 40, the number of a dioptric lens, you also get the focal length of that lens in inches. If the focal length