General Optical Council Approved CET For Optometrists
General Optical Council Approved CET For Dispensing Opticians

Back to basics in dispensing

Part 4 – The focimeter

In part four of our series looking at all matters dispensing, **Shaunagh Aitken** reviews the use of focimeters. C6489, one general CET point suitable for optometrists and DOs

A focimeter is an instrument used to measure vertex powers and prismatic effects of spectacles and contact lenses, to orientate and mark uncut lenses, and to verify the correct mounting of lenses in spectacle frames.

A BRIEF HISTORY

As an undergraduate, Ernst Abbe studied physics and mathematics before meeting Carl Zeiss in 1866. He became very interested in optical problems, and after forming a partnership with Zeiss, in 1867 Abbe designed an instrument that could used to determine the focal power of lenses. In 1912 Troppman introduced a focimeter, an instrument in which light was passed through a lens in such a way that dioptric values could be read directly off a scale. The illumination source, the measuring device and the microscope through which the practitioner viewed the lens were still static at this stage. In 1915 Busch introduced a classic and long-lasting design based on the astronomical telescope and a test target. The light was mirrored onto the device from outside. Later models incorporated their own lamps but before the 1920s the level of illumination achieved was poor.

APPLICATION

Focimeters are used to check patients' existing spectacles, to check and verify new spectacles, to check lens powers in the laboratory, and to enable the marking and setting of uncut lenses before glazing. They are also used to check the spherical lens power, the cylindrical power, verify the reading addition, and the amount of prismatic correction and in which direction (up, down, in or out). The focimeter can be used to mark the actual optical centres of the lenses, the required optical centre of the lens if prism is required and to find the axis direction the cylindrical power lies along.

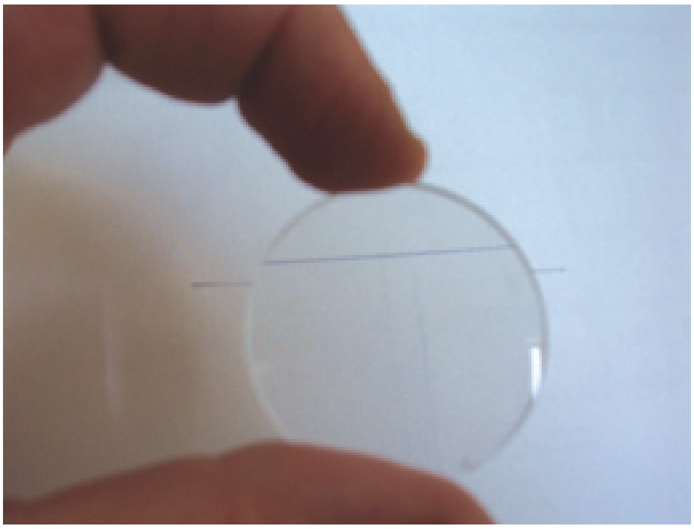

Figure 1 Moving a convex lens shows 'against' movement

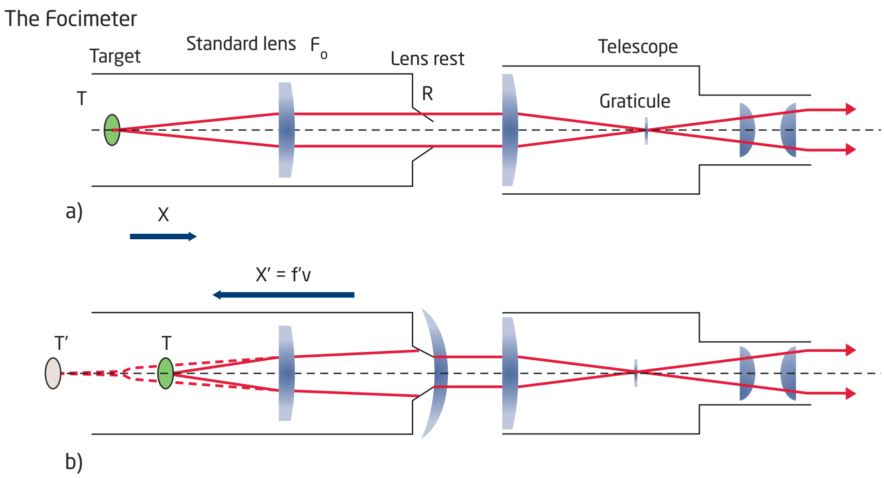

Figure 2 Optics of a focimeter

HAND NEUTRALISATION

There are several ways available to determine the power of a lens, one of these ways is by hand neutralisation.

If you look at an object through a lens and move the lens, the object will appear to move. If the lens is convex (positive) the object will appear to move in the opposite direction to the movement of the lens, or in an 'against' movement (Figure 1). If you look at an object through a concave (negative) lens the movement appears to be in the same direction, or a 'with' movement. If a pair of lenses of equal, but opposite powers are put together there will be no movement of the object, making it possible to determine the unknown power of the lens. This type

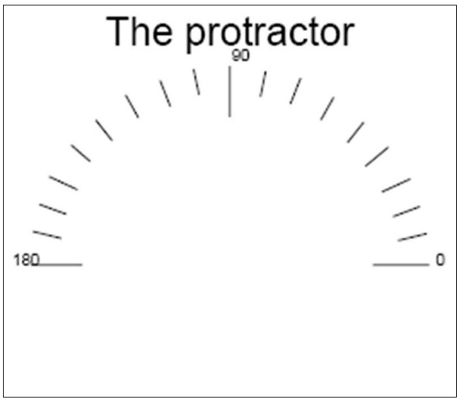

Figure 3

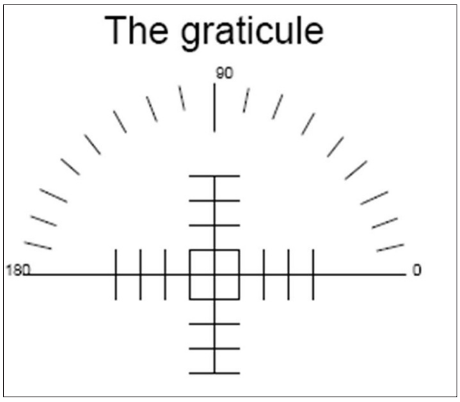

Figure 4

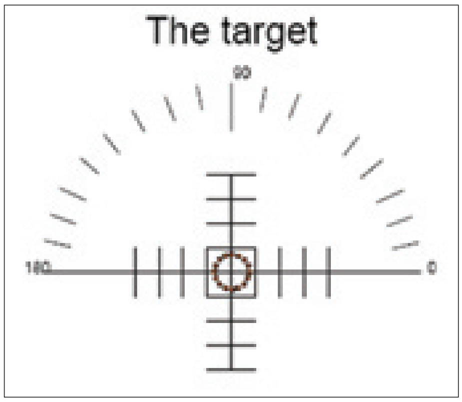

Figure 5

of neutralisation is time-consuming and prone to subjective error, which is why focimeters are used in practice.

TYPES OF FOCIMETER

Focimeters vary according to the type of target viewed through the instrument;

- Fixed ring target: an array of dots which will distort linearly according to the power of lens viewed
- Rotating line target: this will be viewed as a line when rotated to match the cylinder axis
- Projection focimeter: this uses a screen upon which a usually electronically-generated image is presented
- Lensmeter: an automated device which interprets light spread to arrive at the refractive power of the lens being assessed.

THE OPTICS OF FOCIMETERS

The optical system of a simple focimeter (Figure 2a) comprises of a collimating lens (F_0) which sends parallel light from a target and a telescope focusing it. A lens rest is positioned at the second principle focal point of the collimating lens. Within the telescope, a graticule for prism and axis scales is positioned at the point within the tube where the light crosses over, the common focal point of the eyepiece and objective lenses.

Figure 2b shows the situation when a test lens is placed on the rest, in this case a positive power lens. For the target to be seen clearly in the telescope, it must be moved and the amount must be linearly proportional to the vertex power of the test lens. The target movement is denoted as x. The image of the target now is at x' from the lens rest. This represents the back vertex power of the test lens;

$$x' = -f'_v$$

where $-f'_v$ = back vertex power of the lens, the test lens usually being held with its back surface over the rest.

Newton's relationship states that $xx' = -f'^2$, so therefore $xf'_v = -f_0^2$ and so the back vertex power of the lens, F'_v is given by:

$$F'_v = xF_0^2$$

THE EYEPIECE FOCIMETRE

Within the focimeter target there are four basic items which can be seen through the eyepiece of a manual focimeter. The protractor (Figure 3) shows the axis direction of a cylinder and the base direction of a prism. This is used in conjunction with the graticules (Figure 4).

The graticules rotate through 180 degrees so that the cylinder axis can be measured. Each line measures 1 prism dioptre so that the prism in prism dioptres can be measured generally up to 5 prism dioptres. The target (Figure 5) can sit in any position within the area. The type shown is the fixed ring target. The scale (Figure 6) allows the power to be measured. When there is no lens in place the power measurement should read zero. The scale can be on the left or the right side of the target.

Before a practitioner can use a focimeter it has to be set to their eyes. This is done by turning the eyepiece anti-clockwise, until the graticules go out of focus. The power wheel is then turned anti-clockwise until the target goes out of focus. The scale will read mostly positive. Using the most dominant eye (both eyes open) the eyepiece is turned clockwise so that the graticules first come into focus, and following this, the power wheel is turned clockwise until the target comes into sharp focus. The scale should now read zero.

FIXED-RING TARGET

A spherical lens with this type of focimeter will, when placed on the rest, just blur the dots uniformly. By adjusting the power dial, the lens will bring the dots back into sharp focus, whereupon the power can be read and noted (Figure 7).

If there is a cylindrical power, the dots are blurred into lines which can be brought into 2 foci. The most positive (or least negative) is the spherical power and the difference between the two powers is the negative cylinder power. The axis is the orientation of the point spread for the more negative power reading. This will record the lens in minus cyl form.

Figures 8a and b show the view for the lens of power +5:50 x 60 and +3:00 x 150. The first power is the more positive power and is therefore chosen as the sphere power. The difference between the two powers is +5.50 – 3:00 = 2:50. The axis is taken from the second less positive power. In this case it is 150. Therefore the sphere-cyl power is +5.50 /-2.50 x 150.

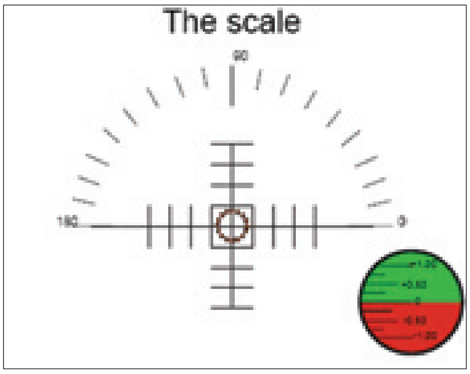

Figure 6

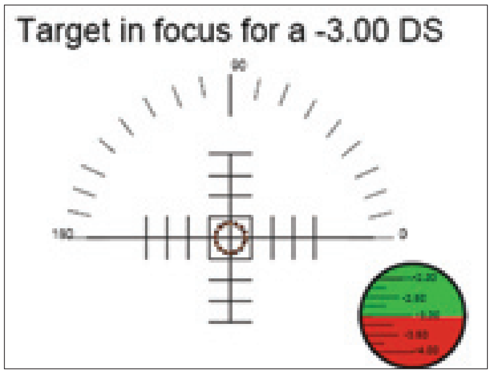

Figure 7

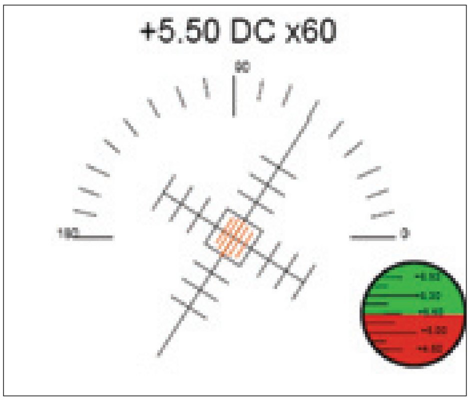

Figure 8a

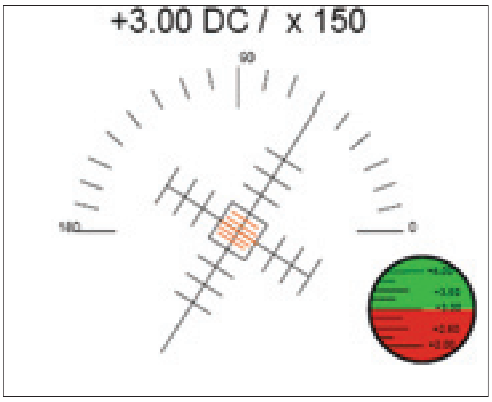

Figure 8b

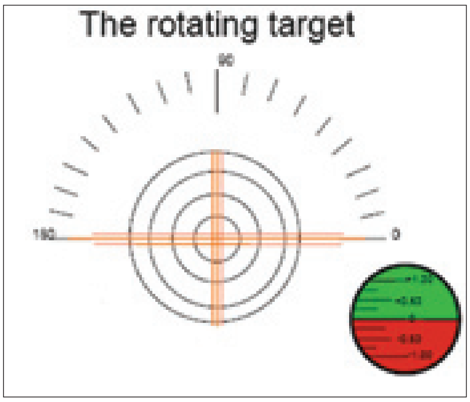

Figure 9

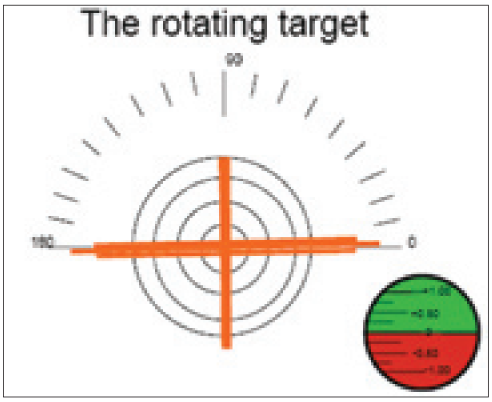

Figure 10

ROTATING LINE TARGET

This has two crossed lines (Figure 9), instead of the circle of dots, which can be rotated through 180 degrees so the cylinder axis can be determined. Again a spherical lens will simply blur the target and can be corrected easily (Figure 10). Place the lens on the lens table and adjust the dioptre scale until it shows a well focused target (spherical lens) or until one meridian is clearly in focus (astigmatic lens) and note the power and axis. The cylinder wheel must be adjusted so the lines are aligned and precisely focused. Refocus to obtain the second set of lines at 90 degrees to the first axis and note the power and axis again. To calculate the sphere cyl power in negative cyl form, select the more positive/less negative power as your sphere. Calculate the difference between the main powers (take the sphere power from the other) and, remembering the power signs, this is the cylinder power. The axis is the one found with the second power not the one selected as the sphere.

Example 1
+ 2:00 x 90 and + 4:00 x 180

The second power is the more positive and is therefore chosen as the sphere power.

The difference between the powers is + 2:00 – (+4:00) = -2:00

The axis is taken from the second, less positive power in this example it is 90

Therefore the sphere/cyl power is +4:00/ – 2:00 x – 90

Example 2
+2.50 x 75 and -3.50 x 165

The first power is the more positive power and is chosen as the sphere power. The difference between the powers is -3:50 – (+2:50) = -6:00.

The axis is taken from the second, less positive power in this example 165

Therefore the sphere/cyl power is +2.50 / -6:00 x 165.

MEASURING PRISM POWER AND BASE

Place a dot in the lens at the optical centre position – this is the point at which the prism power is to be measured – appropriate to the patient's monocular pupillary distance. Place the lens on the lens table with the centre dot in the centre of the rest. Bring the target into focus. As there is prism in the lens, the target will be displaced. The target will be displaced

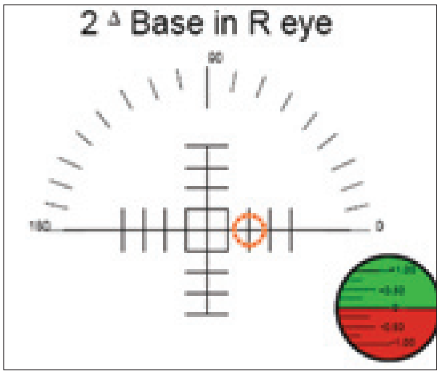

Figure 11

in the direction of the base of the prism. Therefore it will be displaced up (towards 90) for prism base up, displaced down (towards 270) for prism base down. It will be displaced right for base-in prism for the right eye or base out for the left eye. It will be displaced left for base-out prism in the right eye; in for left eye.

Rotate the axis ring until the meridian cross-line cuts through the centre of the target.

The amount of the prism power in the lens is indicated by the displacement of the target centre with reference to the lines on the graticules (Figure 11). The position of the prism base can be read from the graticules at 1 degree intervals. If the target is displaced below the horizontal line, add 180 degree to the reading.

NEAR VISION VERGENCE

If needed, it is possible to measure the vergence of light from a test lens when it is used for near vision. For example, by placing a -3.00D auxiliary lens over the test lens, the vergence measured would be the same as that if the lens were to be used to view an object at 33.3cm. ●

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MULTIPLE-CHOICE QUESTIONS

1 When a convex lens is moved upwards over a drawn line, what appears to happen to the line?

A Moves upwards
B Stays static
C Moves downward
D Distorts

2 What two spherical lenses would be used to hand neutralise a test lens +3.25/-1.25?

A +3.25D and -1.25D
B -3.25D and +1.25D
C -3.25D and -1.25D
D -3.25D and -2.00D

3 A fixed ring target focimeter focuses the ring at -1.75D and then perpendicularly at -2.75D, the latter orientated at 65 degrees. What might be noted as the power of the test lens?

A -1.75/-1.00 x 65
B -1.75/-2.75 x 65
C -1.75/-1.00 x 155
D +1.75/-1.00 x 65

4 A fixed ring target focimeter focuses the ring at +1.75D and then perpendicularly at -2.75D, the latter orientated at 65 degrees. What might be noted as the power of the test lens?

A -1.75/-4.50 x 65
B +1.75/-2.75 x 65
C +1.75/-1.00 x 155
D +1.75/-4.50 x 65

5 How can accommodation error be avoided in focimetry?

A With no test lens in position, check the reading is zero
B With no test lens in position, defocus the eyepiece and then move back rotating inwards until the graticule is first seen clearly. This should be at a zero reading
C The focimeter target is at infinity so no accommodation can be induced
D Ensure the user is fully corrected for near if presbyopic

6 What auxiliary lens will allow measurement of vergence as if viewing a target at 40cm?

A +2.50D
B -2.50D
C +4.50D
D -3.00D

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