A CROSS-ARMED REVERSIBLE SCREEN STEREOSCOPE*†

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This instrument is an improved model of one described many years ago (Hudson, 1918), which was itself a modification of an earlier instrument (Hudson, 1911). It is intended primarily for the investigation and treatment of squint, but is also suitable for the exercise of convergence or divergence when these are deficient, and for the detection of malingering. It may also be used for viewing untransposed and transposed stereoscopic photographs.

Construction

The instrument consists of two cross-bars, each 25 cm. long, with at the distal end a picture carrier 46 mm. wide and at the proximal end an eyepiece comprising a plane prism of 6·5° deviation value rotatable through 180°, and a cell to hold a supplementary lens. Each cross-bar has a central slot in which the pillar supporting the screen can be moved backwards or forwards by means of a rack and pinion, so producing the necessary degree of separation of the pictures for central binocular vision in a wide range of vergence of the

*Received for publication April 18, 1955
†Made by C. W. Dixey and Son, Ltd., 19, Wigmore Street, London, W.1.

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Visual axes. The screen can be tilted 90° on a coronal axis so as to form either a right and left lateral obturator, between which the right eye views the left picture and the left eye the right picture (Fig. 1), or a central obturator, on each side of which each eye sees the homolateral picture (Fig. 2).

The movable screen between the pictures can be used to reduce the illumination of one or other of them.

Two screws control the interval between the proximal ends of the cross-bars on which the eyepieces are centred: it is essential that this should be identical with the inter-pupillary distance of the eyes when, provided with any necessary correction of refractive error, they are focussed for a distance of 25 cm. (or, when supplementary +4 D sph. lenses are in use, for infinity).

Excess convergence can be measured with the lateral obturators by means of the following equations:

\[
\begin{align*}
(a) \quad & \text{with prisms } < < , \quad S_Q = S_C - A - P \\
(b) \quad & \text{with prisms } < > \text{ or } \not\triangle , \quad S_Q = S_C - A \\
(c) \quad & \text{with prisms } > > , \quad S_Q = S_C - A + P
\end{align*}
\]

\(S_Q\) = abnormal convergence

\(S_C\) = angle between cross-bars with central binocular vision

\(A\) = angle of total accommodation convergence

\(P\) = angle of total prisms deviation (13°).

\(A\) varies with the length of the inter-ocular distance (i.e. the distance between the centres of rotation of the eyes) approximately as follows:

<table>
<thead>
<tr>
<th>Inter-ocular distance (mm.)</th>
<th>(A(°))</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>11</td>
</tr>
<tr>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td>55</td>
<td>13</td>
</tr>
<tr>
<td>60</td>
<td>14</td>
</tr>
<tr>
<td>65</td>
<td>15</td>
</tr>
</tbody>
</table>

When the deviation is greater than 15°, the factor \(A\), with its element of uncertainty
due to physiological idiosyncrasy, can be eliminated from the equations by the use of a +4 D sph. lens centred for infinity before each eye directed to infinity, and the equations then become:

\[
\begin{align*}
(a) & \text{ with prisms } \uparrow \uparrow \text{ and no lenses } \quad SQ = SC - P - A \\
(a') & \text{ with prisms } \uparrow \uparrow \text{ and } +4 \text{ D sph. lenses } \quad SQ = SC - P \\
(b) & \text{ with prisms } \triangle \triangle \text{ and } +4 \text{ D sph. lenses } \quad SQ = SC \\
(b') & \text{ with prisms } \uparrow \downarrow \text{ and } +4 \text{ D sph. lenses } \quad SQ = SC + P
\end{align*}
\]

In orthophoria the central obturator should be used, except for the detection of malingering or for the viewing of untransposed stereoscopic photographic prints and transparencies: for these the central aperture is required.

With central obturator, homonymous prisms, and accessory +4 D sph. lenses in orthophoria, there is central binocular vision with parallel visual axes when the distance between the centres of the pictures is equal to the inter-ocular distance; if the scale reading in this position be \( Z^0 \), the absence of squint will be indicated by the following equation:

\[
(d) \text{ with prisms } \uparrow \downarrow \text{ and } +4 \text{ D sph. lenses, } SQ = SC - Z, \quad SC \text{ and } Z \text{ being identical } \quad SC - Z = 0
\]

For viewing stereograms the centres of which are farther apart than the inter-ocular distance, prisms must be base out. From the following equation:

\[
(e) \text{ with prisms } \uparrow \downarrow \text{ and } +4 \text{ D sph. lenses, } SQ = SC - Z - P,
\]

it is clear that, for central binocular vision with visual axes parallel, it is required that \( SC = Z + P \).

Both 45- and 75-mm. stereograms, if supported on the screen at 12.5 cm. distance from the eyepieces, may be viewed under considerable magnification through +8 D sph. accessory lenses.

Divergence can be measured approximately with central obturator by means of the following equations:

\[
(e) \text{ with prisms } \uparrow \downarrow \text{ and } +4 \text{ D sph. lenses, } SQ = SC - Z - P
\]

Fig. 3. — Unbroken lines = cross-bars and obturator.
Broken lines = direction of gaze. With homonymous prisms and accommodation in abeyance, divergence is measured approximately by excess of \( SC \) over \( Z \) (scale reading when distance between \( A \) and \( B \) equals inter-ocular distance). \( Z \approx \) approximately 2.4.
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(d) with prisms $\triangle \triangle$ and +4 D sph. lenses, $SQ = SC - Z$

(f) with prisms $\vartriangle \vartriangle$ and +4 D sph. lenses, $SQ = SC - Z + P$

(g) with prisms $\vartriangle \vartriangle$ and no lenses, $SQ = SC - Z + P + A$

These measurements are approximate because the centre of rotation of each picture carrier is not identical with the centre of rotation of the viewing eye: but with inter-ocular distance 65 mm. and divergence up to 70° the overestimation is not more than 2° (Fig. 3).

All the above equations, valid when retinal correspondence is normal, require modification when there is eccentric fixation.

Measurement of Abnormal Vergence (see Table)

With Obturators Lateral (for Convergence)

SUBTRACT the value of accommodation convergence $(A)$, and of prisms BASE-IN from the scale reading (mnemonic CABIN: in convergence, accommodation convergence and prisms base-in are negative).

With Obturator Central (for Divergence)

ADD the value of accommodation convergence $(A)$ and of prisms BASE-IN to the scale reading, after this has been reduced by the amount of the reading (approximately 2A) when the distance between the centres of the picture carriers is equal to the inter-ocular distance.

TABLE

<table>
<thead>
<tr>
<th>Position of Screen</th>
<th>Estimation of Deviation</th>
<th>Arrangement of Prisms and Lenses</th>
<th>Inter-pupillary Distance</th>
<th>Refraction Requirement</th>
<th>Degree of Abnormal Vergence</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0° to 25°</td>
<td>$\triangle \vartriangle$</td>
<td>For focus at 25 cm.</td>
<td>Correction for infinity</td>
<td>$SC - 13*A - A$</td>
<td>(a)</td>
</tr>
<tr>
<td>Medium</td>
<td>15° to 35°</td>
<td>$\vartriangle \vartriangle$</td>
<td>For infinity</td>
<td>+4 D sph. added to correction for infinity</td>
<td>$SC - 13$</td>
<td>(a')</td>
</tr>
<tr>
<td>High</td>
<td>30° to 50°</td>
<td>$\triangle \triangle$</td>
<td>For infinity</td>
<td>+4 D sph. added to correction for infinity</td>
<td>$SC$</td>
<td>(b')</td>
</tr>
<tr>
<td>Very high</td>
<td>45° to 70°</td>
<td>$\vartriangle \vartriangle$</td>
<td>For infinity</td>
<td>+4 D sph. added to correction for infinity</td>
<td>$SC + 13$</td>
<td>(c')</td>
</tr>
<tr>
<td>Very low</td>
<td>−12° to 13°</td>
<td>$\vartriangle \vartriangle$</td>
<td>For infinity</td>
<td>+4 D sph. added to correction for infinity</td>
<td>$SC - Z - 13$</td>
<td>(e)</td>
</tr>
<tr>
<td>Low</td>
<td>0° to 40°</td>
<td>$\triangle \triangle$</td>
<td>For infinity</td>
<td>+4 D sph. added to correction for infinity</td>
<td>$SC - Z$</td>
<td>(d)</td>
</tr>
<tr>
<td>Medium</td>
<td>15° to 40°</td>
<td>$\vartriangle \vartriangle$</td>
<td>For infinity</td>
<td>+4 D sph. added to correction for infinity</td>
<td>$SC - Z + 13$</td>
<td>(f)</td>
</tr>
<tr>
<td>High</td>
<td>30° to 56°</td>
<td>$\vartriangle \vartriangle$</td>
<td>For focus at 25 cm.</td>
<td>Correction for infinity</td>
<td>$SC - Z + 13 + A$</td>
<td>(g)</td>
</tr>
</tbody>
</table>

* Total deviation value of prisms = 13°.  + This arrangement covers 12° convergence to 13° divergence.
Diagnosis

(1) In Concomitant Convergent squint.—After ascertaining whether retinal correspondence is normal or anomalous, and assessing the degree of eccentric fixation, if such exists, test for:

(i) Simultaneous binocular perception (bimacular or anomalous, or macular suppression, using lateral obturators and diagrams of red spot and green ring, ascertaining whether the patient is able to move the spot into the centre of the ring. The use of the terminal screen between the diagrams to produce contrast in their relative illumination may be of assistance in this test.

(ii) Amplitude of fusion (measurable by means of the scale), using diagrams of black spot with red and green square (above and below).

(iii) Stereopsis.

During the above and all other tests and exercises hyperphoria should be neutralized by rotation of the appropriate prism.

(2) In Concomitant Divergent Squint.—With obturator central, proceed as in convergent squint.

(3) In Suspected Malingering.—With obturators lateral and prisms base-in, use letter (e.g. POT, PET), multiple dot, etc., diagrams.

Treatment

(1) In Squint

(i) Visual exercises designed to elicit or improve simultaneous binocular vision, fusion, and stereopsis, in which use of the terminal screen to produce predominance in illumination of the target facing the squinting eye plays an important part.

(ii) A combination of the above with kinetic exercises, as a curative procedure in certain cases, or as a preliminary to operation.

(2) In Exophoria.—With lateral obturators and prisms base-in, and easily fused diagrams, the function of convergence can be exercised by moving the carriers apart from primary apposition.

(3) In Esophoria.—With central obturator and prisms base-out, the function of divergence can be exercised by separation of the carriers.

REFERENCES
