With best wishes H Asher

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A variable prism unit for range finders

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A variable prism unit* is described in which the effective angle of the prism is varied by a linear movement of one of the parts. The application of this unit to range finders is discussed, and it is shown that when fitted to a camera, the linear movement of the moveable part of the range finder may be made equal to the movement of the camera lens required for focusing.

If a convex and a concave lens of focal lengths $+f$ and $-f$ cm are placed together so that their optic axes are parallel, and displaced from each other by a distance x cm, then it may be shown that rays will pass through the system without any change of vergence and will be deviated away from the axis of the concave lens by an angle of x/f radians. By arranging for the displacement to be variable, we have in effect a variable prism unit.

The figure shows a range finder incorporating such a unit. Let x be the amount of relative displacement of the lenses for a given range setting, b be the length of the base of the

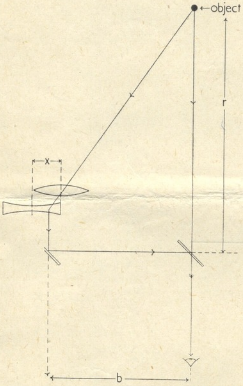

Diagram of the variable prism unit incorporated in a range finder

range finder, r be the range to be measured, f be the focal length of the lenses of the variable prism unit. The angle through which the variable prism unit will deflect a ray from the object will be x/f radians, and from the figure

$$x/f = b/r \text{ or } x = bf/r \qquad (1)$$

In a naval type of range finder the following values may be used: $b = 5$ m, $f = 10$ m, $r = 25$ km.

Thus $$x = \frac{5 \times 10 \text{ m}}{25\,000} = 2 \text{ mm}$$

showing that a 2 mm movement from the infinity setting would be required to measure a range of 25 km. The minimum range that can be measured depends on the radius of the variable prism unit lenses. The maximum relative displacement of the two lenses of the unit will be equal to twice the radius, less the amount of overlap required. Let this maximum displacement be denoted by $2R$. The maximum angle of deflexion will now be given by $2R/f$ radians, so that the minimum range will be given by

$$2R/f = b/r, \text{ or } r = bf/2R \qquad (2)$$

If we take $R = 10$ cm, $b = 5$ m, $f = 10$ m,

$$r = \frac{5 \times 10}{2 \times 0{\cdot}1} = 250 \text{ m}$$

which is the minimum range measurable. In a range finder the rays will always be required to be deflected in the same direction, so that only one-half of each lens need be used, and the lenses may conveniently take the form of rectangular portions containing a radius.

For a range finder for cameras, the minimum range required will be 1 m, a convenient value for R might be 15 mm, b would be of the order of 10 cm.

From equation (2) $f = 2Rr/b$

or $$f = \frac{2 \times 1{\cdot}5 \times 100}{10} = 30 \text{ cm}$$

To find the movement x from the infinity position to the setting for say 10 m, equation (1) is used and

$$x = \frac{10 \times 30}{1\,000} = 3 \text{ mm}$$

while for a range of 1 m the movement will be $2R$ or 3 cm.

There is a curious feature of the variable prism unit applied to camera range finders, namely that it is possible to arrange that the distance moved by one lens of the unit shall be equal to the movement of the camera lens required for focusing.

Let o be the distance of the object from the anterior focal point of the camera lens, and i be the distance of the image from the posterior focal point of the camera lens. Let the focal length of the camera lens be made equal numerically to the focal length of the lenses of the variable prism unit, and let both be denoted by f. From Newton's formula we have

$$oi = f^2 \text{ or } i = f^2/o \qquad (3)$$

Let the range finder be placed at the anterior focal point of the camera lens; then the angle subtended by the range finder base at the object o will be b/o radians,

then $$x/f = b/o \text{ or } x = bf/o \qquad (4)$$

Now in moving from the infinity setting to the focus

* Application for a patent has been made.

appropriate to the object, the movement of the camera lens is i, so that for the variable prism unit lens and camera lens to move the same amount:

$$x = i \qquad (5)$$

from equations (3), (4) and (5), $bf/o = f^2/o$ or $b = f$.

The conditions that the movement of the camera lens and the unit lens shall be the same are therefore:

(1) For a camera lens of focal length $+f$ cm, the variable prism unit lenses will have focal lengths of $+f$ and $-f$ cm.

(2) The base of the range finder should be f cm.

(3) The variable prism unit should be situated at the anterior focal point of the camera lens.

This last condition is unfortunate and prevents the straightforward application of the device to cameras. It is likely, however, that some system based on the above principle could be devised, whereby the variable prism unit is effectively at the anterior focal point. Telephoto lenses are a possibility.

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Design for an auto-focus range finder

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In a previous communication* it was shown that a camera range finder may be designed so that the movement of one of the lenses of a sliding lens compensator may be made equal to the movement of the camera lens required for focusing. The practical application was prevented by the condition that the range finder should be situated at the anterior focal point of the camera lens. Here a modified design is described which overcomes this difficulty.

The following is a description of an improved version of the range finder previously described by the author.*

Fig. 1 shows a diagram of the optical system.

r = the perpendicular distance from the object to the plane aa'. This plane is drawn perpendicular to the direct ray, and passes through the image of the sliding lens compensator in the left-hand mirror.

b = length of the base of the range finder.

$+f'$ and $-f'$ = the focal lengths of the two lenses of the sliding lens compensator.

f = focal length of camera lens.

o = distance of object from the anterior focal point of the camera lens.

i = distance of the image behind the posterior focal point of the camera lens.

x = displacement between the optic axes of the two compensator lenses.

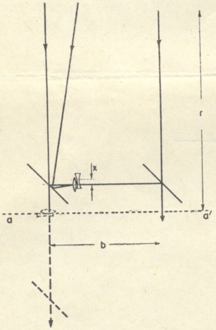

Fig. 1. The optical system of the range finder. The lenses drawn in broken lines represent the image of the compensator formed in the left-hand mirror. The plane aa' is drawn through this image perpendicular to the direct ray from the object

The concave lens of the sliding lens compensator, the camera lens, and the right-hand mirror are rigidly connected, and move together as one piece. The mirrors and the compensator are mounted on the back of the camera in a position such that the plane aa' coincides with the posterior focal plane of the camera lens. The compensator is set by the observer to bring the two images of the object into coincidence in the usual way. When this is effected the deviation of a ray passing through the compensator will be equal to $\tan^{-1}b/r$.

It may be shown that the deviation due to the compensator is $\tan^{-1}x/f'$, thus:

$$\frac{b}{r} = \frac{x}{f'} \quad (1)$$

Now in moving the camera lens from the infinity setting to that required for the object, the movement of the camera lens is i. Since the compensator and camera lenses are coupled:

$$i = x \quad (2)$$

by Newton's formula:

$$oi = f^2 \quad (3)$$

also:

$$r = o + 2f \quad (4)$$

This assumes that the movement of the camera lens is sufficiently small to be ignored in comparison to the range of the object. Consider the case when

$$2f = f' \quad (5)$$

Then from equations (1), (2), (3), (4) and (5):

$$b = \tfrac{1}{2}f + i \quad (6)$$

Equation (6) shows that for auto-focusing action, the base of the range finder is not a constant. It must have the value $\frac{1}{2}f$ when the camera lens is set for infinity, and when the camera lens is moved a distance i, then the base must increase in length by this amount. Now because the right-hand mirror is inclined at 45° to the direction of the ray from the compensator, and because it moves forward a distance i, it will be seen that the point of incidence of the ray on it is displaced to the right through a distance i, so increasing the base of the range finder by this amount. Thus the condition of equation (6) is maintained, and automatic focusing results.

The following alternative design allows the use of a larger base. Consider the case when

$$f = f' \quad (7)$$

Then from equations (1), (2), (3), (4) and (7):

$$b = f + 2i$$

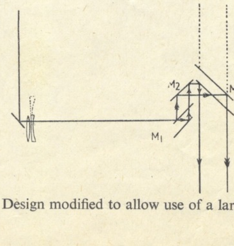

Fig. 2. Design modified to allow use of a larger base

* Asher, H. *J. Sci. Instrum.*, **29**, p. 402 (1952).

This shows that the base must have the value f when the camera lens is set for infinity, and for any other setting it must increase by twice the movement of the camera lens. Fig. 2 shows how this may be effected. Mirrors M_1 and M_3 move with the camera lens, while M_2 is fixed. The point of incidence of the ray on M_3 is displaced through a distance of $2i$, the base is then increased by this amount, and auto-focusing action is ensured.

As with other range finders, owing to the small differences in the path length of the two rays, the two images in the eye will be of slightly different size, so that the relations derived apply strictly only in the centre of the field.

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With compliments

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A New Method of Stereoscopic Viewing*

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ABSTRACT. **A new kind of Stereoscopic Viewer is described which produces the illusion that the object viewed is actually in the room.**

IN the ordinary stereoscopic viewer although the spatial relations between the various objects in the picture are vividly portrayed, there is very little sense of the position of the picture as a whole relative to the observer or to the room in which he sits. The picture seems to occupy a rather ill-defined position somewhere inside the instrument.

When stereoscopic projection onto a screen is used then the objects portrayed are seen in a vivid relationship to the screen and to the room. The modified type of stereo viewer to be described here produces a similar illusion without the necessity for projection. The construction of the instrument is shown in Fig. 1. Light from a pair of illuminated stereo lantern slides passes upwards through a pair of lens-prism combinations arranged as in a normal stereoscope. A half silvered mirror inclined at 45° to the vertical reflects the rays horizontally into the eyes of the observer. Each slide will form a virtual image on the side of the mirror remote from the observer, at a distance from him which depends upon the distance of the slide from the lens. To set up the instrument correctly the observer first uses one eye only, and moves the slides towards the lens until there is no parallax between the image and any chosen object placed at about 5 feet from the instrument. He then moves the two slides towards or away from each other, until alternate closure of the eyes reveals no jump of a selected part of the picture relative to the chosen object. If both eyes are now used, the illusion is that the objects portrayed in the picture are situated in accurately defined positions in the room. The reason for this is as follows.

*MS received 20 March 1953.

When an object in a room is viewed in the normal manner, each eye sees the object in a different relationship to its surroundings, so there is a disparity between the images in the two eyes. The two images combine in the brain to form a single mental picture, and the disparity between them gives a three dimensional effect with accurate sense of distance. In the instrument described here each eye sees the image in a different relationship to the surrounding objects in the room, and the disparity between the two retinal images gives rise to a vivid sense of the position of the image in the room, just as in the case when a real object is viewed.

The setting of the position of the slides is not at all critical. If they are separated more than the correct amount, as shown in Fig. 2 then since each eye sees only one image, the direction of the visual axes will be subconsciously altered until combination of the images again occurs and a single mental picture will again be perceived. It will be clear from the figure that each separate image will be seen against a different part of the background of the room, and thus the retinal images will be just the same as would be formed were a real object to be placed at the intersection of the two visual axes, and consequently the object depicted in the slides does in fact appear to be placed in this position. However, a setting of this kind gives an abnormal relationship between the functions of accommodation and convergence, and if the deviation from the correct position is excessive, trouble in focusing the images accurately will be experienced.

The best effects are obtained if dark cloth or paper is placed behind the images, while other objects are placed in the vicinity of the apparent position of the objects portrayed. The optimal light intensity can only be found by trial and error. The effect is particularly vivid with colour transparencies.

Naturally only one person at a time can use the instrument. Anybody capable of using a normal stereoscope may expect to be able to perceive the effect described. The illusion of position in the room is very vivid for distances of 1-6 feet from the observer, but as the distance is increased the strength of the illusion diminishes, so that it is not usually possible to make the image appear to recede through the wall, though this can be done if the instrument is placed close up to it.

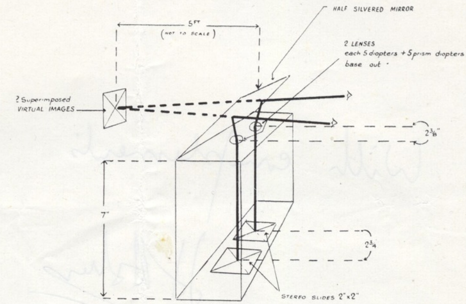

Fig. 1. The general arrangement of the stereoscope.

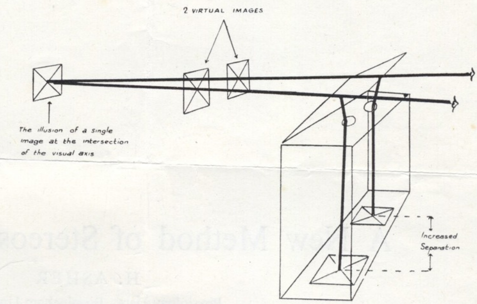

Fig. 2. To illustrate how separation of the slides makes the image appear to recede.

A normal adult head 10 inches long placed 5 feet from the observer creates a very much larger mental picture than does a head portrait 1 inch long placed 6 inches away, although the size of the image in the eye is the same in each case. This is due to a powerful psychological process which effects control over apparent size. The same effect operates when using this stereoscope, and owing to the illusion of distance away from the observer the pictures appear greatly enlarged. For portraiture the safest plan is to make the viewing conditions reproduce the taking conditions precisely. Thus the subject may be placed 5 feet from the camera and the separation of the camera lenses should be made equal to the normal distance between the eyes ($2\frac{3}{8}$ inch). When the picture is viewed, the images should be adjusted to be superimposed at 5 feet, as already described. The illusion will then be of a life-sized three dimensional picture. It is advisable to black out all background in the slides, and the figure is then seen against the background of the viewing room. The dimensions of an optical system suitable for slides of 2 inches $\times$ 2 inches are given in Fig. 1. The lens prism combinations are each of 5 dioptres + 5 prism diopters base out, and they could be obtained from any optician. A mirror with a tenacious semi-reflecting chromium surface was obtained from the United Kingdom Optical Co., 154 Clerkenwell Road, London, E.C.1.

For the design of the optical system of stereoscopes see H. Asher and F. W. Law, *Brit. J. Ophthal.*, **36**, 225-239, 1952.