Sci. Appl. Photo., 1997, Vol. 39 (3), pp. 243-246
Reprints available directly from the publisher
Photocopying permitted by license only

PRINCIPLES OF IMAGE FORMATION IN GROOVE STEREOGRAPHY

D. A. Artamonov

Moscow State Technological University STANKIN, Vadkovskii per. 3a, Moscow, 101472 Russia

(Received November 14, 1996)

A more detailed qualitative and quantitative description (in terms of geometrical optics) is given to the effect of groove stereography reported earlier as a new method for obtaining 3D images.

A novel method for obtaining 3D images that displace upon change in the viewer's position was termed [1] groove stereography. In terms of this method, each point of the object is put in correspondence with a groove circumference drawn on a metallic or transparent base, so that its surface reflects incident readout light. Such a circumference can be readily applied with a well ground pair of dividers. Just as in holography, sharp image can be obtained only upon illumination with low-convergence beams. The principle of 3D image formation was qualitatively described in [1]. In this paper, a quantitative description is given to the above effect along with a specified qualitative description.

First of all, let us explain why the recovered image can be localized both before and behind the stereogram. When incident rays fall onto the outer (with respect to the center), concave side of the groove circumference, the latter behaves as a concave mirror with the focus in point O_2 (Fig. 1) which is the image of a point recorded on stereogram. Now let us consider the situation shown in Fig. 2. Here incident rays are reflected by an inner, convex side of the groove circumference, thus giving an imaginary image of a point. Applying the laws of geometrical optics, we can find the position of this point in the image space (Fig. 3). Let the height (depth) of this point above the stereogram plane be H. Its value was found to depend on the circumference radius R and angle α (see Fig. 3). The focal length is given by:

$$f = R/2, \tag{1}$$

where R is the radius of mirror curvature. Then

$$O_1O_2 = f \sin \alpha = H. \tag{2}$$

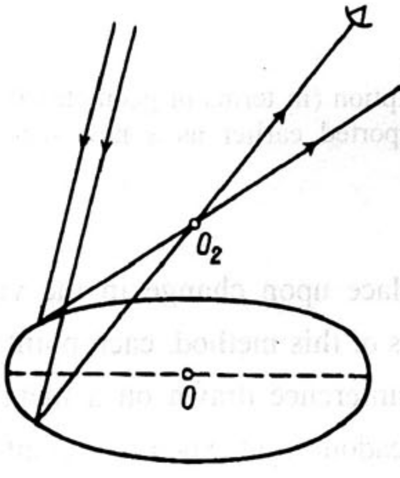

Fig. 1.

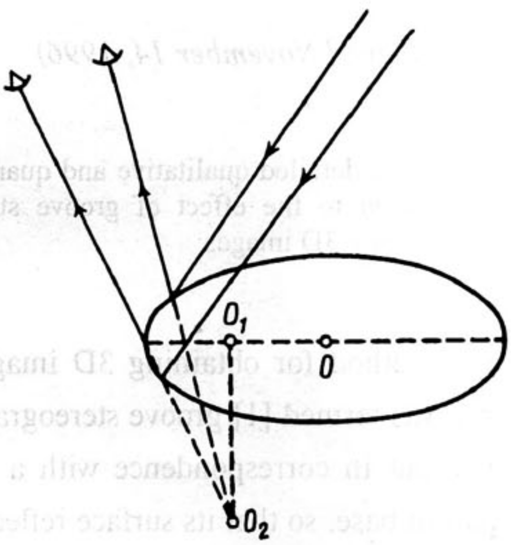

Fig. 2.

Fig. 1. Real image of a point formed upon reflection of two rays from the outer, concave side of the groove.

Fig. 2. Imaginary image of a point formed upon reflection of two rays from the inner, convex side of the groove.

Therefore, a stereogram formed by circumferences of identical radius can be used to recover a planar image whose localization is given by (2). A 3D image can be recovered from circumferences of different radii. Note that the groove has a configuration of half torus, so that inclined incident rays restore a variety of point images on the surface which also is a portion of torus (see Fig. 4). The viewer's eye filtrates these point images by selecting only one of them that is visible from a given position, thus creating the illusion of image motion alongside the circumference. Changing the angle of vision β by Δβ, we begin to observe point *1'* instead of *1*. As is seen in Fig. 4, points *1* and *1'* belong to the same circumference. Therefore, variation of β within the stereogram plane makes the image to move along the circumference. Upon variation of angle α in the vertical direction, the point image moves from one circumference to another in accordance with (2). This corresponds to a change in the height (depth) of localization in the image space.

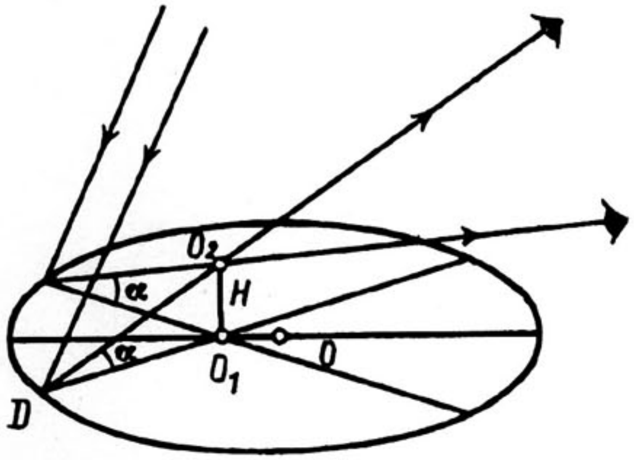

Fig. 3. Determination of height *H* in the image space.

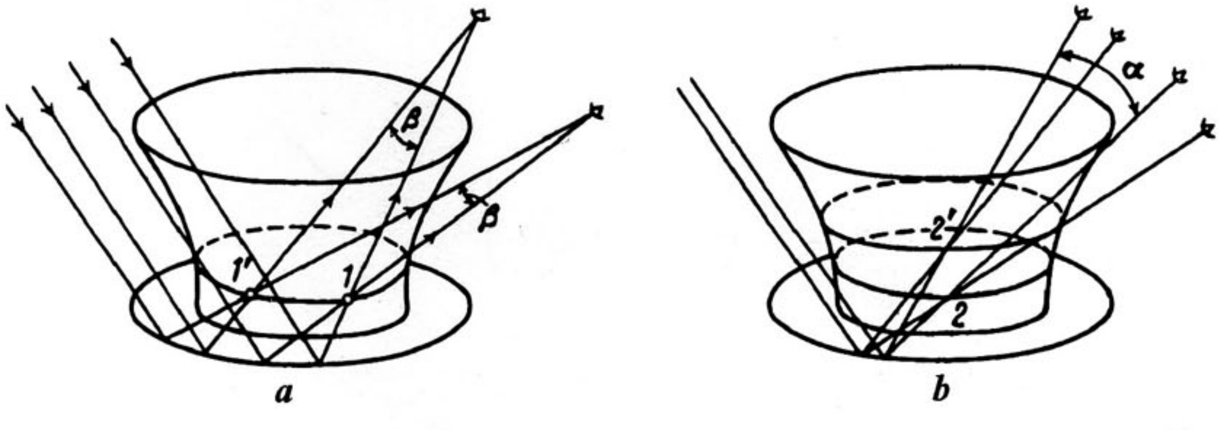

Fig. 4. Explanation of the image displacement upon a change in the viewer's position: (*a*) variation in β and (*b*) variation in α.

So far we considered the case when the groove circumference behaved as a convex or concave mirror. But when the stereogram is made on a transparent substrate and, accordingly, viewed in transmission, the groove circumference will behave as a positive or negative lens. In this case, all of the above considerations remain to hold true with the only difference that the groove circumference behaves not as a mirror but as a positive (negative) lens.

Note in conclusion that the groove stereography is a novel method for obtaining images, including 3D ones. For this reason, its potentialities have been studied inadequately and deserve further profound studies.

REFERENCES

1. Vlasov, N.G. and Koleichuk, V.F., *Optich. Tekh.*, 1995, no. 3(7), p. 14.

Translated by Yu. Scheck