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LOCAL REFERENCE BEAM HOLOGRAPHY

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The method of local reference beam holography and a modification of it was applied for obtaining holograms of objects several meters away from the photographic plate.

Since Stroke and collaborators published their paper [1] on holography in which the reference beam is not a uniform plane or spherical wave, many new studies have appeared which develop this conception [2, 3, 4]. The work of Caulfield and others [5, 6] should also be included into this category. They acquired a uniform reference beam by splitting the image beam into two parts and filtering the spatial frequencies from one of them. This method of obtaining holograms is known as local reference beam holography.

This paper describes the application of the method of Caulfield and his associates for obtaining holograms of objects some distance away (or the order of several meters) from the photographic plate on which the hologram is recorded. Also, a modification of the method described in papers [5, 6] is presented.

Let us consider an arrangement for obtaining holograms as shown in Fig. 1a. If diaphragm P is removed, the distribution of the intensity of the light falling on the photographic plate is given by the formula:

$$I = |A(x, y, d)+A(x, y, D)e^{i\frac{2\pi\theta}{\lambda}}|^2$$

where $A(x, y, d)$ is the complex amplitude of the light wave in the plane of the photographic plate for the wave propagating along path *1*, $A(x, y, D)$ is the same quantity for the wave propagating along path *2*, and θ is the angle between beams *1* and *2*.

For the sake of simplicity, let us assume that the acquired amplitudal transmission of the obtained hologram is proportional to the intensity of the impinging light (*e. g.*, [7]). After illuminating the hologram with light of amplitude A_0 (Fig. 1b), we get the following amplitude distribution in the diffracted beams:

$$kA_0A(x, y, d)A^*(x, y, D)e^{-i\frac{2\pi\theta}{\lambda}}$$

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and

$$kA_0A^*(x, y, d)A(x, y, D)e^{i\frac{2\pi\theta}{\lambda}},$$

where k is a proportionality constant.

The spots at which images of the object arise are pointed out in Fig. 1b by the arrows, the distance from the hologram also being specified. As stems from the formulae and

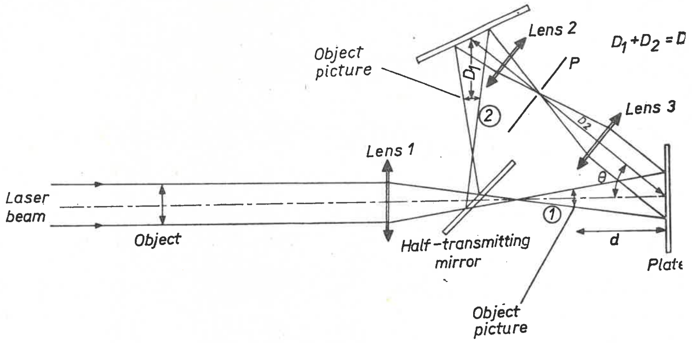

Fig. 1a. Diagram of holography with generation of a local reference beam

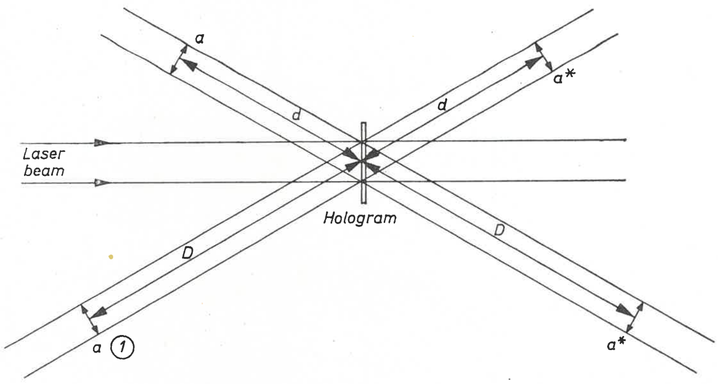

Fig. 1b. Arrangement of images of an object whose amplitudal transmission is described by function a, obtained from a hologram recorded by the method presented in Fig. 1a with the diaphragm P removed

Fig. 1b, real images are visible against the perturbing background due to apparent images. A hologram produced in this manner is depicted in Fig. 2a.

The perturbing background can be eliminated by the method given in the above-mentioned paper by Caulfield and associates [5]. In the focal plane of lens 2, (Fig. 1a), where the amplitude distribution of the light is a Fourier transform of the amplitude distribution of the light in the plane of the object, we place a diaphragm in the form of a circle of appropriately small diameter. In this way, all spatial frequencies except those very near zero frequency are removed from the Fourier spectrum. The spherical wave thus

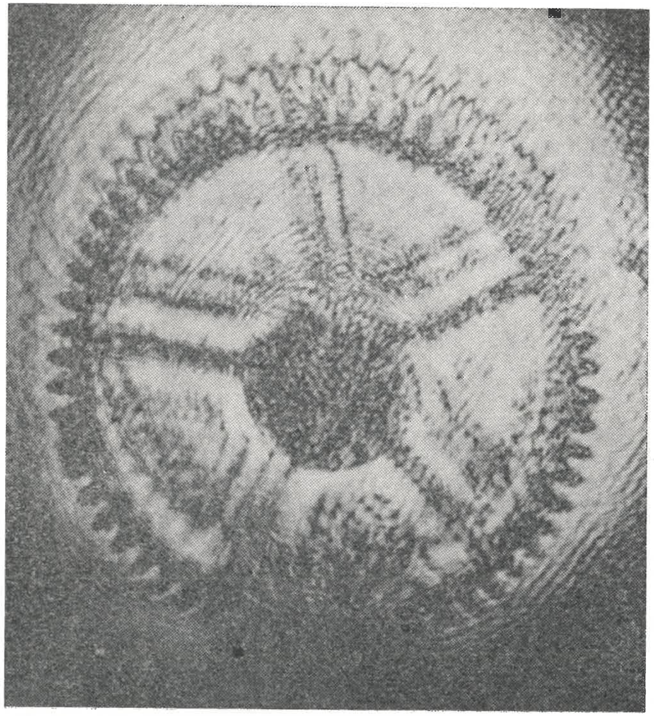

Fig. 2a

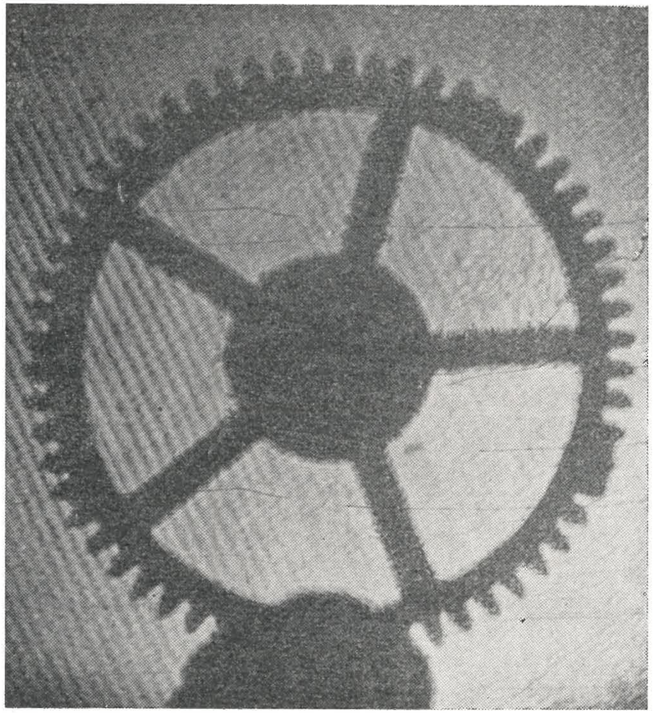

Fig. 2b

Fig. 2a. Image of gear wheel obtained from hologram recorded by the method depicted in Fig. 1a, with the diaphragm *P* removed. Object-to-hologram distance was 5 m

Fig. 2b. Image obtained from hologram recorded by the method depicted in Fig. 1a. Diaphragm *P* filtered out spatial frequencies. Object-to-hologram distance was 5 m obtained is then transformed by means of the lens *3* into a plane wave. The proximity of the wave to a plane depends on the size of the diaphragm used. This fact affects the resolution of the obtained holograms [6]. A hologram of an object 5 m away from the photographic plate produced according to the method just described is presented in Fig. 2b.

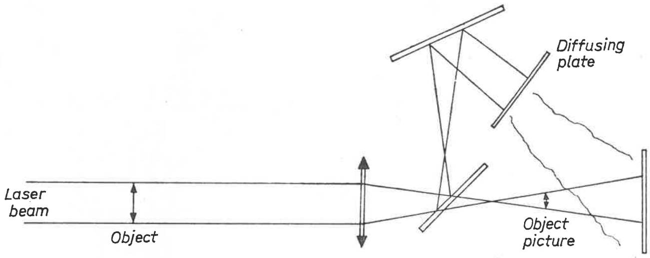

Fig. 3. Diagram of layout for making holograms in which a ground glass is placed in the local reference beam

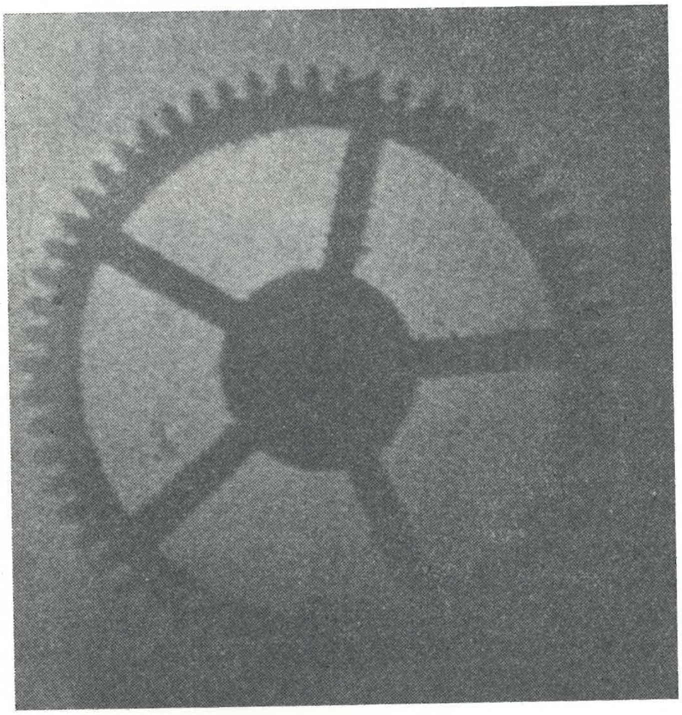

Fig. 4. Image obtained from hologram recorded by method depicted in Fig. 3

The perturbing background may also be decreased considerably by utilizing the scattering properties of a ground glass plate. A diagram of the experimental layout for demonstrating this is shown in Fig. 3. The hologram obtained thus was reproduced in the arrangement shown in Fig. 1b. The real image of the object, represented by the function *a*, is observed against the background of light scattered by the ground glass, the sharp picture of which becomes formed at position *1* (Fig. 1b). The amplitude of the light scattered by the ground glass observed at a large enough distance from it is almost constant, only weakly depending on the amplitude distribution of the light on the ground glass. This is why the non-uniformness of the perturbing background is not seen in the hologram presented in Fig. 4, which was produced with the arrangement shown in Fig. 3.

Finally, it should be pointed out that the holographic methods presented here, generally known as local reference beam holography, are capable of producing holograms of spatial objects.

In conclusion, it must be said that the application of local reference beam holography for obtaining holograms of objects several meters away from the photographic plate indicates that its application for producing holograms of more distant objects should give good results.

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