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Cylindrical Holography and Some Proposed Applications

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HOLOGRAMS of the Leith type[1,2] have been made which can be viewed through angles of 180°[3] and 360°.[4] In both cases, a spherical mirror is used to provide a reference beam. We now report a simpler system[5] for constructing cylindrical holograms without the mirror.

Figure 1 depicts the simplest system conceivable for making flat holograms. A figure of revolution with respect to the beam axis, as shown in Fig. 2, results in a geometry suitable for making cylindrical holograms.

In practice, we use a strip of 35 mm Kodak 649-F film, supported by adhesive tape inside a glass cylinder of 80-mm diam, with the emulsion side facing inwards. The object to be recorded is placed at the center of this cylinder. The laser beam is incident on the object from the top of the system, after having been diverged by a 97X microscope objective and filtered by a pinhole. The central portion of the beam illuminates the object, while the remainder falls directly onto the film, thus providing a reference beam.

For viewing the hologram thus obtained, the developed film is placed back into the original configuration, with the object removed. Because this system uses all the light without waste, the exposure time using a 1-mW HeNe laser is less than one minute.

After the initial exposure, but before developing, a different object can be introduced and the film can be exposed again, with light entering the cylinder from the opposite end. The resulting hologram records two unrelated scenes, each of which can be viewed independently of the other, in all perspectives, depending on the direction of the illumination used for reconstruction.

Figure 3 shows various perspectives of one scene. By turning the cylinder upside down, a completely different scene appears, again in all perspectives, as shown in Fig. 4. Notice that the bottoms of each scene are also illuminated. This is accomplished by placing the objects on supports with white diffusing surfaces, such as plaster or unvarnished porcelain.

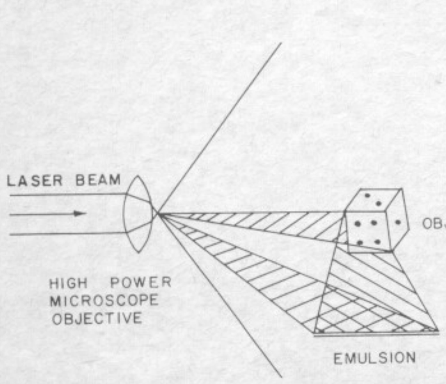

FIG. 1. Simplest configuration for making a Leith-type hologram.

Other than the simplicity, this system has distinct advantages over systems using mirrors. Since light emitted from a laser is usually plane polarized, and since the reflectance of a mirror depends on the relative orientation of the mirror and the direction of polarization for a given angle of incidence, the mirror used in our previous apparatus[4] does not reflect uniformly around the film loop. Our present geometry, not having a mirror, avoids this difficulty. Also, absence of a mirror avoids "noise" on the hologram caused by dirt and defects on the mirror.

Because our cylinder is open ended, the object can be a projectile shot through the cylinder while its image is recorded on film with a pulse of light from a Q-switched laser.

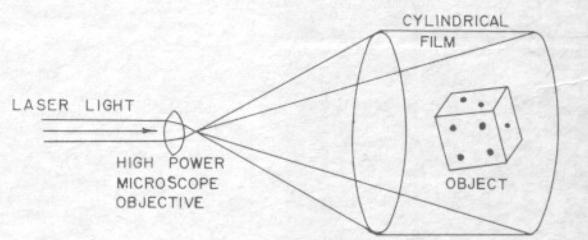

FIG. 2. Figure of revolution of Fig. 1. Configuration for making a 360° hologram.

The object size is also more restricted when a mirror is used because it blocks part of the light to be reflected as a reference beam. In the absence of a mirror, the base of the object can be as large as the cylinder itself.

Following are some proposals for extension and applications of this system:

(1) Hemispherical holograms. By using a judicious combination of the system described and that used by Supertzi and Rigler[3] for their 180° hologram, a hemispherical hologram viewable over a solid angle of 2π sr is possible.

(2) 360° holograms of transient events and shock waves. Brooks *et al.*[6,7] have holographically recorded transient events such as a bullet in flight (and its shock wave), jets, etc. Applying their techniques to our present cylindrical system would increase the information content without a substantial increase of technical difficulty. Of special interest is a scene with no cylindrical symmetry that requires both the front and back views to be recorded simultaneously. For example, when a supersonic projectile tumbles through the cylindrical system, each end would have a different velocity and would cause different shock waves. These shock waves, along with their mutual interactions, can be

recorded from all angles inside the cylindrical film and studied at leisure.

(3) The idea of a cylindrical configuration can be applied to other forms of image formation. The "fly's eye" camera, or integral photography, can use a cylindrical sheet of microlenses and form the image in the usual manner. This configuration would result in an image which can be seen from all directions. Furthermore, the scene can be inside or outside of the cylinder, since coherent light is not necessary during construction. Thus, it would be possible to view from inside such a cylinder and see all the scenes that were outside the system when the exposure was made. This idea could be applied both to cylindrical-lens and hemispherical-lens integral photography, except that in the former case there would be no three-dimensional effects in the azimuthal direction.

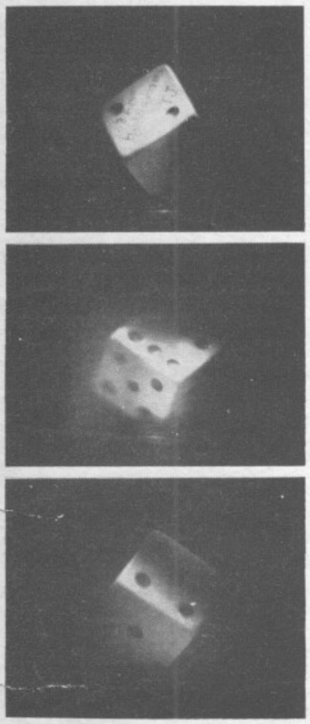

FIG. 3. Reconstructed wavefronts photographed from three different directions on a single cylindrical hologram.

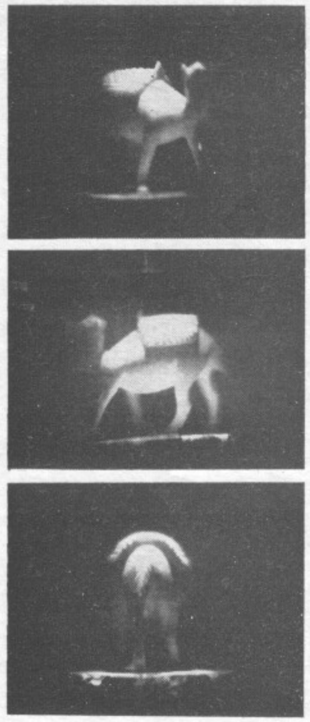

FIG. 4. Reconstructed wavefronts photographed from the same hologram as used for Fig. 3, but with illumination from opposite end of hologram.

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