Laser Physics Lawrence University

## Experiment 1: Producing a Reflection Hologram

**Objective**: To acquaint the student with the optical arrangement, exposure technique, and photographic processes for making a simple reflection hologram.

**Preparation**: Read page 5 of the HeNe Laser Guide appended to these instructions.

**Background**: In 1971, physicist Dennis Gabor received the Nobel prize in recognition of his wide range of holographic experiments and associated theoretical analyses that began in the late 1940's. Gabor named his new type of photographic plate a *hologram* after the Greek word *holos* meaning *whole*. The significance of the "whole" in this context derives from the fact that a holographic plate contains much more information about the light being scattered by an object than does a regular photograph. The additional information concerns the relative *phases* of the light coming from different points on the object. While there are various types of holograms, all share the property that they are created from the interference of two light waves: an unobstructed reference wave and a scattered wave reflected from an object. The spatial interference of these waves is captured photographically in the emulsion on a photographic plate; when this plate is illuminated to create an image of the original object, the image exhibits three dimensional character. In the present case, you will produce a *reflection* hologram meaning that it is intended to be viewed with light reflected from it. Reflection holograms are simple to make, and while their three-dimensionality is not as spectacular as that of other types of holograms, they offer the advantage be being viewable in white light. Other types of holograms essentially require laser light for image reconstruction.

**Procedure**: Figure 1 shows the experimental arrangement that you are to use in this experiment. The object to be photographed is the interior mechanism of a railway pocketwatch. The output beam from a red HeNe laser passes through a spatial filter before illuminating the photographic plate and watch. A spatial filter is an optical instrument consisting of a focussing lens and an extremely small pinhole. Diffraction of the light that passes through this pinhole creates a very

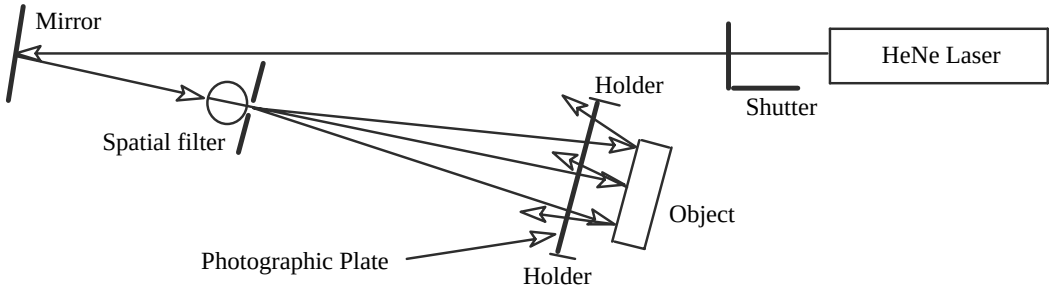


Fig. 1. Topview of experimental layout for producing a reflection hologram.

clean, rapidly divergent, coherent light beam that is convenient for illuminating large objects. In the present case, this divergent beam first serves as an unobstructed reference beam as it passes through the photographic plate. This same beam then proceeds to illuminate the object, thereby producing reflected light that passes back through the plate and creates the requisite interference.

Note that the photographic plate mounts in a special holder. Since the plate should be exposed only to laser light, you need to practice mounting your unexposed plate in the holder under cover of darkness. Once the plate is mounted, the pocketwatch should be pushed into position immediately behind the plate. Then one gently raises the metal screen that serves as a shutter. Count "1001, 1002, 1003, …" to provide state-of-the-art timing of the exposure time; an exposure of about four sec is suitable for this layout. Once the plate has been exposed and the laser beam has once again been blocked, the plate should be removed and totally immersed in photographic developer (Kodak D-19, full strength) for about 60 sec, then in a conventional stopbath of acetic acid for five sec, and finally in the fixing solution (Kodak Rapid Fixer) for two or three minutes. After fixing, the plate should be washed in running water for several minutes. By now the plate has a black appearance, and it needs to be bleached using a rather offensive solution of iodine dissolved in ethanol. Instructors will provide greater detail for each of these steps.

Once the bleaching is complete, the holographic plate requires several minutes of vigorous washing in hot running water until it turns light blue, and finally the plate requires an hour or so to dry. Viewing of the hologram in direct sunlight works well, but almost any bright source should work. Recall that you are looking for an image in the light *reflected* from your hologram.