

Design, Construction and Testing of a
Holographic Measuring Machine

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We have designed and built a device to reconstruct, view and measure holograms to be produced in the Fermilab 15' Hydrogen-Neon bubble chamber.

The measuring machine is built upon a 1.2 m by 3.0 m vibration isolation table (see Figure 1). A full scale real image is produced by illuminating the hologram with an accurate time-reversed reference beam of the wavelength (694.3 nm) used in making the holograms.

The light source will be either a standard dye laser pumped by an Argon ion laser or a cw Ruby laser pumped in the same way. The ruby laser is constructed as shown in Figure 2. The ruby (.03% Cr) is cooled to liquid Nitrogen temperature by thermal conduction through a metallic mount in contact with a liquid reservoir. The Argon laser beam is focussed onto the Ruby through the end mirror of the Ruby laser cavity, which is a dielectric reflector with maximum reflectivity at 694.3 nm (Ruby) but about 60% transmission at 514.5 nm (Argon). We have obtained a quotation for manufacturing a mirror with the same high reflectivity for the Ruby.

A second optical doublet is rigidly mounted to the isolation table directly in front of the hologram which is carried on the rotating stage. This doublet is designed to duplicate the effects, including aberrations, of the bubble chamber fisheye windows on the reconstructed image. In this way a full scale non-aberrated image of a small portion of the bubble chamber is projected along the optical axis. The calculated RMS deviation of many rays from bubble images in several locations in the chamber is 20 μm , substantially smaller than the expected bubble radius of 50 μm .

All optics are designed to permit replay of a region of the hologram 50 mm in diameter (out of a film width of 70 mm, part of which is taken up by sprocket holes.) Considering the resulting illuminated diameter of the final lens (4.4 cm) and allowing for coherent illumination, the calculated radius of the diffraction spot in the midplane of the bubble chamber is 49 μm .

A third direction of motion is produced by translating a corner reflector on a linear digitized stage with a least count of 100 μm . The resulting folded optical path can be varied in length by a total of 2.5 m, just about the maximum depth of the fiducial region in the bubble chamber. The reflected real image is directly focused on the target of a standard vidicon providing a viewing area of 1.4 cm by 1.1 cm and a resolution of about 20 μm .

At the present time a small sample of holograms produced in the 15' bubble chamber have been examined. Using only Argon ion laser light at 514.5 nm and examining the region near the reference beam, where the aberrations due to the wavelength change are small, we have observed tracks of bubbles with an estimated diameter of 200 μm . It appears that the resolution of the optical system is better than this value. Manual rotations of the drive shafts are observed to produce smooth motions on the vidicon screen, leading to the expectation that the motor driven motions will be smooth enough for accurate measurements.

HOLOGRAPHIC MEASURING MACHINE

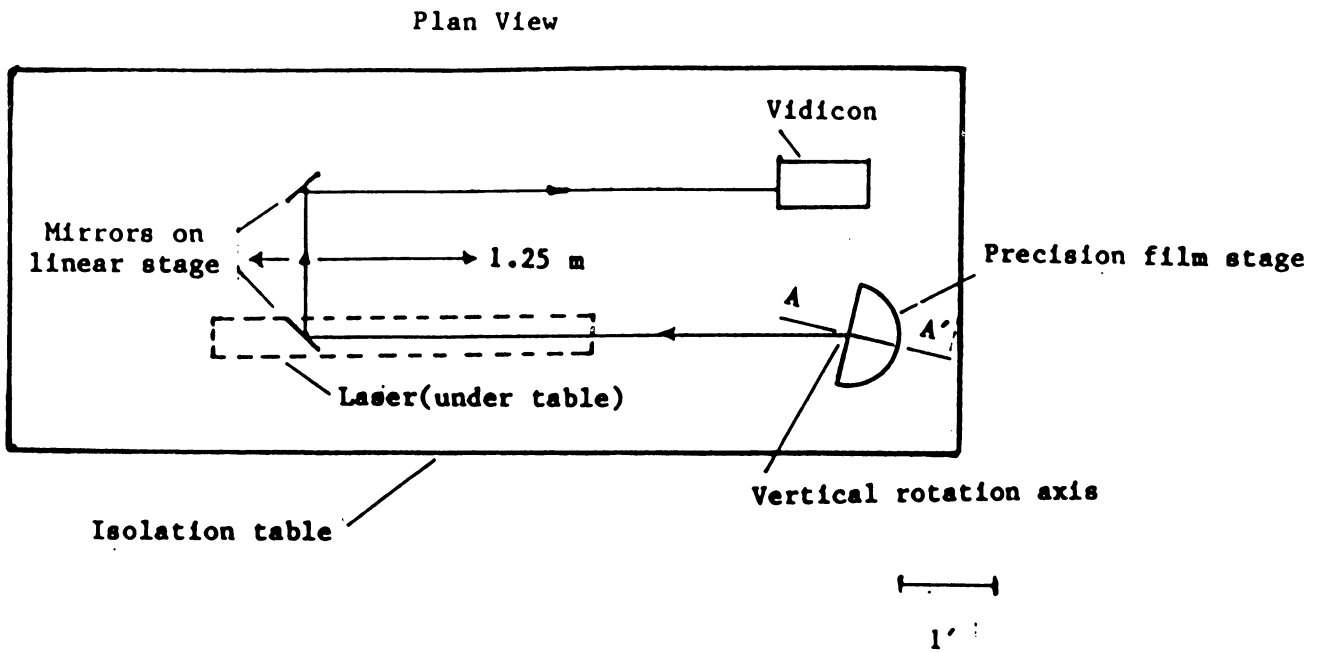


Figure 1

CW RUBY LASER

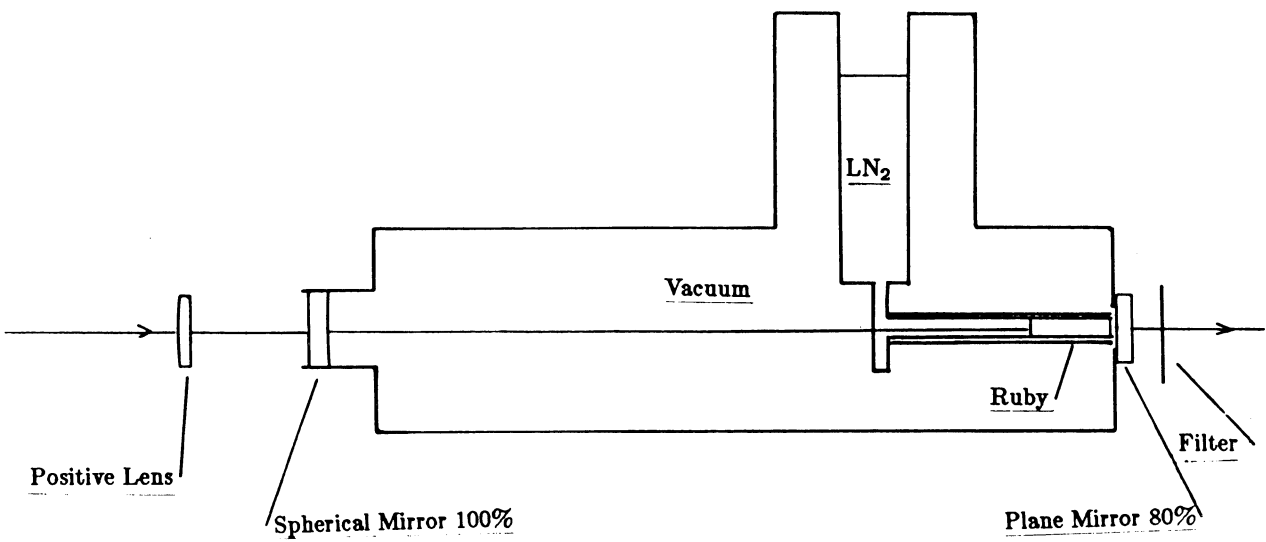


Figure 2

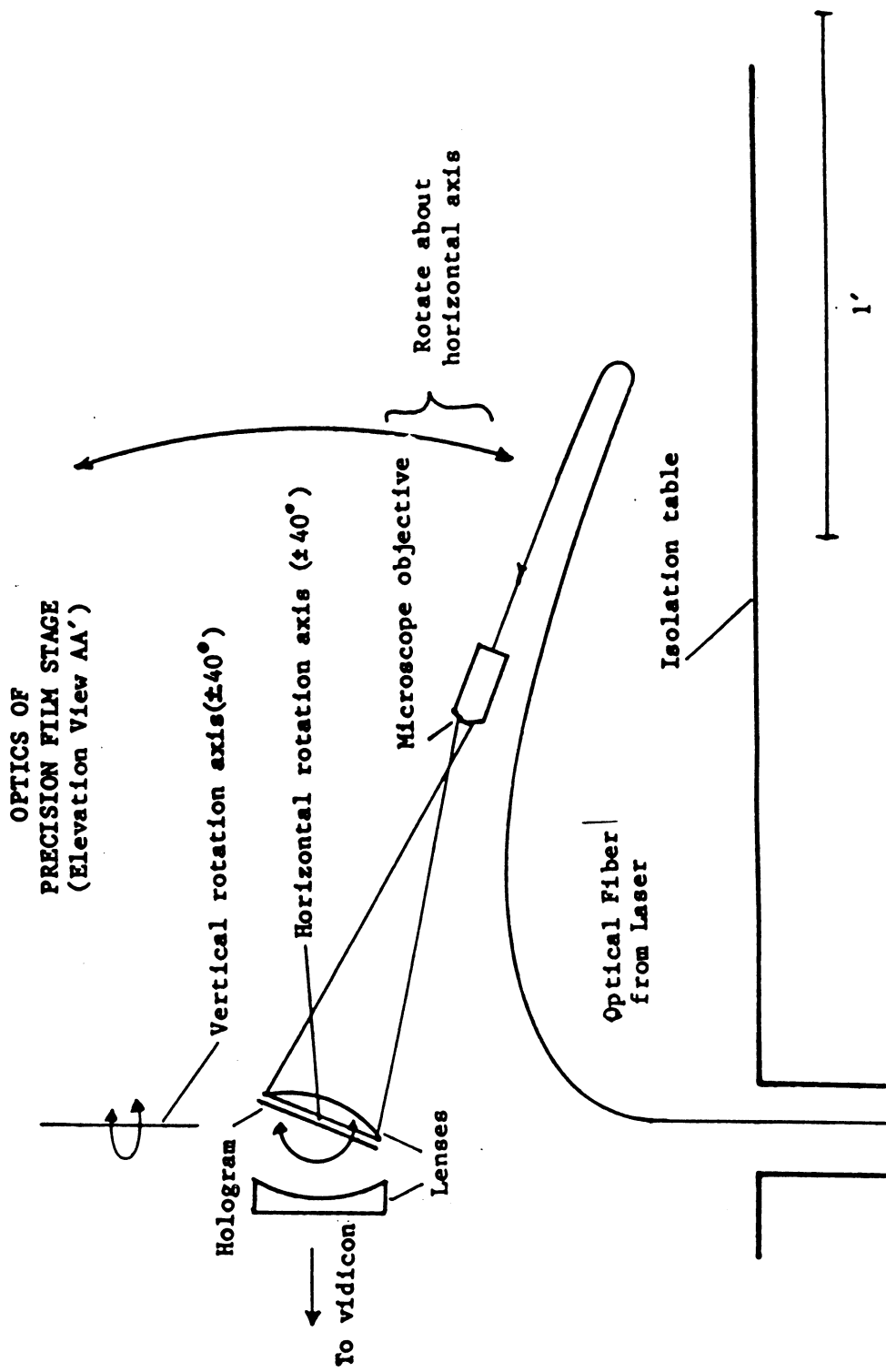


Figure 3