SECRET

[redacted] 25X1

PAR 216

8 Sept 64

SUBJECT: Exposure of Photographic Material with Lasers

TASK/PROBLEM

1. Determine the manner and degree of the interaction of present and predictable future photographic films with coherent radiation from laser sources in red and near IR spectrum ranges.

DISCUSSION

2. During this quarter, two specific areas of laser and photographic film interaction were investigated. The first was a refinement of the study of the effect of 6328A laser illumination on the gamma value of panchromatic film. The second was an investigation of reticle projection using the [redacted] HeNe gas laser. 25X1 25X1

3. Gamma Investigation:

a. In the last quarterly report, we described an apparent difference in the gamma of Type 8401 Plus X Aerecon film with 6328A laser exposure and equivalent filtered tungsten light exposure. This was a surprising result; therefore, a more refined experiment was designed to recheck the results.

b. In the new experiment, one piece of film was exposed with the Model 101 Sensitometer (filtered tungsten light) and a second piece with the divergent laser beam through a calibrated step tablet placed directly in front of the film plane. By developing both pieces of film together and measuring their densities with the 31-A densitometer, their gamma values were compared. The results of these measurements are tabulated on the following page.

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TABLE 1

Exposure Source	8401 Plus X Aerecon Developed in D-19 Series 1	Series 2	Series 3	Series 4	8401 Plus X Aerecon Developed in D-76 Series 5	Series 6	Series 7	Series 8
101 Sensitometer	1.12	1.17	1.06	1.02	.99	1.00	.76	.92
Laser	1.12	1.04	1.10	1.04	.98	1.07	.89	.88

c. Considerable variability in the gamma values obtained for laser exposure was caused by lack of laser beam uniformity. Within the experimental error of this experiment, it was concluded that no difference exists in the gamma obtained with laser exposure versus that obtained with a non-coherent source of the same approximate wavelength.

d. In the various experiments carried out on this project, we can find no evidence that the photographic emulsion (acting as a receiver) reacts any differently to coherent radiation than to non-coherent light about the same wavelength.

e. Discussion of the nature of coherence with [redacted] our consultant optical physicist, and of the probable effect of coherence upon latent image formation with [redacted], has provided theoretical confirmation of that observation. 25X1 25X1 25X1

f. The interference effects observed in photographic exposures to laser (or other coherent radiation) can be explained as interference occurring outside the receiving photographic emulsion.

4. Reticle Projection Investigation:

a. In preparation for studies of the behaviour of photographic materials as the object in optical projection with a laser source, a preliminary reticle projection study was initiated to compare tungsten versus laser sources in an optical projection system.

(1) The laboratory set-up for this study consisted essentially of a single element lens which projected the .005-inch and 0.1 millimeter scales of a [redacted] measuring magnifier onto a 4 x 5 inch sheet of SO-243 film. Exposures were made by positioning the film plane at the geometrical focus of the projection lens and at several positions both ahead of and behind it.

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(2) The initial results of this study are shown in Figures 1 through 9. Figure 1 shows the reticle image at the geometrical focus of the projection lens illuminated with a tungsten lamp. Figure 2 is the same as Figure 1 except that the reticle was illuminated with the laser beam. This second print is comparable in image quality; however, the familiar interference ring patterns are still present. Figure 3 is obtained in the same manner as Figure 2 except that the laser beam was diffused by a ground glass surface. In this print, the image quality is greatly reduced and the ground surface does not appreciably improve the beam uniformity.

(3) Figures 4, 5, and 6 show the reticle image at 3 positions, all beyond the geometrical focus, each illuminated with the tungsten filament source. Figure 4 was exposed with the film plane 3mm beyond the focus; Figure 5, 12mm beyond the focus; and Figure 6, 45mm beyond the focus. This defocussing simply caused a smearing of the image in proportion to the degree of defocussing.

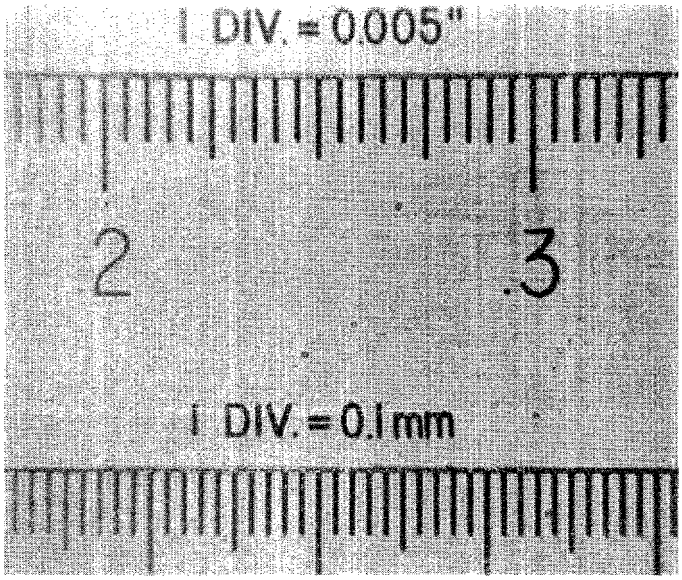

Figure 1. Reticle image at geometrical focus of lens with tungsten illumination.

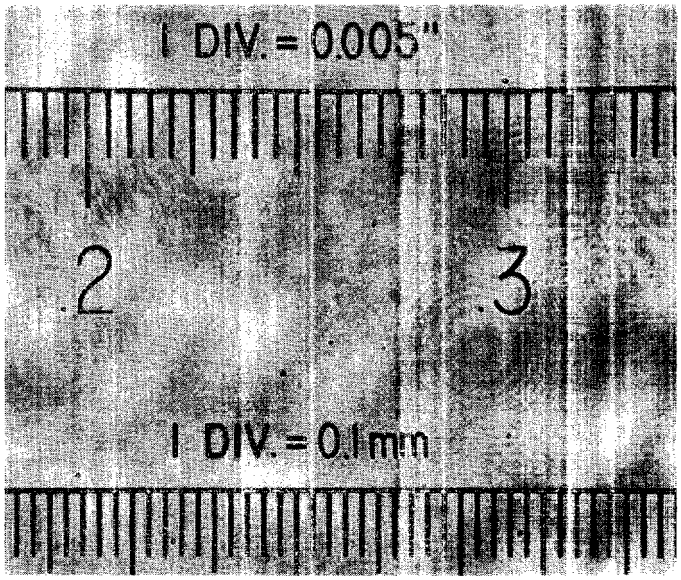

Figure 2. Reticle image at geometrical focus of lens with laser illumination.

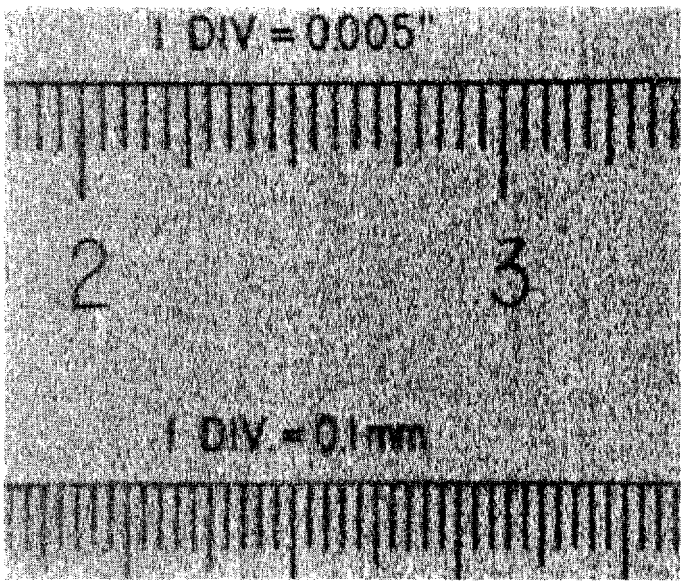

Figure 3. Reticle image at geometrical focus of lens with laser beam diffused by a ground glass surface.

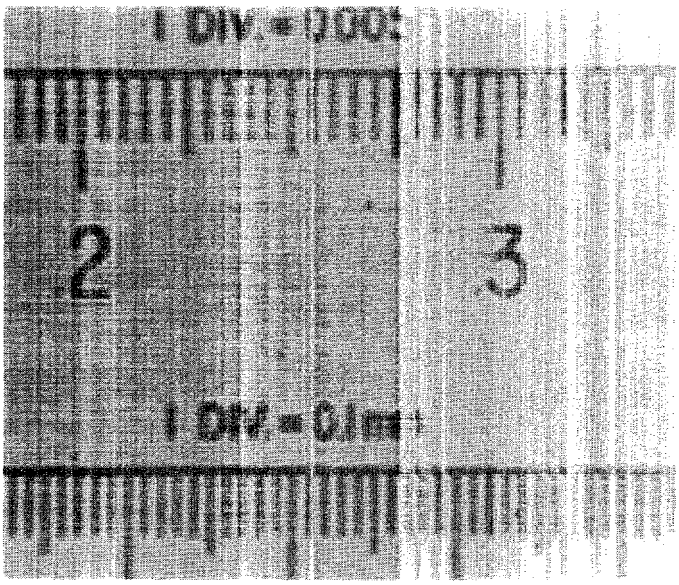

Figure 4. Reticle image with film 3mm beyond geometrical focus with tungsten illumination.

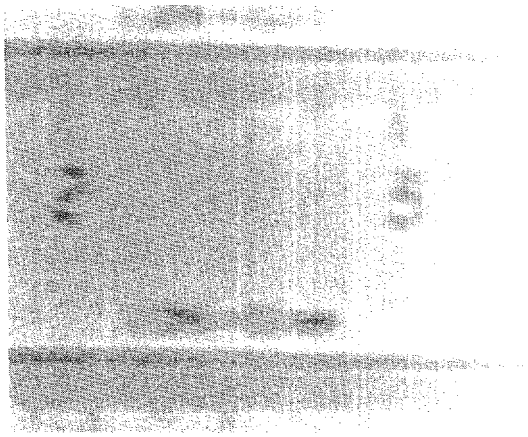

Figure 5. Reticle image with film 12mm beyond geometrical focus with tungsten illumination.

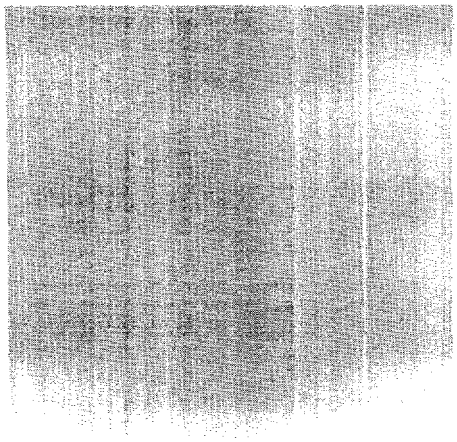

Figure 6. Reticle image with film 45mm beyond geometrical focus with tungsten illumination.

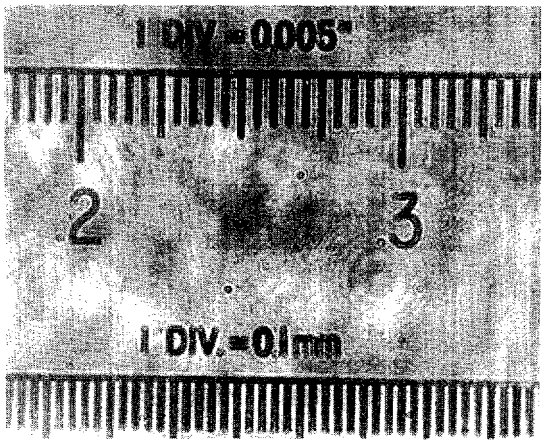

Figure 7. Reticle image with film 3mm beyond geometrical focus with laser illumination.

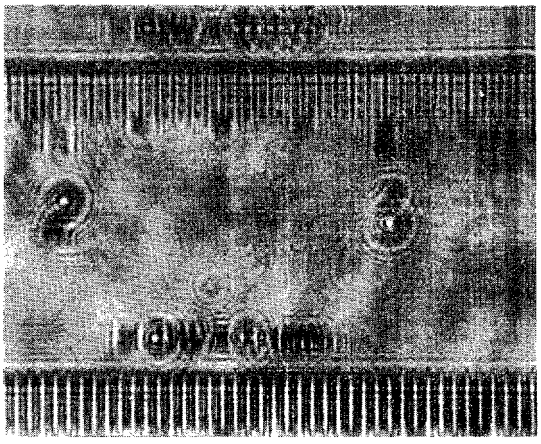

Figure 8. Reticle image with film 12mm beyond geometrical focus with laser illumination.

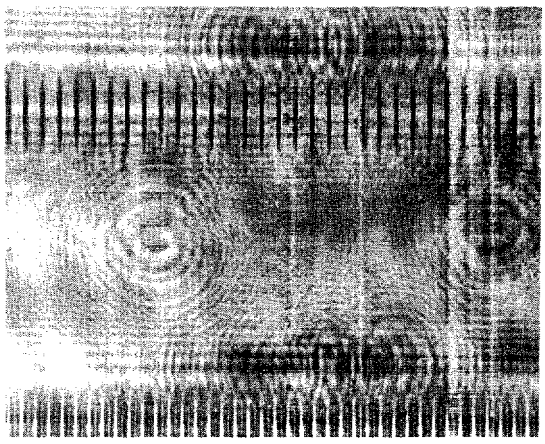

Figure 9. Reticle image with film 45mm beyond geometrical [illegible] illumination.

(4) Figures 7, 8, and 9 show the same projections as 4, 5, and 6 except that each was illuminated with the laser beam. In these three prints, a constructive interference pattern of the regularly spaced lines can easily be observed. Figure 7, for example, shows the diffraction pattern as it begins to form; a pattern that cannot be detected in print 4. Figure 8 begins to show reinforcement in both the line patterns and the numerals as contrasted to the soft blur of Figure 5. Figure 9 clearly shows the regular reinforced line patterns and this is essentially nonexistent in Figure 6.

b. To continue this study, a high quality projection system is required in order to obtain a quantitative evaluation of these interference characteristics. Currently, such a system is being designed and built. This system will be diffraction limited and capable of measuring spatial frequencies in excess of 100 lines per mm. In addition, the system will have provisions for evaluating the effect of aperture size and shape on the modulation transfer function.

PLANNED ACTIVITY

5. The question regarding the behaviour of sensitized materials as a receiver for laser radiation has been answered and this phase of the project should be closed and reported.

6. The consideration of film as the object in a projection system with a coherent source includes a multitude of variables, such as phase shift by the developed image, effect of index matching immersion, spatial filtering effects, etc. This phase of the project should be carefully discussed with the customer to outline a program which will not overlap other activities in progress.

7. The high quality projection system is awaiting delivery of one overdue item to be set up in a dark room ready for use.