Working Notes

To John C.

STAT From

Subj. Holographic and coherent system program plan and schedule.

Date 8 July 1970

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Working Notes

Program Outline for Holographic Filter Generation

Previous notes have described system requirements for generation of holographic filters and their evaluation performance and comparison. The following is a program outline and schedule for continuance of this work.

Program Plan

1. Fabricate matched filter according to described process. Balance reference wave to obtain highest modulation at peak of first side order term. Expose film to peak this term with film's peak modulation response exposure level.

How about balancing for DC?

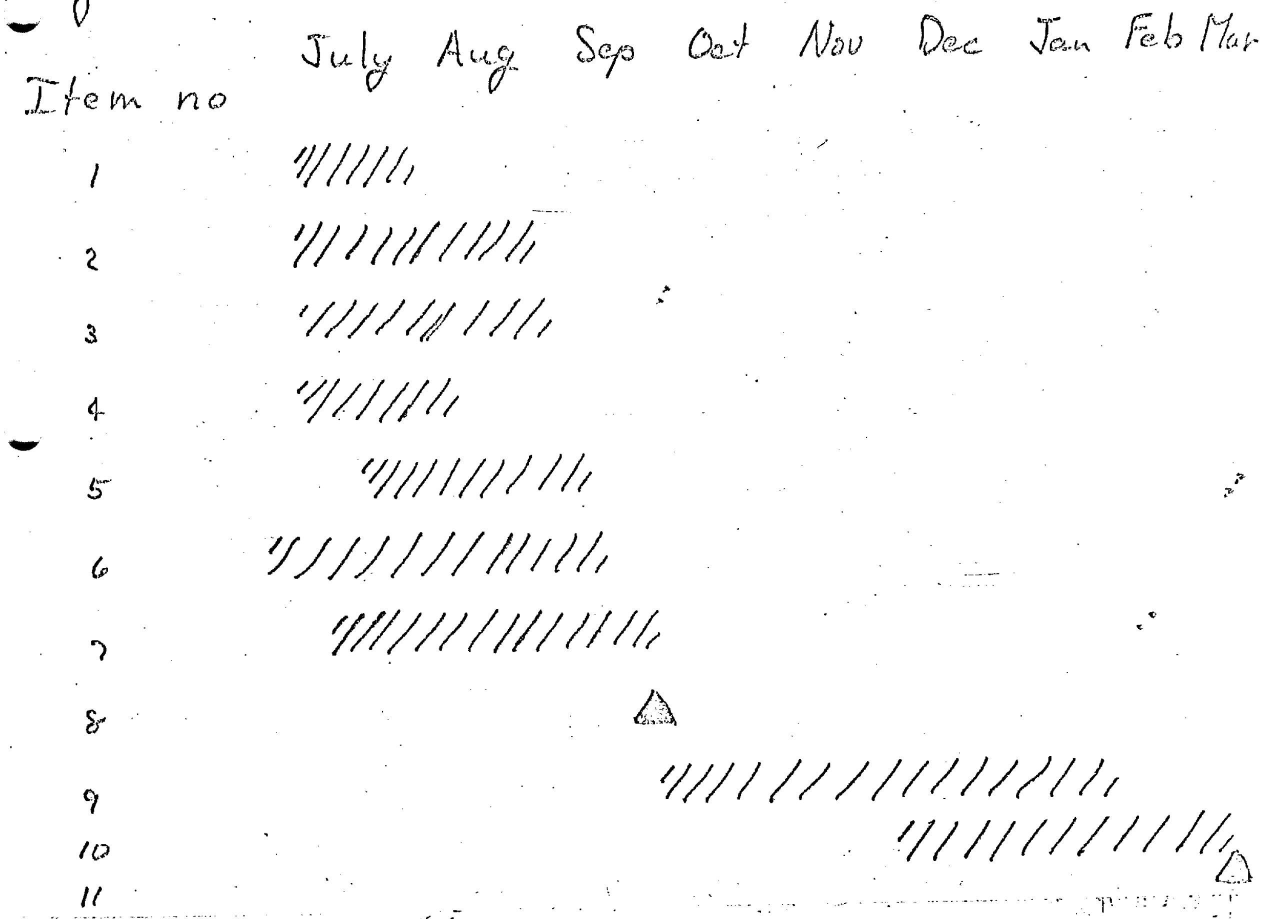
2. Fabricate inverse amplitude component of function on interferometer without reference beam. Gain a series of exposures that can be used in evaluation.
3. Use microd. to determine location of interference fringes with respect to holographic function. This technique will aid determination of optimum exposure and optimum balance between signal beam and reference beam. Evaluate and compare with diffraction efficiency.
4. Apply #1 to matched filtering of blurred imagery. Measure S/N of output by scanning manipulation of slit input. Check a number of filters to ensure that #3 method is valid.

5. Apply #1 and #2 to inverse filtering of blurred imagery. Measure S/N as above, and check out combinations of #1 and #2. Determine parameters for selection at later times.
6. Document results of individual filters and evaluate and compare. Specify best response.
7. Study expected holographic response with extended dynamic range processing to see if XDR has potential for more accurately recording holograms. If affirmative, repeat #1 - #5 using XDR processing and evaluate and compare results.
8. Conclusions from holographic processes.
9. Initiate experiments to compare holographic methods with in-line methods.

10. Determine method that best performs blur removal by comparison of tests.

11. Evaluate posture of coherent image manipulation as compared to processes on Beck optical bench.

Program Schedule



Working Notes

To John C.

STAT From [redacted]

Subj. Program description and plan for the holographic interferometer and coherent processor.

Date 8 July 1970

Working Notes

Summer Program

Working Notes

Holographic Interferometer and
Coherent Processor

The status of this program is such that longer term definition of program direction can be made. This is beneficial especially within the context of the summer months when [redacted] and STAT

STAT [redacted] will be able to continue this work.

Present Status

The holographic interferometer has been set-up and operated for purposes of generating filters for target recognition and image manipulatio The coherent optical processor was set-up and operated for applications in the manipulation of imagery, including the use of the holographic filters for target recognition and blur removal.

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The initial filters generated for these purposes are matched filters, being directly related to the complex conjugate of the image function under process. At present other forms of filters are being generated. This direction is taken to analyze the response obtained from different forms of filter functions The two new forms are another method for generating a matched filter and an inverse filter. The inverse filter is the inverse of the function to be filtered. The past performance and present status is outlined in table 1.

Based upon the present status of this program we have initiated a preliminary evaluation of the results to date and the direction that can be taken during the summer months when the holographic system can be operated by the co-op students, under direction. The results of this evaluation place the past and present effort into proper context with coherent optical image manipulation techniques, and specify a series of analytical and experimental investigations to ensure thorough evaluation of these techniques.

Outline of Preliminary Evaluation

The holographic filter is recorded on film and depends on the response curves of film for an accurate recording. When film is processed to a specific gamma, the assumption that linearity is obtained is bounded by linear limits of the sensitometric response. The hologram consists of an interference fringe pattern superimposed on a certain

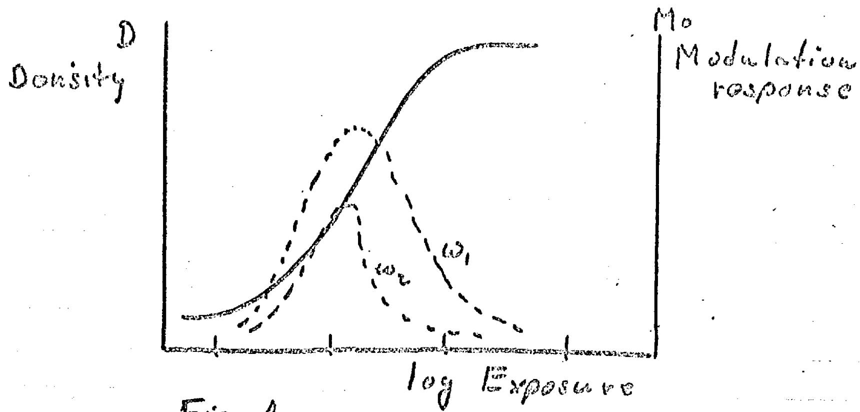

Fig 1

Film density response vs. log exposure (solid line) and modulation response vs. log exposure (dashed line).

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noted by ω. The higher the frequency, the lower the film modulation response and the narrower the range of response. As illustrated, $\omega_1 > \omega_2$. These modulation response curves are directly related to the MTF curves of films, specifying the cut-off and modulation with exposure. The film MTF is illustrated in Fig 2, for a particular exposure of the input modulation and filter function, but the modulation response of film varies as a function of exposure; thus the fringe pattern is modulated other than the linearity often assumed in an analytical description. Finally, film resolution threshold varies as the input signal modulation and the interference fringe pattern can be lost at certain regions of exposure. Since the optical diffraction is a function of the modulation recorded on film, the effective filter function is thereby affected by the fringe modulation variations of film response.

The significant curves are illustrated in Fig 1. Note that the film response to an input modulation is a function of log exposure as well as the frequency of the input modulation,

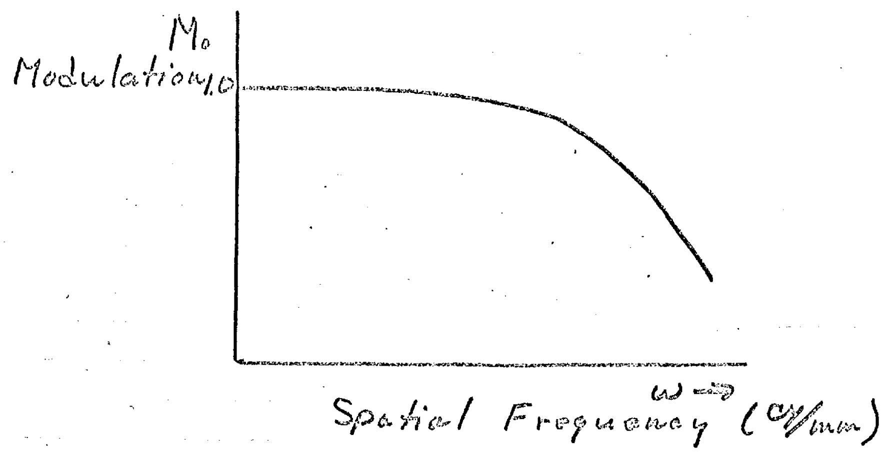


Fig 2. Film MTF for a given exposure and process.

a particular film process. Given these facts, we should now be able to determine the expected response for a given exposing function and holographic interference frequency.

Fig 3 illustrates the method by which the transmittance of a filter can be determined. Fig 3(a) is the output transmittance resulting from the film transmittance vs. exposure curve (Fig 3(b)) and the input exposure function (Fig 3(c)). An even more significa[nt]

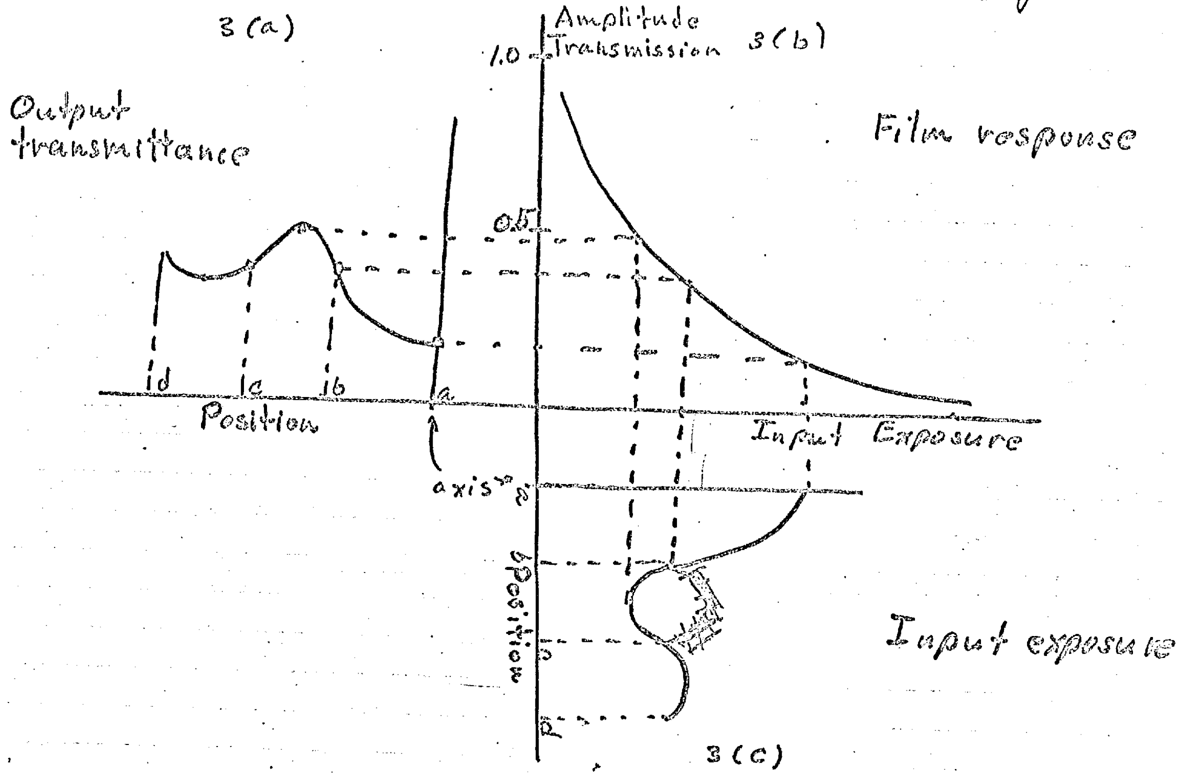


Fig 3 Determining film transmittance response to an input exposure.

response is the modulation that will be superimposed on the output transmittance function. This can be determined by combining Fig 3(c) with the

dashed line response curve in Fig 1
for the fringe frequency of interest.
This is illustrated in Fig. 4 where (a) is

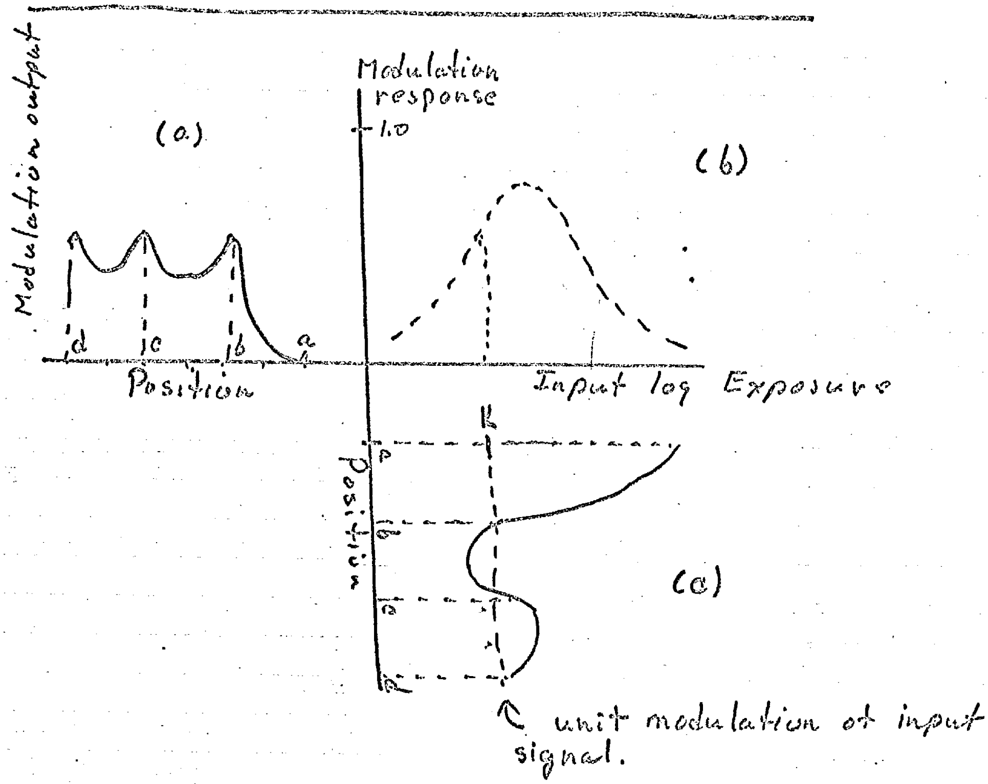


Fig 4 Determining modulation on film containing hologram of function.

the modulation on film, (b) is the modulation
response of the film at frequency ω, and
(c) is the logarithm of the exposure.

The effective filter is then the result from Fig 4(a) and Fig 3(a). The diffraction of light is dependent on the energy passed by the film (amplitude transmittance) at a particular area, and the modulation of the recorded pattern. This is expressed by

$$F(\omega,\nu) = \tilde{T}_A(\omega,\nu)\cdot M_A(\omega,\nu)\cdot K$$

where $\tilde{T}_A(\omega,\nu)$ is the amplitude transmittance of the film described in Fig 3(a), and $M_A(\omega,\nu)$ is the modulation (in amplitude) described in Fig 4(a). Taking these curves we see the result of a simulated effective filter $\mathcal{E}(\omega,\nu)$ response in Fig 5. This describes the

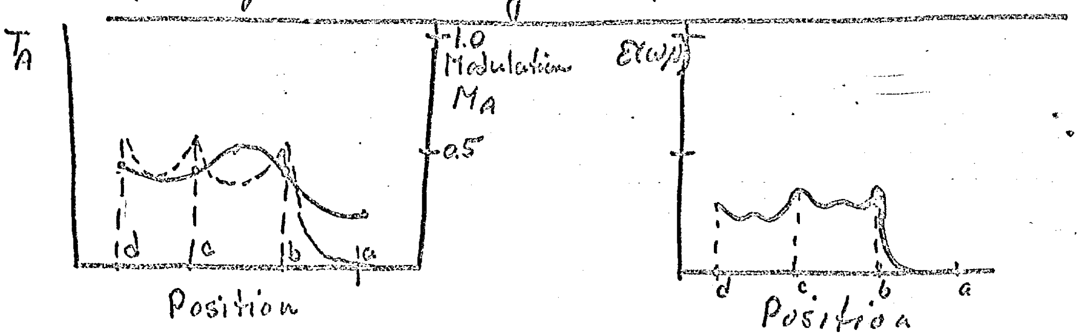


Fig 5 Method to determine effective filter.

diffracted energy of the holographic filter.

By the technique outlined here we can evaluate the accuracy to which a function can be holographically recorded. We should use parameters of present films, compare them with expected responses from extended dynamic range processed film, and determine optimum ways for holographic recording.

Table 1

Program Status

		April 24	May 1	8	15	22	29	June 5	12	19	26	July 3
Interferometer set-up	////	////	////									
Fabrication of Fresnel holograms		////										
Coherent Processor set-up		////	////	////								
Generation of test imagery			////	////								
Generation of quasi-matched filters by Fourier Transform holographic technique				////	////							
Application of technology to target recognition for system tests and demonstration				////	////	////	////					
Generation of blurred imagery for tests.						////	////					
Generation of blur compensating quasi-matched hologram filters						////	////	////				
Preliminary evaluation							////	////	////	////	////	
Generation of holograms for matched and inverse filters.										////	////	

Program Plan

Time Period:- July - Sept. 1970

Tasks:- I) Experimental

1. Fabricate & evaluate matched and inverse holographic filters.

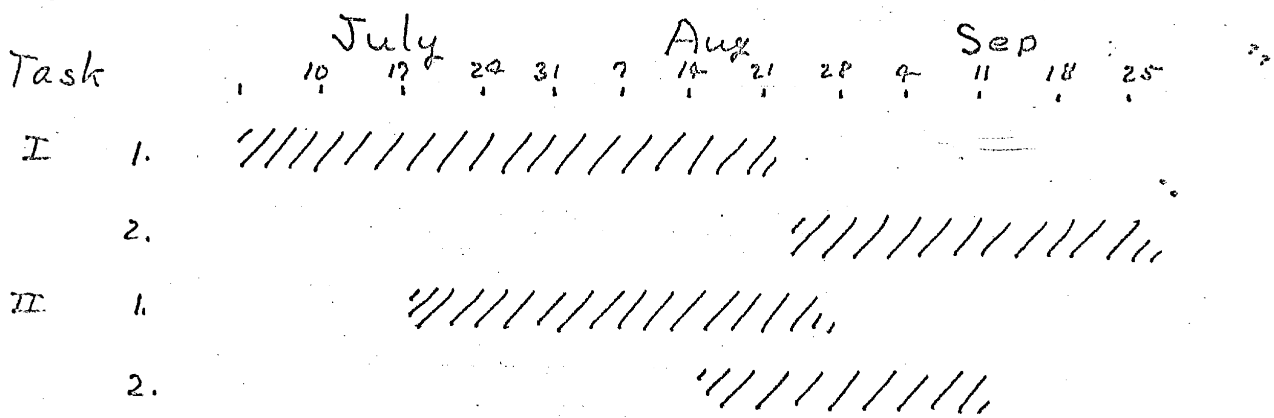
2. Determine best results for application to image manipulation, including quasi-matched, matched and inverse holographic filters.

II) Analytical

1. Obtain required film data, or best estimates, for evaluating film capability for holographic recording.

2. Perform evaluation for correct γ processing of film and for extended dynamic range processing and determine which method can most accurately record holographic filters.

Schedule



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