Fine Arts Research & Holographic Center

HOLO II #3

talk about the holograms -
review the question sheet.
explain why it happens that
way.

discuss tonight's set up and
processing.

layout 2 sets -

BEAM SPLITTERS + CLOTHESPINS

MUSEUM OF HOLOGRAPHY

1134 W. WASHINGTON BOULEVARD / CHICAGO, ILLINOIS 60607 / (312) 266-1007

IM #1

Intermodulation Noise

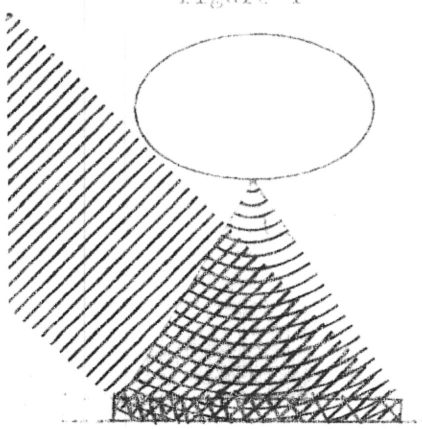
A noticeable speckle pattern can be seen on an object illuminated by laser light. This is caused by the constructive and destructive interference between light reflected from every pair of points all over the object. The holographic recording material is sensitive not only to the reference-object interference pattern but also to the self-interference of the object.

This speckle pattern may get in the way of viewing the image clearly. Anything that manifests itself as unnecessary information in a communication process is called noise. In holography, our signal is information about the object; it is encoded on the carrier which is the reference beam, and in reconstruction it is carried to our eyes.

This particular noise in holography is called intermodulation noise; inter because it is formed between object points, and modulation because it changes the reference beam. In some ways it is analogous to static in radio. Other noises in a hologram are recording medium noise and optical noise. All these effects may be minimized. In fact, reflection holograms are free from the intermodulation noise. Let's examine the causes of this noise and the ways to minimize it. It would be helpful to have the sheets on diffraction and spatial frequency handy for reference.

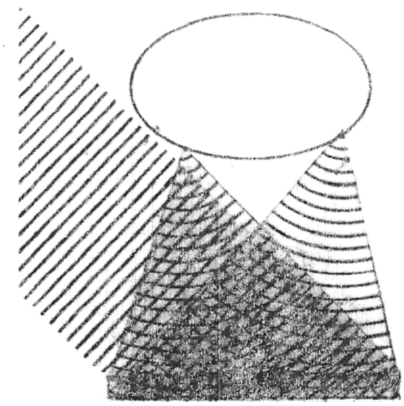
For a particular object, light from every point on it inter-

figure 1



one object point-reference beam interference pattern

figure 2



holographic information plus intermodulation noise

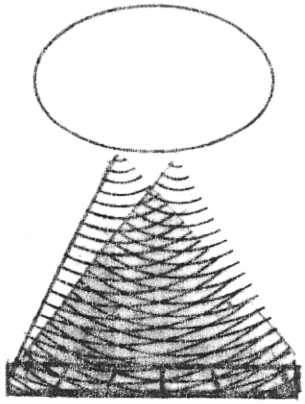
feres with the reference beam, producing a pattern on the hologram. (See figure 1.) Looking at the pattern produced by light from two object points and a reference beam, you can see not only the interaction of the reference and object points but the interference of between two object points. (Figure 2) Notice that the interference pattern of the two object points has a lower spatial frequency than the interference of the reference-object beams; i.e., the fringe spacing is larger. These fringes are arranged in different directions from the signal fringes. The reconstructing reference beam is then scattered in many different directions and does not contri-

IM #2

bute to the object wavefront. It introduces its own speckly pattern into the signal. Every pair of points on the object makes this interference amongst themselves.

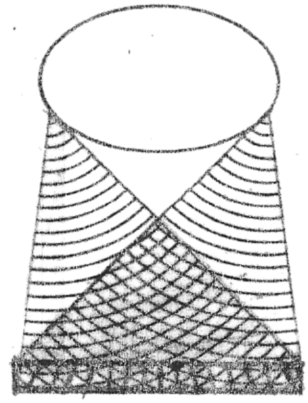
The spatial frequencies of the noise gets larger as the distances between the interfering points increase. The noise from

figure 3



noise from adjacent object points

figure 4

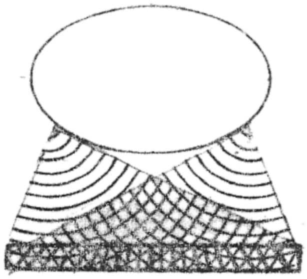


noise from endpoints of object

two adjacent points has low spatial frequency; the upper limit of spatial frequency is set by the light from the endpoints of the object interfering with each other. (See figures 3 & 4.)

Larger objects will of course produce more of this noise because there are more pairs of interfering points. The noise also becomes more serious as the object gets closer to the film plane. The angle between the endpoints is larger, so the fringe spacing gets smaller and closer to the size of the signal fringes. (See figure 5 below.)

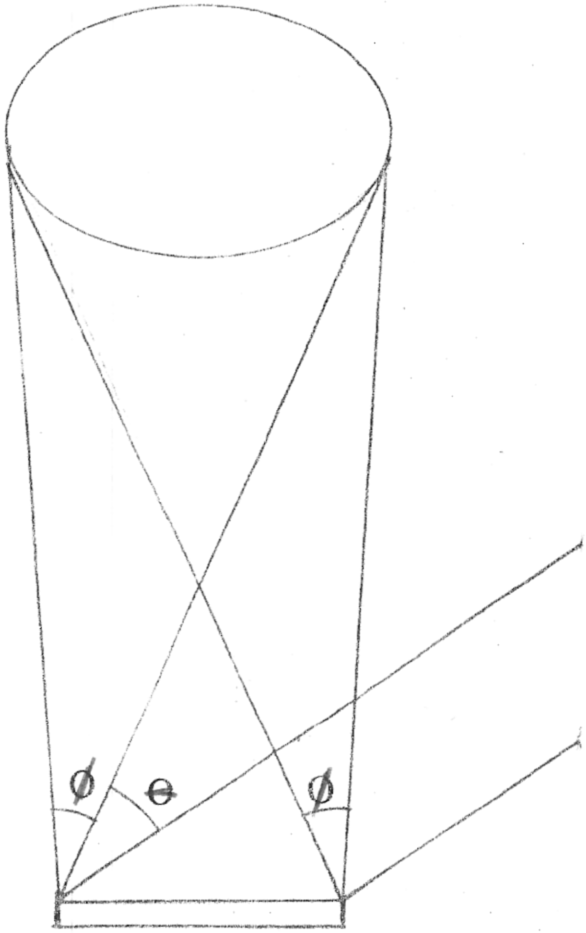
figure 5



noise from the endpoints of a near object

One method of minimizing the intermodulation noise is to keep the spatial frequency of the signal higher than the spatial frequency of the noise. The bigger the distance between the fringes, the smaller the angle of diffraction--the smaller the fringe spacing, the larger the angle of diffraction. By keeping the noise fringes' spacing larger than the signal's, we can diffract the noise to an angle different from the signal's. We can physically accomplish this in recording the hologram by having the smallest angle between the reference beam and any object beam greater than the largest angle formed by a pair of points on the object. (See diagram on the next page.) Of course, this is not always physically possible due to compositional factors.

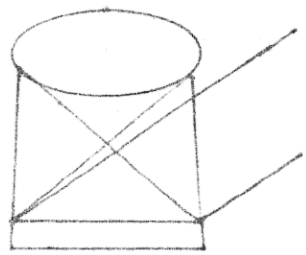
IM #3



Angle Ø is the largest angle between light from two points on the object. This sets the upper limit of the spatial frequency of the noise.

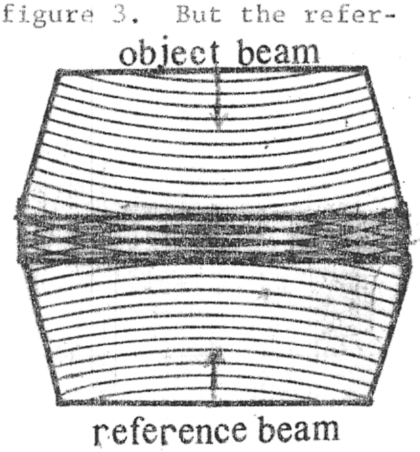
Angle θ is the smallest angle between light from a point on the object and the reference beam. This sets the lower limit of the spatial frequency of the signal.

If angle θ > angle Ø, then the noise will be at a minimum due to the set up. However, practical set ups look more like this:



with the range of the spatial frequencies of the noise and of the signal overlapping.

Reflection holograms are free from intermodulation noise because the noise fringes are arranged more or less perpendicular to the information fringes. Noise fringes are made by point sources on the same side of the film--in effect, a transmission hologram. Note the fringe arrangement shown in figure 3. But the reference and object beams come from different sides of the recording material in a reflection hologram, with fringes formed almost parallel to the film. So in reconstruction, the signal fringes reflect light back to the observer, while the noise fringes reflect light off to the side, out of the viewing bandwidth.



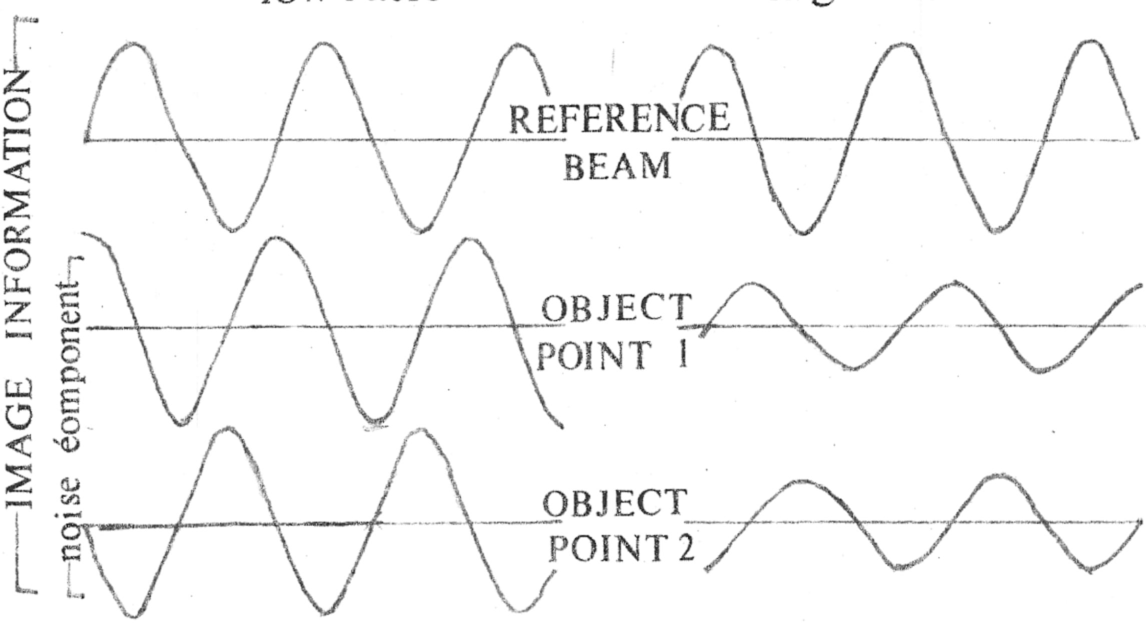
9/24/80
EW

IM #4

Another method of minimizing intermodulation noise is by controlling the ratio of reference to object beams. Remember that the silver halide materials are negative acting; the more light that hits them the denser it gets, and less light leaves a corresponding lesser imprint. The areas of high density (even after bleaching) will act as areas of high reflectivity in the mirror analogy of the reconstructing mechanism, and the areas of low density will have low reflecting power. By making the combined carrier wave and signal stronger than the noise coming from the object, the carrier will expose more silver and create more highly reflective mirrors, while the noise will not contribute as much. This minimizes the effect of the noise because its reflective power is low.

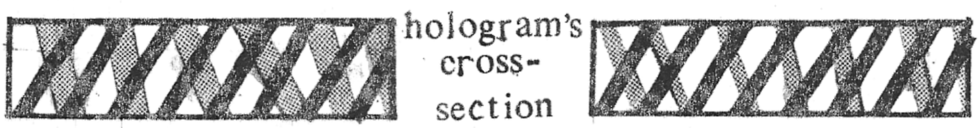
RELATIVE AMPLITUDES

low ratio — high ratio



Noise component's fringes are recorded just as strongly as the image information's

Image information fringes are much stronger than the noise fringes.



= signal — = noise

thickness of the line represents reflectivity

1/25/80

IM #5

However, there is a drawback to using the high ratios because the noise is formed by the light from the object; if there islittle light from the object th then the carrier wave is not modulated as much. As a result the signal is weaker, so brightness of the reconstructed image is lower than when the reference beam is strongly affected by the object beam. There is a constant battle between brightness and noise.

The general rule of the thumb is this: Low reference to object beam ratios, like 1 to 1 or 2 to 1, will produce bright holograms with a good deal of noise, because the noise fringes are almost as reflective as the signal fringes. High ratios are less noisy because the carrier mirrors are more reflective, but the image is not as bright since the modulation of the reconstruction beam is low because the recording reference beam's modulation was low.

The holographer's job is to minimize noise and maximize brightness by controlling the geometry of the set up, the ratio of reference beam to object beam, and the processing of the recording material. All this depends on the object to be holographed. If a set up is too noisy, raise the ratio, but don't be surprised when the brightness decreases. Some applications may place emphasis on brightness first with little or no regard to laser speckle noise. Low ratios will do the job. Control of the ratios is one aspect of successful holography.

9/25/80
EW

HOLO II #4

view + discuss last week's holograms

more density ⇒ more brightness + noise

send up for the ratio test.
do more of the same next week

HOLO II LESSON VI

MOVIES / SLIDES

DISCUSS EVERYTHING DONE SO FAR

FILL IN ON THE NEXT FEW WEEKS – THRU LENS (ONE STEP IMAGE PLANE)

CYLINDRICAL, MULTIPLE OBJECT LIGHTING, MULTI-CHANELLING

COLLIMATED + CONJUGATE BEAMS

COLOR CHANGES

REMIND THEM TO READ P 128 – 129, HOLOGRAPHY BY OSTROVSKY ON IMAGE HOLOGRAMS

HOLO II LESSON VII

- ONE-STEP IMAGE PLANE
viewing is defined by aperture
real vs. virtual image of
lenses vs. holograms
conjugate + collimated
beams
russian book p128-129
Holography by ostrovsky

what rainbow variation
does.

Illinois Bell Telephone Company has presented us with
three f

Fine Arts Research & Holographic Center

School of Holography

NAME ED

DATE

CLASS HOLO II

PROJECT SET UP TIME FOR ONE STEP IMAGE PLANE

OBJECT: TAKES ABOUT 50 minutes TO SET THIS UP IF YOU KNOW WHAT YOU'RE DOING

	1	2	3	4
OBJECT BEAM INTENSITY				
REFERENCE BEAM INTENSITY				
BEAM RATIO TO BARELY MODULATE				
EXPOSURE INTENSITY	11			
EXPOSURE TIME	15"			
DEVELOPER				
STOP HD TRANSMISSION				
FIX PROCESSING				
WASH				
BLEACH 1				
WASH				
FIX				
WASH				
BLEACH 2				

COMMENTS: BEST ONE I'VE DONE YET SEE BACK FOR "TRICKS"

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HOLO II, LESSON IX

MORE IMAGE PLANE MULTICHANNELLING

HOLO II FINAL

I what is the role of the ratio in transmission holography?

II How would you proceed in fine tuning an unknown photosensitive material for reflection holography?

III Draw a workable set up for making a reflection hologram of an object lit from left and right.

MULTI MEDIA - LASER SCANNERS

(1) INTRODUCTION - BASIC ELECTRONICS

(2) + (3) + (4) CONSTRUCTING FOR USE IN THE SAND BOX

5, 6, 7, 8 BUILDING A BASE FOR THE UNIT.

(9 + 10) YOUR SUGGESTIONS

INSTALLATION IN MUSEUM

MULTI-MEDIA LESSON I

SCANNER

MOTORS BATTERIES

SWITCHES - DPDT + SPST

RESISTORS - VARIABLE + FIXED

CURRENT FLOW
SWITCHES
MOTORS
REVERSING SWITCH
RESISTORS

WOBBULATING MIRRORS