HOLOGRAPHY I

Welcome to Introductory Holography, a class that revolves around a practical approach to making four fundamental types of holograms. There will be about 70% lab time and 30% lecture time, and the discussions of the theory of holography will require some mathematics but will not be too involved.

Here are the lesson plans for the ten week session:

I Introduction, Museum tour, Discussion of properties of light, the Michelson Interferometer.

II Making a Single Beam Transmission Hologram.

III Making a Diffraction Grating and more Single Beam Transmission Holograms.

IV Making a White Light Single Beam Reflection Hologram.

V Making better Single Beam Reflection Holograms.

VI Slide Show

VII Making Multiple Beam Transmission Holograms.

VIII Making Multiple Beam Transmission Holograms again.

IX Making Multiple Beam Reflection Holograms.

X Free Period to explore what you have learned or to try a Cylindrical Hologram.

FOR HOLO II

Please report your absences by telephone so that arrangements can be made to make up the missed work. Be on time, as classes will start promptly at 6:30 p.m. Be prepared for the week's lesson by bringing your notebook, pencils and pens, with one of them being a red one, ASSIGNMENTS, objects for the night's holograms, and plenty of enthusiasm. You will only get out of this class what you put in. Here's to a successful quarter of Holography I!

Fine Arts Research & Holographic Center

School of Holography

September 4, 1980

Dear Student:

Here is our new school catalog containing a revised curriculum. Since a major objective of the school is to train students to produce holograms on their own, we encourage you to continue your holographic education.

Our teaching system of practical hands-on instruction on well-equipped systems has proven successful over the last three years. To organize classroom time more efficiently, textbooks are supplemented by our own instructional materials, and audio-visual aids, movies and slide shows complement the class lectures.

The Fine Arts Research & Holographic Center intends to provide an expanding learning environment to actively involve students outside of class. The Annual Fall Lecture Series exposes students to speakers discussing topics of current interest. During the quarter, table time will be available on Sundays for students to practice techniques learned in class and pursue their own holographic interests. Workshops and seminars will be scheduled to cover extracurricular subject matter.

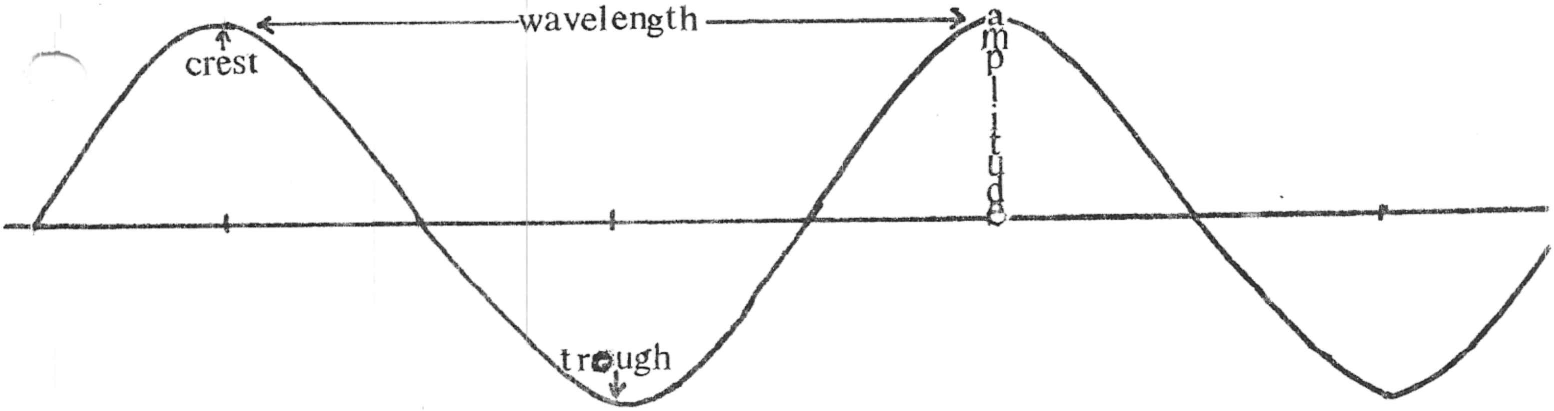
We cordially invite you to sign up for the fall semester. Enclosed are the lesson plans for the next course for which you are eligible. Registration begins the week of September 22, and classes begin the following week. Contact me any day from 9:30 to 5:30 if you have any questions.

Sincerely,

Ed Wesly
Director of Education

1134 W. WASHINGTON BOULEVARD / CHICAGO, ILLINOIS 60607 / (312) 226-1007

PARTS OF A WAVE



SINE WAVE-- Light's magnetic and electric vectors oscillate across space as a sine wave. A sine wave is the graph of the trigonometric function $y=r\sin\theta$, derived from the relationships of sides and angles in a right triangle.

CREST-- The highest point or maximum of a wave.

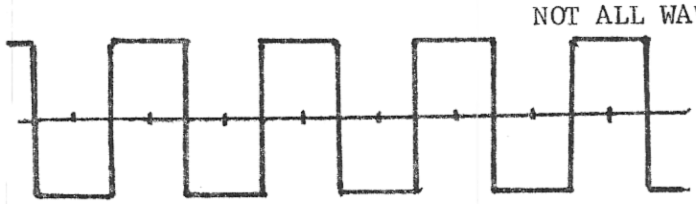
TROUGH--The lowest point or minimum of a wave.

AMPLITUDE--is one-half the distance from crest to trough. It is used to measure intensity.

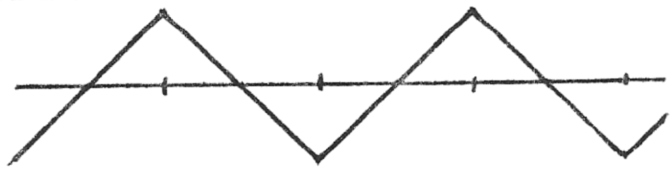
WAVELENGTH--represented by the Greek letter λ, is the distance between two consecutive crests. For visible light the wavelengths are between 400 and 700 nm.

FREQUENCY--tells how often a wave goes through a complete cycle from crest to crest in a unit of time. The unit commonly used to denote frequency is a Hertz, (Hz), one cycle per second, and the range of frequencies for light starts at 430 trillion Hz for red light and goes to about 750 trillion Hz for blue.

NOT ALL WAVES ARE SINE WAVES



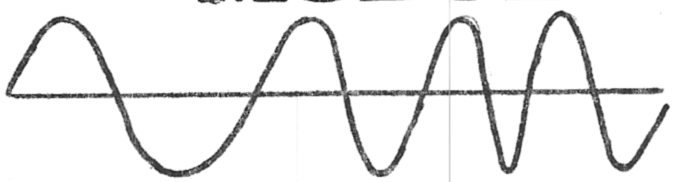
SQUARE WAVE



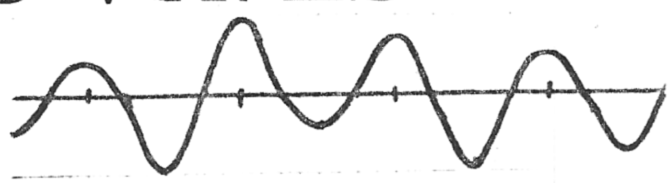
DELTA OR TRIANGULAR WAVE

The above terms are applicable to these waves.

MODULATED WAVES

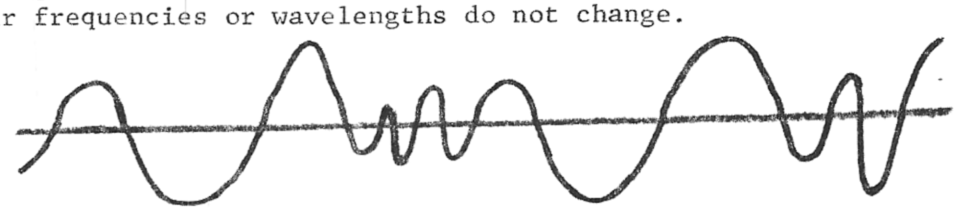


Wave of constant amplitude but varying frequency (Frequency Modulated)



Wave of constant frequency but varying amplitude (Amplitude Modulated)

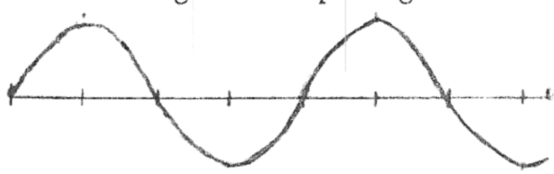
The waves of light which are used for making holograms must be temporally coherent; that is, their frequencies or wavelengths do not change.



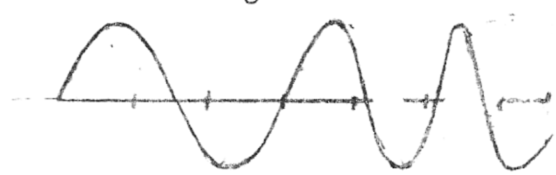
Wave of varying amplitude and frequency

COHERENCE

Light coming out of a laser is both spatially and temporally coherent. Temporal coherence means that all the waves coming out of the laser have the same wavelength-the spacing between crests does not change with time.

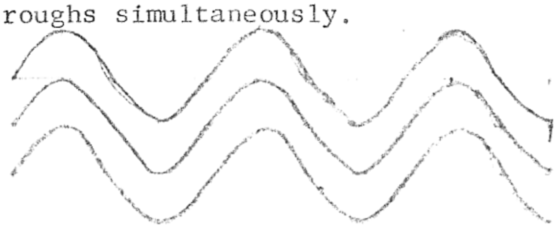


TEMPORALLY COHERENT WAVE

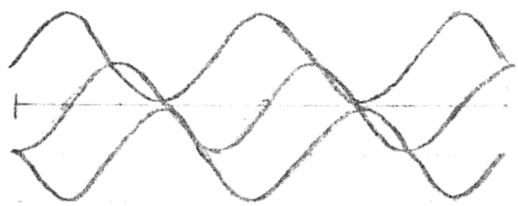


NOT A TEMPORALLY COHERENT WAVE

There is more than one wave of light coming out of the laser and these waves are all in step as they exit the port. They can be thought of as originating at the totally reflective mirror opposite the exit mirror, even though they make many round trips between the mirrors in the resonating cavity before leaving it. This is spatial coherence; all the waves make their crests and troughs simultaneously.

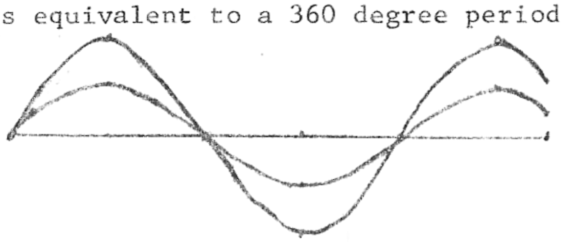


TEMPORALLY AND SPATIALLY COHERENT

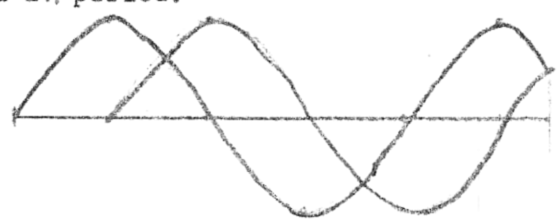


TEMPORALLY BUT NOT SPATIALLY COHERENT

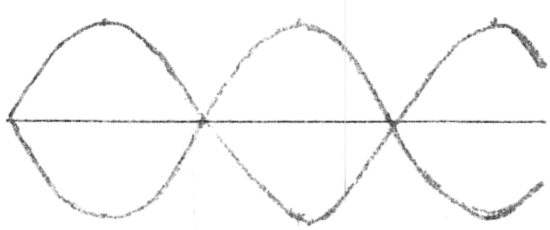
When temporally coherent waves are not spatially coherent, they are "out of phase" with each other. Crests do not match up, troughs don't match up, and neither do points in between. One way to indicate the amount that two waves are out of phase with each other would be to use fractions of a wavelength. Since these wave forms are based on the trigonometric sine curve we can also use degree measure or radian measure, assuming that every wavelength is equivalent to a 360 degree period or a 2π period.



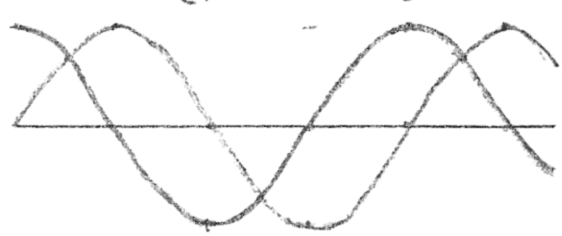
WAVES ARE IN PHASE



WAVES ARE {1/4 WAVELENGTH, 90 DEGREES, $\pi/2$ RADIANS} OUT OF PHASE



WAVES ARE {1/2 WAVELENGTH, 180 DEGREES, π RADIANS} OUT OF PHASE



WAVES ARE {3/4 WAVELENGTH, 270 DEGREES, $3\pi/2$ RADIANS} OUT OF PHASE

It's absolutely essential that the waves used to form a hologram be spatially and temporally coherent to form the constructive and destructive interference fringes.[1] If the wavelength of the interfering beams vary (lack of temporal coherence) the interference will not become a standing wave pattern and will be constantly changing its shape, leaving nothing but a blur on the holographic plate. The reference beam must have all its waves cresting and troughing at the same time to provide a non-random base of reference. The light reflected off the object loses its spatial coherence, but this modulation of the object beam is exactly the information we would like to record.

A phase hologram is recorded on a transparent medium that introduces phase differences in the reconstructing beam by optical path variations. For instance, in a bleached silver halide emulsion, light travels through gelatin, then through transparent silver halide whidh has a different index of refraction from the gelatin, so the light gets slowed down and bent, introducing a phase difference, then through several more gelatin and silver interfaces until when it finally exits it has reconstructed the phase differences between reference and object beams recorded in the hologram. Phase holograms have been recorded on dichromated gelatin, photo-resest, thermoplastics, and photopolymer. Bleached silver halide emulsions are the most popular type of phase hologram because the materials are readily available from commercial manufacturers and relatively easier to handle. Phase holograms are much brighter than absorption holograms since they pass much more light

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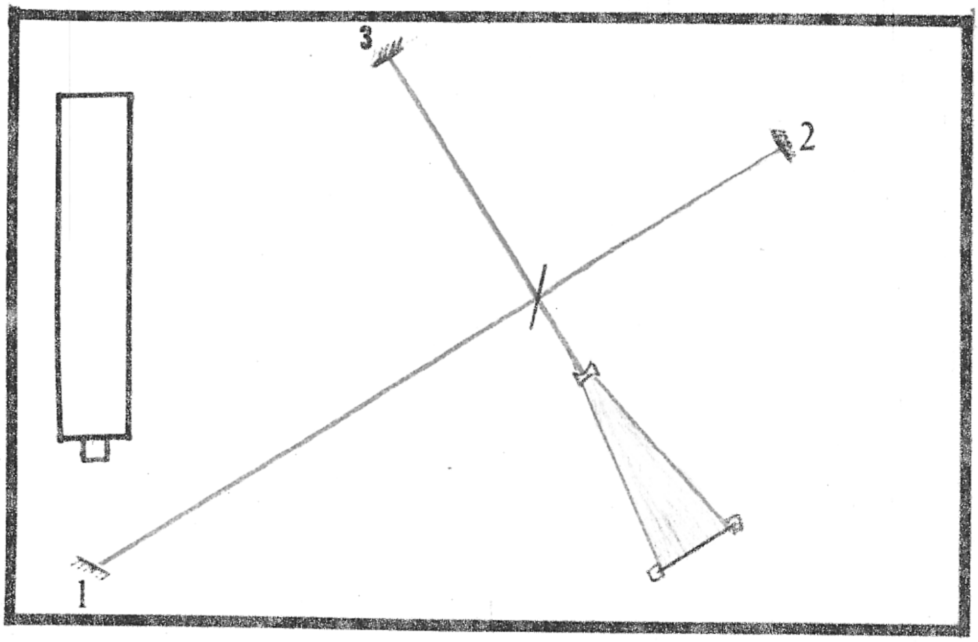
I. Holograms can be made with any type of wave sound, radio, maybe x-rays, and of course, light.

MICHELSON'S INTERFEROMETER



NOTES

This set up is used to measure the relaxation time of the isolation table in its environment. It can be used also to measure the coherence length of a laser.

Interference fringes of low spatial frequency are formed and viewed on a white card. When the table is totally stabilized, the fringes will remain in place. If there is any motion introduced into the system, such as vibration coming from the floor or component drift, the fringes will jiggle around.

SET UP STEPS

I. Direct beam diagonally down the table with the first mirror in the corner by the laser.

II. Position a second mirror kitty-corner down the table and direct the beam back onto itself.

III. Place a beamsplitter in the beam about halfway down the table, so that the two reflections are perpendicular to the first beam's path.

IV. A third mirror sends one of the beamsplitter's reflections back onto itself and onto the reflection from the opposite side of the beamsplitter. The distance from the beamsplitter to the second mirror must equal the distance from the beamsplitter to the third mirror.

V. Block out extraneous beams.

VI. Spread out the two overlapping beams with a lens onto the white card in the film holder.

VII. Observe the fringes. Tap the table and time how long it takes them to come to rest. This is the table relaxation time.

VIII. TO MEASURE COHERENCE LENGTH: Move the third mirror in closer to to the beamsplitter about an inch at a time, observing the fringes. When the end of the coherence length is reached, the fringes will grow dim and lose contrast. The coherence length then is the difference in the beam path lengths from the beamsplitter to the second mirror minus the distance from the beamsplitter to the third mirror.

9/26/80
EW

Fine Arts Research & Holographic Center

School of Holography HOLOGRAPHY I LESSON 2

REVIEW INTERFERENCE
SHOW SET UP

TALK ABOUT FILM IN GENERAL
SUPPORT - EMULSION - SILVER HALIDE
SPECTRAL SENSITIVITY - BLUE + RED
OK* FOR GREEN SAFELIGHT
PHASE VS. ABSORPTION HOLOGRAMS
EXPOSURE - LATENT IMAGE - USING LUNA PRO
PROCESSING:
DEVELOP - CHANGE EXPOSED CRYSTALS INTO PURE SILVER

STOP - NEUTRALIZES ALKALINITY OF DEVELOPER

FIXER - DISSOLVES UNEXPOSED + UNDEVELOPED HALIDES
DISSOLVES DEVELOPED SILVER AT A MUCH SLOWER RATE
WASH - GETS RID OF THE FIXER
BLEACH - CHANGES DEVELOPED SILVER BACK INTO TRANSPARENT SILVER BROMIDE
WASH - TO GET RID OF BLEACH
PHOTO-FLO - GETS RID OF WATER MARKS
GO TO WORK -
9.10 CLEAN UP + VIEW UNDER STREETLIGHTS

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School of Holography

NAME DATE

CLASS PROJECT

OBJECT:

	1	2	3	4
OBJECT BEAM INTENSITY				
REFERENCE BEAM INTENSITY				
BEAM RATIO				
EXPOSURE INTENSITY				
EXPOSURE TIME				
DEVELOPER				
STOP				
FIX				
WASH				
BLEACH 1				
WASH				
FIX				
WASH				
BLEACH 2				

COMMENTS:

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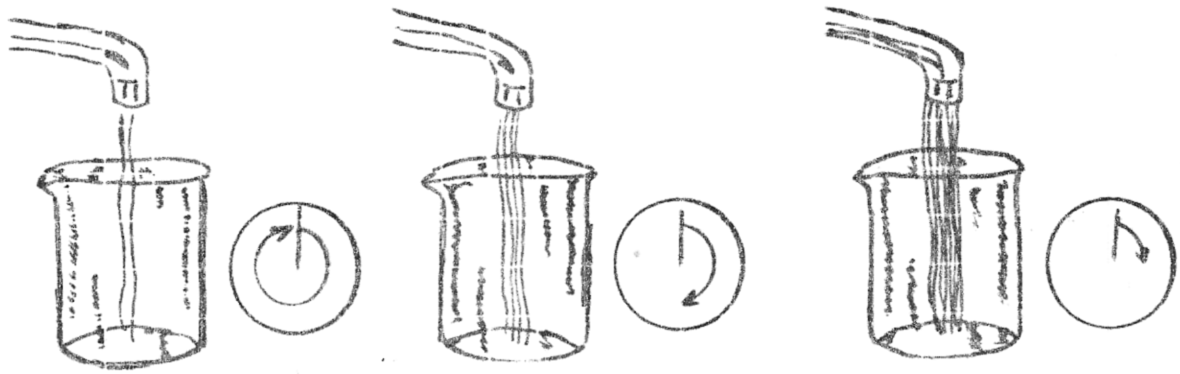
EXPOSURE

Silver halide materials' respnonse to light is negative-acting; the more light that hits them the darker they become. Areas exposed to less light are correspondingly lighter, and areas where no light hit don't change much except for developer fog. This explains why photographic negatives look the way they do; light areas in the subject reflect a lot of light to the film, making their image area on the film very dark, medium tones make a medium change, and dark shadows make a minimal amount of change on the film. The tones are re-reversed in the printing process because the print material is also negative-acting.

Holography captures the interference pattern of reference and object beams which is composed of light and dark fringes. The bright fringes expose the silver halides, darkening them, while the dark fringes don't. The pattern formed on the film is the reverse of the real fringe pattern. How dark the exposed areas become depends on the amount of light that hits them and also on the development. For this discussion, assume that development is constant.

The three components of exposure are film sensitivity, how much light hits the film and the length of time it is exposed. The film's sensitivity is built-in. For a certain film a particular amount of light energy will darken it to a certain degree. This is the statistic given in film instruction sheets under the heading "Energy Requirement", for instance 200 ergs/cm^2 to produce a density of 1.0. These 200 ergs may be accumulated over a period of time. For a very bright beam, it may take a short time, for a dim beam a longer time.

Exposure is analogous to filling a cup with water. The intensity of light is represented by the flow of water; the energy requirement of the film is the size of the cup. If there is a trickle of water, it will take a long time to fill it. If the water runs twice as fast, then the time to fill it will be

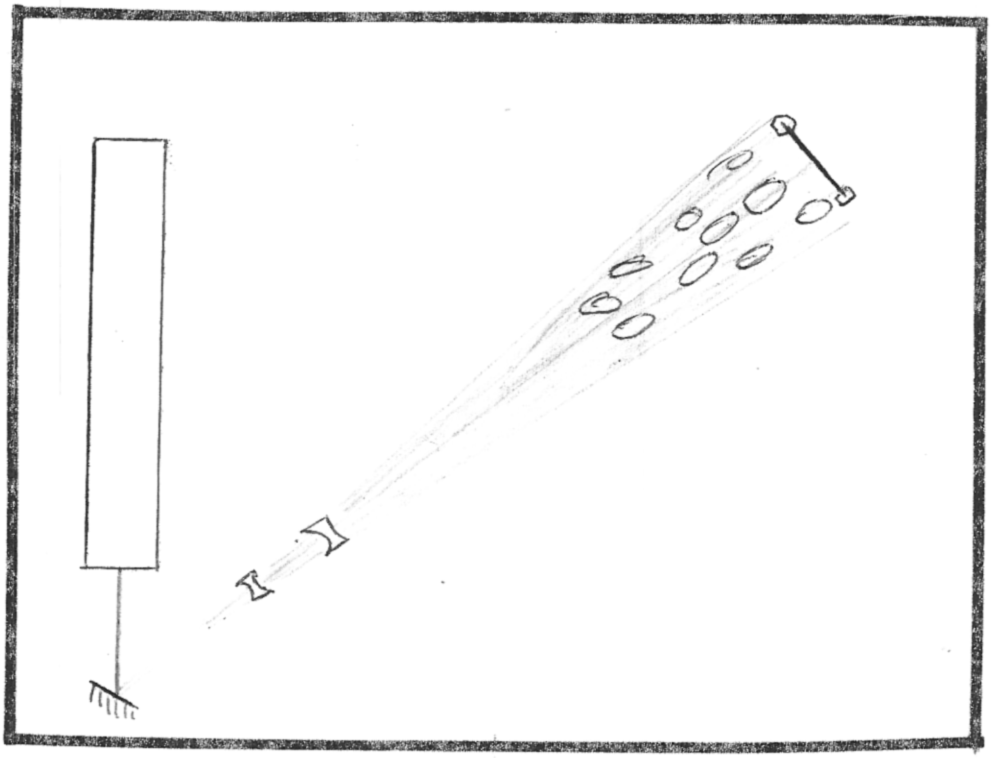


half as long. Doubling the flow again will cut the time down to ¼ of what it had originally been. Conversely, less light/water, the time will increase.

As far as relative sensitivity goes, the different speeds of film are analogous to different sized cups. A film with energy requirement of only 25 erga/cm^2 would be a cup whose volume is only one-eighth that of the 200 ergs/cm^2's cup and then would require only 1/8th the exposure time for the same flow.

In holography, the duration of exposure is a response to the amount of light reaching the film. The light meter is the tool which tells you how much light is reaching the film. The reference beam is metered from the position of the film, and its intensity is compared to a calibrated exposure scale which tells you how long to expose.

SINGLE BEAM TRANSMISSION (DEEP SCENE)



notes

This is the easiest way to holograph scenes that are very long or deep. The disadvantage to this set up is that the abjects are back lit instead of front lit. Therefore you re limited to objects that can be spread out flat in the hologram's volume.

Some light reflects off the objects and travels to the film, while the rest goes directly to the film. The former is the object beam, the latter is the reference beam. Being a transmission hologram, the ratio of reference beam to object beam should be in the range of 2:1 to 8:1. (Reference beam one to three stops brighter than the object.)

set up steps

I. Position small mirror to direct beam down the diagonal of the table.

II. Place film holder at the end of the table.

III. Spread beam out with the lenses. Some light should hit the sand while the rest will hit the film holder in an area the size of the film. The larger the spread, the more area will be included in the hologram.

IV. Position objects in the sand in the beam so that they can be seen from the position of the film. Tilt the film holder if necessary.

V. Take a meter reading of the objects' intensity by blocking with a card the light that goes directly to the film. Point the light meter (with the white diffuser cap on) at the objects from the postion of where the film will be placed.

VI. Now block out the light from the objects with a card to measure the reference beam. Keep the diffuser on the light meter. This reading should be 1-3 stops <u>more</u> than the objects' intensity. If not, adjust the beam position or spread.

VII. Slide the diffuser cap to the side of the light meter and point it directly into the beam, with the objects still blocked. This EV number will determine the exposure. Consult the table on the board for the exposure time.

VIII. Expose and process.

IX. Reconstruct the image by placing the hologram back into its original position.

HANDLING HINTS

BEFORE EXPOSURE:

The film is not very sensitive to light, so it may be handled under a safelight. Follow the manufacturer's recommendations as to what color and strength is necessary.*

Because the gelatin coating is soft and susceptible to physical damage, handle the film or plate by the edges. The next trick is to find the emulsion side of the film. Moisten your lips and place a tiny bit of the corner of the film between them. The side of the film that sticks to them is the emulsion. Generally, the emulsion side goes toward the object beam.

Plates can be inserted into holders as they are. Film must be sandwiched between two pieces of flat glass to hold it flat. Make sure that the glass is clean. Put a heavy weight like a brick on top of the film sandwich to squeeze out all of the air, because air pockets will allow the film to "pop" during the exposure, blurring the interference fringe either locally or all over the film. Small areas of movement cause dead spots on the hologram that cannot be seen through but can be seen around. Total movement ruins the hologram completely.

EXPOSURE:

Relaxation of the table prior to exposure cannot be stressed enough. Imperceptible movements of the components can ruin the hologram. Pieces of metal components can resonate long after they have been touched. Some counterweighted equipment set ups will have a diving board effect. Even just picking up the shutter card off the table can introduce movement into the system. So just be patient -- wait a minute or two after putting the film into position to pick up the

* CHECKING A SAFELIGHT: In total darkness place a piece of material on the working area, covering half of it with an opaque object. Turn on the safelight for the amount of time you would normally be working under it. Then develop and fix the film in total darkness and examine it under room light. If the exposed side is noticeably darker than the side that had been covered, there is a problem. The safelight should then have a smaller bulb put into it or moved further away from the working areas and be retested.

shutter card off the table, and hold it in the air while still blocking the beam another ½ minute or so before removing it completely. Gently replace it after exposure. It is better to take the time prior to exposure and processing to ensure results rather than to have to do it all over again. After removing the exposed film from the set up, double check the set up for any component drift that may have occurred before or after the exposure.

PROCESSING:

Details of processes appear elsewhere, so here are some general recommendations. Because of the latent image decay, process immediately after exposure. For consistent results, keep processing solutions at approximately the same temperature throughout the process and whenever you use the process again. Radical temperature changes will damage the emulsion by swelling it or shrinking it, which can introduce noise by introducing surface relief patterns.

Slide the film or plate into the solutions. Dropping the film into the trays traps air bubbles under it, which prevents the chemistry from reaching all the surface of the film. It helps to keep the emulsion side up. Agitate the tray as directed in all the steps. This replaces the chemicals that have done their jobs with fresh ones in the solution. Developers and bleaches usually require continuous agitation, fixing baths only intermittent agitation. Washes should provide a complete change of water every five minutes. Thorough washing removes all the chemicals and makes the holograms last longer.

The gelatin is extremely soft while it is wet so avoid touching it until it is dry. There are many opinions as to the best method of drying. One school of thought says to soak the washed hologram for ½-1 minute in a wetting agent like Kodak Photo-Flo 200 which prevents the formation of water spots, and then either air dry the hologram naturally or blow dry it with hot air. An alternate method is to avoid the wetting agent and bathe the washed hologram in a solution of 75% methanol (methyl alcohol) which squeezes out the water in the emulsion, leaving the alcohol in the gelatin which air dries much more quickly in air without heat. A transmission hologram can be viewed while damp; reflection holograms cannot be reconstructed while wet because the water droplets stuck between the intergerence fringes do not let the light travel back in the reflected wavefront.

I. BEFORE EXPOSURE

A. Check set up for component drift

B. Find emulsion side by taste test

C. Place plate in holder emulsion side toward object

1. For film - place it between 2 pieces of glass

2. Squeeze out air by placing brick on top of film shadow

3. Place film sandwich in holder, emulsion toward object

II. EXPOSURE

A. Relax table 1 - 2 minutes

B. Lift shutter card off table while still blocking beam, and let table relax another ½ minute more

C. Lift card completely

D. Replace card after exposure

III. PROCESSING (Follow processing procedures found elsewhere)

A. Always slide film into solutions

B. Agitate as recommended

C. Wash well

D. Dry using one of these methods:

1. Bathe in Photo-flo for ½ minute, then air or blow dry

2. Bathe in 75% methanol, then air dry

EXPOSURE ETTIQUETTE

The formation of a hologram depends on "freezing" the fringe patterns formed by the constructive and destructive interference of the reference and object beams. As you have seen from the Michelson Interferometer demonstration, the standing wave pattern is very fragile and any movement of the isolation table, caused by shifting your feet, loud talking, or sneezing will vibrate the table and blur the fringes. For transmission holograms, motion of even a half of a wavelength could ruin the pattern, and the tolerance in reflection holograms is only one quarter of a wavelength or 158 millionths of a millimeter.

So to avoid disappointments in holography, it is extremely important that everyone in the area be as quiet as possible during exposures. No talking or moving around in the immediate area of the table that is exposing, and while some talking in the darkroom may continue, please be alert to the fact that if it is quiet out in the table area, don't come rushing out. No type of horseplay will be tolerated anywhere because there may be some shooting of holograms in the room directly below the sand tables. It is only common courtesy to ensure that yours and everyone's holograms come out well by politely freezing when someone yells out "Making and exposure."

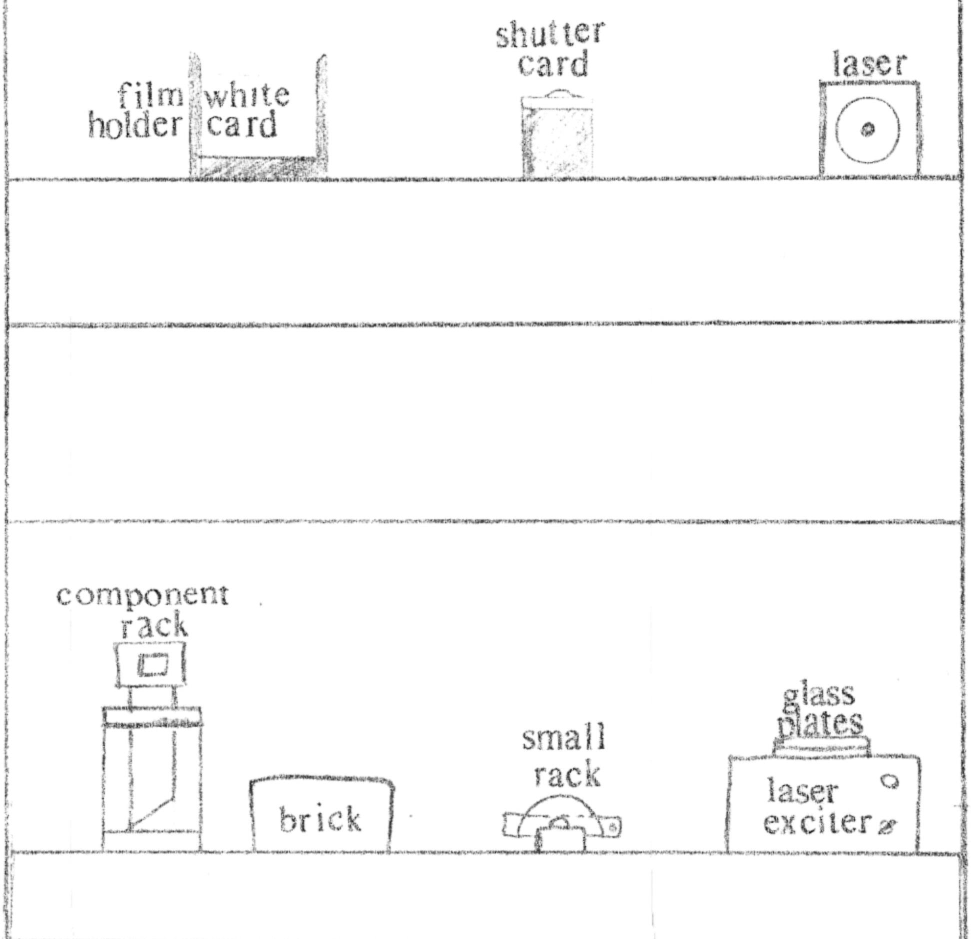
Before announcing that you are going to shoot, double check your set-up prior to putting your film into the holder. Don't forget to squeeze out the air from between the film and glass plates by laying a brick on the film sandwich. Close up the doors on the canopies and then announce your intent to expose. Wait until everyone else stops their movement. Then pull your shutter card out of the sand and hold it in the air while still blocking the beam to let the table settle for about 15 to 30 seconds. Patience is a necessity for holography. Then remove the card completely to let the beam pass through the set-up to expose the film. Put the card back to end the exposure and don't forget to say "Thank you" so that everyone will know that the exposure has been terminated.

CLEAN UP

The responsibility for keeping the table organized and clean belongs to the student, not only for your sake but also because there are students in other classes during the quarter and working with the same equipment over the weekend.

Some components are dot-coded to correspond to their table - one dot for table 1, two dots for table 2, and so on. These components go into their respective places as in this diagram. All undotted components (beamsplitters, large mirrors and lenses, extra small mirrors and lenses, overhead mirrors and object stands) are to be returned to the cabinets from which they were taken.

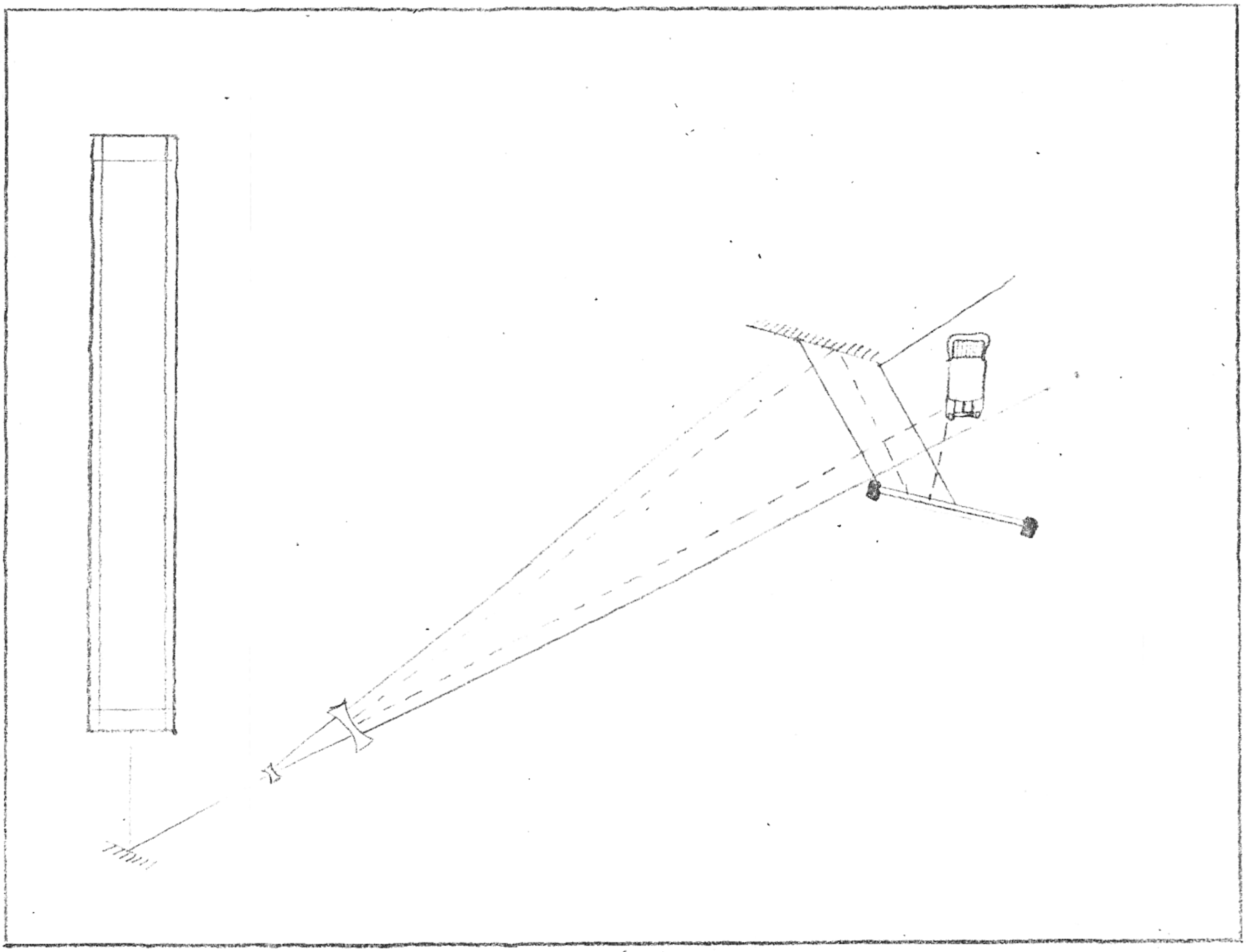
Remember - it is your job to keep fingerprints off optical surfaces and to return components to their proper places to make the lab a pleasant and productive environment for all concerned.



Component rack contains 3 small mirrors, 2 small lenses, and 2 big lenses.

Small rack contains a protractor, tape measure, and 2 beam blockers with pinholes.

SINGLE BEAM TRANSMISSION
division of amplitude



NOTES

THERE IS NO BEAMSPLITTER IN THIS SET UP SO TECHNICALLY IT IS A SINGLE BEAM TRANSMISSION HOLOGRAM. THE ADVANTAGE OF THIS SET UP OVER THE SINGLE BEAM DEEP SCENE SET UP IS THAT THE OBJECT IS FRONT LIT, RATHER THAN BACK LIT. HOWEVER, THE DEPTH OF THE SCENE IS LIMITED TO A FEW INCHES. IT IS CALLED DIVISION OF AMPLITUDE BECAUSE THE SPREAD BEAM IS DIVIDED INTO TWO PARTS, ONE PART GOING DIRECTLY TO THE OBJECT AND THEN BEING REFLECTED TO THE FILM. THE REFERENCE BEAM IS THE OTHER PART OF THE BEAM THAT MISSES THE OBJECT, AND IS REFLECTED OFF A MIRROR TO MEET THE OBJECT BEAM AT THE FILM PLANE.

SET UP STEPS

I. PUT SMALL MIRROR AT LASER EXIT TO DIRECT LIGHT DOWN DIAGONAL OF TABLE.
II. SPREAD BEAM.
III. PLACE OBJECT AND FILM HOLDER IN RELATIVE POSITIONS SO THAT THERE IS A FRONTAL VIEW OF THE OBJECT FROM THE VIEWPOINT OF THE FILM HOLDER, AND THE FILM HOLDER IS NOT IN THE BEAM PATH. MAKE SURE THE OBJECT IS WELL LIT.
IV. MEASURE DISTANCE FROM LAST LENS TO OBJECT TO FILM.
V. POSITION BIG MIRROR TO REFLECT LIGHT ONTO FILM PLANE WITHOUT HITTING THE OBJECT, MAKING SURE THE DISTANCE FROM LAST LENS TO MIRROR TO FILM HOLDER IS THE SAME LENGTH AS IN IV.
VI. CHECK THE BEAM RATIOS.. REFERENCE BEAM INTENSITY SHOULD BE ONE TO THREE STOPS GREATER THAN THE OBJECT BEAM INTENSITY.
VII. MAKE THE EXPOSURE READING WITH THE WHITE DIFFUSER CAP OFF THE LIGHT METER.
VIII. EXPOSE AND PROCESS.
IX. RECONSTRUCT THE HOLOGRAM.

LESSON 3 HOLO I 2/5/81

congratulate on first holograms
show div. of amp. set ups. (pulsed portrait)
review processing
explain reflection set up for next week + objects to bring

Fine Arts Research & Holographic Center LESSON PLAN

School of Holography LESSON 3 HOLO I

Congratulate on first holograms

SHOW DIFFRACTION

SHOW INTER FERENCE FRINGES AGAIN

SHOW RAINBOW GLASSES

DESCRIBE DISPERSION IN
A PRISM AND D. GRATING

DESCRIBE SET UPS,
BEAM SPLITTERS

GO TO WORK

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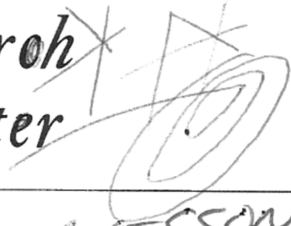


School of Holography

LESSON 3 HOLO I

CONGRATULATE ON FIRST HOLOGRAMS

SHOW INTERFERENCE FRINGES AGAIN

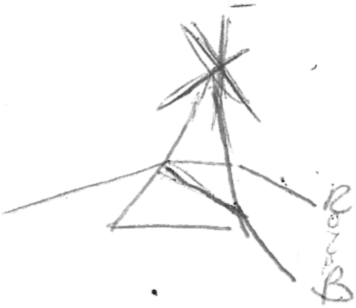
GET RAINBOW GLASSES

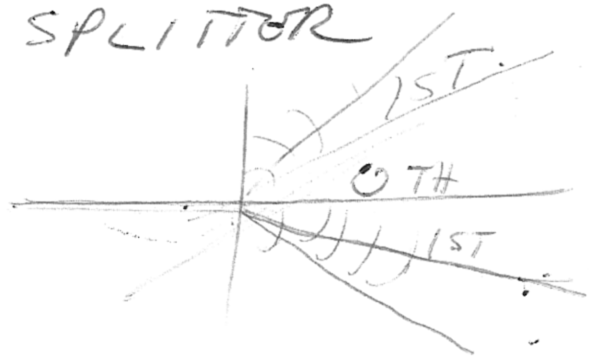
DESCRIBE DIFFRACTION GRATING

HOLOGRAM OF NO OBJECT

WHY DO YOU GET A RAINBOW

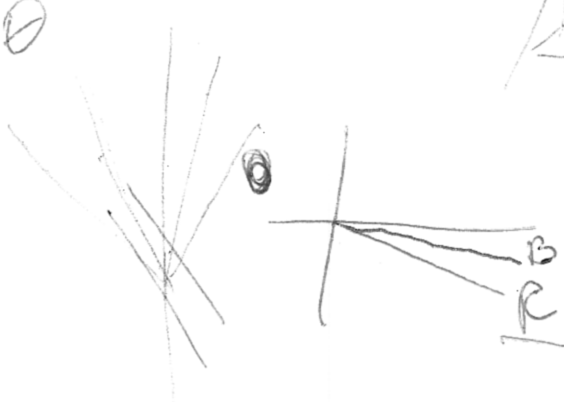
BEAM SPLITTER

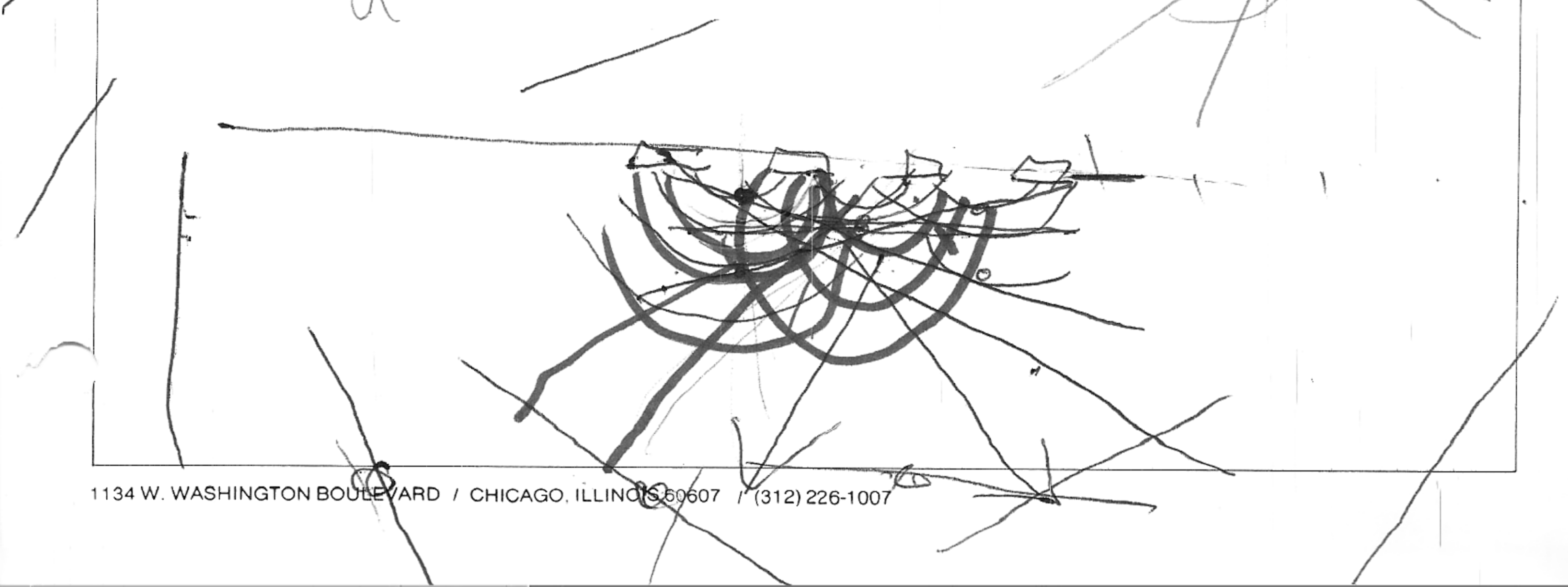




$m\lambda = d \sin\theta$

$\frac{m\lambda}{d} = \sin\theta$





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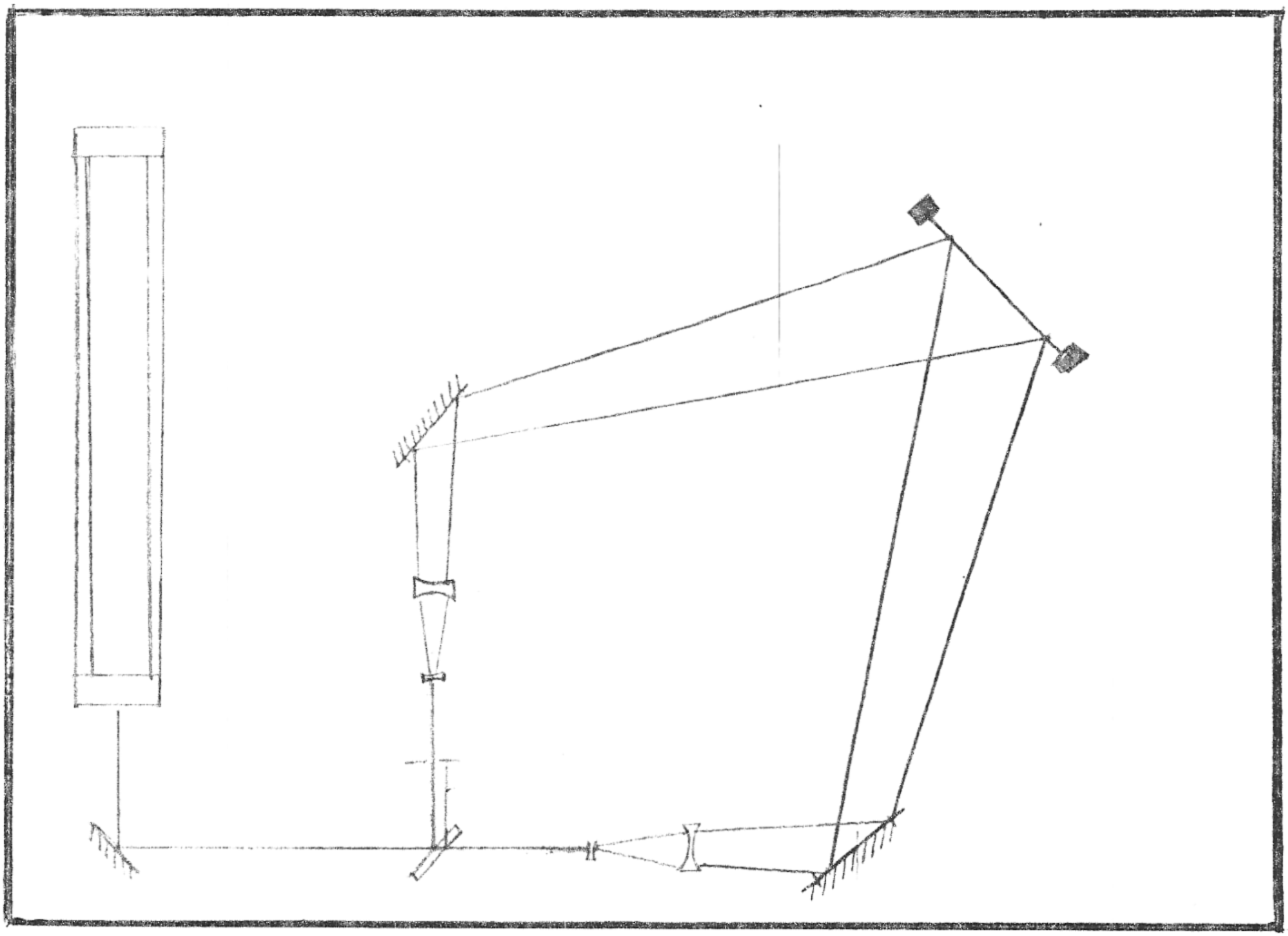
Diffraction Grating Set up



notes

THE ANGLES AT WHICH THE BEAMS HIT THE FILM HOLDER ARE NOT CRITICAL UNLESS YOU ARE INTERESTED IN A SPECIFIC SPATIAL FREQUENCY. HOWEVER, IT IS VERY IMPORTANT THAT THE BEAM PATH LENGTHS ARE THE SAME FOR THE SHARPEST INTERFERENCE FRINGES.

set up steps

I. PUT SMALL MIRROR AT LASER EXIT TO LET LIGHT RUN ALONG EDGE OF TABLE.
II. PUT BEAM SPLITTER IN BEAM PATH ABOUT A THIRD OF THE WAY DOWN THE TABLE.
III. PUT DOWN TWO BIG MIRRORS EACH THE SAME DISTANCE FROM THE BEAM SPLITTER.
IV. PLACE FILM HOLDER AT A POINT THAT IS EQUIDISTANT FROM BOTH MIRRORS.
V. SPREAD BEAMS WITH LENSES.
VI. TAKE EXPOSURE READING WITH BOTH BEAMS HITTING THE LIGHT METER.
VII. EXPOSE AND PROCESS THE FILM.

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School of Holography LESSON IV HOLO I

WAVE FRONTS
DIFFRACTION

HOW IT'S MADE SHOW BRAGG DIFFRACTION
DENISYUK

ATTRIBUTES OF REFL

COLOR
REAL VS. VIRTUAL
CAN'T PROJECT LIKE T.
SET UPS + PROCESSING

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SINGLE BEAM REFLECTION
overhead set up

notes

THIS SET UP HAS THE ADVANTAGE OF MORE STABILITY THAN THE HEAD ON SET UP BECAUSE ANY VIBRATION TRAVELLING UP FROM THE FLOOR WILL CAUSE THE OBJECT AND FILM TO MOVE TOGETHER AS A UNIT. IN THE OTHER SET UP, VERTICAL MOTION WOULD MOVE THE FILM AND OBJECT SEPARATELY, BLURRING THE FRINGE PATTERNS. THIS IS AN EXCELLENT SET UP FOR MAKING HOLOGRAMS OF FLAT OBJECTS LIKE KEYS, COINS, WATCHES, BELT BUCKLES AND RAZOR BLADES.

SET UP STEPS

I. PUT A SMALL MIRROR AT END OF LASER TO DIRECT BEAM BOTH DIAGONALLY ACROSS TABLE AND UP.

II. DIRECT BEAM STRAIGHT DOWN WITH AN OVERHEAD MIRROR.

III. TEMPORARILY PLACE OBJECT STAND WITH WHITE CARD ON IT UNDER THE BEAM.

IV. SPREAD BEAM WITH LENSES SO THAT THE CLEAN AND BRIGHT PART JUST COVERS THE SIZE OF THE FILM YOU ARE USING TO MINIMIZE EXPOSURE.

V. SLIDE OBJECT STAND OFF TO THE SIDE AND TAKE AN EXPOSURE READING WITH THE LIGHT METER POINTING STRAIGHT INTO THE BEAM AT THE PLANE WHERE THE FILM WILL BE PLACED. NO RATIO READING IS NECESSARY, AS THE OBJECT DETERMINES THAT.

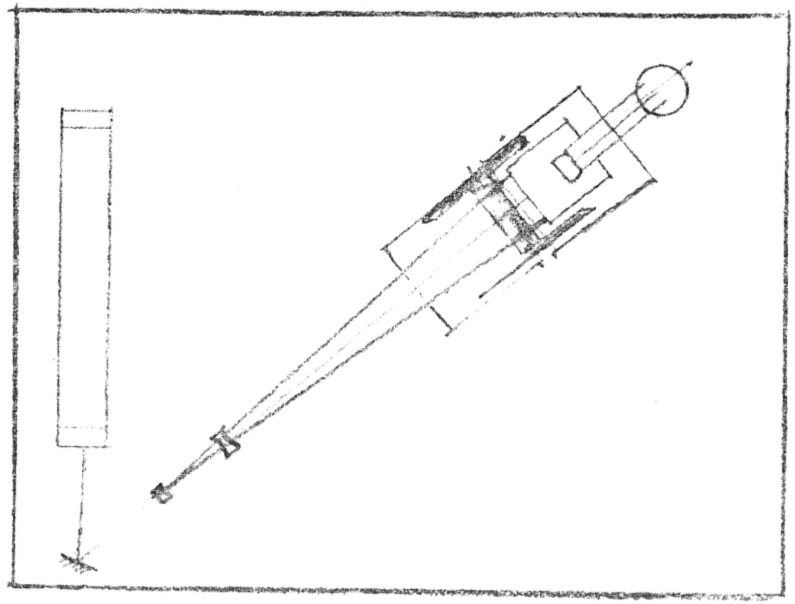
VI. REPLACE OBJECT STAND AND PLACE THE OBJECTS IN THE CENTER OF THE BEAM.

VII. BLOCK OFF THE BEAM WITH THE CARD.

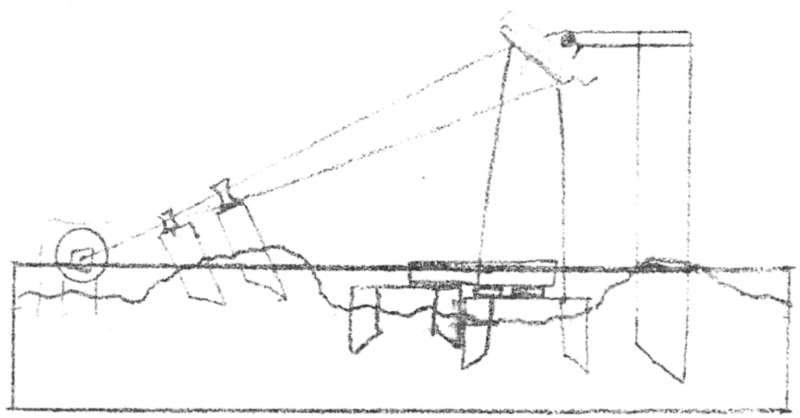
VIII. AN EXTRA OBJECT STAND MIGHT BE NEEDED TO SUPPORT THE FILM HOLDER AS IT LAYS ON TOP OF THE OBJECTS.

IX. EXPOSE AND PROCESS.

X. RECONSTRUCT THIS HOLOGRAM UNDER WHITE LIGHT.

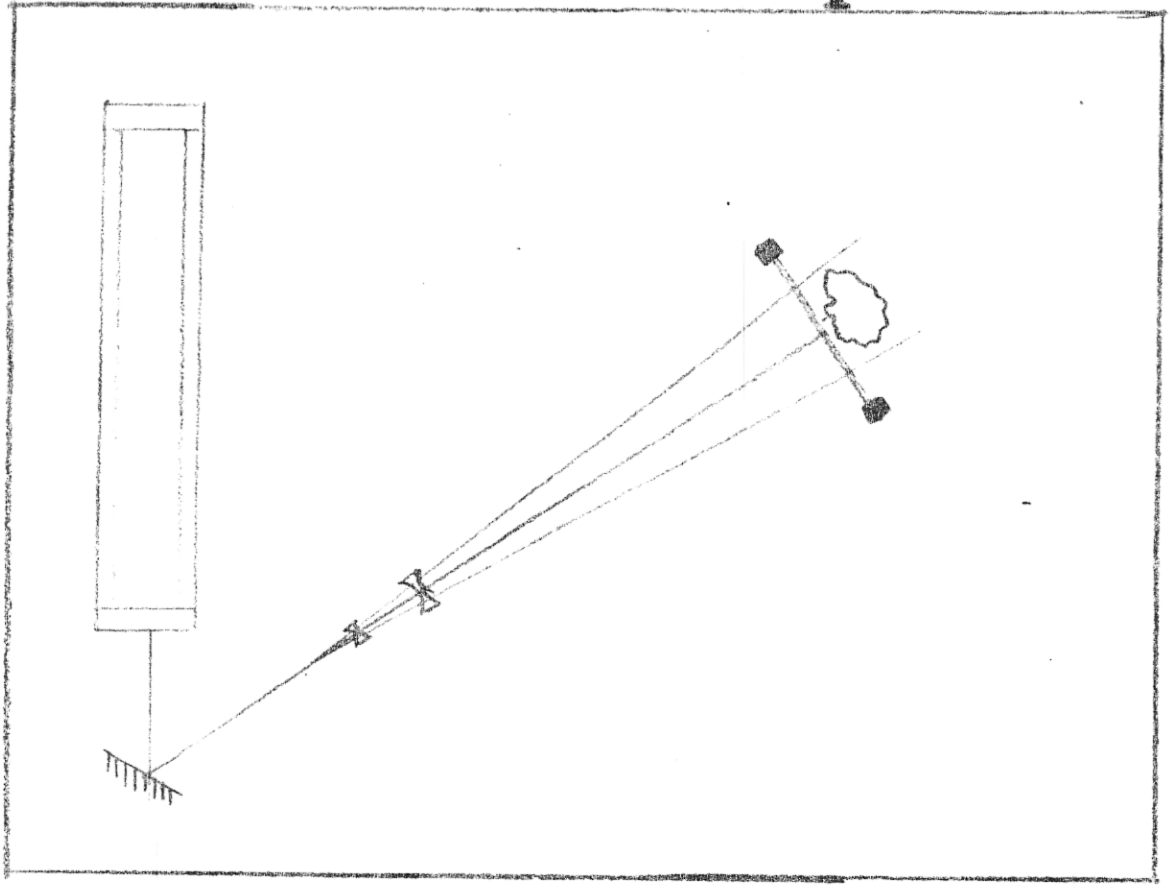


top view



side view

SINGLE BEAM REFLECTION
head-on set up



notes

BECAUSE THE DEPTH OF THIS HOLOGRAM IS ONLY ABOUT TWO INCHES AND THE RATIO OF REFERENCE TO OBJECT BEAMS MUST BE 1 TO 1, YOU ARE LIMITED TO OBJECTS THAT ARE SHALLOW AND AS NEAR TO 100% REFLECTIVITY AS POSSIBLE. COINS, KEYS, NUTS, BOLTS, SPRINGS, HOOD ORNAMENTS AND LITTLE ROBOTS ARE USUALLY SUCCESSFUL. NO MOVEMENT CAN BE TOLERATED DURING EXPOSURE SO PILE PLENTY OF SAND AROUND ALL THE COMPONENTS AND HOT GLUE DOWN THE OBJECTS THAT MIGHT MOVE.

set up steps

I. SEND BEAM DIAGONALLY DOWN THE TABLE WITH A SMALL MIRROR.
II. SET UP THE OBJECT STAND AND FILM HOLDER.
III. SPREAD THE BEAM SO THAT THE CLEAN AND BRIGHT PART OF IT JUST COVERS THE SIZE OF FILM YOU ARE USING.
IV. MEASURE THE AMOUNT OF LIGHT HITTING THE FILM PLANE BY POINTING THE LIGHT METER INTO THE BEAM WITHOUT THE WHITE DIFFUSER CAP IN PLACE. THIS IS THE EXPOSURE READING. THERE IS NO NEED TO TAKE RATIO READINGS SINCE THE RATIO IS CONTROLLED BY THE REFLECTIVITY OF THE OBJECT.
V. POSITION OBJECT RIGHT NEXT TO THE FILM HOLDER.
VI. EXPOSE AND PROCESS.
VII. THIS HOLOGRAM CAN BE RECONSTRUCTED UNDER WHITE LIGHT.

LESSON V

Test strips
½ min development
restress problem areas

HANDOUTS