ONE STEP RAINBOW SHADOWGRAM
For 8 by 10 inch or Smaller Holograms on the Beginning Table

SKETCH THE SET UP IN THE BOX ABOVE

PARTS LIST

1. LASER
2. SHUTTER
3. SPATIAL FILTER
4. 8 by 10" MIRROR in GOALPOST CONFIGURATION with TWO MAGNETIC BASES and RIGHT ANGLE CLAMPS
5. 10 by 12" MIRROR in GOALPOST CONFIGURATION with TWO MAGNETIC BASES and RIGHT ANGLE CLAMPS
6. 8 by 10" FILMHOLDER ASSEMBLY in GOALPOST CONFIGURATION with TWO MAGNETIC BASES and RIGHT ANGLE CLAMPS
7. HALF-WAVE PLATE ASSEMBLY
8. POLARIZING BEAMSPLITTING CUBE ON MAG BASE AND TILT PLATFORM ASSEMBLY
9. HALF-WAVE PLATE ASSEMBLY
10. FIRST OBJECT BEAM STEERING MIRROR ASSEMBLY
11. SECOND OBJECT BEAM STEERING MIRROR ASSEMBLY
12. CYLINDRICAL LENS ASSEMBLY
13. THIRD OBJECT BEAM STEERING MIRROR ASSEMBLY
14. DIFFUSELY REFLECTING SLIT ASSEMBLY
15. SLIT BAFFLES
16. DRILL PRESS VICE TO HOLD OBJECT
17. CLEAN GLASS PLATE
18. GNOMON
19. S & M LIGHT METER
20. OFFITIAL RULER
21. MIRROR COVER WITH VELCRO

NOTE

Notice that this set up grows out of the **SINGLE BEAM TRANSMISSION WITH MIRROR MASTER SET UP**, and that parts 1-5 and 7 may already be on the table, with only slight tweaking to get the beam where you need it.

SET UP STEPS

1. Send the Beam from the **LASER** held in its usual position at the end of the **ISOLATION TABLE** to the center of an **8 by 10" MIRROR** held between two **MAGNETIC BASES** in the GOALPOST manner. Check for the **OFFICIAL BEAM HEIGHT** with the **OFFITIAL RULER** at the **MIRROR**.

2. Direct the Beam from **MIRROR (4)** diagonally across the Table to the center of the **10 by 12" MIRROR (5)** held between two more **MAGNETIC BASES** in the usual GOALPOST manner. Check for the **OFFICIAL BEAM HEIGHT** with the **OFFITIAL RULER** at the last **MIRROR** and tilt **MIRROR (4)** if necessary.

3. Direct the Beam from **MIRROR (5)** across the Table more or less parallelto the Table's edge. Check for the **OFFICIAL BEAM HEIGHT** with the **OFFITIAL RULER** at the edge of the Table and tilt **MIRROR (4)** if necessary.

4. Direct beam from **MIRROR (5)** more or less parallel to the table edge to center of **8 by 10" FILM HOLDER (3)** also held between two **Large Magnetic Bases** in the <u>goalpost manner</u>. Check the angle of incidence of the raw undiverged beam with a **PROTRACTOR** and adjust it to <u>45 degrees from the normal</u> (or whatever you need). Use the **Gold Painted Lines** on the **Tabletop** as positioning guides. The center of the **FILMHOLDER** should be lined up with the right bar of the **SLIT ASSEMBLY**.

5. Insert the **FIRST HALF-WAVE PLATE ASSEMBLY (7)** into beam after **LASER**, before the **SHUTTER (2)**. This **HALF-WAVE PLATE** will be used to control the **BEAM BALANCE RATIO**.

6. Insert **POLARIZING BEAMSPLITTING CUBE ASSEMBLY (8)** into the beampath, oriented so that the reflected beam (the one that makes the 90 degree turn) heads away from the center of the table, toward the edge.

7. Measure the **REFERENCE BEAM PATH Length** with <u>string</u>, from **POLARIZING BEAMSPLITTING CUBE ASSEMBLY (8)** to **LARGE CORNER MIRROR (4)**, to other **LARGE CORNER MIRROR (5)**, to **8 by 10"**

FILM HOLDER (6). Tie one end of the string to the **BEAMSPLITTING CUBE SUPPORT ROD**, and mark the other end of the string with a piece of tape.

8. The **OBJECT BEAM PATH** starts at the **POLARIZING BEAMSPLITTING CUBE ASSEMBLY (8)** and is defined by a trio of **SMALL MIRROR ASSEMBLIES (10), (11) and (13)** (consisting of a **Newport MM-2** or equivalent on **Magnetic Bases**) reflecting light to the **DIFFUSELY REFLECTING SLIT ASSEMBLY (14)** and then to the **8 by 10" FILM HOLDER**. Since **(8)** and **(14)'s** positions are defined, and the **OBJECT BEAM PATH Length** must match the already-measured **REFERENCE BEAM PATH Length**, use the string to find the proper locations of **(10), (11)** and **(13)**. Attach one end of the string to the **POLARIZING BEAMSPLITTING CUBE ASSEMBLY** and follow the **REFERENCE BEAM PATH** with it and attach the other end to the **FILM HOLDER** with tape. Keep the string attached to the **FILM HOLDER** and draw it taut over to the **DIFFUSELY REFLECTING MIRROR ASSEMBLY**. The slack will then be taken up by the trio of **SMALL MIRROR ASSEMBLIES**. Usually the first one, **(10)** will be placed almost immediately after the **POLARIZING BEAMSPLITTING CUBE ASSEMBLY** and direct the undiverged beam along the table edge to locate the second **Mirror, (11)**, next to the **8 BY 10" MIRROR** which then sends the beam to the center of the table. With the **BEAM PATH STRING** wrapped around the first two mirrors, the remaining slack, from **Mirror (11)** to the **SLIT ASSEMBLY** must be taken up by the third **Mirror**. This **Mirror** may be placed anywhere the string allows, but the best location is where the knobs are convenient for tuning the color.

9. Another **HALF-WAVE PLATE ASSEMBLY (9)** needs to be placed in the **OBJECT BEAM PATH** to rectify the **POLARIZATION VECTOR** of the beam reflected out of the **POLARIZING BEAMSPLITTING CUBE** to match that of the transmitted **REFERENCE BEAM**. Verify that the transmitted beam is indeed <u>horizontally polarized</u> with a sheet of **POLARIZING FILTER**. Put the **POLARIZING FILTER** in the **OBJECT BEAM PATH** and rotate this **HALF-WAVE PLATE (9)** in its mount until the two polarizations match. (See the handout, **ALIGNING POLARIZATION VECTORS**, for additional hints.)

10. A **CYLINDRICAL LENS (12)** is placed before the **THIRD SMALL MIRROR ASSEMBLY (13)** to vertically expand the laser beam. Adjust the **SMALL MIRROR ASSEMBLY** so that its <u>horizontal adjustment</u> is racked out to the maximum right position. Adjust the **SMALL MIRROR ASSEMBLY'S Magnetic Base** so that the undiverged laser beam impinges on the **DIFFUSELY REFLECTING SLIT ASSEMBLY** on its right edge, (the one lined up with the center of the **FILMHOLDER**), at the height

of the center of the **FILMHOLDER**, and then the diverged stripe should have its bright center at that spot. The stripe should be completely vertical. Simply turning the horizontal control on the **SMALL MIRROR ASSEMBLY (13)** should sweep the stripe across the **DIFFUSE REFLECTOR**.

11. With the **Light Stripe** at the right edge, tilt the **DIFFUSELY REFLECTING MIRROR ASSEMBLY** so that the maximum amount of light is reflected onto the **FILMHOLDER** from the right **MIRROR STRIP**. Try not to move the right edge of the **REFLECTOR** away from the center of the **FILMHOLDER**.

12. With the **THIRD MIRROR** move the stripe beam to the **SECOND REFLECTOR** on the **SLIT ASSEMBLY**. Loosen the knobs on the top and bottom of the **REFLECTOR** and aim it so that the maximum amount of light is reflected onto a white card in the **FILMHOLDER**.

13. Tune the rest of the **SLIT ASSEMBLY'S REFLECTORS** to direct the maximum amount of light onto the **FILMHOLDER**.

14. **REFERENCE BEAM PATH:** (The beam straight through the **Beamsplitter**) Add the **SPATIAL FILTER (3)** after the **POLARIZING BEAMSPLITTING CUBE ASSEMBLY**. Align it so that the diverged beam is centered on a white card in the **8 by 10" FILM HOLDER**. Verify that the **angle of incidence** of the diverged beam is **45 degrees** with a **gnomon**. For **8 by 10" holograms**, use the **10X MICROSCOPE OBJECTIVE** with the **25 micron PINHOLE**. Put off installing the **PINHOLE** until the end.

15. Balance the **BEAM RATIO** by rotating the first **HALF-WAVE PLATE (7)** for a **REFERENCE TO OBJECT BEAM RATIO** between 2:1 and 4:1. Find the appropriate exposure time from the handout, **S & M's SUPERSENSITIVE PHOTO METER DARKROOM MODEL A-3**.

16. Insert the **SHUTTER ASSEMBLY (2)**. Add the **CARDBOARD SLIT BAFFLE ASSEMBLY (15)** (consisting of two closely spaced tall pieces of cardboard in a grooved holder) to eliminate the scatter on the **DIFFUSE REFLECTOR** from the **CYLINDRICAL LENS**. Add other baffles as necessary, especially one near the **LASER**, which should also be posItioned to prevent the **HOLOGRAPHIC FILM** from seeing the spot of light reflected from the **SHUTTER**. Don't forget to put the **PINHOLE** in the **SPATIAL FILTER**.

17. Expose, process, and evaluate.

CALIBRATION OF THE ONE-STEP RAINBOW SHADOWGRAM SET UP

I. EXPOSURE

Usually the recommended exposure time determined by the **SCIENCE & MECHANICS A-3 PHOTO METER** is good enough for a decently bright hologram. But if you are going to mix images and colors with this set up, it is essential to make a good exposure test series hologram for reference, as the response of the eye to brightness and different colors and that of the holographic film don't necessarily match. Our eyes are most sensitive to green colors, less to the red, and even less to the blue. To compound the problem even further, the typical incandescent source used for reconstruction is strongest in the red, and weakest in the blue. To make a **RAINBOW HOLOGRAM** in which the three primaries are apparently matched in luminosity would require that the blue image be the brightest, the red a little weaker, and the green weakest. By examining the dynamic range available in the hologram through a test strip, good results can come quicker.

A good starting point is to make a series of four exposures on a single sheet, one-fourth of, one-half of, the recommended time and twice the recommended time. You might not be able to see much difference between the first three, so you might like to expose even shorter, (keeping the development time the same!) to find the threshold of exposure for the set up, as subtle colorings are essential for mixing. The extra overexposure is necessary to find the saturation point of the process, as you may want to expose three or even four times, and may need to use up all the available information storage capacity.

II. COLOR CALIBRATION

Control of color in any **RAINBOW HOLOGRAM** (using a single color of laser light) is determined by the position of the slit during the exposure. With the **ONE-STEP RAINBOW SHADOWGRAM SET UP** on the **Experimental Table**, color tuning is made as simple as turning a knob on a **Newport MM-2 Mirror Mount**. The stripe of laser light on the **SLIT ASSEMBLY** determines the location of the dispersed spectra in the final holographic replay. (For the Theory, see the diagrams later on in this handout.)

MAKING A COLOR CALIBRATION HOLOGRAM

1. Make sure that the stripe of laser light is directly in front of the normal to the **FILHOLDER**. This will become the red exposure.

2. Cover all but one-fourth of the **FILMHOLDER** with a **CARDBOARD BAFFLE**. Expose for the Normal Time.

3. Take the **CARDBOARD BAFFLE** off the **FILMHOLDER**, and uncover the next quarter strip of film, covering the rest. Cover

the **FILMHOLDER** with a **VELCROED MIRROR MOUNT COVER**. Open the **SHUTTER**. Move the **SLIT BAFFLE** out of the way. Translate the **STRIPE OF LASER LIGHT** to the next **REFLECTOR** on the **SLIT ASSEMBLY**. Replace **SLIT BAFFLE**. Close **SHUTTER**. Remove **VELCROED MIRROR MOUNT COVER**. Expose again for the Normal Time. (Now it may become apparent why the **CYLINDRICAL LENS** is placed before the **MIRROR MOUNT**.)

4. Repeat **STEP 3** twice, moving the slit to the left each time and uncovering a fresh quarter of film, keeping the other ones covered.

5. Process the film and let it dry for the evaluation.

EVALUATING THE COLOR TEST

The colors in a **RAINBOW HOLOGRAM** are <u>iridescent</u>; they change with position of the hologram with respect to the viewer or to the reference beam. To properly evaluate this tester, flatten the hologram between two pieces of glass, hold the sandwich at arm's length, your eyes located in the center of the vertical dimension, and look along the NORMAL. Walk toward or from the replay light with the hologram until the first quarter is red, and observe what colors the other quarters replay in. If lucky, the last one will be blue or violet. If the last quarter is green while the first is red, then the slit was not moved enough; if the last is vacant (barring recording difficulties) and the third is blue, then the slit was moved too much.

OTHER OBSERVATIONS: Try tilting the hologram; in one direction the red part will become green, the green blue, the blue disappearing, (actually turning ultraviolet). The other way will make the red disappear, (turning infrared), with the green becoming red, and the blue turning green.

Have someone else hold the hologram, and position yourself so that the first quadrant is red again. As you squat down, the red will become green, the green blue, and the blue UV. Standing on tippy-toes will make the red IR, the green red, and the blue green. When creating **RAINBOW HOLOGRAM ARTWORK**, you should keep in mind these effects, and program your colors for a certain viewing height.

OBJECT PLACEMENT

Usually the object is placed far enough back from the **FILMHOLDER** so as to not intrude into the reference beam, which would create a dead space on the surface of the hologram. But if the object is too far back, its edges start to blur out and may become too vague and greatly enlarged.

Sometimes in the case of generating abstract patterns it may be more interesting to let the object cast its shadow into the reference beam. A moire pattern could be generated by the object generating a beat frequency with the light transmitted through it from the slit and the reference beam.

If text is to be used, its orientation is important so that it will become readable in the final replay. Since the real, pseudoscopic, or "flipped" image is used, the letters need to be "pre-flipped" in the recording stage, but not written backwards! As an example, consider the simple message, **SAIC HOLO**, to be used in a top lit hologram. It should read thus from the viewpoint of the **HOLOGAPHIC FILMHOLDER**:

It is best to rehearse the placement of the object, by holding it in front of the plateholder as it would float in the final reconstruction, and then rotate it along the flipping axis of the **FILMHOLDER** back into the recording zone. Sometimes if you make a mistake, you can display the hologram with a bottom reference beam. However, this type of hologram will not work with side references, at least not for three-dimensional effects. With a side reference an object would have a rainbow wash across it from side to side.

FUN WITH OBJECTS IN THE ONE-STEP RAINBOW SHADOWGRAM

THREE-DIMENSIONAL OBJECTS: The most obvious thing to do is to make black three-dimensional silhouettes of things, surrounded by a colored ground. The objects used could be less than stable, since their surface is not holographed, only their shadows cast by the backlighting strip. This means that parts of the body, like finger language, or facial profiles can be made without pulsed lasers or stereographic techniques.

Transparent or translucent objects can also be used to great advantage. One of the best things made in this lab were spider webs of hot glue on glass sheets.

2-D GRAPHICS (Holographic Silkscreening): This is the basis of the holographic sticker industry. Color separated graphics are typically used, but continuous tone photographic imagery could also be utilized. The underlying design principles are similar to the thinking required for silkscreening. If a certain color is desired in an area, clear areas will let light through, like ink, and then to color in the other areas, a negative of the above is used when the slit is changed.

The transparencies could be sandwiched with the film itself, on the cover glass of the **FILMHOLDER**, or separated completely, leaving the imagery floating in space. Watch out so that the object isn't located in the **Reference Beam**.

HOLOGRAPHIC NEON: Cutting thin outlines out of cardboard will result in colored lines floating in a black space, like a neon sign. Hold a couple of razor blades together side by side, maybe with a piece of cardboard between them to vary their width, and the design will be cut as a pair of parallel lines. Carefully poke out the cardboard inside, and use in the setup.

Another source of materials to use are recycled dud holographic film or plates. Develop the non-hologram with the room lights on until it gets as dark as it possibly can. Wash and Photo-Flo and dry. Then scribe away the black emulsion with a pointy object for your design.

MOIRE PATTERNS: Using chunky grids, with visible moire patterns, like the white plastic racks in the **AGFA PLATE BOXES**, will give cool patterns that can be collaged into new designs. But Moire can also be generated by two objects that were were not exposed simultaneously, by first holographing one grid, then moving the slit and grid for a second exposure.

CAUTION: Serious consideration must be given to the choice of transparency material used in the above configurations. Some plastics are birefringent; they twist polarizations. Light may pass through them, but its exiting polarization may become oriented 90 degrees to the way that it came in, when it was aligned in the same plane as the reference beam. It may not interfere with the **Reference Beam**. Black bars may appear on the artwork. <u>Polyester</u>, especially <u>Kodak **Estar**</u>, used in **Kodaliths**, is the worst. <u>Acetate</u>, which is what **Holographic Film** is made of, does not have this problem, and neither does glass. Since our eyes do not detect alignment of polarization vectors, the material must be interrogated.

TEST FOR BIREFRINGENCE, WHITE LIGHT: Place a sample of the material between a pair of <u>crossed polarizers</u>. (No light passes through the two crossed "picket fences" for polarization vectors.) If <u>colors</u> are seen through the sandwich, then the material is <u>birefringent</u>.

TEST FOR BIREFRINGENCE, LASER LIGHT: Put the material in the **ONE-STEP RAINBOW SHADOWGRAM SET UP** and look at the light of the slit through it with a <u>polarizing filter</u>. If black bands appear on the artwork, it is unacceptable. Watch the black bands change positions as you rotate the <u>polarizing filter</u>.

As contradictory as it sounds, a birefringent piece of transparency can be used if it is in contact with the **HOLOGRAPHIC FILM**. This is because both the **Reference** and **Object** beams will have their polarizations twisted the same amount, and therefore will still be able to interfere.

However there is a different danger when film is in contact with the **Holographic Film**. Some overhead transparency films have a toothy texture to their surface to accept the toner and will destroy the spatial coherence of the **reference beam**. This results in **ONE-STEP RAINBOW SHADOWGRAM HOLOGRAMS** that reconstruct with weak pastelly results.

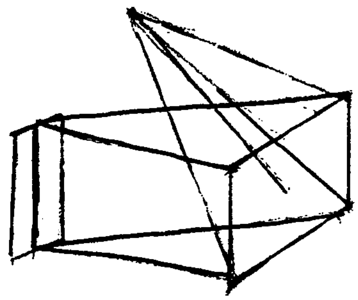
THE TEST FOR FUZZINESS: Look through the overhead material (and even some photographic film bases exhibit this defect) at a point source, like a holographic replay light, an LED, or the pinhole of a **Spatial Filter**. If there is a hazy cloud around the source of light, then the material is unacceptable for placing in contact with the **Holographic Film**. It is OK to use in the **Object Beam Path** only.

PERCEPTION OF THE ONE STEP RAINBOW SHADOWGRAM

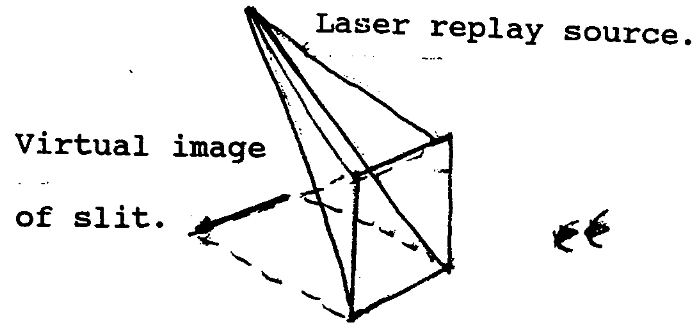
This is perhaps one of the most difficult holograms to perceive; sometimes it takes moments of study to establish spatial relationships in the reconstruction. The reason is that the observer is looking at the holographic plate in the same relationship as a pair of eyes positioned along the diffusing slit views the holographic plateholder during the recording. Because the latter pair of eyes are linked to the slit, allowing lateral movement the perception of the vertical aspects of the object cannot be made by vertical repositioning of the observer but rather by tilting the eyes up and down, which takes longer to process. It is like looking at the entirety of a construction site through a gap in horizontal fence boards. Since the non-image plane objects (those generated by masks not placed directly on the filmholder but separated) are silhouettes (pure black shadows) or are filled in with different colored shapes, spatial relationships cannot be deduced until their edges are established, using temporal paralactic movements by seeing which things occlude what, but complicating this is the fact that some objects are transparent.

Another problem is that the hologram's image is typically pseudoscopic, and more than likely severely aberrated because of mismatching of the recording and replay reference beams. Motion of the viewer's head will cause the objects to move unnaturally fast and contrary to the expected result. Of course, this is the fun of this type of hologram.

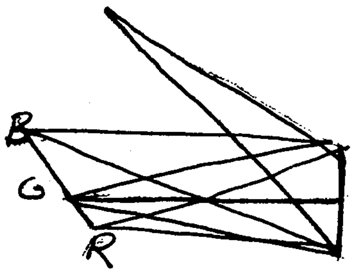
Because of aberrations, the size of the holographic image is much larger than the object, and the danger is that the objects may be so much enlarged that they do not fit in the frame of the plate. When an object is occluded by the edge of the hologram, the perception of it floating in front of the film plane immediately changes to that of an object at the film's surface or behind it. (In actual, non-holographic space the only reason why an object would disappear at the edge of a frame is because it is behind the window.) Keep the object placed pretty much in the center of the frame. This is also the reason that fields of pure color, with no objects in the way, seem to lie on the surface of the plate and not off the surface.



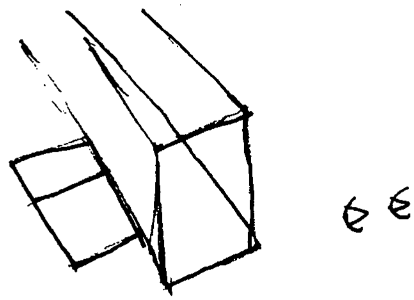
Although the reference beam enters the holographic plate from the side and the stripe of laser light on the ground glass is oriented vertically,



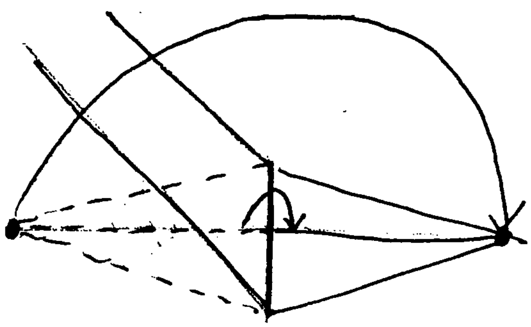
the hologram is designed to be reconstructed with an overhead reference beam with the slit horizontal.



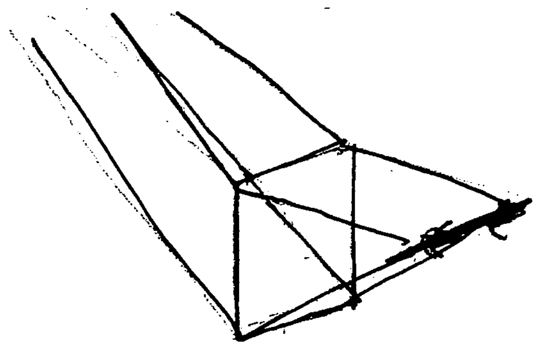
When the hologram is illuminated with white light, each color reconstructs its own image of the slit at a different position.



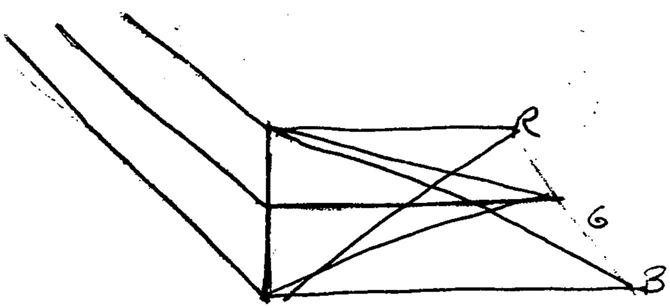
The viewer sees a rainbow virtual image of the slit.



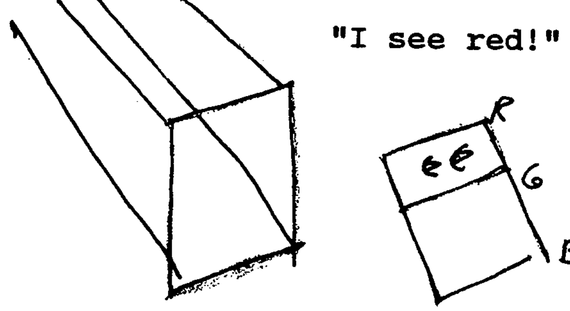
If the laser lit hologram is "flipped" a real image of the slit is focussed in space.



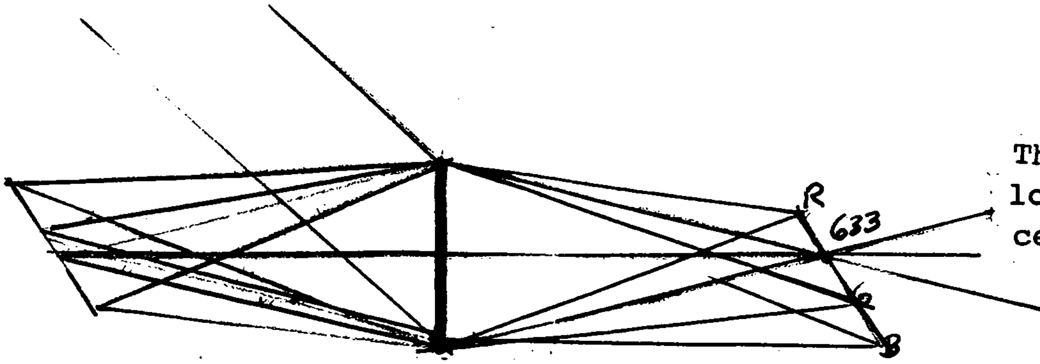
When the viewer's eyes are positioned at the slit the whole hologram glows red.



White light replay of the flipped hologram produces a separate real image of the slit for every wavelength.

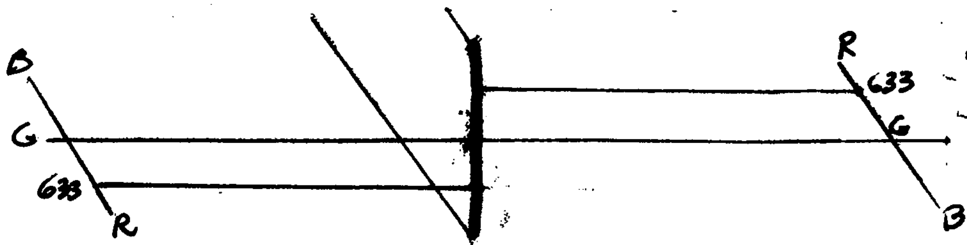


The image changes color with the vertical position of the viewer.

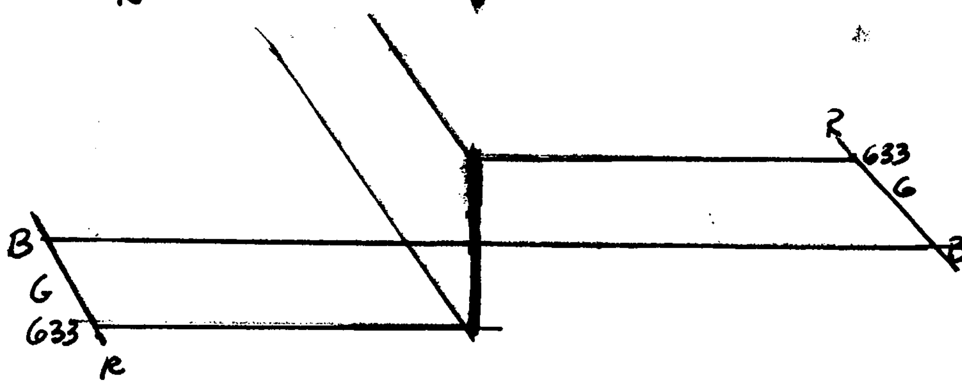


The viewer sees red looking at the center of the plate.

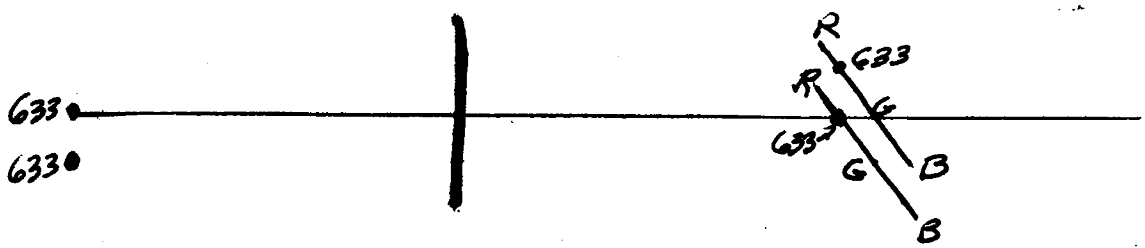
The position of the slit during the recording determines where the 633 nm component of white light will appear in replay. The rest of the rainbow spreads out proportional to wavelength.



The viewer sees green along the center of the plate.



The viewer sees blue along the center of the plate.



A pair of slits can blend colors according to the additive primary rules.

Where the colors fall can be calculated, but making a color pallette is more fun.

PARAMETERS WE USED:

_______SLIT DISTANCE

_______REFERENCE ANGLE

DISTANCE FROM NORMAL CENTERLINE

_______RED

_______GREEN

_______BLUE

Designing for Embossing

Dorothy James

This is the second article written for people with a graphic arts background who want to work with embossed holography. In the Winter 1984 article, general design considerations were discussed. Here I will go into more detail about the design process and expense for embossing.

Your design process should start with some homework: get a small selection of embossed holograms and study them carefully. With really dimensional images, how deep does the volume of the image appear compared with the frontal dimensions of the hologram? If part of the image projects, how far does it appear to project out of the image plane? Does part of the image appear pseudoscopic (inside out and backwards)? Are you satisfied with the clarity of the image? What is the content of the image, and what market would it appeal to? Looking at dimensional images which have been embossed, you will find that most are images of objects which have a "generic" quality to them – seashells, rocks, bones, dice, etc. Occasionally a hologram with narrative content will be embossed, such as Dan Schweitzer's *Stargate*. Too little work has been done with 3D "sets" for there to be much reference available in this aspect of holographic design. Generally it seems that someone has said: "Here's a neat object to make into a hologram. It's small and dense and probably will appeal to a lot of people." Not much imaginative use of space inside the image volume is in evidence in most of the 3D embossed holograms. This is a good area to show your stuff as a creative person: how can you use the volume effectively? What can you offer to the viewer besides just an object? Can you evoke emotion or tell a story?

More creative work is being done in the 2D/3D design area, although the general idea seems to be to produce cute, innocuous images. The "generic" idea in these graphic holograms tends towards hearts, stars, rainbows, mythical beasties, city scenes and the like – common symbols with proven mass market appeal. Many of the 2D/3D's have a "star field" background, which does not always seem congruous with the graphic content of the image.

Looking at the 2D/3D stickers analytically, count the numbers of separate layers which constitute the total graphic image. Manipulate the hologram under a good point light source and count the different colors visible at any given angle of view. Each separate color area in a layer represents an exposure at a different diffraction angle when the master hologram was made.

The following illustrations may help you to analyze the 2D/3D images you have seen. Fig. 1 shows the black and white graphic elements as they may appear in the design for the hologram.

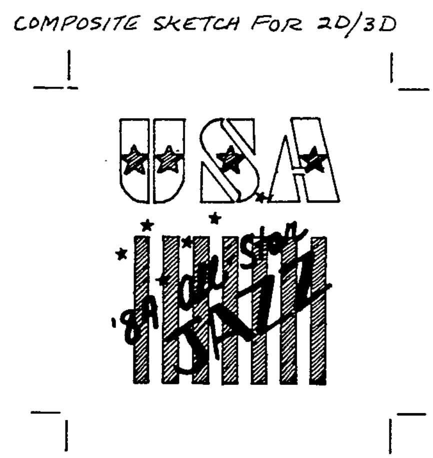


fig. 1

In Fig. 2 you can see how these elements may be separated for color and spatial arrangements. Note the use of crop marks and center marks for registration. This is critical in 2D/3D's and diffraction grating artwork, where a slight misregistration may produce a line of light or an opaque gap where edges adjoin.

Dimensional images and graphic elements can be combined in a design. Be sure that you have indicated clearly how they are to be placed in the image volume relative to one another; provide detailed sketches for the embosser to go by. For registration of a 3D object to your 2D graphics, some leeway should be planned into the design. Try not to make the position of the object and graphics critical to within 1/8 in., for example, in a 2 in. x 2 in. image. If you have 2D graphics at the surface of the image, plan on anything directly behind that to be obscured by the 2D – you cannot see through the diffraction grating to look at something behind it.

Mount your 3D object so that it is as stable as possible, supported from behind and in a manner which will provide that stable support whether your object is upright or turned 90° on its side. This will allow the embosser maximum flexibility in lighting for proper reconstruction. If you are not sure of how to mount the object, wrap it securely and send it with detailed sketches (fig. 3, 4) for the embosser to use as guidelines in placement. (An alternative: mount the object on nondistorting optical glass, with registration marks on the glass.) Make sure you indicate clearly what part(s), if any, of the object will project in the finished piece. Ron Erickson recommends that depth for embossed holograms be under ½ in. for small images like 3in. x 3in., and only a few inches for larger images such as 8in. x 10in. Projection should be about half the depth behind the image plane (¼ in. for 3 in. x 3 in., 1 in. for 8 in. x 10 in).

No one said it would be easy! Now that you have an idea of how to produce your design in concrete terms, what about cost?

Start with the embossing master. It will cost you from $1000 up, with $3500 being a good round figure to start your budget for an image of any complexity. The first 1000 images may be included in the cost, if the image is 3 in. x 3 in. or smaller. The embossing masters are very ticklish to make (which is why there are so few companies in embossing to date). The more angles of diffraction, layers of depth, or numbers of elements to be combined in the image, the more the embossing master will cost. The