

## **HOLOGRAPHY SUPPLEMENTARY MATERIAL NOTES AND OBSERVATIONS: MOUNT HOLYMPUS**

### **EYEWITNESS DEMONSTRATIONS: Recall what you saw.**

What makes viewing a Gabor hologram inconvenient?

What is the set up for viewing the virtual image of a classical laser transmission hologram?

What happens when an undiverged laser beam passes through a classical laser transmission hologram?

How can more than one image be stored on a hologram?

How is the real image of a classical laser transmission hologram used to form a focussed image hologram?

Where is the rainbow in a rainbow hologram?

Could you see the thin slits in the holographic stereograms?

How can you tell a true volume reflection hologram from an embossed reflection hologram?

### **SCAVENGER HUNT: Enjoy these optical phenomena outside of class.**

Holograms in galleries, libraries, supermarket checkout scanners, Head's Up Displays, and embossed ones on magazines, credit cards, baseball cards, comic books, CD and cassette covers, potato chip bags, pens, etc.

### **RELEVANT TRIVIA: Useful facts for these lectures.**

The first laser did not operate until 1960; the first holograms of Gabor and Denisyuk were made with filtered Mercury vapor lamps.

### **OPTICAL SCIENTISTS AND INVENTORS: Remember the endeavours of these gentlemen which make them gods on Mount Holympus.**

\* Dennis Gabor \* Yuri Denisyuk \* Emmett Leith \* Juris Upatnieks \* Tung Jeong \* Stephen Benton \* Lloyd Cross \*

### **IMPORTANT WORDS: Know what they mean!**

\* hologram \* reference and object beams \* reconstruction or replay beam \* real and virtual images \* coherence length \* depth of field \* isolation tables \* holographic interferometry \* multi-channel holography \* light-in-flight recording \* volume holograms \* classical laser transmission holograms \* white light reflection hologram \* Lippmann hologram \* white light transmission holograms \* image plane holograms \* focussed image holography \* master and copy holograms \* true-color holograms \* integral holograms \* holographic stereograms \* embossed holograms \* redundancy \*

### **HANDOUTS YOU SHOULD HAVE RECEIVED: "A Guide to Identifying Holograms in the Field"**

## **A GUIDE TO IDENTIFYING HOLOGRAMS IN THE FIELD**

There are two broad categories of hologram types; transmission, or lit from the side opposite the observer, and reflection, lit from the same side as the observer. To complicate matters, the holograms mass-produced by embossing techniques are lit like reflection holograms, but they are actually transmission types with a mirror backing.

### **CLASSICAL TRANSMISSION HOLOGRAMS**

The earliest types of transmission holograms were lit monochromatically, or with a laser. These are easy to identify, as the light in the image will have that distinctive laser speckle. They are the "Holographer's Hologram", as the scene in them can be very deep. Emmett Leith and Juris Upatnieks described this technique applied to the recording of diffusely reflecting objects in 1963. A company called Conductron made some impressive imagery in this mode circa early seventies, about a meter square, some of it pulsed, for instance a room full of people drinking beer and playing cards, or a deep sea scene with seven divers, with the reference beam emerging from one of their flashlights! Horex was a company producing large quantities of small holograms into the eighties.

### **WHITE LIGHT TRANSMISSION HOLOGRAMS**

Dr. Stephen Benton made a major improvement in the reconstruction of transmission holograms when he introduced a slit into the imaging system. This slit eliminates vertical parallax, which is not all that necessary, since our eyes are oriented in a horizontal plane, but also eliminates the need for monochromatic light. A simple, unfrosted incandescent light bulb is all that is necessary to replay these holograms. The distinguishing characteristic of this type of hologram is the iridescence of the color of the image; it changes through all the hues of the rainbow as the viewer translates vertically while in front of it, or if the hologram is tilted. A bright one will project a rainbow onto the viewer's face, hence the name Rainbow Hologram. Multiple colors can be generated with this system, but the relative color hues will change as the vertical viewing angle changes. This technique is favored by the New York Holographic Artists. The typical mass-produced hologram is the Benton type of hologram embossed into a plastic backed with aluminum, which acts as a mirror backing, turning a light from the front into one which seems to be coming from behind the hologram. The holograms can then be attached to book covers, record jackets, clothing, cereal boxes, etc.

The real image of a laser lit hologram is usually used as the object wavefront in the production of the Benton hologram, so

that most of these holograms exhibit an object which pierces the plane of the hologram.

Another type of White Light Transmission Hologram is a variation of Benton's slit technique which looks colorless, or black and white. These holograms are called "Achromatic", and the technique is often used for holographic stereogram images of people.

It is possible to make true-color images with this technique, but color veracity is achieved only at a certain vertical viewing position.

### **REFLECTION HOLOGRAMS**

The first reflection type of holograms were reported by Yuri Denisyuk in 1962, so they sometimes bear that name in holographic shop talk as well as the Lippmann or Bragg label. They are made by interfering the reference and object beams from opposite sides of the hologram during recording and they are reconstructed with the replay light on the same side of the hologram as the observer. They can be distinguished from the embossed hologram as they exhibit vertical as well as horizontal parallax and will not change color as the viewer moves up and down. As the hologram is tilted, a slight shift in color can be noticed, but it is only a small slice of the spectrum rather than the complete one of the Rainbow hologram. Many of these holograms are made in one step, where the hologram was exposed to the object in the scene, and their image is only virtual. But many more are made in a two-step process using the real image from a transmission hologram as the object for the second reflection one so that the object straddles both sides of the copy plate.

### **HOLOGRAMS OF LIVING PEOPLE**

Since skin is constantly moving microscopically thanks to blood circulation and respiration, it presents a problem in the holographic recording of living subjects. Because of the fraction of a wavelength stability requirement in recording, holograms of living tissues are usually recorded with pulsed lasers whose short, strobe-like emissions do not allow the fringe pattern to be blurred by the moving subject wavefront. The choice of laser is limited to either ruby (694 nm) or frequency-doubled Nd:YAG (532 nm). The long ruby wavelength penetrates the surface of the skin, and returns to the hologram well-diffused, so that the subject acquires that all-too-familiar waxy or cadaver look. The green color of the YAG reflects directly off the surface, giving a much more real appearance. Holographers have not switched over to this type because there are not many YAG's out in the field that are capable of a single giant Q-switched pulse. Sometimes the portrait is reduced to smaller than actual size, and the people look flatter than pancakes because

the minification in the z-axis is the product of the x- and y-axes, so if the person's face is reduced to 1/4 life size horizontally and vertically, their depth is  $1/4 \times 1/4 = 1/16$ ! Extreme minification will make the subject look like they have been run over with a steamroller.

Indirect recording of people can be achieved by **Holographic Stereograms**, which integrate a variety of photographic views into a hologram which acts as a Viewmaster, except that there are many stereo pairs of the object. The earliest experiments were performed in the late sixties, but the commercialization of the technique was achieved in the mid-seventies by Lloyd Cross and his Multiplex Company's holograms, which used 1080 motion picture frames holographically printed onto a cylindrical piece of holographic film. Nowadays the technique has been perfected to encompass flat, white light transmission and reflection image plane copies, in formats from tiny embossed ones to meter squares. Because it is based on stereophotographic principles, magnification as well as minification of images can be quite convincing. Computer generated images can also be used, so holograms of things that never existed can now be made. True color rendering is possible in this technique, with some images available in the embossed format, for instance Shakespeare, Michael Jackson, children in a toy store, etc., from Applied Holographics.

#### **HOLOGRAMS THAT ARE NOT FLAT**

The earliest curved film holograms were made in a cylindrical shape. ("If you're going to go 3-D, why not go 360!" quote the inventor.) They are true transmission holograms, and are lit monochromatically. Flattened out, they transform the objects in them quite wonderfully. The record for largest one in this format is about a meter in diameter.

Multiplex is the trademark of the company which made cylindrical stereograms. They are about 30 to 35 cm in diameter, sometimes on rotating displays, white light transmission types lit with an unfrosted 100 Watt light bulb from below. Some images were produced that are less than a full cylinder. The most widely distributed one is "The Kiss", which shows a woman blowing a kiss and winking.

An Alcove hologram is basically an inside out Multiplex. A real image of the object floats in front of a concave semi-cylinder, as opposed to a virtual image floating behind a convex semi-cylinder. The Alcove hologram is lit with a laser, but the reference beam must be shaped by a concave plexiglass semi-cylindrical mirror larger than the hologram itself to focus the light below and in front of the hologram. The prototypes were made at M.I.T. by Benton in the mid-eighties.

## HOLOGRAPHIC RECORDING MATERIALS

The different types of recording materials influence the quality of the holographic image and its cost. Some materials are industrially produced, and are either commercially available (Agfa, DuPont, Ilford, Kodak) and the holographer uses and processes the holograms himself, or the holographer can have the mass production done by the producer of the material in their own labs (Polaroid). Sometimes holographers coat their own brews on glass plates (Dichromated Gelatin, Photopolymers, Other Experimental Layers), or buys plates coated with Photo-Resist from a specialist.

**SILVER HALIDE:** The most popular recording material amongst holographers, due to its high sensitivity and ready availability compared to all the others below. Handling of the media is well enough understood nowadays so that high quality results can be achieved consistently. Gabor and Denisyuk made their first recordings on silver halide plates. Agfa dominates the market with their Holotest line up of products, while Ilford is coming on strong with their Hotec series of films, plates and chemicals. Apparently the field is too small for Kodak to even think of competing, and they market a variety of materials that have essentially remained unchanged for 15 years.

Each hologram is individually exposed and processed, and equipment for high volume production has been utilized, for instance the "Holocopier" of Applied Holographics which cranked out the "Supernaturals" series of holographic toys. But the silver halide holograms for sale in the galleries are mainly produced by a "Cottage Industry" of small (>10 employees) businesses.

**DICHROMATED GELATIN:** For many years the dichromated gelatin holographic pendant was the mainstay of the mass-produced holotrunket market. Each hologram was individually coated with gelatin layer containing ammonium dichromate to make it light-sensitive, exposed to laser light, (The material has sensitivity to violet and blue but starts losing it in the green and is totally blind to the red end of the spectrum, and it needs about 100 times the light exposure as silver halide under the same circumstances.), then processed in Kodak Rapid Fixer, Kodak Photo-Flo, and baths of hot isopropyl alcohol. The hologram can be destroyed by high humidity, so they are sealed under glass with either epoxy or an Ultraviolet curing adhesive. Older dichromates, (as they are known in the trade), have been observed to be disappearing as water penetrates the seal around the edge. They were produced by the thousands by several companies, (Electric Umbrella/International Dichromate/Dikrotek/Holographic Products, Holo-Source, Holo-Crafts, Portson, Holographic Design, etc.) mainly in the 38 mm diameter pendant format, but 4 by 5 and

larger have been made, with anything larger than 8 by 10 inches pretty rare.

Although requiring large Argon lasers for exposures, the process itself is inexpensive in materials but labor-intensive, which is why the pendants would list for \$20.

**PHOTOPOLYMERS:** This class of chemicals are totally artificially prepared from industrial materials so quality is more consistent than that of dichromates. Plus they don't seem to have the need to be hermetically sealed like the above.

Polaroid manufactures DMP-128, but it is very fussy about its environment before it is exposed and processed that Polaroid only uses it in-house to mass produce holograms. The "Red Beam" series of images are made on this material.

DuPont makes their own variety of photopolymer that is available to the holographer. It has the potential of true color recording of reflection holograms. Applications of this material have not surfaced yet.

**PHOTO-RESIST:** A Photo-Resist Master Hologram is the first step of many in the replication of embossed holograms. A nickel shim (the "Mother") from which ultimately thousands of copies will be formed in plastic is electro-formed on the Photo-Resist hologram, which usually results in the master's destruction. This accounts for the scarcity of actual photo-resist holograms in the field, although their descendants are many. Typically Shipley AZ-1350 positive working photo-resist is coated by a micro-electronics pattern producing house onto glass plates for the holographer, although some spin-coat it themselves. The resist is clear, but is usually coated onto a layer of ferric oxide on top of the glass substrate to prevent back reflections from the resist/glass plate boundary causing a troublesome standing wave pattern, so that the plates themselves have a rusty red color. The resist is not very sensitive to ultraviolet, the violet and not much else, so its use is restricted to holographers who can supply copious amounts of the expensive blue photons.

**EMBOSSSED HOLOGRAMS:** "Daughter" holograms are grown from the "Mother" from above and those are placed on presses which smash the holographic pattern into plastic. The characteristic tin foil appearance of the embossed hologram comes from the back of the plastic which is aluminized to reflect the reference beam so that they can be displayed in a reflective mode. (Embossed holograms reconstructed in a pure transmission mode are very rare.) Sometimes an adhesive backing with a peel-off release cover is applied for the sticker trade, or the foil is "hot-stamped" with an electrically warmed die onto a magazine or

package. Millions of holograms have been made using this technique, viz. the National Geographic magazine covers, credit card and bus pass holograms, stamps, foreign currency, album covers, cereal boxes, raffle tickets, liquor packages, kids' stickers, ad nauseum.

# h<sup>o</sup>losphere

the advocate of holographic  
science, technology and art

## All That's 3D Is Not Holography: Disney World's Haunted House

By Charles Otis Swezey  
Associate Professor  
Department of Theatre and Dance  
Southern Illinois University  
Edwardsville, Illinois

Ghosts are fascinating creatures of the supernatural. They float through the air, appearing and vanishing, possessing a translucent quality as if made of vapor. Usually inhabiting old houses and grave yards, their more recent residence is a building in Disney World appropriately called the "Haunted Mansion". How these ghosts came to be has been a long-kept secret of Disney World. Many people believe them to be elaborate holograms, for they are three-dimensional, appear to be translucent, and have the characteristics of a hologram. This, however, is a misconception which is furthered by the fact that few people have a real understanding of holography.

Disney World is also known as "The Magic Kingdom," and like a true magician, it has never revealed the mechanics of the ghosts, knowing that an illusion is never as effective once the trick is discovered. I had heard many people insist that these ghosts are holograms; others stated that they were created by lasers. What bothered me about their beliefs is that the art of holography is still in its infancy. It would require a great deal of time and money before such effects could be possible and still, Disney's expectations would not be satisfied. It was this bafflement that enticed me to travel to Disney World to discover how the ghosts really "haunt" their Mansion.

Upon entering the Mansion for the first time, I was greeted by an eerie presence. The rooms are dark and covered with dust and cobwebs. A cold, clammy draft blew across my shoulder. The journey proceeded through the house on a "Doom Buggy" which is designed to turn around, tilt forward and backward, and turn one's attention only in the direction desired for one to observe the full effect of the attraction. Like a skilled magician, Disney has total

control, having one see only what he wishes, and not observe what one shouldn't.

The ride through the Mansion is quite effective and one of the most enjoyable and popular attractions at Disney World. The total effect is impressive. After several journeys, I learned what to expect, and began to decipher how the ghosts are manufactured. It is readily apparent that they are not produced by holography, but by an elaborate combination of illusionary effects, which make use of the latest in technology mixed with nineteenth century magic. The entire production is controlled by a sophisticated computer system.

The "talking heads" present an interesting illusion. "Madame Leota's" head appears in a crystal ball and chants a message to the visitors. Near the end of the journey there is a group of singing marble busts. At the exit, a small doll-like figure, "Little Leota", bids farewell and extends a "ghoulish" invitation to come back again. All of these apparitions are created in the same manner. The facial features are provided by a 16mm film which is projected into a faceless mannequin head. A closer look at "Madame Leota's" head reveals an image on the glass of her crystal ball, caused by the projection entering the glass just below her chin.

Other ghosts and ghouls are translucent versions of mechanized robots, similar to ones used elsewhere in the park. As in the Hall of Presidents, the Haunted Mansion makes use of "animatronic" figures. These figures use an elaborate system of hydraulics and computers to make them move. In this particular application, Disney goes a step further and uses figures which were cast in clear plastic; only around motorized areas, as the head, are they more opaque. The figures are dressed in sheer fabrics, and to increase the sense of fogginess, are viewed from behind a gauze fabric. The effect is heightened by the lighting.

The largest "ghostly" effect in the Haunted Mansion and the one which most resembles

a hologram is the illusion created in the Grand Ballroom. Here ghosts are seen dancing, floating, and waving in a large, three story room. The viewer observes these ghosts by looking down into the room. This effect is modeled after a nineteenth century magic trick in which a woman is seen in a room, and a magician aims and fires a gun at her. This illusion is created by a special two-chambered box. A sheet of glass, set at an angle, is situated between the rooms. When light is brought up in the first chamber, the glass acts like a mirror and reflects the room and woman. Changing the lighting from the first chamber to the second, causes the glass to become transparent, allowing the audience to view through it. Both chambers have identically decorated rooms but only the first has the woman; by adjusting the lights she appears and disappears.

The Haunted Mansion uses the same principle as this nineteenth century magic trick. The "Doom Buggy" carries the viewer above the Grand Ball Room and tilts forward so that the rider is looking down into it. The viewer is not aware that there is a sheet of glass between him and the room. Above and below the room and out of sight are mechanized ghosts which are moving and dancing. By using strong lighting, the reflections of the figures appear on the glass and the observer is tricked into thinking that there are ghosts in the room.

Additional effects and illusions are incorporated throughout the ride. The eerie sounds and general darkness make the rider susceptible to seeing things that are not real. Effects like doors that "breathe" and rooms that "stretch" create the desired mood. With all the elements working together the viewer begins to wonder if they are not "real ghosts" inhabiting the Haunted Mansion.

## Goldsmith's Classes in Holographic Art

LONDON — Introductory and practical courses in holography are being offered on a regular basis by the Goldsmiths' Holography Workshop in Camberwell. Established last May in the College's Fine Art Department, the workshop is a facility where artists and others can learn about and make holograms, according to the  
(continued on next page)



## **HOLOGRAPHIC ARTISTS**

**ALEXANDER (Australia)**

**ANAIT (USA)**

**MARGARET BENYON (United Kingdom)**

**RUDIE BERKHOUT (New York)**

**PHILLIPPE BOISSONNET (Canada)**

**PATRICK BOYD (United Kingdom)**

**RICHARD BRUCK**

**HARRIET CASDIN-SILVER (USA)**

**ROBERT CONNOLLY**

**JONATHON COPE (United Kingdom)**

**MARIE ANDREE COSSETTE (Canada)**

**SUSAN COWLES (United Kingdom)**

**MELISSA CRENSHAW (USA?)**

**TOM CVETKOVICH (USA)**

**SALVADOR DALI (Spain)**

**PAULA DAWSON (Australia)**

**REBECCA DEEM (USA)**

**SYDNEY DINSMORE (Canada)**

**GEORGES DYENS (Canada)**

**PASCAL GAUCHET (France)**

**HOWARD GERRY (Canada)**

**NANCY GORGLIONE (USA)**

**MARY HARMON (Canada)**

**SERGE HONINOW (USA)**

EVA JONSON (Sweden)  
DIETER JUNG, (Germany)  
EDUARDO KAC (Brazil)  
JOHN KAUFMAN (USA)  
CHARLIE LYSOGORSKI (USA)  
MICHAEL MEDORA (United Kingdom)  
MELINDA MENNING, (Australia)?  
SAM MOREE (New York)  
LON MOORE (USA)  
DOMINIC MULHEM (France)  
AUGUST MUTH (USA)  
BRUCE NAUMAN (USA)  
SCOTT NEMTZOW (USA)  
RUBEN NUNEZ (Argentina)  
DIETMAR OEHLMANN-ROSENBRUCH (Germany)  
VITO ORAZEM and TOMAS LUCK (Germany)  
DEAN RANDAZZO (USA)  
J. ROBB (United Kingdom)  
DAN SCHWEITZER (USA)  
RICK SILBERMAN (USA)  
FRED UNTERSEHER (USA)  
HEIDI VON DER GATHEN (USA)  
DORIS VILA (New York)  
SALLY WEBER (USA)  
STEVE WEINSTOCK (USA)

DAVID WILCOX (Canada)

## **HOLOGRAPHIC SUPPLEMENTARY MATERIAL NOTES AND OBSERVATIONS STEREO LECTURE**

### **EYEWITNESS DEMONSTRATIONS: Recall what you saw.**

Where did the cross-over point go when you looked up and down the string?

Compare and contrast the different styles of stereo viewing:

Discrete (old stereoscope, 35 mm stereoviewer, Viewmaster, Single-Mirror);

Anaglyphic (comic books, Jaws cards, books);

Lenticular Screens (Parallax Panoramagrams, Nimslos).

How can you make a Viewmaster image pseudoscopic?

Are you capable of free-fusion?

Could you finally get the Random Dot Stereogram to appear in 3-D?

How does the direction of the apparent "spin" in the Pulfrich Pendulum depend on which eye is occluded?

What is the trick behind "Wild Vision"?

### **SCAVENGER HUNT: Enjoy these optical phenomena outside of class.**

The Agam sculpture in front of the Stone Container Building, (formerly the Associates' Building) NW corner of Michigan and Randolph.

### **RELEVANT TRIVIA: Useful facts for this Lecture.**

#### **STEREO PHOTOGRAPHY SUPPLIES**

Reel 3-D Enterprises, Inc.  
P.O. Box 2368  
Culver City, CA 90231  
310-837-2368

American 3-D Corporation  
15 Cactus Garden Drive  
Henderson, NV 89014

#### **RANDOM DOT STEREOGRAM SOFTWARE**

Depth Painter  
N. E. Thing Enterprises  
19A Crosby Drive  
Bedford MA 01730

### **IMPORTANT WORDS: Know what they mean!**

depth \* depth cues \* accommodation \* convergence \* parallax \*  
intra-ocular distance \* binocular disparity \* orthoscopic \*  
pseudoscopic \* stereoscopes \* anaglyphs \* lenticular screens \*  
parallax panoramagrams \* Nimslo \* Nishika \* integral photography  
\* Pulfrich phenomenon \* "Wild Vision" \*

### **BIBLIOGRAPHY: Outside reading for the truly faithful.**

**Amazing 3-D**, Hal Morgan and Dan Symmes, Little, Brown and Company, Boston and Toronto, 1982, ISBN 0-316-5823-2.

**The Stereo Image in Science and Technology**, Dieter Lorenz, German Aerospace Research Establishment, Koln, Oberpfaffenhofen, 1985, ISBN 3-89100-009-X.

### **FINAL CRIB NOTES:**

Be able to identify the different types of stereoscopes.

**NOTES AND OBSERVATIONS EMBOSSED HOLOGRAPHY LECTURE****EYEWITNESS DEMONSTRATIONS: Recall what you saw.**

What kind of recording material sees the light in the first step of embossed holography manufacturing?

Why will a surface relief hologram work?

**SCAVENGER HUNT: Enjoy these optical phenomena outside of class.**  
The world of embossed holography on magazines, CD jackets, album covers, cereal boxes, credit cards, postage stamps, currency, CD players, etc.

**RELEVANT TRIVIA: Useful facts for this Lecture.****MANUFACTURERS OF EMBOSSED HOLOGRAMS**

Robert Sherwood Holo Design  
400 West Erie St.  
Suite #405  
Chicago, IL 60610  
312-944-3200

American Banknote Holographics  
Corporate Headquarters  
399 Executive Boulevard  
Elmsford, NY 10523  
914-592-3248

Chromagem  
573 South Schenley  
Youngstown, OH 44509  
216-793-3515

Holographic Dimensions, Inc.  
16115 SW 117th Avenue  
Miami, FL 33177-1615  
305-255-4247

There are of course dozens more, but this is to just get started collecting samples. See the **HOLOGRAPHY MARKETPLACE** published by **ROSS BOOKS**, Berkeley, CA 94702, 510-841-2474

**IMPORTANT WORDS: Know what they mean!**

\* photo-resist \* alkaline solution \* acid solution \* micro-chip industry \* silver painting \* nickel-plating tank \* anode \* cathode \* nickel bag \* fishtank \* shims \* mother \* daughter \* grand-daughter \* heated roller \* pressure roller \* supply spool \* take-up spool \* mylar \* vacuum-deposited aluminum \* double-sticky adhesive \* hot-stamping foil \* die-cutting \*

**BIBLIOGRAPHY: Outside reading for the truly faithful.**

There really are no good books on the topic as it is considered to be peppered with "trade secrets".

**FINAL CRIB NOTES:**

Be able to describe the process step by step.