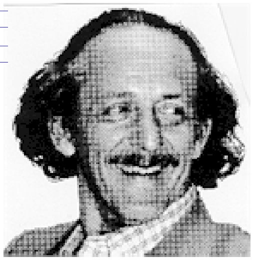
The World Brain is now housed at the Chemical Heritage Foundation in Philadelphia.
Go to World Brain Picture at CHF



Current Comments

To see pictures of the "World Brain" click on figures 1-4
Figure 1 Figures 2 & 3 Figures 4

ISI's "World Brain" by Gabriel Liebermann: The World's First Holographic Engraving

Number 52 December 28, 1981

Throughout this past year, I have written about the many fine works of art we have installed to enhance ISI®'s main offices on Market Street in Philadelphia.[1-3] Now, I would like to tell you about the latest addition to the "ISI collection": a unique holographic engraving entitled "World Brain," executed for us by artist Gabriel Liebermann of Dallas, Texas.

The title of Liebermann's engraving will be familiar to any of you who recall some of my essays on the concept,[4,5] which was first discussed in 1938 by H.G. Wells in his book *World Brain*.[6] I first mentioned the world brain in *Current Contents*® (*CC*®) in 1964, when this column was called *The Informatorium*.[7] Wells argued for sweeping reforms in the process by which we bring our accumulated knowledge to bear on social, economic, and political affairs. He envisioned a "World Encyclopedia," in which multidisciplinary research information of a global nature would be gathered together and made available for the immediate use of anyone in the world. It is from this visionary ideal that Liebermann was asked to develop his holographic engraving.

The world brain was an impossible goal when Wells was alive. But the computer technology of our own day is beginning to make such a concept feasible. Similarly, engravings have been around for centuries, but only recently has it become possible to create a three-dimensional image with an engraving. Holography was first conceived in 1948 by Dennis Gabor,[8] for which he won the Nobel Prize in Physics in 1971. It was Liebermann who invented a technique that applied holography to the ancient art of engraving. Incidentally, both Liebermann and Gabor were born in Hungary.

I first met Liebermann in 1979 while attending a library convention in Dallas. At the time, we were conducting a search for muralists who could capture the information theme for our corporate headquarters.[1] The meeting was arranged by a mutual friend, Vicki Lynn, an artist who designs theatrical stage sets. Although Liebermann designs computer hardware for a living, he also studied oil painting at l'École Nationale des Beaux Arts, which is part of the University of Paris. He also attended the Northwood Institute, Dallas. It was at the latter institution that he met Vernon Porter, senior research scientist at Texas Instruments. Porter is also on the faculty at Northwood, where he lectures on the relationship between art and technology. Porter was a major influence in Liebermann's unique blending of art and science.

Liebermann found that his daily contact with engineering at work had a positive effect on his art. These interactions produced a spate of new ideas which eventually led to a technologically based, new and unique art form. When he told me of his concept of sculpting with light through holography, I was so intrigued that I commissioned him to execute a work with the world brain as a theme. Porter acted as technical adviser on the many complex problems Liebermann encountered while working on the piece. Like so many other creative people, Liebermann also needed considerable prodding from me and my associate Calvin Lee to make sure he completed one assignment before taking off on another.

Most Americans' only experience with the illusion of depth in an image came with the 3-D movie fad of the 1950s. In 3-D photography—called stereoscopy—two cameras were used in tandem to film separate left-eye and right-eye images. The two images were then printed in different complementary colors on the same strip of film. If the left-eye image was printed in blue-green, for instance, then the right-eye image was printed in red. The two images were then projected onto a metallic screen in such a way that they overlapped. Viewers wore special glasses in which the left eyepiece was made of red cellophane and the right eyepiece of green. The red filter allowed the left eye to see only the blue-green image, while the green filter over the right eye allowed only the red image through.[9]

This system was inexpensive, but had a number of major problems. Only black-and-white films could be made, since the property of color had already been used for the purpose of image-separation. Also, looking at different colors with each eye causes an effect known as retinal rivalry, which can cause headaches and even nausea.[9] Finally, since the color filters were not perfect, the 3-D movies were blurry. So Hollywood producers limited the technique to the production of such B-grade films as *Bwana Devil* and *House of Wax*.[9]

The assorted inconveniences and amateurishness of the 3-D movies were more than enough to offset their technical novelty. And although 3-D film technology has become more sophisticated over the years,[10] it still relies on basically the same principles of trick photography to achieve the illusion of depth.

Holography, however, bears little resemblance to stereoscopic photography. The viewer needs no special equipment to see the three-dimensional image. Moreover, holographic images possess a real size, shape, and position in space that are independent of any viewer.[11] But to really understand how holograms are made, you first have to know something about the basic properties of light.

Suffice it to say that light is a series of electromagnetic vibrations. These vibrations consist of zones of compression and rarefaction, called waves. The wavelength is the distance between one zone of compression, the crest of the wave, and the next. For light waves, this distance is extremely short: about 55-millionths of a centimeter. Minute variations in the wavelength of light are perceived by us as changes in color.

Of special importance to holography is a characteristic of light waves known as coherence, or the degree to which light waves are in phase with one another. In ordinary sunlight, incandescent, or fluorescent light, the relationship between one wave and another is completely random. This light is said to be out of phase—that is, incoherent. In a laser, however, the intense light consists of a single, nearly pure color, in which all of the waves are of equal size, move in the same direction, and match up crest to crest and trough to trough. This light is in phase, or coherent. It was the development of the laser which made holography practical.[11] Incidentally, the 1981 Nobel Prize in Physics was shared by Nicolaas Bloembergen, Harvard University, and Arthur L. Schawlow, Stanford University, for their work in laser spectroscopy.[12,13] Both are highly cited and Bloembergen is included in our recent study of the 1,000 most-cited contemporary scientists,[14] while Schawlow appeared on our list of the 100 books most-cited by researchers[15] for *Microwave Spectroscopy*,[16] which he coauthored with C.H. Townes.

To make a typical hologram, a laser beam in a darkened room is directed through a special mirror—called a beam-splitter—which, appropriately, splits the beam in two. One half strikes the subject, becomes diffracted by its physical features, and is reflected through a piece of exposed film. The other half shines directly onto the film itself to act as a reference. The distorted wave fronts of the beam reflected from the subject combine with the undisturbed waves of the reference beam to create on the film a complex pattern of whorls known as "interference fringes." These fringes consist of light and dark areas. The brighter areas correspond to spots where the two incoming beams are in phase, while the dark areas result when the incoming waves are out of phase.

When the film containing this interference pattern is developed, the result is called a hologram. "Hologram" comes from the Greek words *holos*, "whole," and *gram*, "message." The image on the film bears no resemblance to the subject recorded, but it does contain all the optical information in the beam reflected from the subject. When the hologram is placed in a beam of the same type of laser light that produced the original pattern, the light is bent to exactly the reverse of the original conditions. The result is an image of the subject, fully three-dimensional and perfectly detailed.[17]

Liebermann's holographic engraving also relies on the creation of interference patterns. He became fascinated with the idea of sculpting with light and drawing in space, but for a number of reasons, conventional holography proved unsuitable for Liebermann's purposes.[18] Producing a hologram is by no means simple.

A special facility is required to eliminate all vibration of the equipment in order to accurately record the minute wave fronts. Even a sound in the room can cause enough vibration to ruin an exposure.[17] And a hologram cannot depict a two-dimensional painting or drawing, since the laser light must be reflected from a three-dimensional subject in order to reconstruct a three-dimensional image.[11] Moreover, 12" × 12" (30.48 cm × 30.48 cm) is the maximum size hologram possible using current techniques—far smaller than Liebermann had envisioned.[19] Finally, the hologram could only be viewed in a darkened room,[11] an impractical consideration for publicly displayed art. Incidentally, a one-room Museum of Holography, 11 Mercer Street, New York, New York 10013, opened in 1977 and displays state of the art holographic technology. America's largest such museum is the Chicago Museum of Holography.[20]

Liebermann overcame these frustrating limitations with an entirely new method of creating a three-dimensional image. He uses a device of his own invention, a modified function plotter. How this device differs from other function plotters is proprietary information which the artist does not wish to divulge at this time.[19] In mathematics, "function" refers to an equation composed of variables and constants. Such equations have a range of "answers" that will make them true, and can be substituted for the variables to satisfy the equation. This range of answers can be visually represented on a graph, usually as a line or curve.

By using his special function-plotting system Liebermann draws curved-line or arc functions, so that the original drawing is translated into a complex arrangement of overlapping arcs. These arcs are then engraved directly into the work surface, where they combine to form elements very similar in form and function to the interference fringes of a hologram. The process is designed so that the artist can work in real time and watch his creation take shape before his eyes.[19]

The effect achieved by this process is shown in Figure 1. The images drawn by the artist on the plotter screen are re-created, even though the configuration of the arcs themselves does not resemble the drawing. When bright light is shone on a surface inscribed with these arc functions, it is reflected back off the curves in such a way that it is concentrated in front of the surface in the shape of the drawing.[19] Thus, the images are translated into lines of light that seem to hover at various heights above the surface of the work. Moreover, as the viewer's perspective changes, the image itself changes. While certain lines and figures remain visible from all angles, others seem to appear and disappear. (This phenomenon is visible in Figures 2 through 4.) Thus the engraving is not just a static work of art, but a dynamic process. In this way, the engraving includes itself in the viewer's relativistic world: it appears different from different angles, yet remains always the same.

Liebermann's techniques represent the kind of practical success that has so far largely eluded holography itself.[21] When the first holograms were created in the early 1960s, the technology was widely touted as the long-sought means to literally add a new dimension to photography, movies, and television. Holography almost all but faded from view as its limitations in this regard were discovered. But according to a recent *Omni* article, in 1976 the Soviet Union managed to create a holographic movie screen for a short, 70mm 3-D film. The screen was made of elliptical mirrors that directed the image to each seat, so that if the viewer moved around or stood, he or she could actually look *around* objects onscreen.[20]

Figure 1: Close-up of the holographic engraving "World Brain," showing arc functions etched into the surface of the aluminum alloy plate.

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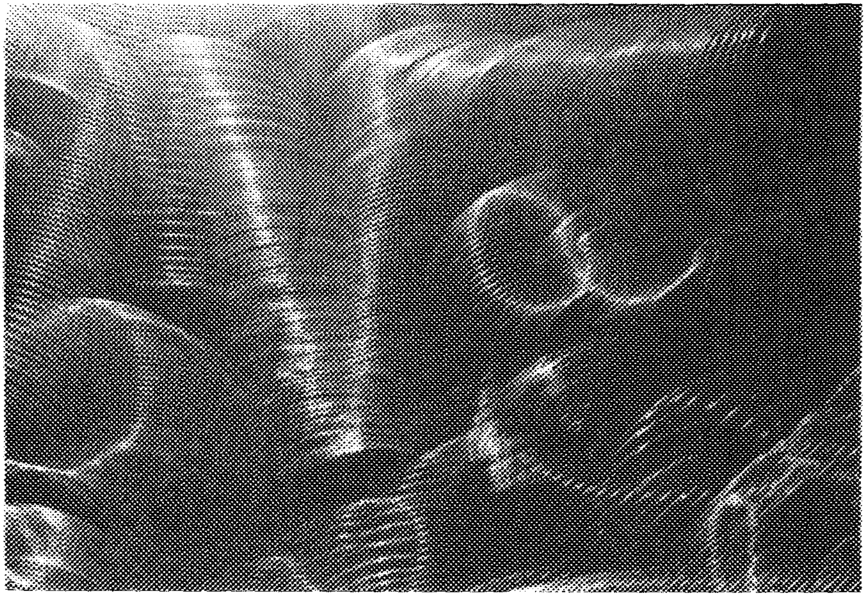

Figures 2-3: Two photos of "World Brain" show how the image changes with the viewer's perspective. Some lines and figures remain the same as the viewer moves past the work. Others appear to shift or completely disappear at different viewing angles.

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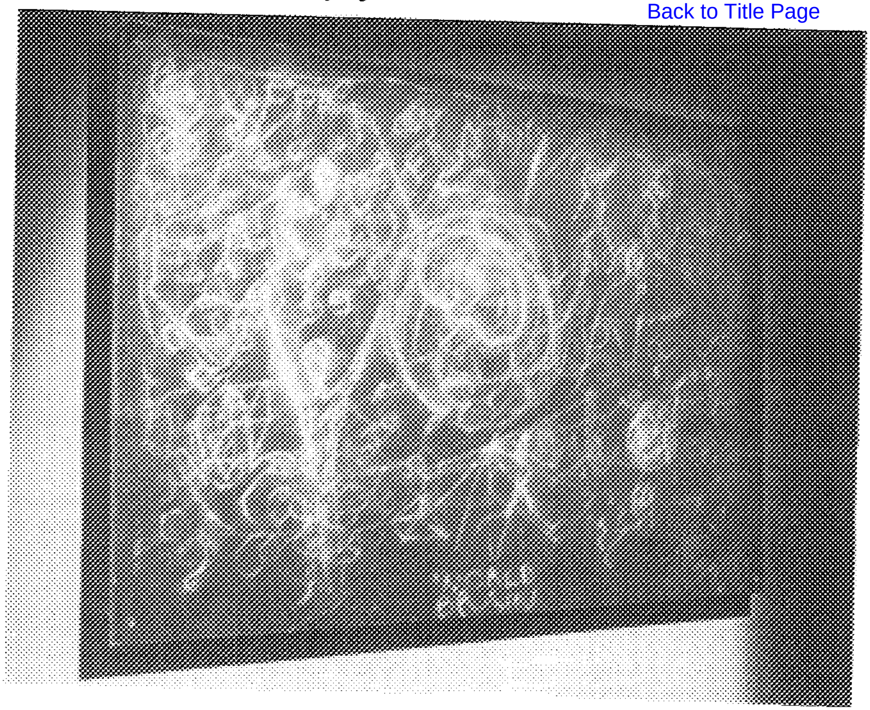

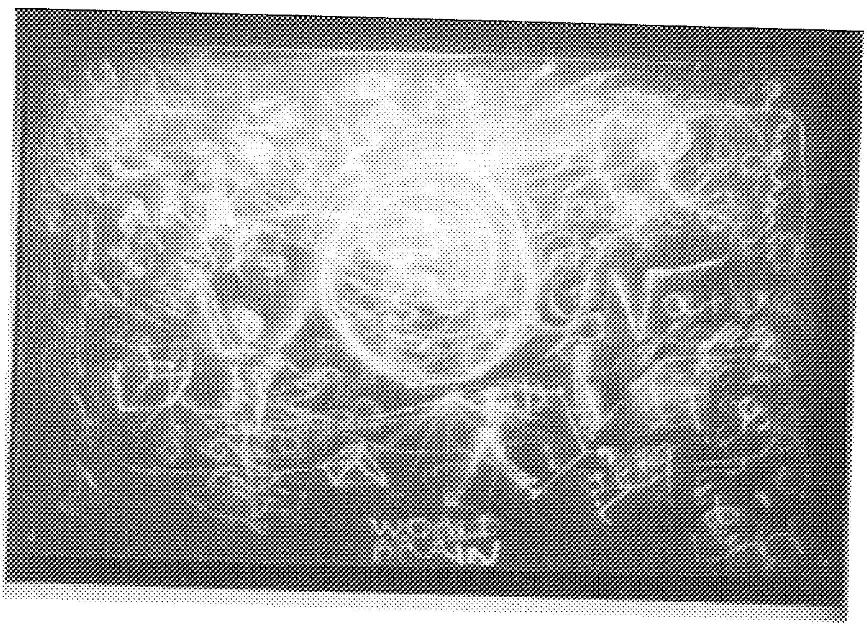

Figure 4: "World Brain" as seen from yet another perspective.

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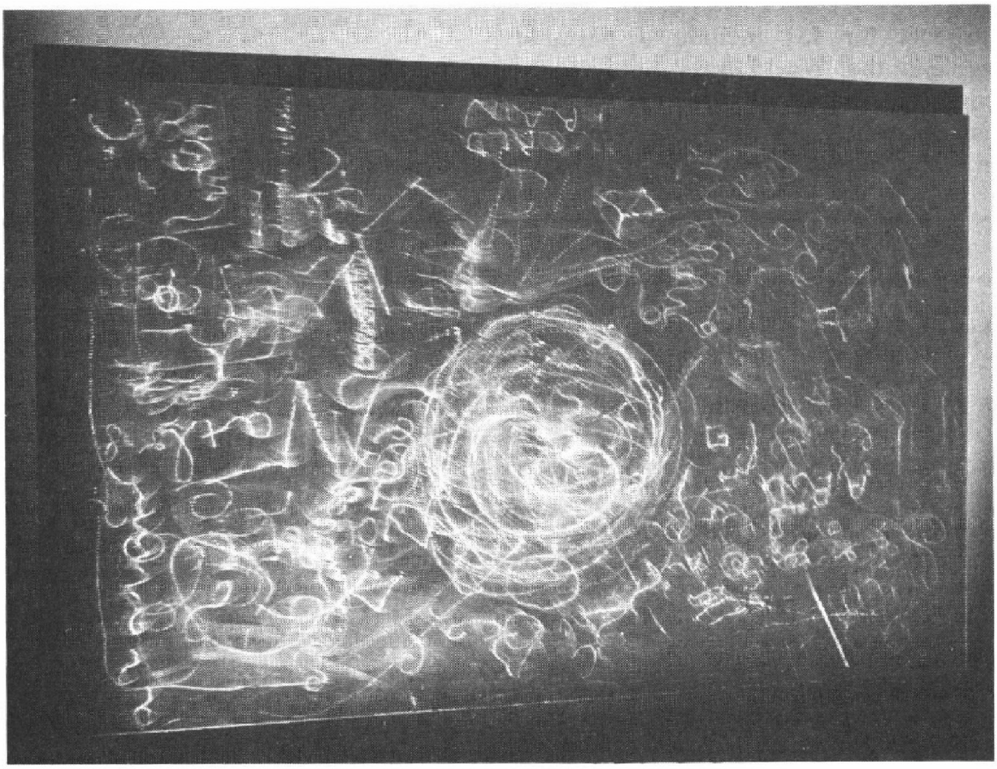

Holography has many applications in science and technology, as well. Since holograms are extremely sensitive to vibration, they can be used as a method for monitoring changes in an object caused by stress, temperature variation, or pressure. Moreover, holography's ability to record vast amounts of detail holds enormous promise for the information industry.[21]

Since holography is on the frontiers of information storage techniques it is aptly, if not uniquely, suited as a medium for the creation of the "World Brain" for ISI. The work itself consists of a $3' \times 4'$ (91.44 cm $\times$ 121.92 cm) aluminum alloy plate, coated with a clear plastic to enhance the natural luster of the metal. It was installed last spring in a dimly lit alcove at ISI so that the illumination provided by the single spotlight above it is turned to maximum effect.

The engraving (Figures 2 through 4) centers on the image of a human brain enclosed by a globe, nestled in a sea of biomorphic and geometric shapes, human figures, and scientific equations. Especially notable is the large figure in profile emerging from the background to the right of the central image. Nearly as large as the world itself, the figure gazes down on the globe from a slightly higher position in space, while the unfinished gesture of its arm suggests that its hand is directly beneath the world, supporting and guiding it. The fact that the central image is a globe with a human brain at its center indicates the extent to which science is interwoven into the fabric of our lives.

I feel that "World Brain" is a most appropriate addition to the works of art at ISI. The very nature of the piece, its skillful blending of art and science, reflects the eclectic interests of the users of ISI's services. Liebermann's future projects for ISI include a portable model of the "World Brain" holographic engraving and a sculpture of a microcircuit. I cordially invite anyone interested in Liebermann's holographic etching technique to come and enjoy this latest addition to the "ISI gallery."

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My thanks to Stephen A. Bonaduce and Patricia Heller for their help in the preparation of this essay.

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