My First 10 Years as Artist/Holographer (1968-1977)

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Source: *Leonardo*, Vol. 22, No. 3/4, Holography as an Art Medium: Special Double Issue (1989), pp. 317-326
Published by: The MIT Press
Stable URL: https://www.jstor.org/stable/1575386
Accessed: 24-03-2020 21:22 UTC

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Harriet Casdin-Silver

ABSTRACT

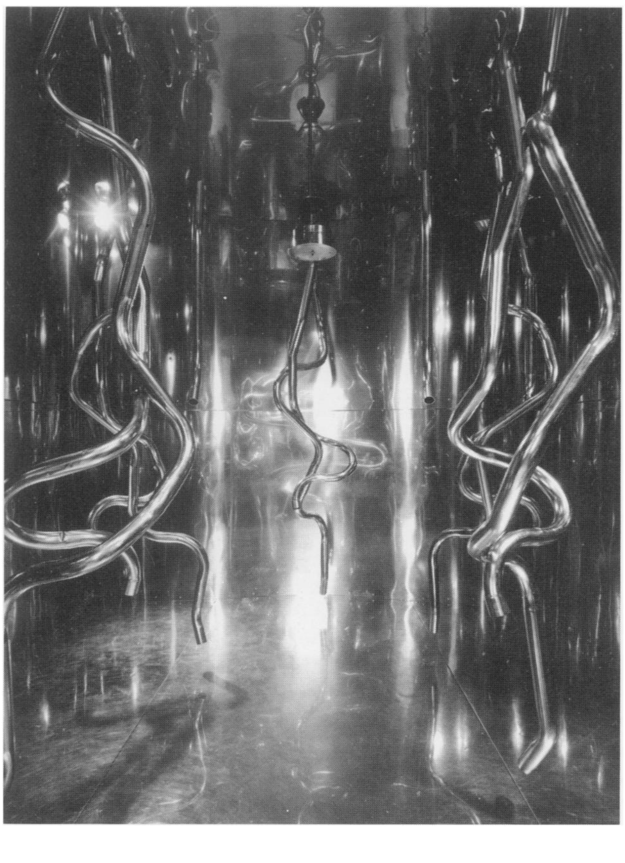
The author reviews the first decade of her career, concluding with an analysis of her solar-tracked hologram series on *Centerbeam*, a collaborative environmental outdoor sculpture by artists of the Center for Advanced Visual Studies, Massachusetts Institute of Technology, and participating scientists. The author's philosophy and politics of the art of holography are touched upon, and certain misinformation in books and catalogues concerning her history is refuted.

My professional background before holography entered my world comprised both the visual arts and the theatre arts; the latter included stage, radio and television production and performance.

Before 1968, I had been constructing stainless steel environments that incorporated sound, lighting effects and participation from the spectators, who entered these fabrications draped in mylar couture of their own design, thereby blending in both in texture and in color value with the steel. I created and performed the sound tracks, synchronizing them with the lighting; I used the whole presentation to stimulate the audience to react. These were the 1960s: in the United States the Civil Rights movement, demonstrations against the Vietnam war, Women's Liberation and student uprisings were all exploding. The steel pieces were socially, indeed politically, oriented. For me personally, they acted as an integrating force. They resolved my internal conflict concerning the choice of medium—theatre, performance or the visual arts. I could do them all. The consummation of these installations was a 10-ft cube titled *Exhaust* (Fig. 1) [1].

Searching for lighting that was more sophisticated than the type I had been using, I went to the American Optical (AO) Research Laboratories, then located in Framingham, Massachusetts, to borrow a laser to use on the steel. Raoul van Ligten, head of the optical physics department, showed me his holography laboratory and some small 4-×-5-in holograms of toy rabbits. Having seen a recent exhibition of mine, he invited me to AO to learn holography; he was interested in exploring artistic imagery in holography.

Light and spatial possibilities were holography's most fascinating aspects. I immediately saw potential images, and in line with my philosophy of social change, I thought, "What a powerful communications medium this could be". I assumed that I would learn holography and incorporate it into my environmental interdisci-



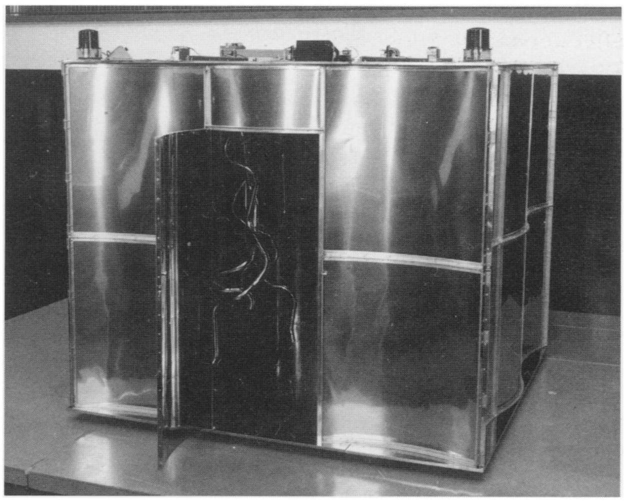


Fig. 1. *Exhaust*, stainless steel, chrome exhaust pipes, synchronized light and taped sound performance, 10 × 10 × 10 ft, 1968. (Photo: Marvin Richmond) (a) (left) Interior view; (b) (above) exterior view. The spectators/participants, draped in mylar to blend in with the work, create their own sounds by clanging the exhaust pipes together, producing chimelike sounds that reverberate through the space.

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Received 24 March 1989.

Pergamon Press plc. Printed in Great Britain.
0024-094X/89 $3.00+0.00

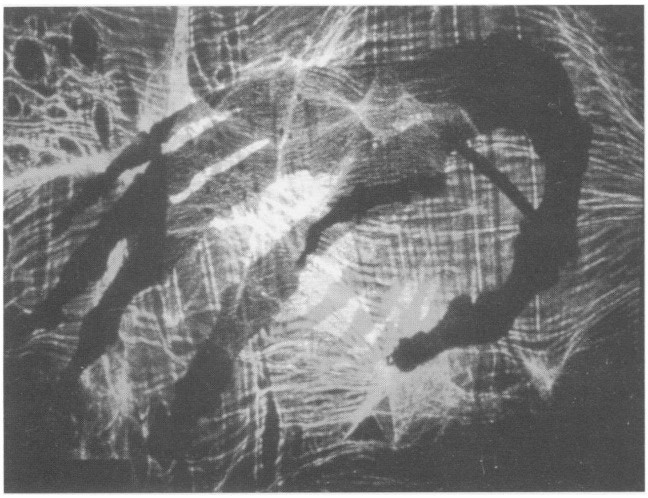


Fig. 2. Harriet Casdin-Silver and Stephen Benton, *Hologram IX*, multicolor white-light transmission hologram, plate size 11 × 14 in, depth of holographic image (behind plate) ≈ 60 in, frontal projection ≈ 12 in, 1972. (Photo: Charles Slatkin) This was the first multicolor white-light transmission art hologram.

plinary work. Never did I expect that this new medium would surpass my other endeavors.

The Beginning

At AO I was taught holographic techniques by a physicist. I came prepared with found objects or constructions. After examining them in the laser light and experimenting with plausible lighting, one object was chosen to holograph. We set up the system and made the hologram.

I suppose that no one who knows my *Equivocal Forks I* and *Equivocal Forks II* will be surprised to learn that my first 4-×-5-in plate was a dishwasher basket filled with silverware. I turned the basket on its side, and the silverware shot out of the basket, tilted upwards towards the viewer [2]. Immediately, I wanted the objects to push through the glass. Actually, I wanted to eliminate the glass. (I still do. That being impossible, I try to make the glass unobtrusive or to use it as part of the concept.)

The silverware did seem to protrude through the glass. My first goal in holography thus was all laid out for me with my first laser transmission hologram: to bring the image in front of the plate. This was in 1968, and no one at AO suggested that I turn the plate around, that I make the object small enough so that with the plate turned around, a spectator at a reasonable distance could see the whole pseudoscopic image within the edges of the plate, or that I create a second-generation hologram. I would eventually discover these means and others.

When I could work without help, I moved on to 11-×-14-in plates. Nowadays, an 11-×-14-in plate is not considered large, but in the late 1960s it was huge. I knew that the coherence length of our 50-mW Spectra Physics helium-neon (HeNe) laser would record only up to a certain dimension. "Think of the space as a 12-in cube," I was told. I had jumped from 10-ft cubes of steel to 12-in cubes of immateriality. My artist friends jeered. I saw more and more potential exposed.

Milk and Meat [3] was my first 11-×-14-in piece: two old-fashioned, beautifully crafted meat grinders, one placed slightly behind and to the side of the other to show parallax. Though I was still using everyday objects and still attempting feminist statements, I was at a crossroads. Marshall McLuhan's idea that the medium is the message was prevalent then, and I was enveloped constantly in the laboratory by instant laser light shows. When the laser beam by chance bounced off metal, ground glass or other materials, it would cover the entire environment with wild patterns. In the near future, I would use the laser light alone to form the initial configuration, eliminating the object entirely. The phantasmagoria I could concoct over all of the laboratory was too electric, too energetic to resist. I deviated from my aim of communicating sociopolitical ideas—but only for a period. The laser light configurations were important not only for their end results but also for the freedom they generated to expand my holographic techniques. These holograms would materialize when I later started to work with the scientist Stephen Benton.

In the meantime, I found glass spheres at AO that held gases such as helium, neon, argon and others more dangerous. The spheres themselves were beautiful shapes. I designed glass 'tails', as I called them, which the AO glassblower formed and attached to the spheres, so that the spheres could stand on the optical table without being propped up. The structure formed by these spheres traveled almost the full length of the table, which was 8 ft long. The space the spheres occupied was long and narrow: I was certain, therefore, to capture some of them. The object beam was split five ways. Five object beams and the reference beam all had to meet at the same time at the plate in the exposure—with no etalon on the laser. This seems so simple today, now that many more complex systems have evolved. But in 1969 the AO scientists, from the optical physics and other laboratories, came to study the strange intruder building a weird construction—which they thought would never culminate in a hologram. Moreover, the strange creature was not like them at all: it was female. There were no others like it in any of the labs.

At this point I could not have changed course had I wanted to. I had a fixed time limit for this project. (AO's plates, at that time, were Kodak's slow 649F, another factor to battle.) However, the glass spheres in laser light looked quite magnificent with all five object beams hitting the spheres. First, as I always do, I made 4-×-5-in plates, to be certain of the system and the artistic results. But the 4-×-5-in plates captured only parts of the structure. They could prove stability and a workable system, but could only indicate how much of the composition would be recorded. The only way I would know the outcome was by shooting an 11-×-14-in plate.

Blocking the object light, I replayed the image with its original reference beam and stepped back from the plate to get a better view. The glow of the glass was astonishing; the depth of the image seemed to continue into infinity. Since I was replaying the image in light directly over the real construction on the table, I could readily see which spheres I had lost, but I was totally unprepared for the extra spheres I had gained. Apparently, all the object beams hitting the glass formed reference point sources of their own at different angles to the plate from the intended reference beam, thereby causing a redundancy of the spheres as part of the image [4].

Soon after *Glass Balls* was produced, van Ligten's department moved to a separate building with four laboratories, in one of which I was able to work consistently. Life changed considerably; with a fine laboratory at my disposal, I progressed rapidly in expertise and production.

Working with Stephen Benton

At my request, van Ligten arranged for Stephen Benton [5], a scientist from another company, to work at AO with me. Our first collaboration was *Cobweb Space* (1972), both as a laser transmission hologram and as a white-light transmission hologram, each measuring 11 × 14 in. As I had been invited by the Polaroid Corporation to present an exhibit of my work, I suggested that we participate in the Polaroid show together, exhibiting the two collaborative holograms of *Cobweb Space* and three of my pieces. From this exhibition emerged three consequences. First, the laser light configuration holograms were successful. Second, Edwin Land, who was still at Polaroid at that time, apparently saw the exhibition. Benton's invention, the white-light transmission technique, had never been used for an artwork measuring 11 × 14 in. Our 11-×-14-in *Cobweb Space* enabled him to demonstrate to Land the potential of larger holographic images reconstructed in white-light. Third, the Fellows of the Center for Advanced Visual Studies (CAVS), at the Massachusetts Institute of Technology (MIT), came to examine the holograms and the installation. CAVS founder and director, Gyorgy Kepes arrived, influenced by Friedrich St. Florian [6], whose interest in holography prompted the CAVS excursions. Later, I would become a Fellow at CAVS.

During production of *Cobweb Space,* which at that time was untitled, my first concern was the composition. For numerous reasons, I chose a rectangular glass fish bowl through which to beam the object light against ground glass. A problem existed in that the chosen pattern of light on the ground glass was, of course, two dimensional, whereas our intention was three dimensionality. The second-generation factor of the white-light transmission system solved this problem. With diverging beams and no collimating lens, the second-generation process can round and expand the image. The farther the image is projected in front of the plate, the more it will enlarge and distort.

In addition to our 50-mW Spectra Physics HeNe laser, we had objective lenses of the highest quality, a marble-topped vibration-free table and almost all the sophisticated equipment necessary for holography. We had no collimating lens, but with our diverging lenses we achieved a three-dimensional cylindrical image in the second-generation plate (H2). In this case, a handicap became an asset.

We had not yet projected imagery in front of the plate, but the exposure that recorded the pattern closest to the plate in *Cobweb Space* rounded and expanded in H2 to the degree that it seemed to skim through the plane of the plate. In the next work that Benton and I created, the image was clearly projected frontally.

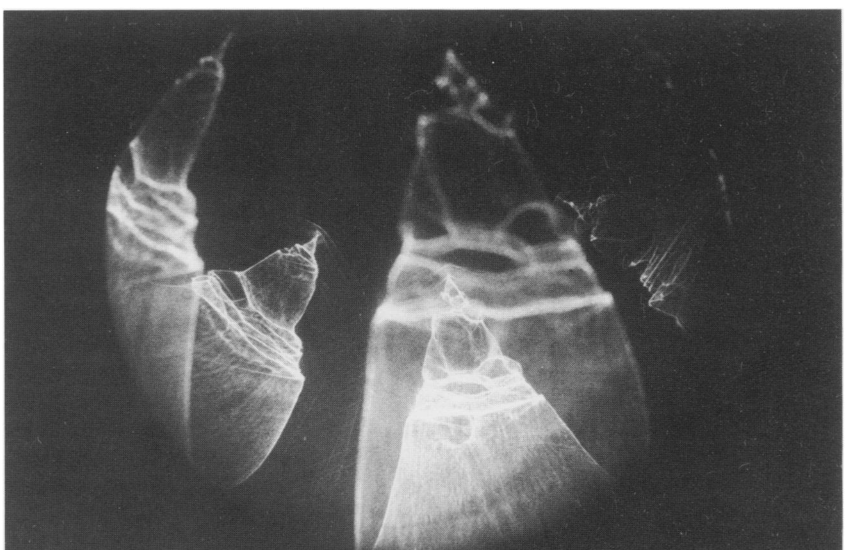
In *Cobweb Space,* the composition in each of the three exposures, though spatially oriented at varying distances from the plate, was the same. Each had what seemed to be a hole in the center of its myriad lines of light. Therefore, the spectator, standing directly in line with the plate, 2 ft or more back, could look right down the cylinder through the hole. This was an unnecessary extra, I thought, but it was a delight to most viewers, and especially to scientists.

The AO physicists were astonished by the brightness of the hologram, its spectral colors and its reconstruction by white light (with an angle of approximately 45°, top reference). I was slightly ambivalent. Benton and I had a new piece that would startle the holographic community, small as it was then, and some of the art world. But I missed the mysterious phantasma of the laser light.

I determined instantly that any white-light transmission images I would do in the future, with or without Benton, would be seen, as *Cobweb Space* was, in one color at a time. But this can be achieved only to a degree. The distance from the plate and the eye level height (the angle of view) from which the spectator sees the hologram determine which spectral color will predominate at that instance. If the color bands are not spread apart sufficiently, a rainbow effect ensues. No matter how lovely a celestial rainbow may be, there would be none in my holograms. White-light transmission holograms unfortunately are now widely known as rainbow holograms; they should be called white-light transmission or Benton holograms.

Why did I continue with white-light transmission holography? I was excited with *Cobweb Space* and I was curious; there were practical considerations in reconstructing with white light as distinguished from laser light. Most museums and galleries, knowing little about lasers, are intimidated by them. Furthermore, in the United States, regulations vary from state to state as to how much laser power can be used in public. Why did I not pursue white-light reflection holography? At least reflection holograms reconstruct in one color. At that time, the only color I had seen in reflection holograms was an

Fig. 3. *Holos 17,* laser transmission hologram, plate 11 × 14 in, depth of image to infinity, frontal projection ≈ 8 ft, segments in space to 30 ft, 1973. (Consultant: Stephen Benton. Photo: Scott Nemtzow.) A concave hemisphere recorded in the first exposure was turned around in the darkness between exposures so that it became a convex hemisphere. When recorded in the second exposure, the convex hemisphere met the light pattern of the concave hemisphere, whereupon we had a complete sphere, not outlined as such but formed by its own laser light pattern.



ugly green. Reflection holograms, moreover, were not as intense as white-light transmission holograms, and the depth of image achievable, as well as the frontal projection, was less by far than in white-light transmissions. Spatial scope, either in back or in front of the plate, was important to me. Along with holographic light, dwells holographic space: "Light slicing through space but also gently shaping it" [7]. Later, I backed white-light transmission pieces with front surface mirrors. These holograms may be hung on a wall and front lit, thereby acting as reflection plates.

Hologram IX (1972), was the next piece on which Benton and I collaborated. This was the first multicolor white-light transmission art hologram. As with *Cobweb Space,* the composition holographed was made of laser light, but this time one of the exposures was shot in combination with a realistic object (Fig. 2). The multicolor technique, invented by Benton, is also called pseudocolor and is now popular with holographers. We started with five spectra—via five exposures—to attain a multicolor junglelike background. Then we eliminated two spectra; the jungle was too complicated artistically. From the background colors, so much more varied and subtle than in a single spectrum that the rainbow effect became less consequential, a skeletal hand protruded through the plate approximately 12 in. The imagery was both in front and in back of the plate. And the hand looked realistic in hue, possibly in contrast to all the color from which it emanated.

Initially, without a pulsed laser, we tried to use a real hand on the optical bench, clamped in a tight stocklike contraption for the sake of stability. It was not stable enough. We did achieve a shadow hand, and we could have used it; but for Benton and for me, both of us perfectionists, the hand was not adequately defined. I had reservations about the skeletal hand also. In the early 1970s, it seemed trite to me. In the 1980s, with expressionistic and science-fiction imagery so much the trend, the hand now is highly applauded, but I still think of it as slightly trite [8].

During this period, Benton spent 6 months in England for further exploration of optics. I continued the work with laser configurations at AO, and on Benton's return we resumed our previous working arrangement. With a crystal bottle bottom, I found I could form abstract but structured patterns, reminiscent of Constructivist art, though my philosophy is unlike that of Constructivism [9].

Ultimately, *Holos 17* (1973), a laser transmission hologram (Fig. 3), was the result. A concave hemisphere recorded in the first exposure was turned around in the darkness between exposures so that it became a convex hemisphere. When recorded in the second exposure, the convex hemisphere met the light pattern of the concave hemisphere, whereupon we had a complete sphere, not outlined as such but formed by its own laser light pattern. We intended to use the laser transmission holograms as exhibition pieces, with the best of them as masters for white-light transmission imagery that would project frontally. Although segments of the H1 (master) pseudoscopic design could be seen from a distance of approximately 30 ft, which I found tantalizing (and have shown this way), the total H1 image was too large to emerge through the H2 plates to be seen easily at a moderate distance. Furthermore, the second-generation white-light holograms seemed to have unfathomable problems other than size. After much searching, it was finally determined that the emulsion on the second-generation plates was defective (we had been using Agfa-Gevaert 8E75; as all holographers know, it is not unusual to receive a batch of plates with imperfect emulsion).

Since we had to redo the H2s, we put

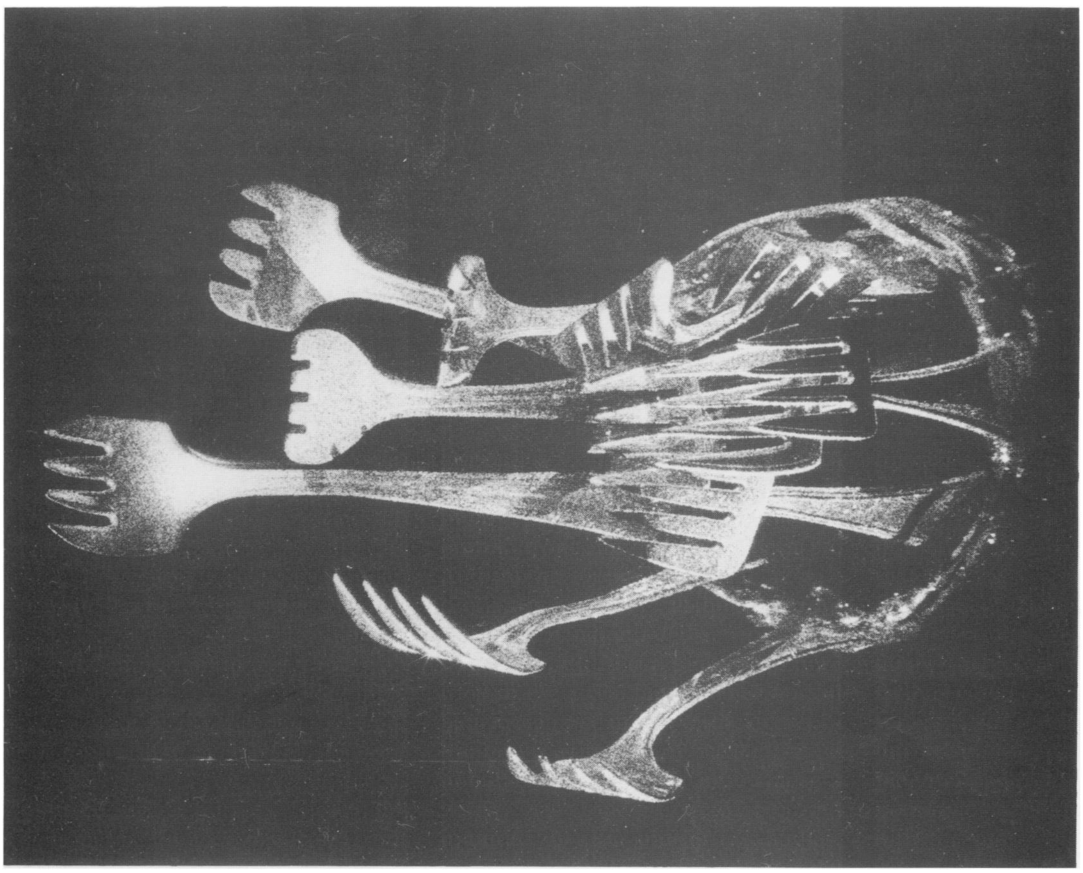


Fig. 4. *Equivocal Forks I,* laser transmission hologram, plate 11 × 14 in, pseudoscopic image projecting in front of the plate ≈ 24 to 30 in, 1977. (Photo: Nisham Bichajian) Using a cluster of forks as the object, I placed much effort in the frontally projected imagery so that the glass would not be an obstruction between the spectator and the finished sculpture made of light.

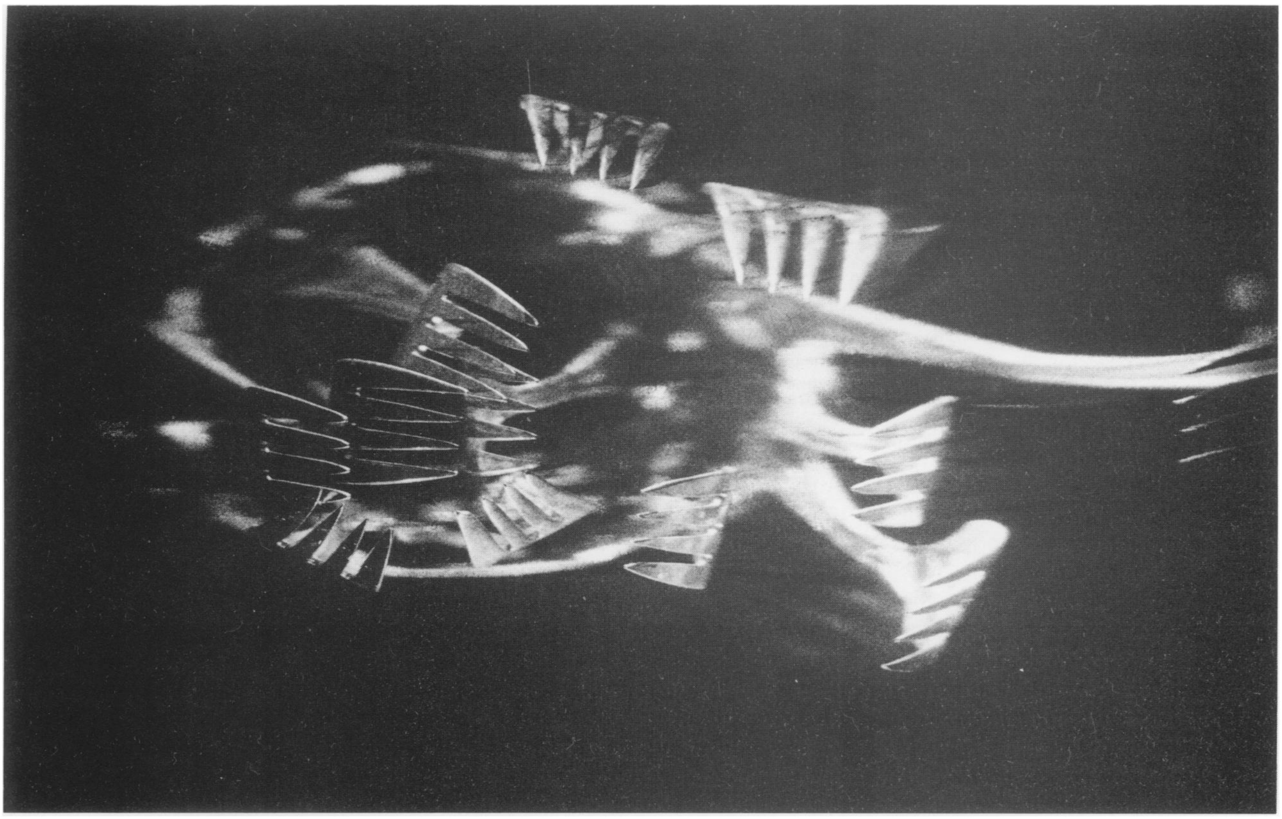


Fig. 5. ***Equivocal Forks II,*** **white-light transmission hologram, plate 12½ × 16½ in, image projects frontally 36 in, 1977. (Photo: Ken Winokur) Unlike *Equivocal Forks I,* which begins its forward projection about 6 inches in front of the plate, thereby floating in space completely unattached to the plate, the frontal projection of *Equivocal Forks II* starts directly at the plane of the plate.**

aside *Holos 17* and its sister plate *Holos 71* to use as exhibition holograms; for masters we tried smaller spheres, allowing them to expand in the frontally projected white-light versions and still be visible as full images from a reasonable distance. Actually, the white-light spheres started behind the plates and cut through to form the larger part of the spherical compositions in front.

When we began to experiment on the exact size that the first hemisphere should be in H1, I made the first of the smaller laser-transmission hemispheres alone. In reconstructing the plate for the pseudoscopic concave image, I experienced feelings similar to those I had had when I first saw *Glass Balls.* This was the vision I had been anticipating: three-dimensional luminous energy floating in space, completely disengaged from the plate. The glass could not be seen. It was at this point that my work at AO was about to end because van Ligten was leaving. I started to look for another laboratory.

Brown University (1974–1978)

Where would I find, in 1973, a facility such as I had been using at AO? Having heard of Hendrik Gerritsen of Brown University, Providence, Rhode Island, and of his interest in holography, I showed him my holograms and the collaborations with Benton. We talked about holographic goals and philosophy. Gerritsen arranged, through the department of physics at Brown University, for the purchase of a Newport Research Corporation 5-×-12-ft optical table, a Spectra Physics 50-mW laser, a variable beam splitter, spatial filters and other necessary equipment. Some components were already there, and I owned some equipment—the darkroom was fully equipped. A second small laboratory with a table approximately 4 × 5 ft and a 5-mW HeNe was also available for experiments.

Gerritsen, like van Ligten at AO, was to act as a kind of patron. He did not work with me, but he was available for theoretical discussions on any optical or holographic obstacle. Since the art department at Brown University was fairly conservative and taught no photography, let alone holography [10], I was given an appointment in the physics department, which was sympathetic towards my work; I have always been grateful for the understanding shown me.

The *Sphere* series, as I call it, was completed at Brown University. In addition to *Holos 17* and *Holos 71,* the series includes several laser transmission holograms and several white-light transmission holograms. Except for one, all the hologram plates measure 11 × 14 in; all the images were projected frontally from 18 to 40 in. The laser transmission pieces have been shown as virtual images behind the plates as well.

The series was composed of laser light: there was no real object in the optical system. Although I favor the delicacy of the linear light patterns in the laser transmissions, the white-light *Sphere* series is special for me in that the illusory form projecting through the plate and back again seems to curve the flatness of the plate; the glass and sphere attain a symbiotic relationship [11].

After I went to Brown University, Benton's and my joint activity was considerably curtailed. Benton became more consultant than collaborator—the best of consultants to be sure—but mostly via the telephone.

Regarding composition, holographers too often have positioned every object in the center of the hologram, so that the image would not disappear too quickly as the spectator moved to the side. This design has become less prevalent as more art-oriented people have entered the field. I consistently try to use the positive and negative space in the composition in a way similar to painting or sculpture. If an image requires a strong central position, fine. Most often, I want to cover as much of the plate as possible.

Unlike in painting or sculpture, in holography if a portion of the image moves off the plate, the segment(s) remaining should still hold the attention of the viewer. A good example of this, I believe, occurs in my *Equivocal Forks* series *I* (Fig. 4) and *II* (Fig. 5). Each hologram contains a cluster of forks projected 2 to 3 ft in front of the plate. As the viewer moves to the left, the forks start to travel towards the right, and vice versa. Soon part of the image moves off the plate entirely, but a section remains. In my opinion, even when only one or two forks are visible, the positive/negative space is arresting; the kinetic movement and changes in composition contribute to the excitement of the piece.

I would like to correct the misconceptions about my laboratory work that have appeared in certain texts. Some authors apparently assume that the physicists with whom I had contact performed as technicians. This is untrue. From my technical efforts at AO and at Brown University, I was immersed in laboratory techniques and systems, steadily attempting to expand the medium, incessantly searching for efficacious means to attain my goal of trenchant communication and singular expression. It is true that my explorations were never for the sake of technology alone. When I moved from Brown University to CAVS/MIT, my laboratory work was less consistent but nonetheless committed to the same goal. At AO there were always scientists with whom I could attempt to solve a problem; but after my learning experience, I did the technical production as well as the conceptual creation. In the later stages of my artist's residency at AO, apprentices from Clark University, Worcester, Massachusetts, did independent studies in holography with me, which they continued at Brown University. Other apprentices worked with me at Brown as laboratory assistants. These students did technical work for me under my direction.

I believe that the initial misconception started with the 1977 exhibition catalogue *Harriet Casdin-Silver Holography*, which contained such phrases as "her productive collaborations with several physicists in the field" [12]. Nothing uncomplimentary was implied; the statements simply were interpreted incorrectly. One of the errors in that catalogue with which I am confronted to this day was the attached "in collaboration with Dr. Stephen Benton" to *Equivocal Forks I*. Benton was not involved in that piece. Donald Thornton, now teaching holography at Brown University, and Gordon Cates were my laboratory assistants during the *Equivocal Forks I* period and both worked on this hologram [13]. Thornton's contribution continued for a lengthy interval.

By 1975, I had used the laser light in many forms. I now needed to explore and hopefully to fulfill, through holographic art, my social commitment. To communicate more directly was as much an internal decision as an intellectual one. *Phalli* (1975), in which white-light transmission imagery is frontally projected 3 ft, is political. (Its production occurred before the phallic image became overly exposed in the more traditional media—painting, drawing, sculpture). These holographic images, extended and enlarged in space, disembodied, are disturbing. There is ambivalence in the piece: animosity but also sympathy. Because of the white-light spectral colors, to me the phalli unfortunately look more like ice-cream cones than bodily extensions. Spectral colors work much better for abstractions than for sociopolitical expression [14].

It was *Phalli* that convinced me I had to work alone conceptually, at least for a while, so that my personal insights and perceptions might emerge in my visual statements without compromise.

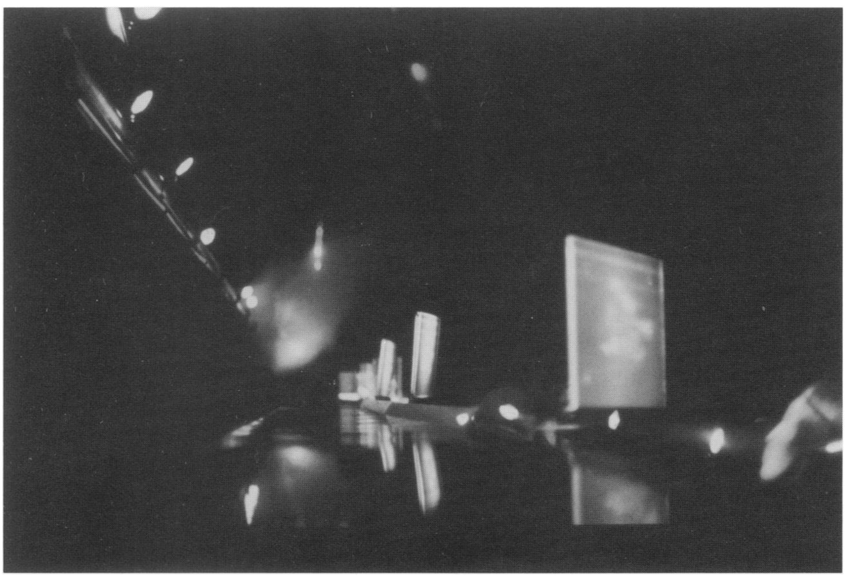


Fig. 6. Harriet Casdin-Silver's solar-tracked holograms on *Centerbeam I*, a CAVS/MIT collaborative outdoor environmental sculpture, at *documenta 6*, Kassel, West Germany, 1977. (Photo: D. Lohl) The holograms, which are from the *Equivocal Forks II* series, each measure 12½ × 16½ in, with the images projecting frontally 36 in. Sunlight reconstructed the holograms during the day, and quartz halogen lamps were used to reconstruct the holograms at night.

CAVS/MIT (1976–1985)

In 1975 I participated in ARTTRANSITION, a conference and exhibition on art and technology at CAVS. At the invitation of the Center's new director, Otto Piene, I became the first CAVS Fellow with a major commitment to holography.

I moved to CAVS in the fall of 1976 and stayed 9 years. Between 1976 and 1978, I retained my appointment at Brown University, commuting between the two universities. Finally, I opted for CAVS for many reasons. Environmental art, the base of CAVS, had been my primary mode of expression before holography, and environmental art that included holography was my target; after 9 years of consistent endeavor in the laboratory, it was time to come out of the darkness into a brighter and more comprehensive milieu.

The Master of Science in Visual Studies program had recently been instituted at MIT. CAVS was one of the five entities integrated in the plan [15]. My participation and teaching in the program, along with my own research and exhibitions, enabled me to inaugurate formally the art of holography and to advance the medium. I started to teach a course on "Holography as an Art Medium" in 1977. Except for two or three semesters, I taught for 9 years at CAVS. Depending on the needs and experience of the students, I varied the class content each semester. Every course, however, included hands-on holography [16] with emphasis on artistic concepts and their realization. Practiced students were encouraged to explore the environmental and interactive possibilities of holography.

Before joining CAVS, I had begun a piece using a cluster of forks as the object. The reconstructed image would fall approximately 2 ft in front of its 11-×-14-in plate and be completely separated from the plate. I had placed much effort in frontally projected imagery so that the glass would not be an obstruction between the spectator and the finished sculpture made of light. Spectators invariably attempt to touch the image.

The work became *Equivocal Forks I* (1977), the laser transmission hologram shown in Fig. 4 [17]. This work extends the concept of the *Phalli* but is more subtle—it is perhaps more provocative and certainly less hostile. The forks are not only phallic; they are also female. The handles emanate from a circular feminine form and travel towards the plate, prongs headed away from the viewer. The photographic camera has difficulty capturing this aspect of the piece, because the camera lens turns the image around so that most people, seeing only photographs, expect the prongs to be aiming at them. All the forks head in one direction, but perceptually they—or some of them or one of them—reverse direction, thereby becoming equivocal. There is also more kinetic activity in *Equivocal Forks* than in *Phalli,* more interplay of positive/negative space.

I had planned the final laser transmission results to be pseudoscopic and to be used as exhibition holograms. Depending on the outcome, I also considered using one piece as a master from which to make white-light transmission holograms. On seeing the pseudoscopic image in its placement exactly as planned, I knew I needed no white-light transmission. (Later, an *Equivocal Forks II* series did evolve, shown in Fig. 5, but from a larger master, positioned differently and for another purpose.)

The lighting system used three object beams, one from behind the object, a second from front left and a third from front right. The metal of the real forks and the illumination of the object combined to achieve a sparkling glow in the image unlike the flat red seen in some holograms made and reconstructed with a HeNe laser.

One other hindrance presented itself, but it turned out to be desirable. The reference beam caught a set of prongs in one of the first exposures on an experimental 4-×-5-in plate, causing a shadow image of the prongs at the top center of the plate. The beam easily could have been moved slightly and the shadow eliminated. But the shadow was so perfectly formed, and it interacted so well with the holographic image, that I allowed it to remain. Because this hologram was shown in one color, deep red, the black shadow of the prongs and the holographic red prongs slipped through each other as the viewer moved from side to side. The black negative space completed the integration. When the *Equivocal Forks II* series with its spectral colors was made, I eliminated the shadow. The colors and the shadow together would have complicated the composition.

During this period, my first holography course at MIT was established, and CAVS was invited to participate in *documenta 6* in Kassel, West Germany, scheduled to open in June 1977. I flew to Germany to install my solar-tracked holograms (from the *Equivocal Forks II* series) on the outdoor sculpture *Centerbeam* (Fig. 6 and Color Plate A No. 3). *Centerbeam* was—and could be again—a 144-ft environmental outdoor sculpture by the artists of CAVS and participating scientists and students. It was commissioned for *documenta 6* and exhibited again in Washington, D.C., on the mall near the Smithsonian Institution's Air and Space Museum in 1978 (Fig. 7).

The work was intended as an installation of kinetic performing sculpture. Viewer participation, as summarized by Otto Piene, *Centerbeam* project director, included the manipulation of holographic images by the mirror trackers [18]; play with human beings and objects transposed into spectral hues and rainbow shapes; the computer-encoding of laser space drawings (in Washington, D.C.); 'video reflections'; the launching of flowers and other features that required the understanding, interference and initiative of the viewer.

The work has been referred to as an

Fig. 7. Harriet Casdin-Silver's solar-tracked holograms on *Centerbeam II*, a CAVS/MIT collaborative outdoor environmental sculpture, in Washington, DC, 1978. (Photo: M. Palumbo) The holograms, which are from the *Equivocal Forks II* series, each measure 12½ × 16½ in, with the images projecting frontally 36 in. For this installation, the system for reconstructing the holograms by both sunlight and artificial light was refined.

aqueduct or as an idea-collage. For me, the work was essentially an energy beam. With the holograms using the sun as the reconstructing reference beam, their brightness was dazzling.

My contribution to *Centerbeam* was the holography line: holograms, mounting and solar-tracking units. (We referred to each artist's contribution to the work as a line.) The holograms, eight to 10 plates from the *Equivocal Forks II* series, each 12½ × 16½ in, would project imagery frontally about 3 ft. Each piece would be placed at a strategic vantage point along the 144-ft line of the work and mounted at the front of the water prism, thereby causing a reflection of itself in the water. Holograms had never been exhibited outdoors for long periods of time nor illuminated by solar-tracking devices.

Along with each artist concentrating on her or his individual lines, we were all collaborating on the total configuration. Meetings were held day after day; sketches, drawings, conversations, arguments and ideas were generated, digested, rejected or (occasionally) accepted. Sensitive egos shared talent, intelligence, perception and expertise towards creating a unified whole.

In regard to the solar tracking, Walter Lewin of MIT's Center for Space Research was recruited to develop a system that could be used for the 3-month exhibition at Kassel. Lewin and I assembled a group of graduate and undergraduate students to work with us. We also enlisted Benton as a consultant. One of the students collaborating directly with me conceived and assembled the electronics for the trackers; another two worked on the action of the photocells and their placement on the holograms. Lewin's students constructed the trackers in their machine shop [19]. Lewin himself devised, via computer, an elegant system.

> Our objectives [he writes] were to design and build a system that would allow solar illumination (using mirrors) of Harriet Casdin-Silver's holograms for *Centerbeam* in Kassel. The solar tracking had to be automatic, and it had to provide enough light for the holograms between June and October, 1977.... The holograms were specially designed to produce the holographic image ... if a white-light source illuminated the holograms at a 45° angle from the vertical. Our task was to design and construct a mirror system that would reflect a beam of light from the sun onto the holograms so that the above condition would be met independently of the position of the sun in the sky. We examined the possibility of using flat mirrors, convex mirrors and cylindrical mirrors [20].

It became evident that cylindrical mirrors would work best and were the most practical. "The tracking systems were designed so that they will work not only in Kassel, Germany, but anywhere on Earth" [21]. Additional mirror trackers could be manually manipulated by viewers to reconstruct the holographic images in space.

A 60° arc of a cylindrical mirror with a radius of 40 cm was mounted on a vertical axis at the necessary 45° angle at a distance of 2 m from the hologram. Though the mirrors weakened the reflected sunlight somewhat, their cylindrical structure was advantageous. Solar tracking was required only in the vertical dimension. The curvature of the cylinder eliminated the need to track horizontally. Further, the holographic images were bright enough to withstand the decreased intensity.

Each mirror rocked back and forth on its axis, a motion achieved by a two-directional motor controlled by a pan of photocells mounted at the bottom left edge of every solar-tracked hologram. The motor was directed by a logic circuit until the photocells sensed light and the hologram was illuminated. With inadequate sunlight, power was transferred from the servo system to a quartz halogen spot lamp [22].

Aesthetic considerations remained of primary importance. The cylindrical mirrors had to integrate with *Centerbeam* and with the holograms. Ultimately, the trackers, with their kinetic, reflective surfaces, became artworks themselves. They were far enough away from the holograms to cause no distraction to the images.

But the sun would not always be shining. We needed illumination for the night and for cloudy and rainy days. We employed quartz halogen sources, which had to be efficient since the images in daylight (the intensity of light on a cloudy day is much stronger than bright indoor light) would be seen against a backdrop of pipes, trees, crowds of people, vivid blue stanchions and the entire panorama of *Centerbeam* and its surroundings.

The holograms themselves had to be three generational. First, a new laser transmission master would be made because the one of *Equivocal Forks I* was too small. The second-generation white-light holograms would turn the master pseudoscopic image around so that the fork prongs would head towards the viewer. The third generation would redirect the forks, prongs and all, towards the plate, away from the audience. The forks would still be in front of the plate with the circular form, from which the phallic handles and prongs emanate, proximate to the spectators, as in the *Equivocal Forks I* series. Just as in the latter, one or a few of the forks would also seem to turn and face in the other direction. The effect was still eerily equivocal.

It was finally determined, because of the shortness of time, that we would have the holograms made by scientists or technicians using my *Equivocal Forks I* structure as the object. Benton and two of his co-workers at the Polaroid holography laboratory, Herbert Mingace and Will Walters, were contracted to make them. The erroneous reporting in some texts about whether or not I produced my own plates may have originated here. In fact, this was the first time that any of my holograms were made in a laboratory other than my own.

Benton's group used my *Equivocal Forks I* lighting system. We wanted to be sure that the new master would contain the sparkle—without hot spots—of that hologram.

Unlike *Equivocal Forks I*, however, which begins its forward projection about 6 inches in front of the plate, thereby floating in space completely unattached to the plate, the frontal projection of *Equivocal Forks II* starts directly at the plane of the plate. The reason for this is that in reconstruction by sunlight, the farther the image is in front of the plane of the plate, the more it will blur. The indistinctness of the image would be worse than if reconstructed by ordinary white light, e.g. quartz halogen. In retrospect, Benton and I erred in allowing the fork prongs to touch the plate perceptibly. Absolute reality was not important to my concept. As soon as any part of a frontal image touches the plate, it seems to draw the rest of the imagery back towards the plate. If this occurs, the three-dimensional frontal protrusion may be hurt, demanding a discerning eye to see the image suspended in space. For the untrained eye, it takes more time to experience the phenomenon.

However, the fork clusters were so bright that they floated out from both sides of the plates. This meant that they could be seen from both the front and the back of *Centerbeam*. Walking along the line of holograms, the viewers would see each image in one color at a time, each color dependent on the viewing angle and the angle of the solar trackers or other illuminators, which were mounted at slightly different heights. Even with the 3 ft of projection out in front, the resolution was amazingly sharp.

documenta 6 opened on 24 June 1977. I wrote, "We are opening up environmental holographic possibilities formerly unattainable. Scale and color are limitations still to be overcome. We must beware of the 'beer bottle in the sky' mentality—the risk exists" [23].

The Washington, D.C., *Centerbeam* gave me an opportunity to refine and perfect the system (see Fig. 7). The electronics were adjusted [24] to afford solar illumination of the holograms for longer periods of the day. They were less affected by clouds blocking the sun. For sunless days and night reconstruction, more intense lamp-illumination was devised [25]. The forks were reconstructed by the trackers at the angle for which they were designed and again by the sun's beams directly without the intervention of the trackers, so that an ever-changing multitude of forks appeared.

To be fully experienced, the holograms, like the rest of *Centerbeam*, had to be seen at different times and from many vantage points—in the sunlight, at night, at close range, from a distance. The forks emerged through the steam, tentatively, one at a time, until the steam disappeared and they were all visible in concert [26].

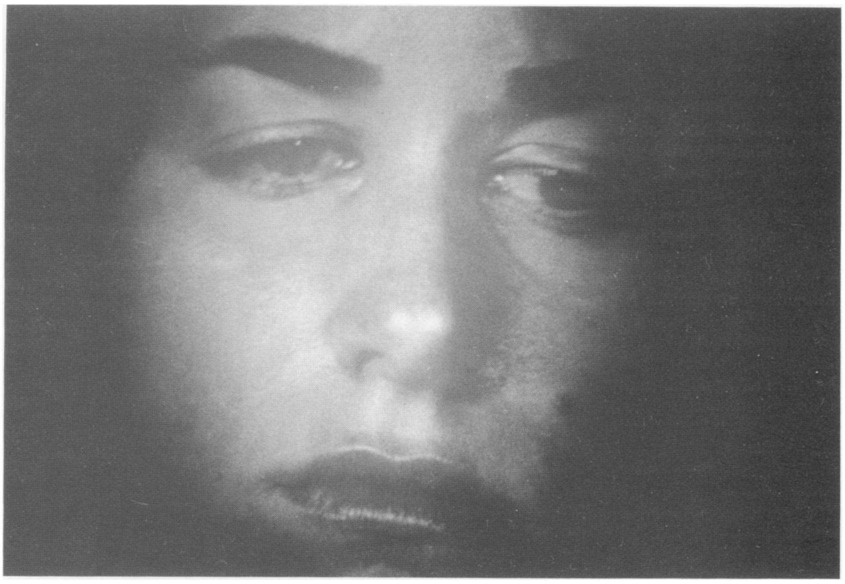


Fig. 8. Harriet Casdin-Silver, *Beth Dara*, achromatic (black-and-white) hologram, plate 11 × 14 in, image depth 12 in, 1982. (Photo: Paul Foley) *Beth Dara* is representative of my holograms of women in transition. Women are still struggling to become equitable members of society. This image reveals a burgeoning comprehension of life's disparities.

CONCLUSION

Following the installation of *Centerbeam* in Kassel, I turned towards people as subjects that would best communicate my social philosophy. Since one of my priorities has always been feminism, I focused on women.

A Woman, Compton I, the recent *Compton II,* and *Beth Dara* are examples of my holograms of women in transition. Women are still struggling to become equitable members of society. *Beth Dara* (Fig. 8) and her sister image *Karen Stefani,* both suddenly women, reveal a burgeoning comprehension of life's disparities. A few of my holograms portray men—but through a feministic viewfinder.

Soon I would come full circle to create interactive environments again, as I had in my stainless steel *Exhaust* in 1968. Through these media interactions—holography, video, robotics, sound—I feel I am communicating with heightened intensity. I intend to write a continuation of this article to analyze my research and production of the last 12 years and perhaps to discuss future productions, those concepts of mine filed away, dutifully waiting for technical advances to make possible their fruition.

At the time of this writing, I am preparing for a trip to the U.S.S.R. to work with a group of Soviet scientists and technicians. The results of this venture will be shown in the U.S.A., in spring 1990 if all goes as planned, and in the Soviet Union, Canada and other countries.

I want our collaboration to express a sense of this momentous moment in history: the promise of a more enlightened, less fearsome world for all of us, East and West.

References and Notes

1. *Exhaust* was shown at the Experiments in Art and Technology (EAT) exhibition at the Brooklyn Museum in New York in 1968.

2. This untitled silverware piece was one of my first exhibited holograms; it was shown with the Art Technology Inc. group for the Northeast Electronics Meeting in Boston, Massachusetts, in 1969.

3. This work is now in a private collection in Rome.

4. I made three plates of *Glass Balls* (1969), one of which was bought by the Museum of Holography, New York City, for its permanent collection. One is in my own collection and the third is an artist's proof.

5. Before the advent of Benton into my holographic milieu, many events took place. The 11-×-14-in *Glass Balls* was exhibited in the Nelson Gallery at the Atkins Museum of Fine Arts, Kansas City, Missouri, in 1970. Among other shows the same year, I exhibited at the Chicago Museum of Contemporary Art and at the Sixth National Sculpture Conference, University of Kansas, Lawrence, Kansas. At a demonstration evening of my holograms at Clark University, Worcester, Massachusetts, a visitor from Polaroid Corporation, Cambridge, Massachusetts, invited me to meet with a Polaroid group to plan an exhibition of my work and a lecture at Polaroid. While there to organize the event, I met Stephen Benton. Soon after, we viewed each other's work and decided to collaborate.

6. Friedrich St. Florian is now the Chairman of the Department of Architecture at the Rhode Island School of Design, Providence, Rhode Island. When he was a Fellow at CAVS/MIT, he created futuristic fantasy drawings of holographic images, such as a hologram over the Charles River. Perhaps some day the fantasies will materialize. [*Editor's Note:* see Friedrich St. Florian, "On My 'Imaginary' Architecture", *Leonardo* **11**, No. 1, 53–54 (1978); and "A Choice of Reality", *Leonardo* **19** No. 4, 320-321 (1986).]

7. Harriet Casdin-Silver, "Harriet Casdin-Silver Holography", exh. cat. (New York: Museum of Holography, 1977) title page.

8. Through Harold Jones, then Director of the Light Gallery in New York City, *Hologram IX*, the *Cobweb Space* pieces and a white-light transmission I produced alone titled *Schirmer* were shown at the Hudson River Museum "Light and Lens" photography exhibition, Yonkers, New York, in 1973. Jones was also responsible for *Cobweb* being placed in Van Deren Coke's traveling exhibition "Light and Substance" (1973–1975), which opened at the University of New Mexico Art Museum. The "Women Choose Women" exhibition, also in 1973 in New York City (at the museum then called the New York Cultural Center), included *Glass Balls*. The art in this exhibition was mostly painting and sculpture, which required bright lighting. *Glass Balls*, being a laser transmission hologram, required darkness. Using electrical conduit tubing as the frame, I constructed a rectangular structure, approximately 12 × 4 ft, covered in black felt. It was essentially a long black hole. The hologram was positioned at the opening in front; the laser was at the rear of the structure in darkness, so that only its point source showed. The laser point source

became part of the image, enhancing the illusion of the balls traveling into infinity.

9. "In constructivism, the means of production were identified with the meaning of the work, but the artists in '5/5' do not believe that new systems are expressive in themselves apart from the intention of the artist. Both Otto Piene and Harriet Casdin-Silver have discussed expression in art in ways that state their belief that art originates in the artist not in the hardware" (Lawrence Alloway, "Introduction", in *5 Artists/5 Technologies,* exh. cat. [Grand Rapids, MI: Grand Rapids Art Museum, 1979]). The exhibition included environmental light works by Peter Campus, Harriet Casdin-Silver, Paul Earls, Otto Piene and Alejandro Sina.

10. Students in Brown University's art department may now take a course in holography with Hendrik Gerritson, physicist, and Donald Thornton, adjunct lecturer in the art department and research associate in the physics department. Thornton received his M.S. in visual studies with a concentration in holography from MIT. Based at CAVS, he was a student of mine and graduated as an artist/holographer. To my knowledge, he received the first master's degree in holography.

11. One of these *Spheres* is in the collection of Brown University under the auspices of Hendrik Gerritsen. The other was bought by the German holographic entrepreneur, Matthias Lauk, for his Museum of Holography, Pulheim, bordering Cologne, West Germany.

12. Casdin-Silver [7]. This exhibition was the museum's first one-person show. It began with *Glass Balls* and included many laser light configuration pieces. It concluded with *Phalli* and *Equivocal Forks I*, representative of the sociopolitical direction I was to follow from that time to the present. See also Edward A. Bush, "About the Artist", published in this same exhibition catalogue.

13. Donald Thornton is discussed in Ref. [10]. Gordon Cates was a student at Amherst College, Amherst, Massachusetts. The summer of 1976 he came to Brown University to do independent studies in holography.

14. *Phalli* was exhibited at the International Center of Photography (ICP) in New York City in 1975, as were *Cobweb Space* and *Sphere.*

15. The other four units were Film/Video, Architecture Machine, Visible Language Workshop and Creative Photography.

16. Hands-on holography means learning holographic techniques by assembling systems on the optical table and making holograms.

17. *Equivocal Forks I* has been in too many exhibitions to name; it has traveled the world. One of its 'multiple originals' is currently traveling with the Canadian exhibition "Images in Time and Space", a comprehensive international show of holography, mounted by the Associates of Science and Technology. Another plate was purchased by The Laser Inc. and the Chunichi Shimbun of Japan for their "World-Wide Holography" exhibition, presently traveling.

18. Most of the holograms were solar-tracked using a servo-controlled solar tracking system. To construct images by themselves, spectator/participants could manually manipulate two additional trackers.

19. Kenneth Kantor, solar tracking systems; Michael Naimark, Brian Raila, photo cells in conjunction with Kantor; James Ballantine, Patricia Downey, machining of trackers.

20. Walter H. G. Lewin, et al., "Solar Tracking of Holograms for 'Centerbeam'", *Centerbeam,* exh. cat. (Cambridge: MIT, 1980) pp. 79–81.

21. Lewin [20].

22. Derived form Harriet Casdin-Silver's "Holography Line: Special Requirements for 'Centerbeam'", in Lewin [20] p. 78.

23. I am referring to commercial interests seeking to exploit holography. Many advertisers and public relations firms assume their clients' products can be emblazoned in the sky: immaterial billboards.

24. This was done by Kenneth Kantor, who at the time was a student in electrical engineering at MIT. Kantor did his master's work at CAVS/MIT, graduating with a M.S. in visual studies.

25. This was done by Donald Thornton; see Ref. [10]. Thornton's holograms were also shown on *Centerbeam* for a period during the work's 3-month installation in Washington, DC.

26. See Lewin [20] pp. 77–78.