Spatial Correspondence

A Study in Environmental Media

by

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ABSTRACT

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submitted to the Department of Architecture on 26 June 1979
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This thesis is a reflection upon the fact that movie cameras move and projectors do not. This reflection is partially metaphoric; artistic, technological, and cultural issues concerning our media structure, particularly movies and television, are discussed in an ecological context. The concept of a *spatial correspondence* between record and playback environments is outlined; a theory is developed; and the factors are examined. This reflection is also literal; a "moving movie" system is designed and implemented. Imagery is explored.

Thesis Supervisor: ____________________

Title: ____________________

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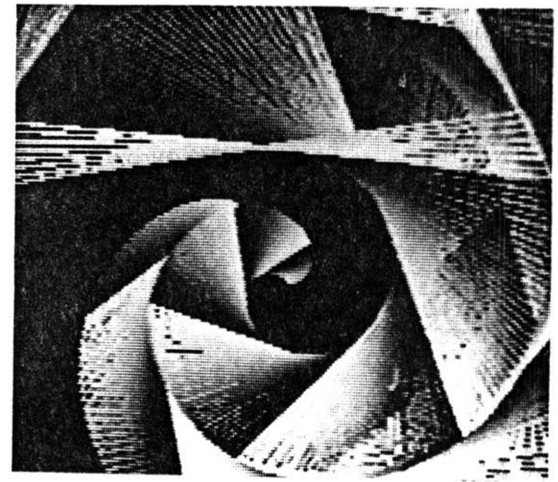
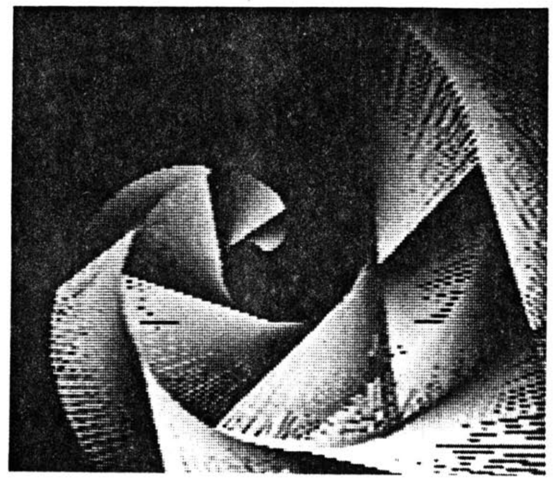
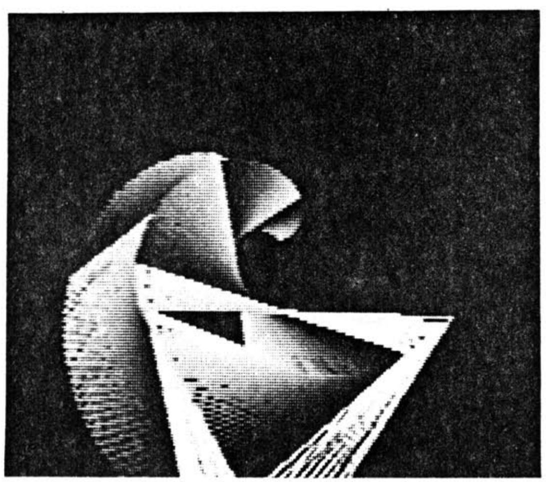
Introduction



(from *Spiralling Triangles*, 1978)





I am not convinced that movies and television evolved the same way here as they did on other intelligent planets. For one thing, we locked ourselves into a uniformity early on so that, in many respects, what we have now is not very different from what we started with. And what we started with was largely based on our culture, our technology, and chance.

As it turned out, television broadcasting evolved a few years before television recording. All of the early video productions were live. What if recording had evolved first? Similarly, the chemistry of film evolved earlier than the electronics of video. Consequently, the television form adapted to the film form. What if video evolved first? Perhaps today's movie theaters would have circular screens.

Our present movie and television structure is hardwired into a very narrow range of media forms, when one starts to imagine the possibilities. We are deeply enculturated into these forms and accept them as "only" and "natural." Most Americans, I think, believe that there exists "only" one "right" way of seeing, the "natural" way, and that television and movies are like *windows* and show us "reality."

How often, for example, do we see media images that are not flat and rectangular? (How many pictures of yourself have you seen that were not flat and rectangular?)

In the fall of 1977, while involved in a not-very-academic art project, I started thinking about moving a film projector the same way as the camera moved during shooting to achieve a *spatial correspondence* between record and playback environments. I spent the following couple of months building a modest system that could slowly rotate a camera or a projector. The result was a "moving movie." After spending some time discovering the factors involved, I dropped it completely for a year.

During that year I was primarily involved in optical videodisk research and production. I also produced a few short film and video pieces that were, in part, investigating the factors involved in moving movies. Some are used for illustration here.

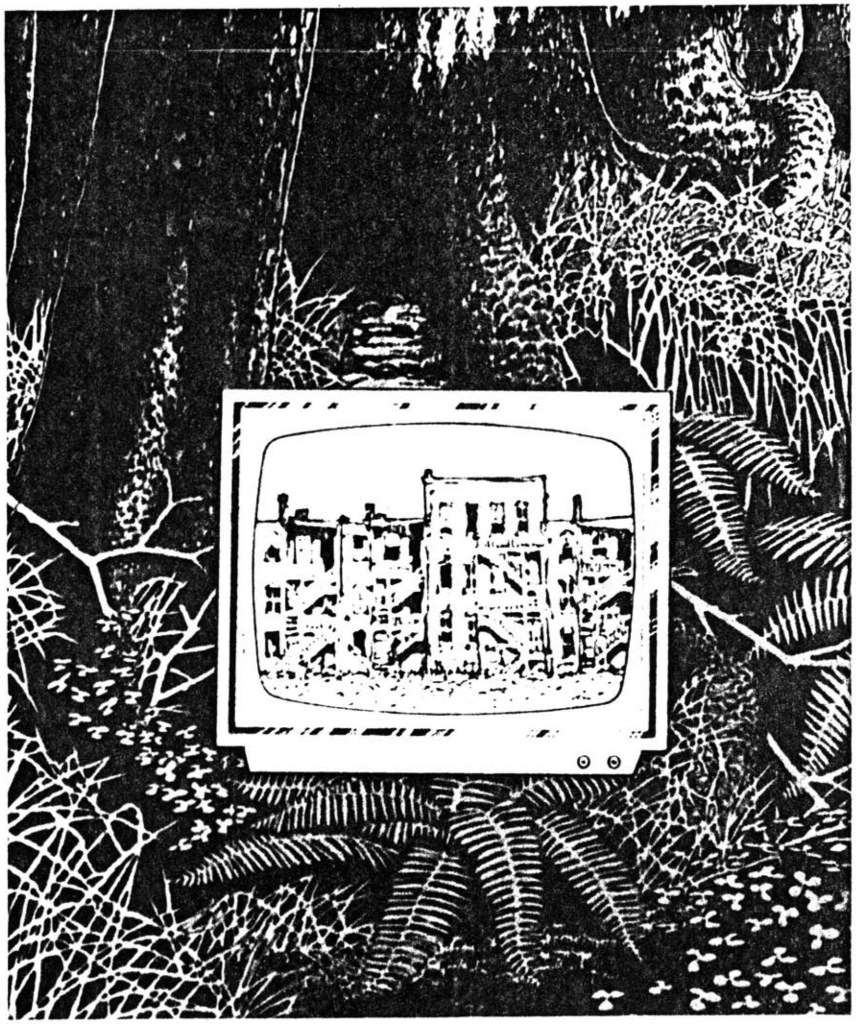
The present moving movie system is the result of the past five months of work. The decision to continue to investigate moving movies was based primarily on visual curiousity. In addition, it became apparent that the issues involved were cultural as well as artistic and technological. People were asking the right questions.

This thesis is an attempt to organize what I have done, my knowledge, and my ignorence regarding spatial correspondence. This thesis does not attempt to prove anything, but rather it tries to *point out* various connections, distinctions, and relationships between moving movies and our present media structure.

Chapter one is an overview; it is speculative and perhaps somewhat controversal. Chapter two outlines the basic concept of spatial correspondence and discusses its factors. Chapter three involves the design process and is somewhat technical. Chapter four is personal and discusses what to do with a moving movie system. Chapter five, the pictures, is visual documentation of moving movies as well as past work with spatial correspondence. Documentation, particularly with the second section, was difficult and may appear cryptic. Still picture documentation of movies is hard enough, with moving movies it is even worse. Two different techniques were used.

Bateson defines *information* as "*any difference that makes a difference*."[1] As our eyes look around a movie theater or television environment, that area of greatest visual *difference* lies in a place to which we've most acclimated, and is central to this thesis. It lies neither in the screen norin the room itself: it is at the *window's edge*.

I. Environmental Media




Cybernetics

Cybernetics is the study of messages. The term was invented by Norbert Wiener who, in 1948, published the book Cybernetics. The term was derived from the Greek word kubernetes, or "steersman," the same word from which "governor" came. In his definition, Wiener classed communication and control together.[2] Cybernetics, communication theory, information theory, and systems theory deal with this same aggregate of ideas.[3]

There are two principal realms of cybernetics.[4] One is the notion of circuit: feedback, cycles, homeostasis. It takes both a message from brain to hand and one from hand to brain to hold a pencil. Similarly it takes two wires from a battery to a light bulb to get light.

The other realm is the notion of levels: hierarchies, meta-relations (relations between parts and wholes),[5] logical types,[6] self-referential systems.[7] What is good for a cell may or may not be good for the organism. A group is not a member; a computer is not a processor.

The birth of cybernetics happened during a time of intense technological acceleration. It provided powerful guidelines for information processing, automated control, and communication efficiency as new hardware was rapidly developing. It is directly responsible for the computer industry. Today, cybernetics is often equated with computers.

Cybernetics applies both to living and artificial systems. Brand reminds us that "It has little to do with machines unless you want to pursue that special case, it has mostly to do with life . . ."[8] This broader view was apparent during its infancy: the famous Macy Conferences on Cybernetics (1947-1953) were instigated by Bateson, an anthropologist.[9] Cybernetics is directly responsible for a second, perhaps less obvious movement, the one concerned with living systems: ecology. Ecology is generally regarded as the study of the interaction between living systems and their environments. Bateson further defines ecology as "the study of the interaction and survival of ideas and programs (i.e., differences, complexes of differences, etc.) in circuits."[10] He elaborates:

> There is an ecology of bad ideas, just as there is an ecology of weeds, and it is characteristic of the system that basic error propagates itself. It branches out like a rooted parasite through the tissues of life, and everything gets into a rather peculiar mess. When you narrow down your epistemology and act on the premise "What interests me is me, or my organization, or my species," you chop off consideration of other loops of the loop structure. You decide that you want to get rid of the by-products of human life and that Lake Erie will be a good place to put them. You forget that the eco-mental system called Lake Erie is a part of *your* wider eco-mental system--and that if Lake Erie is driven insane, its insanity is incorporated in the larger system of *your* thought and experience.[11]

Ecology is most often applied to life systems. This is changing. An ecological perspective is beginning in computer science and in technology in general. As machines become more advanced and their similarity to living things becomes more apparent, ecological and life terms become applicable and take on new meaning and importance: health, adaptivity, insanity, addiction and sanctity, to name but a few. Negroponte's realization of a "Terminal Garden" as the computer user's environment for MIT's Architecture Machine Group is significant, albeit a bad pun. An effort must be made to seek further connections between computers and ecology. Both groups have the same roots. Perhaps both groups need each other. We're all on the same boat.

Environmental Art

Children today live in an ambiguous world. Almost all their homes have stereos and televisions, which sometimes include video recorders and games. Their toys have built-in computers. They learn reading and math often before they enter kindergarten. They accept the brownness of our skies, the odor of pollution, the noise and the broken glass of our cities, the chemicals in our water. They rarely see a butterfly.

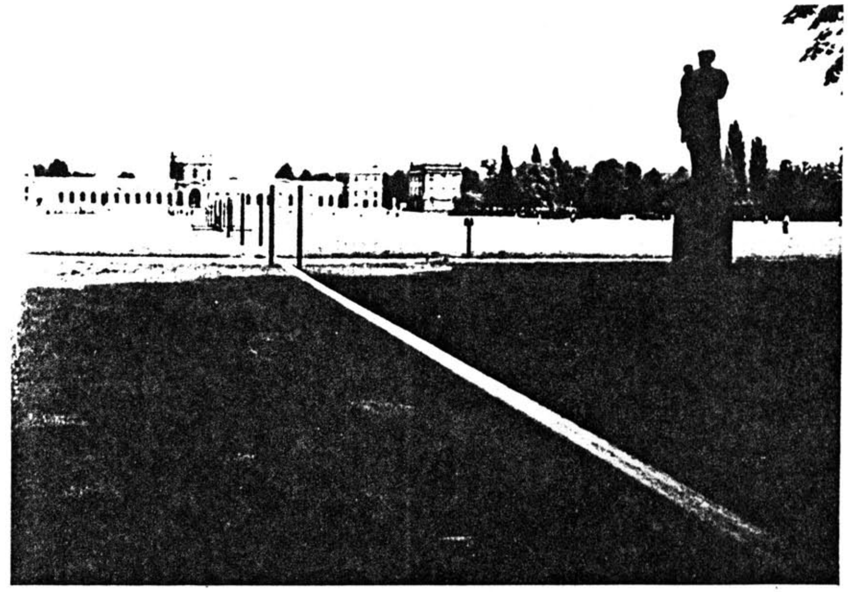
They are not completely attracted to our tales of the "good old days." Though they may be enchanted by animal stories, swimming holes, and tree forts, they are unwilling to sacrifice the high technology that is so much a part of their everyday environment. They shouldn't have to.

The tragedy is that they, and often we, view it as an either/or situation. In our drastically changed and changing environment, the ability to imagine, to see alternatives becomes increasingly difficult at a time when it is so badly needed.

Artists and ecologists share a common process in seeking alternatives: they both "step out" of their cultural bounds and take a meta-cultural view of things. In ecology, the anthropologist looks at other cultures, the biologist looks inside organisms, and the evolutionist looks at other life forms. In art, the artist may "step out" a variety of other ways as well: looking into the past, looking into the future, looking into inner spaces, and often simply looking at the random.

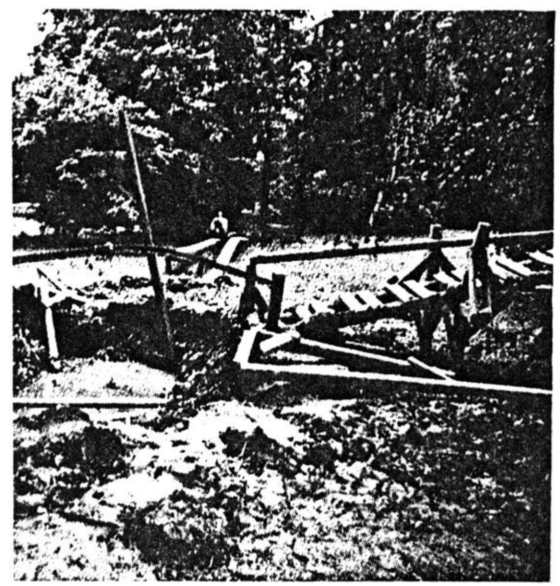
The traditional view of artist as object creator is being replaced by process pointer. Piene concludes that we have had a "close to pathological obsession with objects"[12] and suggests we think of the artist as an "economist of sensually perceptible means."[13] Youngblood elaborates:

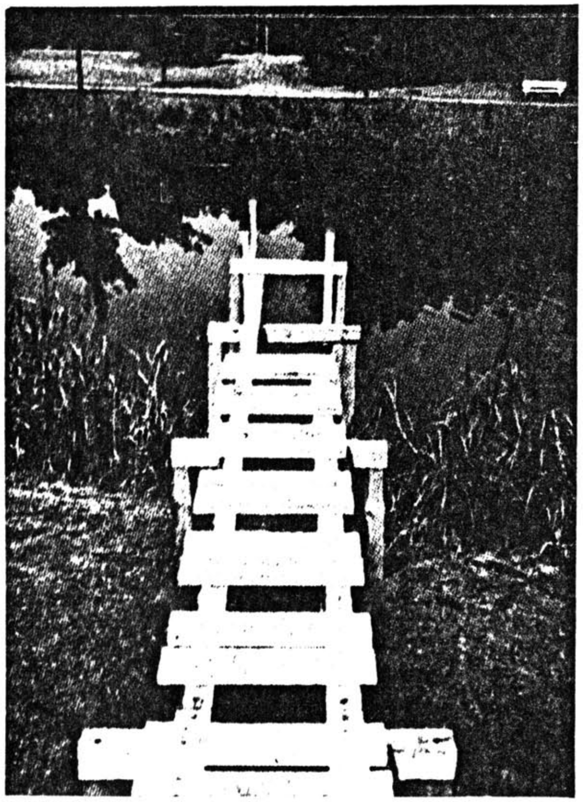
> . . . the act of creation for the new artist is not so much the invention of new objects as the revelation of



Steel bridge 224 meters long.

George Trakas' Union Pass, at Documenta 6, Kassel, W. Germany, 1977.





Wood bridge 122 meters long.

"The work consists of two independent bridge constructions: a steel bridge which relates to the Baroque axis of the auepark and a wooden bridge which poses as a modern counter-axis. The bridges cross each other in the rear of the park and will be dynamited at the point of crossing."

> previously unrecognized relationships between existing phenomena, both physical and metaphysical.[14]

We have lost a sense of whole by breaking things down into too many parts. Perhaps we are afraid to look at the big picture. We need an integrated vision. Kepes believes that

> where our age falls short is in the harmonizing of our outer and inner wealth. We lack the depth of feeling and the range of sensibility needed to retain the riches that science and technique have brought within our grasp.[15]

He further suggests that the artist uncovers values that give "sharpness and definition to the need we sense for union and intimate involvement with our surroundings."[16] The artist, he concludes, "has moved from a marginal role to a more central social position."[17]

Environmental art is environmental awareness. We have the tools to give our environment whatever shape we desire. We are beginning to learn its basic principles and those of our relationship to it. What else is needed is imagination.

Media

Definition

Media may be defined as that which transposes certain sensual attributes from one environment onto another environment. Since this thesis deals mostly with dynamic visual media (movies), we may elaborate: that which transposes or "pipes in" images from one environment onto another. These images may be live or recorded.

Media Spaces

Following is a list of the various types of environments where we encounter dynamic visual media:

1. Television Environments (mostly in homes);
2. Movie Theaters;
3. Multiple Screen Environments (Cinerama, fast paced slide shows like "Where's Boston?", Expo exhibits, etc.);
4. Rides (media spaces through which the participant physically moves, like Disneyland);
5. Information Spaces (utility monitoring rooms, war rooms, stock exchange, airports, etc.).

Though a wide variety of media forms exist, practically all of what most people experience on a day to day basis falls in the first two categories: television and movies (and, for most Americans, mainly television). When the alternatives are examined, we see that television and movie forms have much in common. Their images are flat, rectangular, and are recorded by a one-point perspective machine (the camera). We sit upright and passively in front of the screens. Movie and television images are interchangeable and devices exist to transfer film to video (the film chain or telecine) and video to film (the kinescope).

Matching Medium with Message

In 1977, the movie "2001" was nationally televised. It didn't work. "2001" was produced for the big screen; on television, the otherwise spectacular images were reduced to a joke. This admittedly extreme example shows that all messages cannot be successful in all media. A

To depict a whole object on a flat surface, literate man employs three-dimensional perspective: he shows only the surface visible from a single position at a single moment. In short, he fails.

---Edmund Carpenter

Another way of seeing- Picasso's *Les Demoiselles d'Avignon* (1906-7).

harmony between medium and message is required. Perhaps this is what Bateson means by the term "metalogue" where the structure of a conversation as a whole is relevant to the subject of the conversation.[18]

Mander argues that no technology is neutral, and that technology as a benign instrument is a myth believed by most Americans.[19] (If the reader is still skeptical, consider the "neutrality" of mass producing wristwatch-size nuclear bombs.) Television and film technologies are no exceptions. It therefore follows that television, the most pervasive and powerful medium of our time, is inherently biased toward some classes of messages and against other classes of messages.

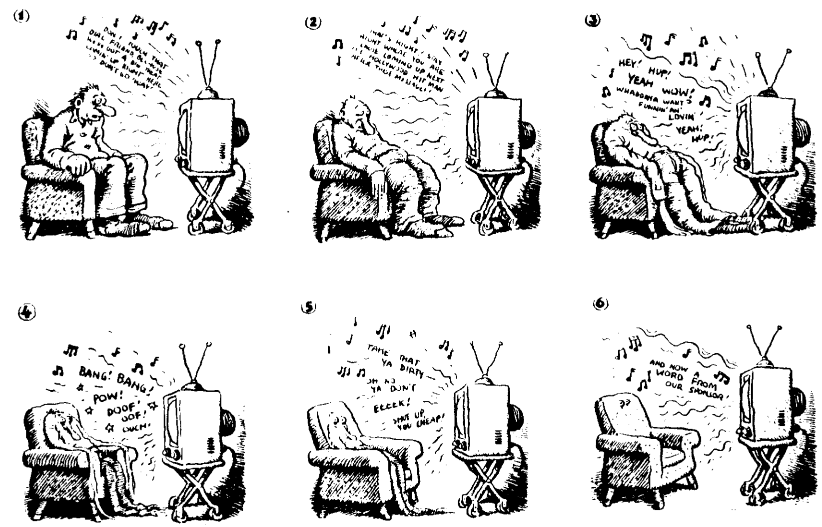
I am not arguing that the television medium is harmful, but rather that its exclusivity is. What is lacking is diversity of media forms. Diversity relates to the general health of an ecosystem. Margalef notes that "a system formed by more elements with greater diversity is less subject to fluctuations"[20] and adds that "ecosystems with greater diversity are sustained by a lower energy flow per unit biomass."[21]

Television is a Passive Medium

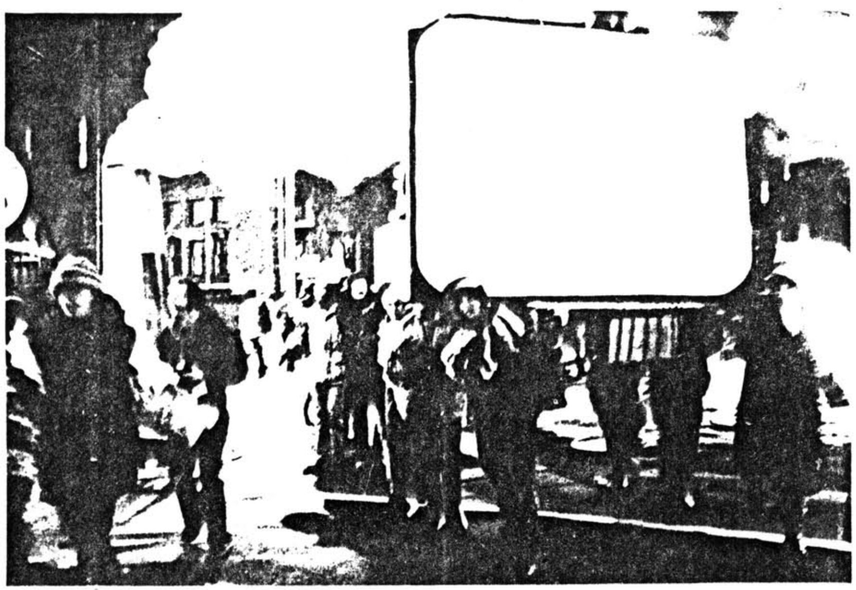
Unlike older media art forms such as architecture, sculpture, and even painting, television is experienced passively. You just sit there. McLuhan's view of television as a cool, participatory medium[22] may have been true when television was young and novel. But today, television is a completely accepted household fixture. The fascination has worn off.

The passivity of television watching may be far greater than simply sitting still, as one might do while being with friends or reading a book. Mead tells a story:

> Sartre discussed at one point what happened when you peek into a keyhole. When you look through a keyhole, the whole body is focused to try to use this very small aperture, and he described what happens if you touch somebody who is looking through a keyhole. They jump. I have a big set, now, of comparative pictures of family groups (they weren't taken for this, they were taken for family albums) reading and looking at TV. When the family is reading, they're a thousand years away from each other, their eyes are all down, but you get a sense of community



Interactive media- John Whitney using a light pen as input to an IBM 2250 computer.



Active Media- Jon Rubin's media procession through downtown Boston on "First Night," 31 December 1978. Spectator/participants keep moving to see the film.

> and relaxation. Their bodies are very loose, and undoubtedly there's movement going on as they read. But when they're watching television, the same people sit like this, they don't touch each other, and they're very rigid.[23]

New Media Technologies

It is possible to organize the major new media technologies into two groups:

1. computers, videodiscs, TV games, 2 way cable TV, and live satellite video;
2. large and curved screens, high resolution television, three dimensional films and television, and multiple screens.

The first group is of interactive media, you effect it. Your messages to it are taken into account. The second group is not; rather, it concerns a type of participation distinctive from interactiveness. The jaw-dropping impact of experiencing a seven story high IMAX film has nothing to do with interactiveness, yet the viewer is definitely involved. Let us call this type of participation active.

A great deal of research has been conducted on interactive media. Surprising little research has been conducted on active media. Even such an obvious issue as the effect of screen size is often ignored, to say little of curved or multiple screens (and to say nothing of moving ones). The thrust of this study involves this active component.

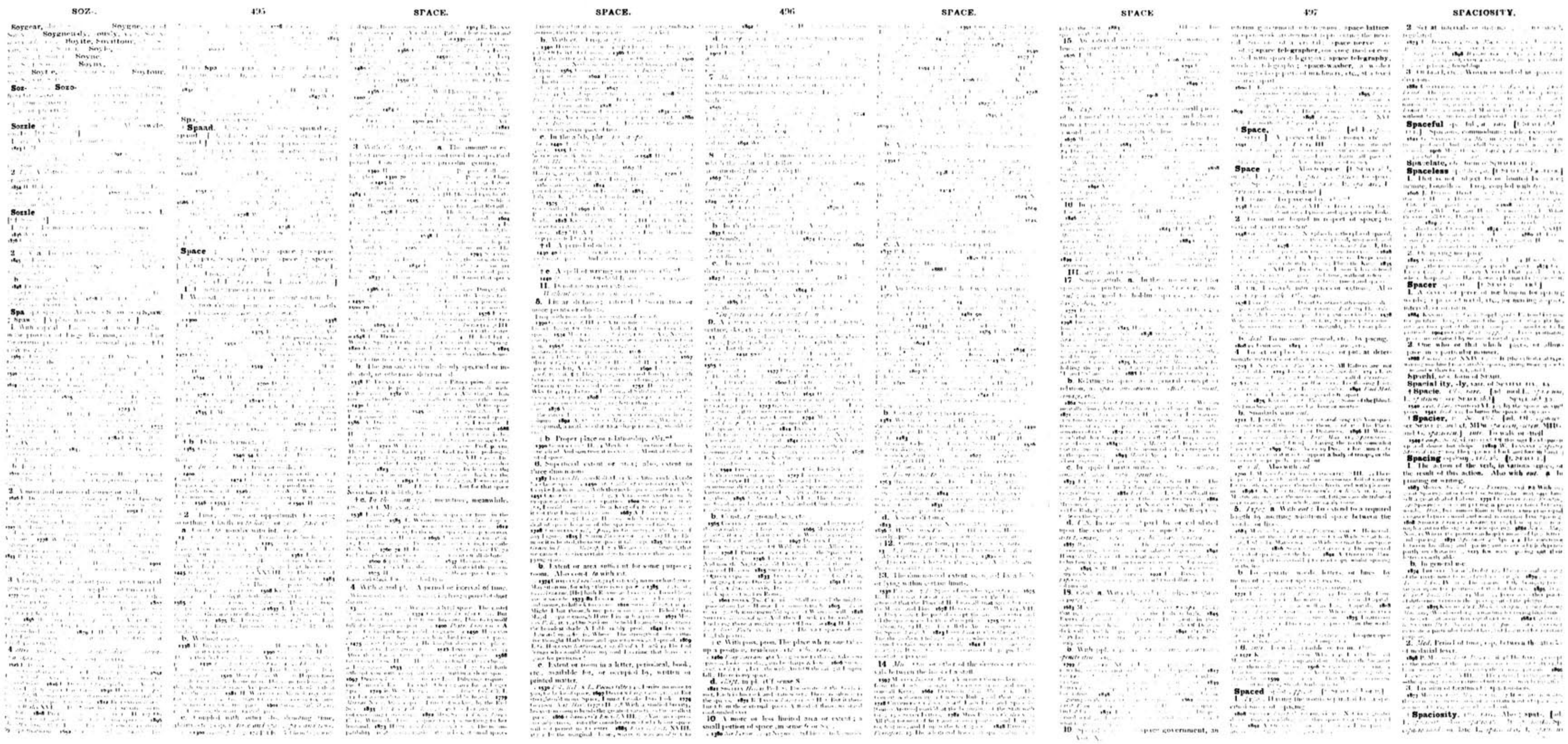
Environmental Media

Environmental media involves the search for new media forms of expression, exploration, and communication. That we are hardwired into such a narrow range of forms has restricted our range of messages and has "hardwired" our thinking and imagination of possibilities. We have lost perhaps the most basic sense of what media is: its sense of environment.

With the television medium, this sense of environment, of space, is at best sporadic and ambiguous and at worst completely lost. Millions of us may have felt like we were on the moon, but we certainly didn't feel like we were in Vietnam. Many of us ate our dinners as we watched.

In a rapid growing and changing complex society/ecosystem, there exists a need for a greater diversity of media forms to match a new and wider range of messages, of contexts. I have chosen to study one such alternative. There are many others.

II. Spatial Correspondence



Concept

The concept is simple; it is to move a projector the same way the camera moves. The camera pans left ninety degrees; the projector pans left ninety degrees in synchronization.

Now, imagine what happens. The projected image moves around the playback space. The entire playback space becomes fair game. The projected image can move anywhere.

Images of stationary objects stay put on the walls of the playback space. Imagine a pan of a stationary object, say a building. On a conventional movie screen, we would see the image of the building enter on one side of the frame and move across the frame to the other side. It follows that if you physically panned the projector the same way as the camera panned, the image of the building would stay put on the screen; only the frame itself would move.

The effect is exactly equivalent to viewing a dark space with a flashlight.

What is happening is a spatial correspondence between the record space and the playback space. If an image of the east is projected east in the playback space, then an image of west, north, and south will correspond to west, north, and south in the playback space.

When the temporal interval between frames correspond between record and playback, we have temporal correspondence or real time, which is what we are used to in movies. When the spatial interval between frames correspond between record and playback, we have spatial correspondence (or real space?).

Cameras move through time, projectors move through time. Cameras move through space, projectors do not. Curious.

Theory

True spatial correspondence occurs when the angular movement of the camera and projector are equal. Focal lengths of the camera and projector must also be equal. Angular movement is measured in terms of degrees per frame. Focal length translates to angle of view.

Let

R = rotational speed (degrees per second)

F = fps rate (frames per second)

θ = angle of view (degrees)

and let the subscript "$_r$" denote record mode and the subscript "$_p$" denote playback mode.

True spatial correspondence occurs when:

$$\frac{R_r}{F_r} = \frac{R_p}{F_p} \quad \text{and} \quad \theta_r = \theta_p$$

When focal lengths of camera and projector are not equal, spatial correspondence is possible by altering the angular movements by the ratio of focal lengths:

$$\frac{R_r}{F_r} \cdot \frac{\theta_p}{\theta_r} = \frac{R_p}{F_p}$$

When the ratio of focal lengths equals one, we have true spatial correspondence where camera's and projector's angular movements are equal. When the ratio of focal lengths does not equal one, we have spatial correspondence in that images of stationary objects will "stay put" on the walls of the playback space, but a "warping" of sorts will occur.

Suppose we film a 360° pan where the camera's focal length is half that of the projector's (so we are recording with an angle of view twice that of playback). The ratio of angles of view, (what the hell) the *warp factor*, equals 1/2. If we record with an angular movement of 2° per frame, we must play back with an angular movement of 1° per frame to achieve spatial correspondence. To record a 360° pan will require 180 frames, but 180 frames will play back as only 180°. If north is set at north in the viewing space, then west becomes northwest, south becomes west, east becomes southwest, north becomes south, and the process repeats. And that is only dealing with one dimension of movement and fixed focal lengths.

Besides true and warped, a third type of spatial correspondence is possible and noteworthy. When an object is filmed with a black background, there exist no spatial cues of stationary objects and *arbitrary* spatial correspondence can occur, depending on the object and the speed of projector movement. For example, dress someone up in a spacesuit and film him or her rocking back and forth in front of a black background. When projected, say, in a planetarium, moving the projector would create the effect of a floating astronaut, though the astronaut never really moved.

It should also be noted that spatial correspondence deals only with angular motion, not lateral motion. Lateral motion creates parallax, where objects in the foreground move faster than objects in the background. This differential movement across the frame prevents spatial correspondence by definition, since not everything can "stay put."

The Factors

To further understand spatial correspondence, this section looks into the three factors in the formula: frame per second rate, angle of view, and rotational speed. Of particular interest are record/playback correspondences, why they are what they are, and what is new.

Frame per Second Rate

That which makes movies, the difference between a still picture and a moving one, is frame per second (fps) rate. We see apparent motion due to a physiological phenomena which Ingmar Bergman calls a "defect" in human sight,[24] persistance of vision. This phenomena was investigated as early as the tenth century, but was not intensively studied until the nineteenth century.[25] We begin to see motion when still pictures change at a speed of 12 to 15 fps. Early movies were produced at speeds from 16 to 18 fps, and in 1927, when "talkies" were introduced, the American standard became 24 fps (in Europe it is 25 fps). American television has an fps rate of 30, strictly speaking, but each frame consists of two independent full size fields, or half frames, interwoven on the screen. Also, the image is recorded and played back by raster scanning, that is, an electron beam very rapidly scanning the image line for line.

It can be argued, in terms of motion perception, that video has an effective fps rate of 60, not 30, since each field contains independent motion information. It is my belief that the major difference between film on television and video on television lies in this almost threefold difference in fps rate. There are other differences, and while some may disagree, I feel that fps rate has a direct relationship with "presence."

Douglas Trumbull, special effects producer for "2001" and "Close Encounters," holds a similar view and is presently producing a film system that, among other things, records and plays back film at 60 fps.[26] The effect has been described as an "indescribable increase in the level of reality."[27]

Aspen Mountain recorded at 1 frame per 5 minutes (.003 fps).

A bird recorded at 24 frames per second.

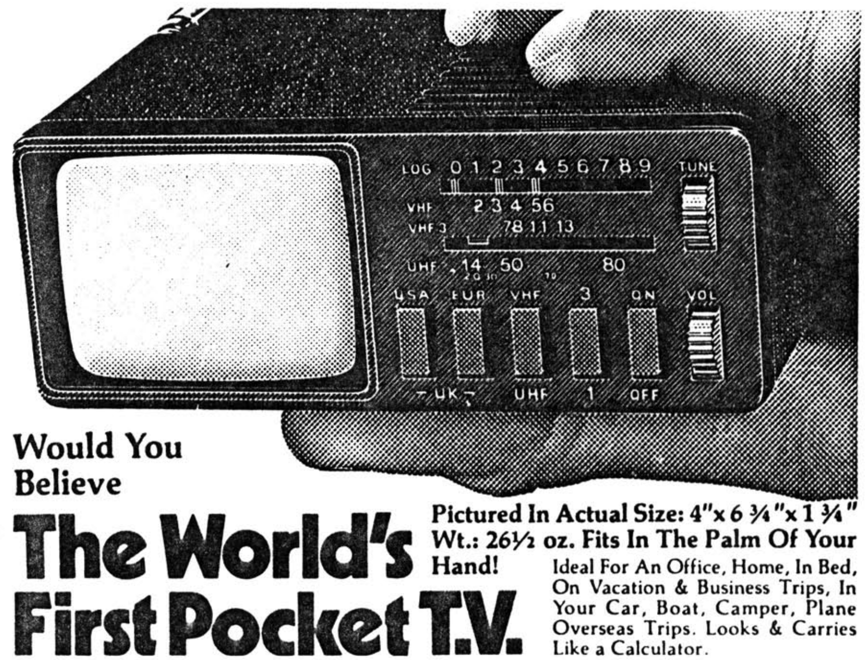
A dog recorded at 64 frames per second.

"Real time" defines a relationship between recording and playback. All of the above will play back in real time if the playback fps rate equals the recorded fps rate.
(from *Aspen Scraptape*, 1978)

Recorded fps rate irrelevant. Intended playback is 24 fps.
(from *All My Worldly Things*, 1979)

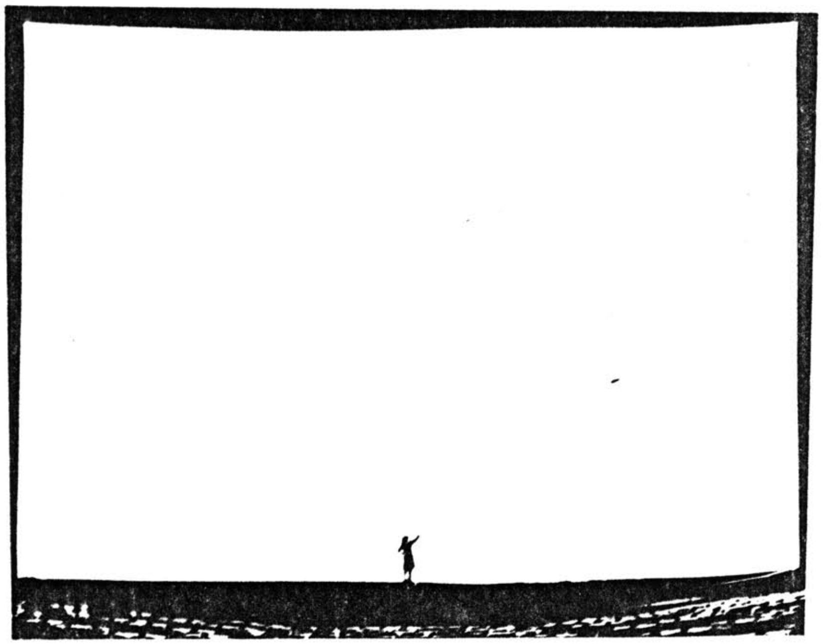
Another innovation concerning fps rate at the other end of the spectrum is the optical videodisk. The videodisk is similar to an audio disk in that it is about the same size and shape, is a "read only" device (one cannot record their own), and plays on a turntable, of sorts, that is connected to a television set. Each videodisk holds a half hour to an hour per side of high quality color video plus two audio tracks. Unlike videotape, it can easily be held in still frame mode and can play at a variety of speeds up to the standard 30 fps. This variable fps rate makes the videodisk system unique among standard television and film playback equipment. "Real time" is when the record fps equals playback fps; it defines a relationship and is independent of fps rate. The standard 24 fps of film projectors is only "real time" because the film was shot at 24 fps. Similarly, pictures taken one every second and played back one every second is "real time," though it would be considered a "slide show" instead of a "movie." The videodisk offers exploration into the realm lying between real time slide shows and real time movies.

Very wide angle of view- 180° fisheye lense.



World's smallest television.

Very narrow angle of view- camera was over a half mile away.



World's largest movie screen- over 7 stories high (IMAX theater in U.S. Pavilion, EXPO '74, Spokane).

Angle of View

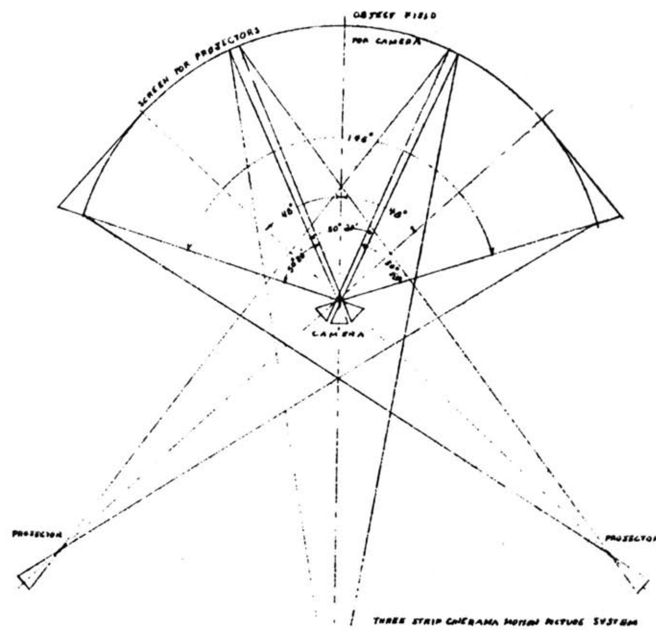
Angle of view is a function of the focal length of the lens. For cameras, fisheye lenses have the widest angle of view; the widest available is 220°. Telephoto lenses have the narrowest angle of view; the narrowest available is about 2°. "Standard" lenses (whatever that means) have an angle of view of about 46°. Filmmakers rarely consider angle of view correspondences between record and playback spaces. Many film and video works are shot with a variety of different focal length lenses, for which there is no counterpart in playback. The zoom lens further complicates things. Imagine a zoom lens correspondence between record and playback systems: as the camera zooms in, so would the projector, and the viewer would see the projected image decrease in size and increase in resolution.

In playback, it is often more useful to discuss angle of view from the viewer to the screen rather than from the projector to the screen. Angle of view in playback, therefore, usually translates into screen size. Screen size presently range from the one inch diagonal screen of the Sinclair television to the 70 foot tall IMAX screen in the United States Pavillion at EXPO '74.

Film original . . .

Reshot for television.
(from *Dance Study*, in progress)

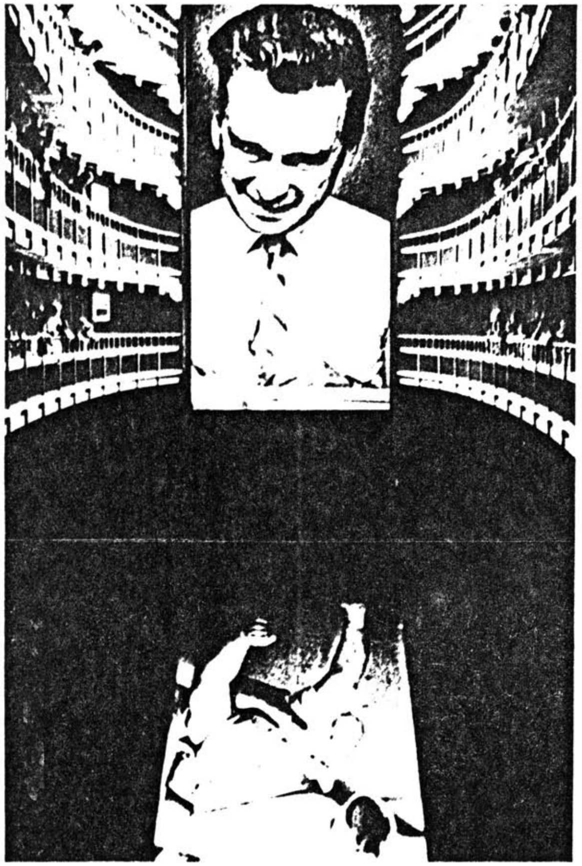
Certainly the most obvious difference between film theaters and television environments is screen size. Shooting for television must be different than shooting for film theaters (though it all too often isn't). As noted earlier, screen size is a major reason why some movies don't work on television. Composition must be different. Films can compose more of a space in the frame; television must compose tighter or the detail will be lost. Tighter composition, especially with things moving within the frame, means more camera movement.



Blueprint for Cinerama system.

Rotational Speed

Rotational speed correspondence is the unique issue of spatial correspondence. Rotational speed in record mode translates into camera movement; in playback mode, projector movement.



Chamber One of Labyrinthe at EXPO '67, Montreal.

There have been some rare and visually exciting cases of spatial correspondence, not by using a moving projector (rotational speed), but by using more than one stationary projectors (rotational position). The most popular was Cinerama. One of the most novel was in the Labarynth exhibit at EXPO '67 in Montreal, where one screen was on a four story high wall and another screen was on the floor. Viewers stood along eight balconies.

Consider what we see when we watch a "normal" (stationary projector) movie when there is camera movement, a pan, for example. We sit still facing straight ahead. Our "piped in" world moves. We, quite unconciously, interpret it as a pan. Is this "natural?" I doubt it. It required years of collective learning. With few exceptions ("talking heads" being one), practically everything on television has camera movement.

I conducted research into who "invented" camera movement. The first films had none: they were true to their theatrical roots. Though I found nothing definitive, the earliest reference I did find is noteworthy. The year was 1914. A ten-reel epic from Italy called "Cabiria," written by

Gabrielle D'Annunzio and produced by the Itala Company premiered in New York. The film was among the first to use both panning and tracking (lateral motion) shots. The "New York Dramatic Mirror" writes:

> Scenes are slowly brought to the foreground (tracks-author) or moved from side to side (pans), quite as though they were played on a movable stage. By this method full value is given to the deep sets, and without any break the characters are brought close to the audience.[28]

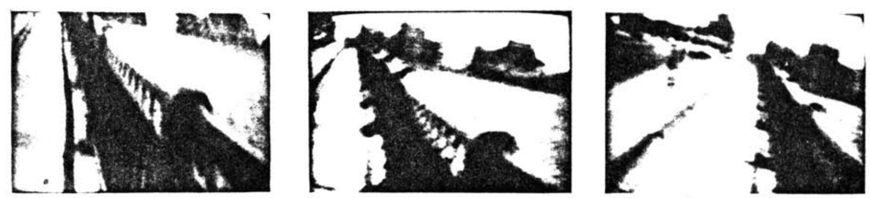
Equally noteworthy and curious, Edmund Carpenter, after leaving movie cameras among natives in New Guinea, reports:

> In Port Moresby . . . our cameras were in much demand. The subjects favored were friends and cars. Cameramen might zoom and pan on scenery, but with friends and cars, they held the camera steady, preferably on a tripod: the cars they filmed were parked, the friends immobile. In other words, movie cameras were used like still cameras.[29]

With normal, non-spatially correspondent movies, camera movement amd object movement, though independent of each other, produce the same effect:

Camera is stationary, taxi moves (from *Aspen Scraptape*, 1978).

Both camera and baby move (from *Babies on the Subway*, 1978).



Camera moves, street and buildings are stationary (from *Jogging*, 1978).

Composition within the frame can change <u>either</u> by camera motion, object motion, or both.

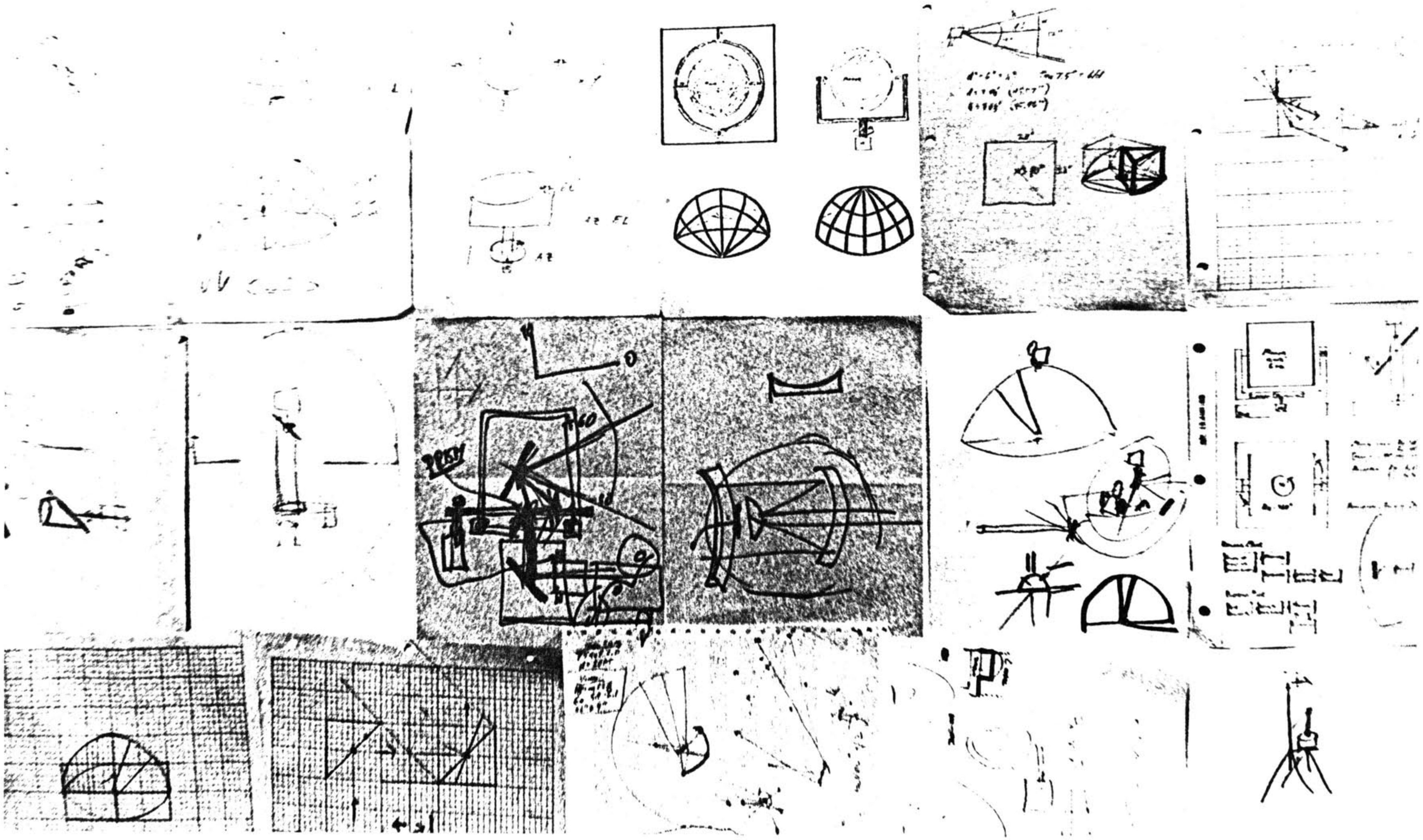
change in composition. They are often indistinguishable, and are exploited as such. In one scene from "The Last Waltz," The Band was carefully illumunated; the background was black. As the camera arced around them, it was impossible to tell who was moving, the camera operator or the bandmembers.

Steadicam camera stabilizer.

Similarly, camera movement which is too abrupt creates such drastic changes in composition that it is often hard to "read." Smoothness is generally considered desirable. Hollywood occasionally uses abrupt hand-held camera movement to indicate crisis, as in running away from a pursuer. At the same time, free hand-held camera movement offers a richness of expression, a sense of life behind the camera similar to the sense one feels while fishing when something alive is nibbling at the bait. Hand-held camera movement is often the standard for cinema verité.

Consider now that camera movement and object movement remain separate with a spatially correspondent system. Camera movement translates only into projector movement; object movement remains only object movement.

III. Designing A Moving Movie System



Background

I began work on producing moving movies in the fall of 1977. The simplest, cheapest thing I could do to at least *see* what spatial correspondence looked like was to film a series of 360° panoramas using a motor to rotate the camera on its tripod. The processed film would be loaded into an endless loop cartridge and played back with a projector rotated on a turntable by the same motor used for shooting.

Such a system is ultimately frustrating because of its non-interactive nature.

I chose a one rpm AC synchronous motor, an unmodified Nizo super 8 camera from the MIT Film Section that could shoot at approximately 18 frames per second, and one of those awful Technicolor super 8 film loop cartridge projectors, which runs at 18 fps.

Most shooting was done with the camera's focal length equal to the widest focal length possible on the projector, 20 mm (15° horizontal angle of view). During playback spatial correspondence did occur, in the sense that you could stand by the wall and put your finger on, say, the image of the Prudential Building as it was being panned and the building would "stay put" as the frame moved by.

The major problems were ones of slight blurriness and wobbliness of the image due to the system's relatively slow fps rate. At 18 fps, a one rpm rotation results in a $1/6^{\circ}$ pan per frame (with a 180° shutter). Played back at the center of a 20 by 20 foot room, each frame would move over 1/3 inch while it is projected on the wall. Both problems are surmountable by using a higher fps system, or possibly a well synchronized raster scan system.

Another problem inherent in a moving movie system is finding a planetarium for playback. Predictably, in a square playback space, problems occur with focus and shape distortion. Neither were intolerable. The blurriness and wobble mentioned above tended to be worse than that caused by the small depth of field. The shape distortion went surprisingly unnoticed; my guess is that this illusion is largely a perceptual thing. Most of us are unaware, for example, that when we view a movie from the side of a viewing space that we are looking at a trapezoid.

Many viewers, myself included, found the rectangular shaped frame itself disturbing. Perhaps a circular frame would look more "natural," as it is reminiscent of a spotlight, whose properties are more spatially equivalent to a moving movie. A more interesting alternative may be to eliminate the frame edge itself, possibly by diffusion.

Attempting to work within the limitations of the medium, I produced a very short film loop projected on a cylinder placed on the floor. The cylinder was six feet in diameter, seven inches high and constructed of translucent white plexiglas which served as both a front and rear projection screen. My intent was to film a ring of dominoes falling, such that on one edge of the frame the dominoes are standing up, on the other edge of the frame the dominoes are fallen down, and somewhere in the middle the action is taking place. Those little bastards fall alarmingly fast, too fast to film accurately, at a rate of about three feet per second (independent of their spacing, a curious bit of trivia). I resorted to animation. Three animated situations were produced, one where camera and projector focal lengths were equal (*true* spatial correspondence) and two where they were not equal (the *warp factor* was accordingly adjusted). Spatial correspondence did occur in all three instances, using the put-your-finger-to-the-screen test.

It is noteworthy that the translucent screen could be viewed from both sides. With the domino film loop it was of little consequence: a ring of dominoes does look about the same when viewed from either the inside looking out or the outside looking in. Consider viewing the panoramas from the outside of the cylindrical screen. They remain spatially correspondent, of course, but are "inside out" ("outside in" when they should be "inside out," to be exact). This visual riddle has some similarities with two unrelated types of holograms. Pseudoscopic holograms have reverse relief: when you move your head you see the background move more than the foreground. Also, integral holograms are cylindrical shaped and are made from movie film of a subject rotating on a turntable: outside looking in.

In sum, the primary limitation of this first attempt of moving movie making was virtually no camera control. You turned the motor on and ducked. At one point, I was on the roof of the New England Aquarium with the system watching airplanes land across the Boston Harbor at Logan Airport. I tried turning the motor and camera on such that it would follow an airplane landing. It looked as though it was practically right, although I could not look through the viewfinder as it would jar the camera. When I projected the processed film I saw what really happened. It just missed. The airplane must have been right in front of the moving frame and moving at about the same angular speed. I can see it. Nobody believes me.

As a media tool, a moving movie system must allow for freedom of camera movement. It must therefore include a means of recording the camera's position and using this information to move the projected image accordingly.

Use Of A Mirror

Cameras are often small and lightweight; projectors rarely are either. In designing a user controlled recording system, camera/projector movement can be more intricate and preferably along more than one dimension. I therefore began with a simple premise: it is easier to move a mirror in front of a projector than it is to move the projector. If the mirror is flat, no image distortion will occur other than reversing the image. It also makes the moving movie system independent of the projector. Any projector can be used, from a super 8 to a 1000 pound video projector.

A second premise naturally follows: use the *same* mirror system for recording. From here on the design algorhythm is straightforward. Construct a mirror mount such that the mirror can move itself and knows its position. Record by aiming the camera at the mirror, keeping the camera stationary, and moving the mirror in front of the lens to achieve "camera motion." Record the position of the mirror in synchronization with the film. Playback is achieved by placing the projector in the same place the camera was relative to the mirror and controlling the mirror's position by the recorded position signal.

The symmetry of such a system eliminates an entire class of problems because they cancel themselves out: image reversal, non-linear motion due to mechanical limitations, tricky transformations, etc. Theoretically, the mirror need not be flat; it could even be cracked.

One problem with using a mirror is that there exist two blind spots in the total potential *sphere* of viewing: one where the mirror is perpendicular to the source (camera or projector) and one where the mirror is parallel to the source. The former problem exists because the source is obstructing the view and can be minimized by minimizing the physical size of the source or by using a small second mirror in its place (with the source off to a side). The latter problem exists because the virtual size of the mirror from the source's point of view diminishes to zero as the mirror approaches parallel and can be minimized by using a large mirror. Only one blind spot need exist if the total potential viewing area is less than a sphere, like a planetarium.

Suppose the mirror can rotate about two axes and is controlled by a joystick in record mode while the camera operator is looking through the viewfinder. There are two types of two-axis mounts: to borrow radar terminology, x-y and azimuth-elivation (az-el). Moving one axis while holding the other constant produces longitude-longitude lines with x-y and latitude-longitude lines with az-el. A normal pan-tilt tripod corresponds to az-el. Thus, mounting a mirror in an az-el mount and placing the camera above it would operate similar to a camera on a tripod. The blind spots will be directly above and below the mirror, again similar to a camera on a tripod.

A second problem relates to ease of shooting. When shooting through a mirror that moves to achieve pan and tilt, roll will also be seen through the viewfinder of the camera, which may be disorienting to the camera operator. This problem is perhaps best imagined by comparing it to a periscope where the top mirror rotates to achieve pans. The user will see the image roll equally to the pan: when the top mirror is rotated 180° so the user is now looking to the rear, the image will have rolled 180° also and be upside down. This problem can be eliminated by correcting with an image-rotating prism. The roll problem only relates to ease of shooting, since it cancels itself out during playback. With a non-circular shaped frame however, the frame will also roll in playback though the image will remain spatially correspondent.

A third problem with using a mirror, an inescapable one, is that a lateral component of motion is introduced. When the mirror rotates about either axis, the virtual image of the camera arcs around it. It is exactly equivalent to booming the camera out and behind the center of rotation of a tripod, the distance of the boom equalling the distance from camera to mirror. Since the virtual image of the camera is not rotating about its own axis, there will be some lateral motion, which means there will be some parallax. (Similarly, since our eyes are not mounted on the axis of rotation of our neck, we experience parallax with one eye closed by simply turning our head.) A pan with some parallax means that foreground objects will traverse the frame at a different rate than background objects. Everything cannot be spatially correspondent by definition (not everything can "stay put"). If camera and projector focal lengths are equal, and if the mirror moves in playback exactly as it did in record mode, background objects will be spatially correspondent while foreground objects will not be. Because our eyes work this way, it may be a curious feature.

Specifications and Limitations

The present system is essentially a programmable pan-tilt (az-el) machine with a mirror mounted in it and a camera or projector mounted above it via a small stationary mirror. A joystick controls the mirror in record mode. The audio track of the film serves as memory.

The mirror is a recent version of aluminized mylar stretched over foamcore. It has a front surface, is washable, and has a 96% reflectivity.

Its size is 12" by 16" and it weighs nine ounces.

The mirror mount is an az-el mount capable of complete rotation about both axes, limited only by the motors used. Mechanical interface between motors and mirror is by two gears for each motor: a one-to-one ratio in azimuth and a one-to-two ratio in elevation, since the image reflection ratio to mirror rotation is one-to-one in azimuth and one-to-two in elevation. The base of the mount is cylindrical. A second cylindrical unit houses the elctronics, batteries, and joystick.

The effector/sensor systems are off-the-shelf model airplane servo motor positioners. Position corresponds to pulse width of input signal. The servo is self-contained.

Processing is mostly analog. In record mode, the joystick feeds both a pulse width modulator to move the mirror and a voltage to frequency (v to f) convertor to correspond the mirror's position to an audio frequency. Since two axes are used, there are two audio bands: azimuth is 6000-8000 hertz and elevation is 1000-2000 hertz. The two frequencies out of the v to f's are filtered to assure independence, mixed, and fed to the audio track for recording. In playback mode, the joystick is disengaged and the mirror is controlled by the audio track. It is first filtered where the two bands are separated, then each band is fed into a frequency to voltage convertor. The output is fed into the pulse width modulators to control each servo motor.

Memory is the audio track, which at present is the magnetic sound stripe of a single system super 8 camera and projector.

Limitations are the degree of mirror movement, the speed of movement, and the accuracy. The degree of mirror movement is limited by the servo motors. The ones I have selected have a 90° peak to peak excursion, which corresponds to one quarter of a planetarium or one wall of a square room. Speed and accuracy are interdependent. The limiter is the wow and flutter of the super 8 playback system. The speed was damped from a 2/3 second peak to peak travel to about 4/3 second to minimize wow and flutter inaccuracies.

Overall, the present moving movie system has an accuracy of one to two degrees. Depending on mirror speed, type of imagery, and playback space, such accuracy is what I would consider marginal to experience spatial correspondence. When the projected image moves *exactly* like the recorded image, the experience is extremely orienting. When the projected image moves too inaccurately, the experience can be extremely disorienting. The ideal system should have an accuracy of perhaps a tenth of a degree.

The Ideal System

The ideal moving movie system would allow for maximum freedom of movement and control for the camera operator and accurate reproduction of movement during playback. While playback through a mirror has its advantages, shooting through a mirror is cumbersome. Among other things, a tripod is required.

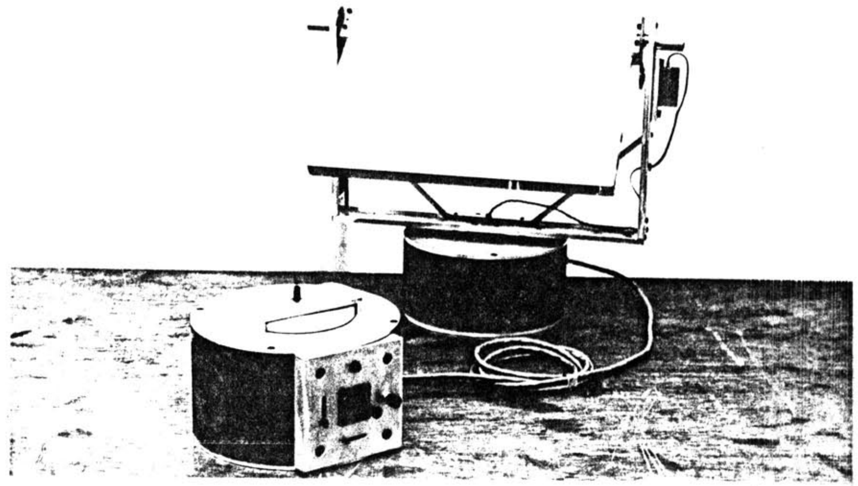
The ideal record system would be no more than an inconspicuous attachment to a conventional camera. Miniature solid state position sensors will be available within the next few years. The necessary electronics to transform the camera's position into a recordable signal is trivial in size and complexity.

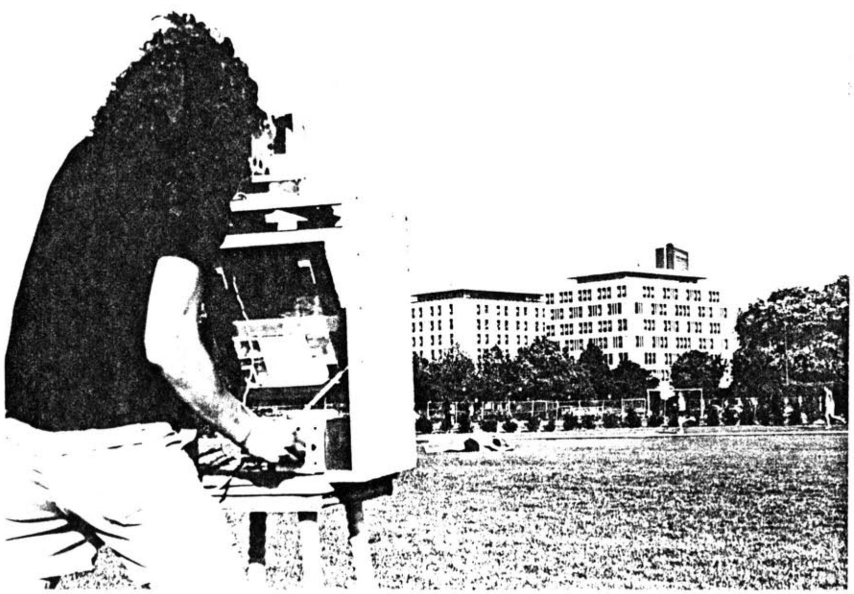
The ideal playback system would use a mirror, since projectors will probably always remain large and heavy. The lateral motion introduced by the mirror is only a problem in record mode, since the mirror only "sees" a flat film plane during playback. The distance from projector to mirror will only produce an offset that can be compensated electronically.

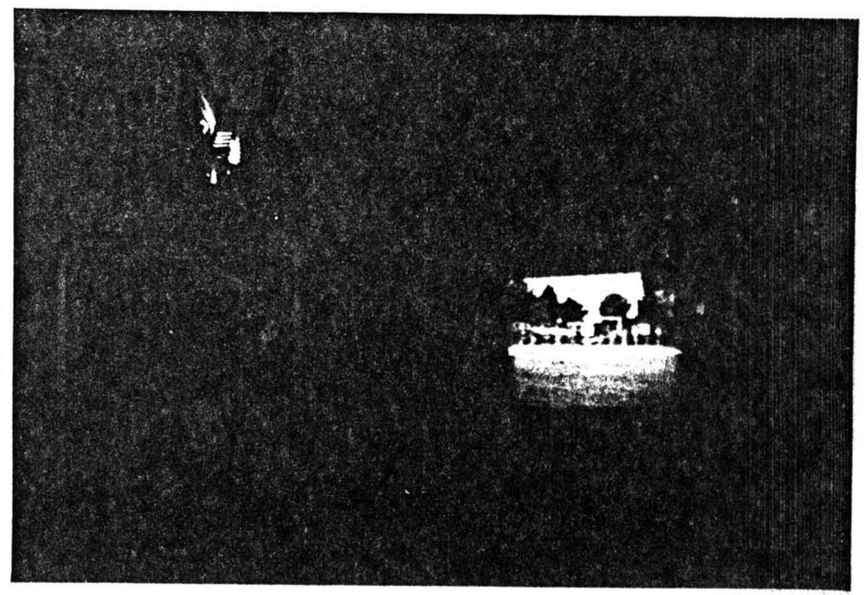
Since this ideal system records without a mirror and plays back with one, roll transformation will be necessary. With film, this would require an image rotating prism on the projector or compensation by optical printing. With video, the image can be digitized and the transformation can be performed electronically.

Finally, the ideal system would allow for complete control over all three of the factors: fps rate, angle of view (zoom), as well as rotational speed (camera movement). Each would require their state recorded for playback. During playback, manual variation of the factors (*warping*) could be possible such that spatial correspondence is automatically retained by altering the other factors.

IV. Using It







The constructive powers of the human mind are no more artificial than the formative actions of plants and bees, so that from the standpoint of Zen it is no contradiction to say that artistic technique is discipline in spontaneity and spontaneity in discipline.

---Alan Watts

Recording

The complete system was housed in a frame 16 by 21 by 21 inches. The camera was mounted above aimed horizontally at a small front surface stationary mirror mounted at a 45 degree angle. The camera was a small Nizo super 8 with magnetic striped sound capabilities. For playback, the camera was removed and a projector put in its exact place. Most recording was done at a focal length of 27mm (which, incidentally, gives about the same resolution for a 90^{o} by 90^{o} angle of view as an IMAX film. The difference, of course, is that with the moving movie, one only sees a small portion of the potential viewing space at a given time.)

The system was portable enough to carry around to a variety of environments. Capturing a sense of "being" was of particular interest to me: no script, no performers, no story, simply "being" in a place. As such, my intent was to feel comfortable enough with the system that I could freely capture the natural movements of my eyes.

(This preoccupation has led me to spend a great deal of time putting my eyes in "automatic pilot" and monitoring their movement while sitting still in a particular place, e.g., how I respond to movement, to familiar spaces, to strange spaces, how I "cut" from scene to scene, etc.)

Keeping in mind that the playback of a moving movie has little peripheral imagery, I tried to shoot with the surprise, the hesitation, and the playfulness of exploring an unknown dark space with a flashlight.

I began by filming what I felt were *basic distinctions* between environments: urban and rural, inside and outside, peopled and uninhabited, being up close and being far away.

In addition, I was interested in the difference between following a moving object and following the contours of a stationary object.

My success with using the joystick to control mirror movement was only fair, though it seemed to improve over time. Not being able to physically hold and move the camera as well as the roll of the image through the viewfinder often created misleading "brain to hand" messages.

Playback

Most of my playback screenings have been in familiar rectangular rooms with white walls. A distinction must be made between "normal" rooms and "media" rooms (rooms specifically designed for media playback). Given that media transposes aspects of one environment onto another, with media rooms, the "other" is intentionally null. Media rooms are designed to have no distinguishing characteristics and to be "all media" (which is, of course, why screens are white). Playback in familiar spaces can give the viewer the ambiguous feeling of "being" in two places at once. Media rooms convey the feeling of "being" only somewhere else.

Wall or screen shape turns out to be a major factor in determining how we "read" an image. Moholy-Nagy was aware of the challenge and possibilities of screen shape and had designed various concave multiple screens.[30] Screen shape and position are often environmental and deceptive. For example, a spotlight operator who stands directly behind the spotlight will always see the spot in the shape of a perfect circle, regardless of the angle of the wall on which the spot is thrown. This is usually not the case, especially if the operator knows the shape of the room. As previously mentioned, the converse is also true: we see the trapezoid shape of a movie screen when viewed from the side as a rectangle.

I had been involved earlier in exploring various screen shapes. "Dome Projections," fisheye images projected in a small rear screen dome, don't work in conveying a sense of environment. "Talking Heads," head-shaped screens on which a movie of a real head is projected, very much do work. The closer the shape of the screen is to the shape of the projected head, the more startling the effect. When the screen shape is significantly different from the projected head shape, a sort of double distortion occurs.

Getting back to moving movie playback, room cues, like corners and curtains, tended to interrupt the continuity of the projected image. Selecting and shooting a specific environment to "fit" in a specific playback space is a major challenge. I did shoot the obvious: the playback room itself, and played it back with the system in the exact same position used for recording. Needless to say, every flaw of the system becomes extremely apparent; it is the ideal way to check the system's accuracy. The overall effect, however, is something like a magic lantern, especially if things in the room have been moved.

Feedback

The risk in building a moving movie system is that if it does not perform with a high degree of accuracy, what would otherwise be extremely orienting becomes doubly disorienting. As such, the damping mentioned earlier to minimize projector wow and flutter produced a noticeable delay in motion changes. When the motion was kept slow, however, the system performed reasonably well.

Like the earlier system, some viewers found the rectangularity of the frame disturbing. Unlike the earlier system, as the image panned and tilted, the frame would roll. Some viewers found this fascinating and deceptive: as the frame rolled, though the images stayed "upright," viewers often found them "crooked." Our enculturation of seeing the horizon parallel to the frame edge is strong.

Tilts appear more visually exciting than pans. Again, we are more used to pans than we are to tilts in movies and perhaps view tilts more innocently.

Many viewers were less aware of the frame when the camera followed moving action, say people walking, than when the camera followed the contour of a building.

Some said viewing it was like looking through a narrow tube, a sort of tunnel vision.

Practically everyone, myself included, found the overall effect "funny," for what that's worth.

Moving Movie Fantasies

Following is a brief list of moving movie ideas, explorations, and fantasies:

-Outdoor Playback. Large-scale projections on buildings, cliffs, sand dunes, clouds, and invisible screens. Setting up sheets of thin screen material responsive to the wind.

-More Than One Moving Movie. An interplay of motion. Imagine two or more dancers, each shot separately, sometimes overlapping.

-Shooting Inaccessible Spaces. Underwater, outer space, microscopic environments, etc.

-Super Closeups. Imagine a face the size of a wall, where only one small section is seen at a time.

-Abstract Environments. Created to be explored by flashlight.

-Use in Theater. A moving movie projected like a spotlight, integrated with live performers.

-Documentation. Rituals, for example.

-Use with Conventional Film. John Borden's idea: two conventional films separated from each other, one of cowboys, the other of Indians. A moving movie flaming arrow streaks across the separation.

-Moving High Resolution Overlay. Nicholas Negroponte's idea: for wall size computer video screen in media room, project user controlled small but high resolution moving image over full size low resolution image.

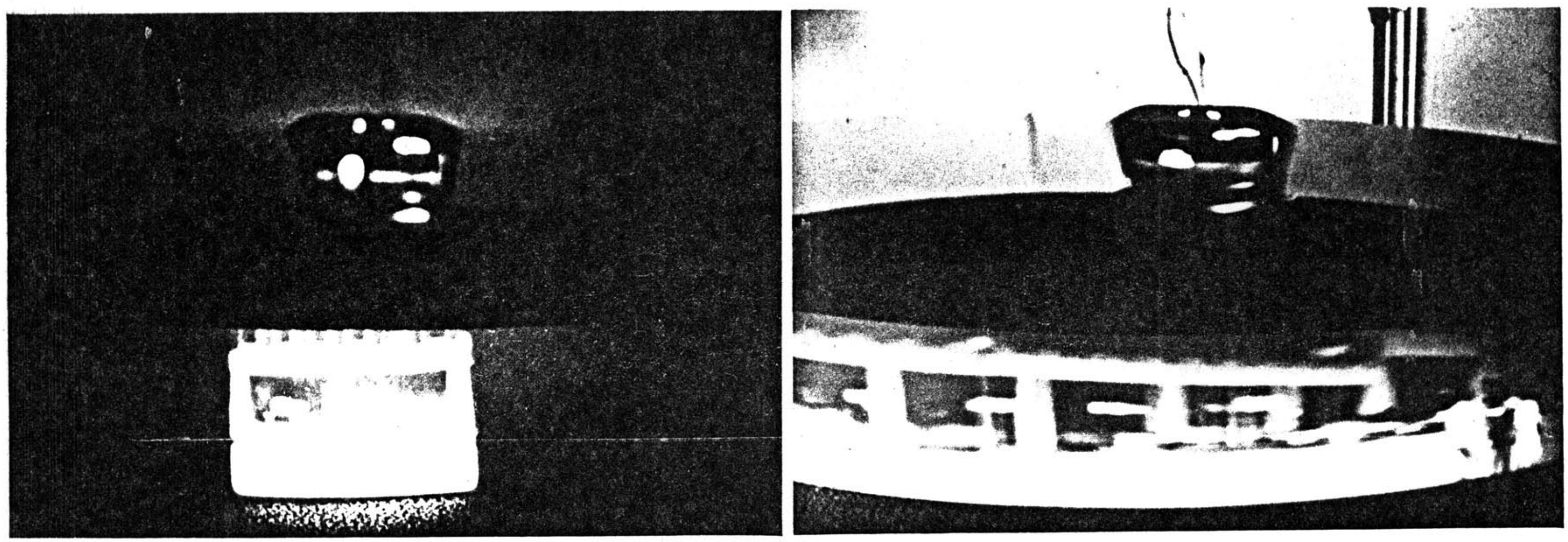
-Solarize a Room. Record a moving movie in a particular space; play back a slightly offset negative image in the same space.

-Video Flashlight. Construct flashlight-shaped position sensor. It controls position of remote video camera. Image from camera is projected always in front of flashlight sensor in playback space.

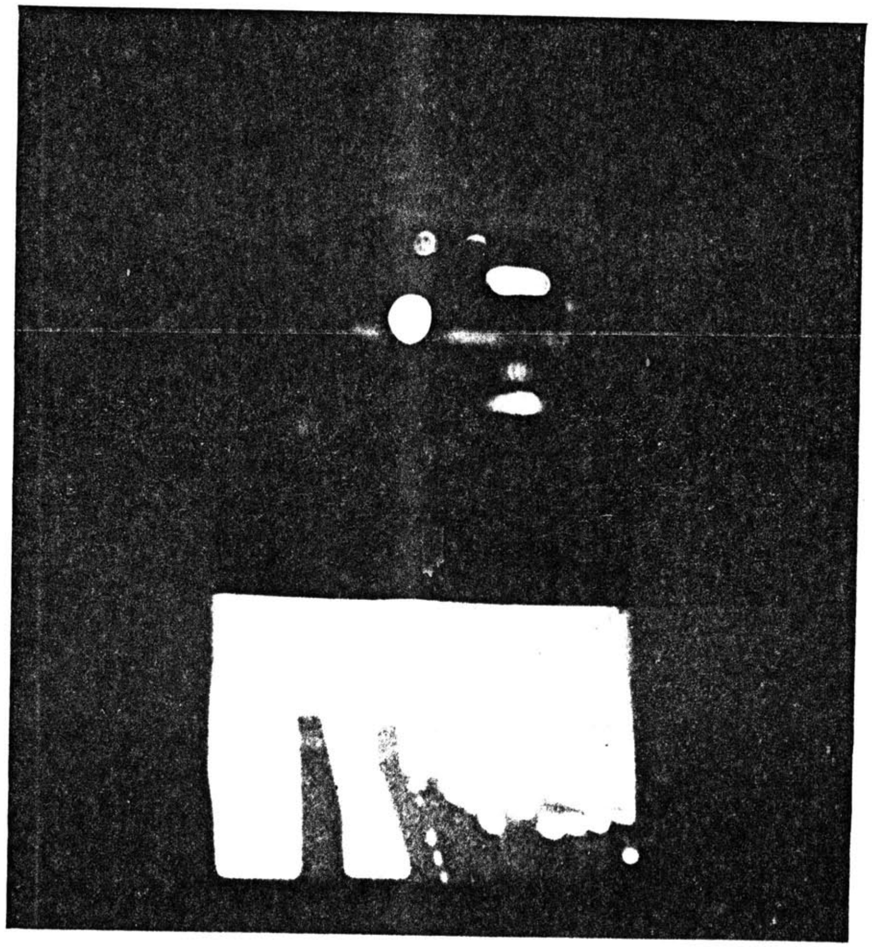
Spatial Correspondence offers an alternative way of making movies, and an alternative way of viewing movies. I am not advocating one in every home. Rather, I am advocating a further exploration into its creative potential, and at the same time a search for more alternative ways of visual communication. Hopefully, our communication, creative exploration, and art-making in the future will enjoy a cornucopia of media forms, creating a richness and balance of experience in line with our times. When the channels are open, things happen naturally.

V. Pictures

Past Work



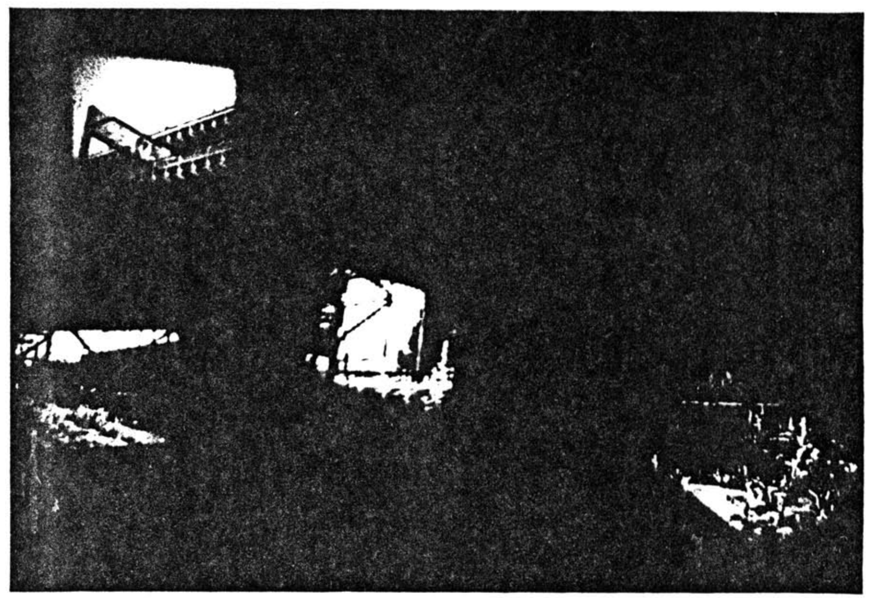
Author's first moving movie system, 1977.



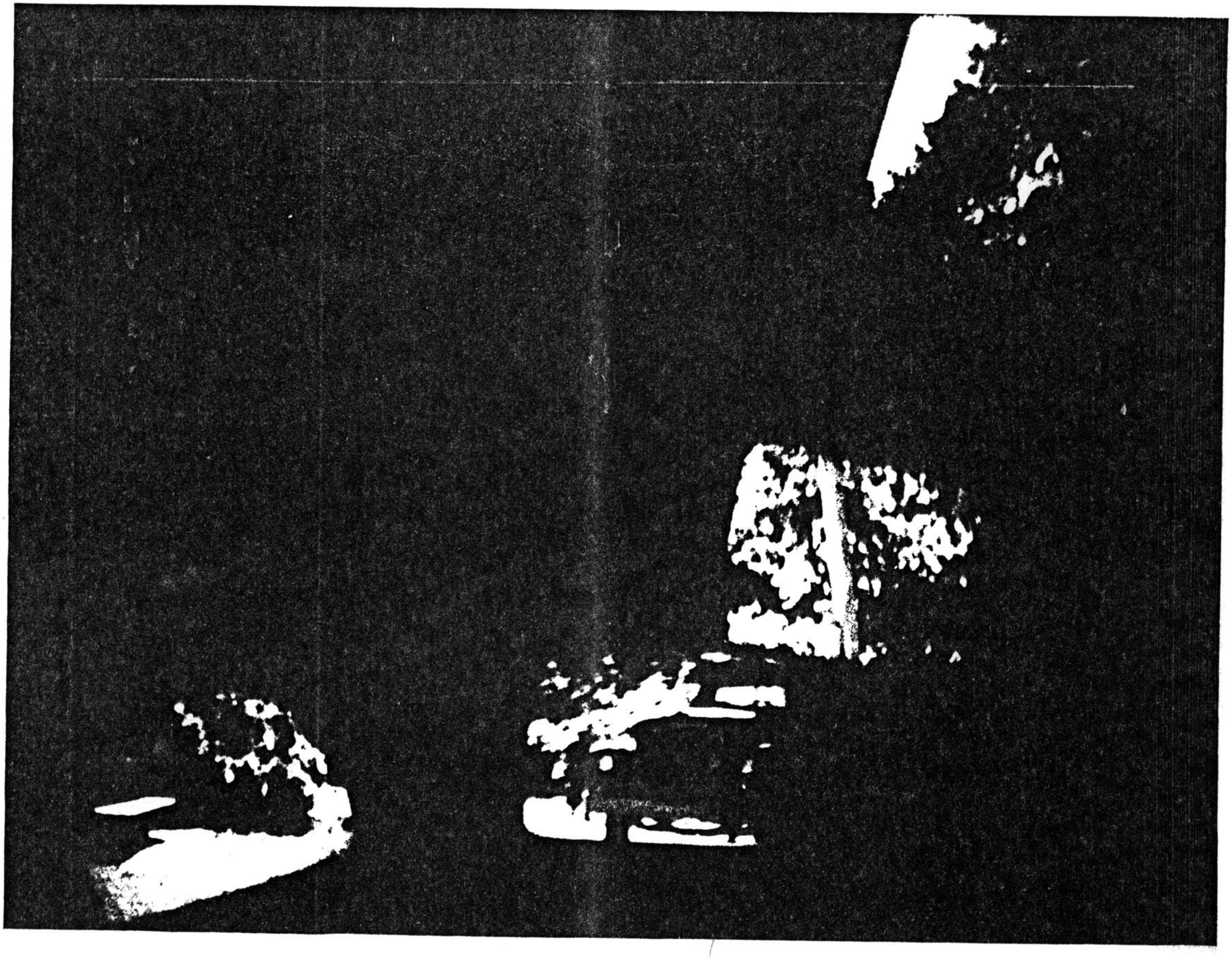
Dome Projection, 1978.

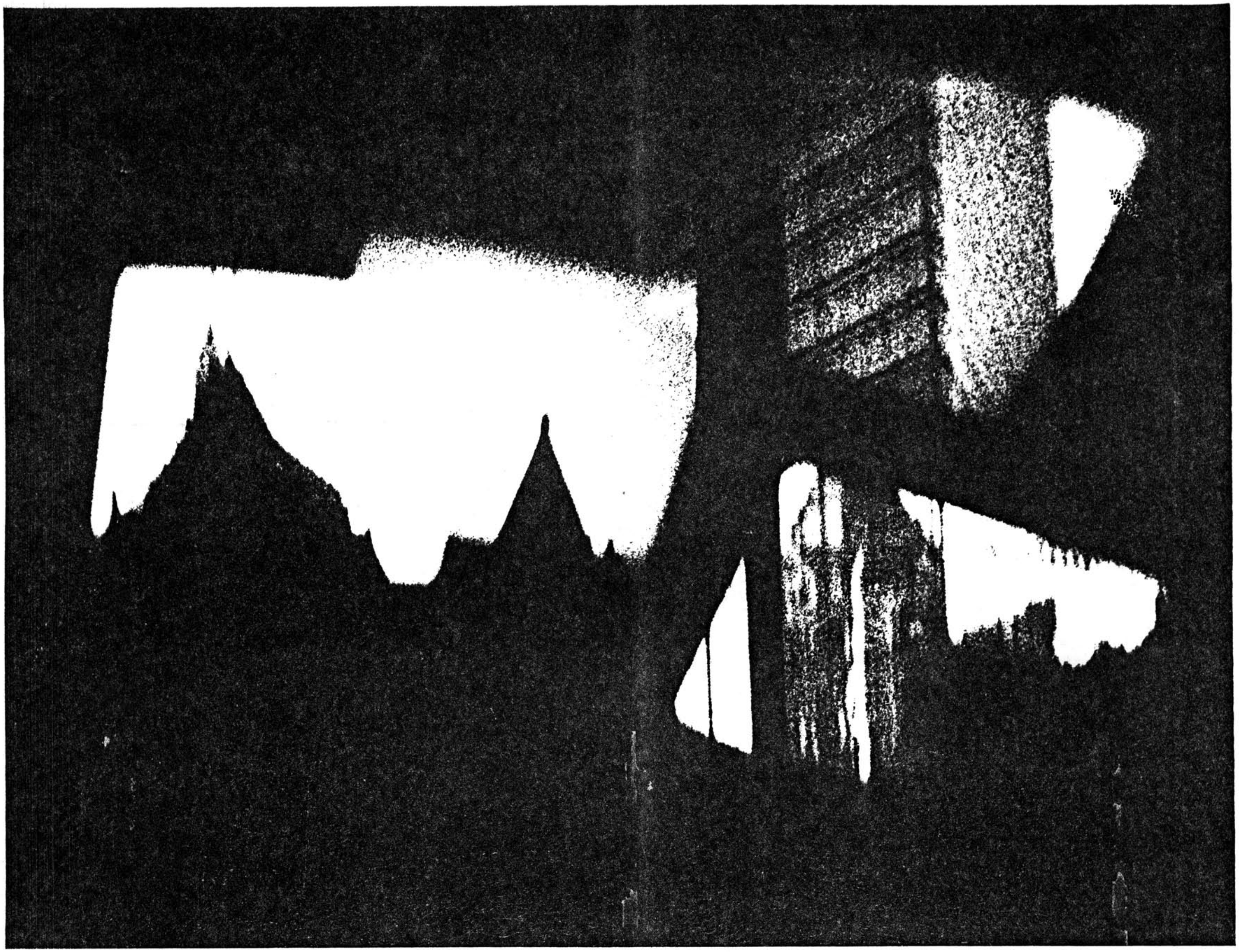
Talking Heads, 1979. (Note that the same "head screen" was used for both projections.)

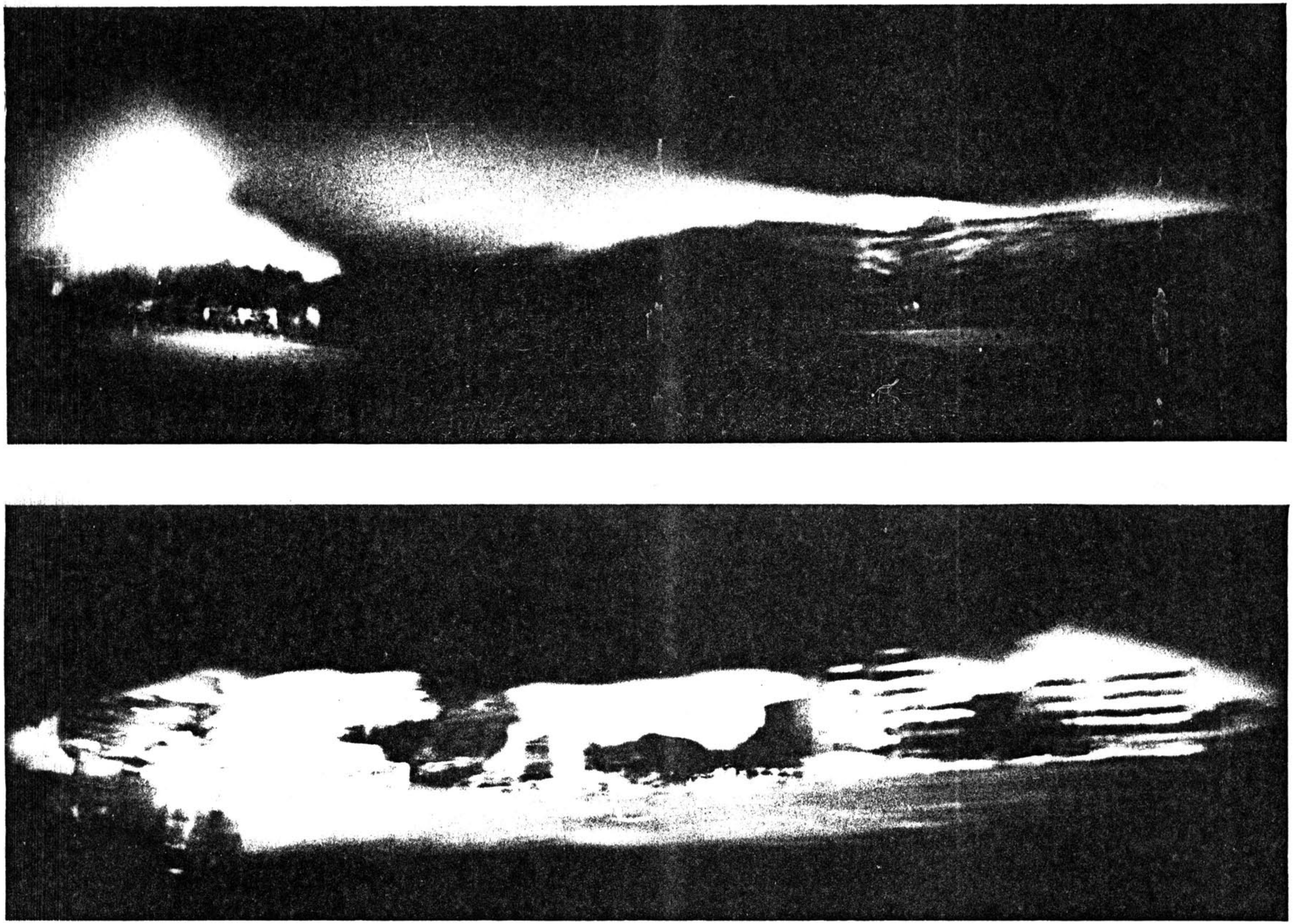
The Present System



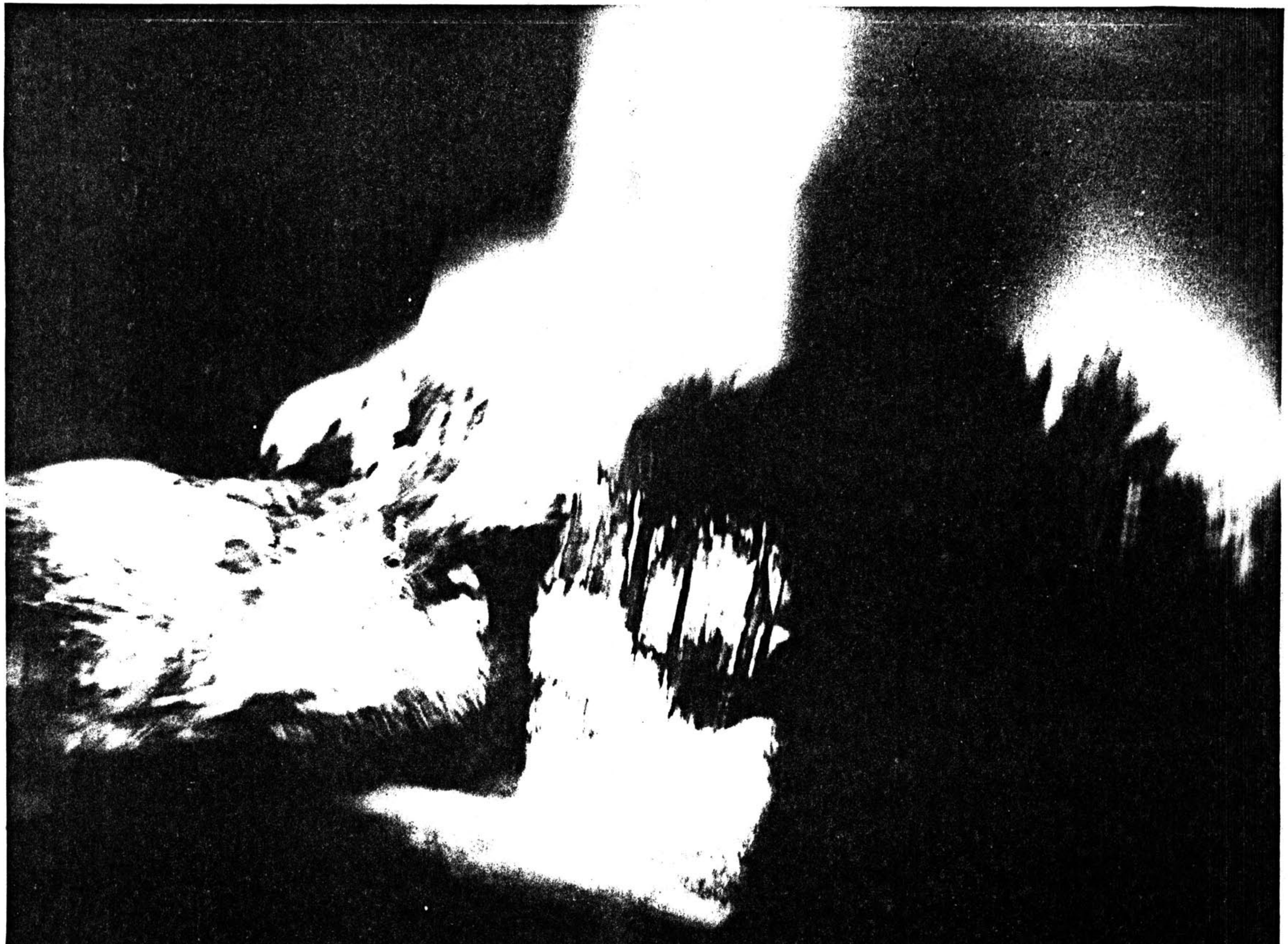
Multiple exposure as frame moves.

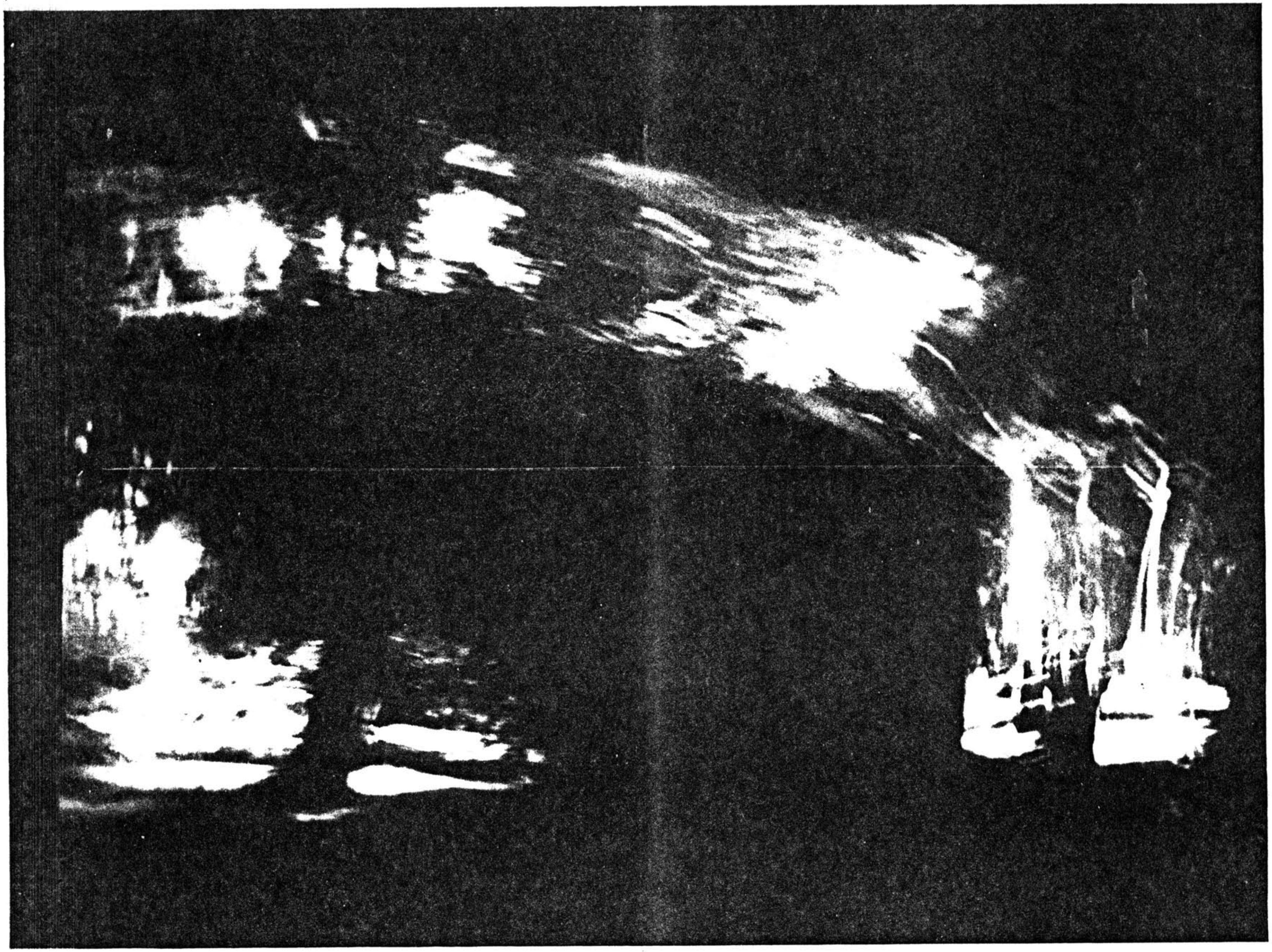


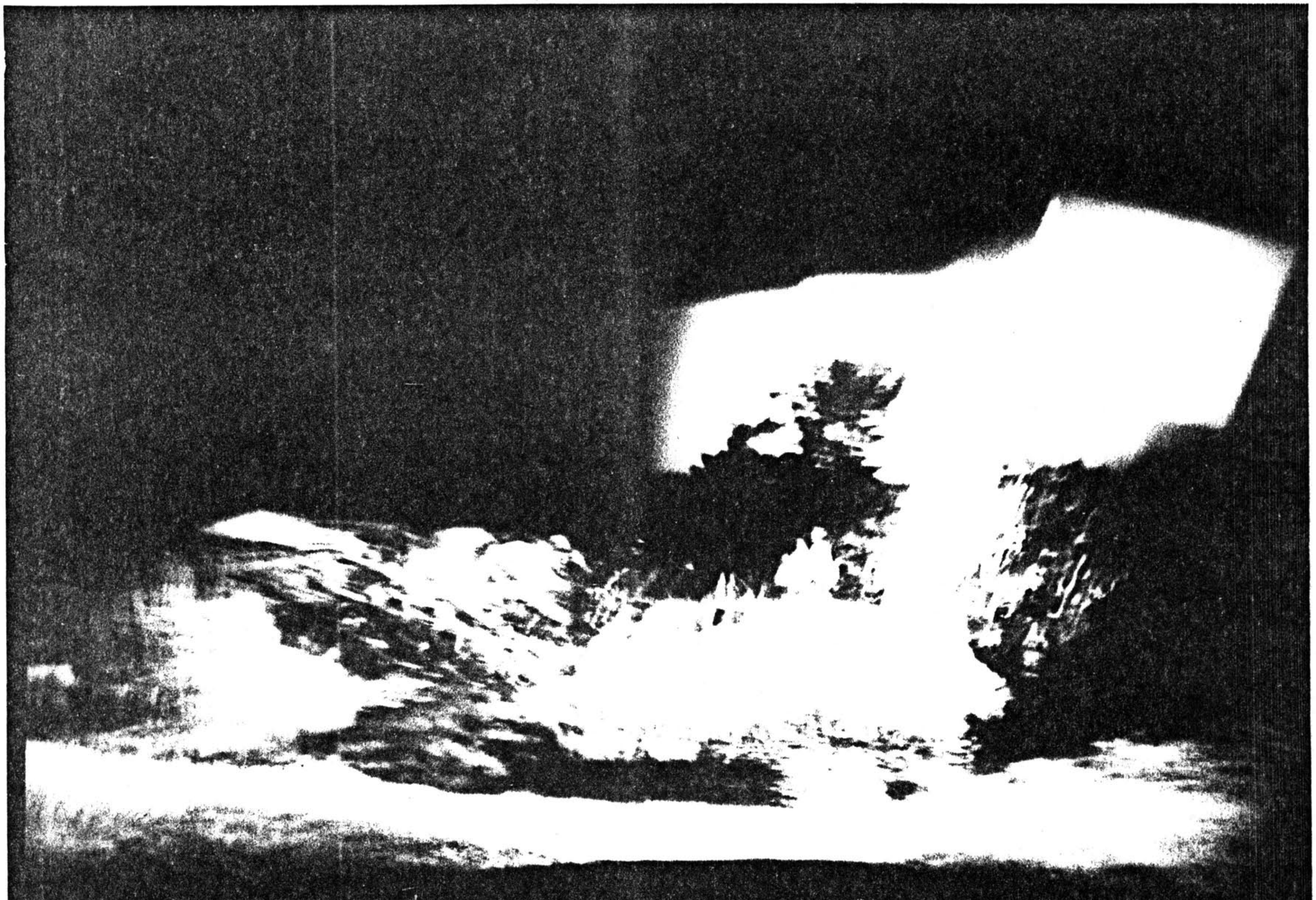




Continuous time exposure as frame moves.







Footnotes:

[1]Gregory Bateson, Mind and Nature, a Necessary Unity (New York: E. P. Dutton, 1979), p. 228.

[2]Norbert Wiener, The Human Use of Human Beings (New York: Doubleday Anchor, 1954), pp. 15-16.

[3]Gregory Bateson, Steps to an Ecology of Mind (New York: Ballentine, 1972), p. 474.

[4]Stewart Brand, II Cybernetic Frontiers (Berkeley: Bookworks, 1974), p. 3.

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[6]Bateson, Mind and Nature, pp. 19-20.

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[8]Brand, Frontiers, p. 9.

[9]Stewart Brand, "For God's Sake, Margaret," CoEvolution Quarterly, Summer 1976, p. 33.

[10]Bateson, Steps, p. 483.

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[12]Otto Piene, Rainbows (Cambridge, MA: Migrant Apparition, 1971), p. 5.

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[14]Gene Youngblood, Expanded Cinema (New York: Dutton, 1970), p. 346.

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[17]Ibid.

[18]Bateson, Steps, p. 1.

[19]Jerry Mander, "Four Arguments for the Elimination of Television," CoEvolution Quarterly, Winter 1977/78, p. 39.

[20]Ramon Margalef, "Perspectives in Ecological Theory," CoEvolution Quarterly, Summer 1975, p. 53.

[21] Ibid., p. 52.

[22]Marshall McLuhan, Understanding Media (New York: McGraw-Hill, 1964), p. 22.

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[24]James Monaco, How to Read a Film (New York: Oxford University Press, 1977), p. 73.

[25]Ibid.

[26]Gene Lees, The Spaced-Out World of Douglas Trumbull," American Film, February 1978, p. 73.

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[28]George C. Pratt, Spellbound in Darkness (Greenwich, CN: New York Graphic Society, 1973), p. 126.

[29]Edmund Carpenter, Oh, What A Blow That Phantom Gave Me (New York: Bantam, 1974), p. 188.

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Photographs/Margin Quotes

(unless otherwise noted, are work of author)

Pg. 11: CoEvolution Quarterly, Winter 1977/78, front and back cover.

Pp. 14-15: (photos) "A View of Kassel," Artforum, September 1977, p. 61.

(quote) Documenta 6 catalog (Kassel, W. Germany: Druck and Verlag GmbH, 1977), I:246.

Pg. 17: (quote) Carpenter, Oh, What A Blow, p. 29.

(photo) H. W. Janson, History of Art (New York: Prentice Hall, 1977), p. 652.

Pg. 18: (photo) Robert Crumb, CoEvolution Quarterly, Winter 1977/78, pp. 42-52.

Pg. 19: (photo) Douglas Davis, Art and the Future (New York: Praeger, 1973), p. 98.

(photo) Jon Rubin, 1978 portfolio, photo by Patty Fagan.

Pg. 21: (photo) Oxford English Dictionary, 1961 ed., s. v. "space."

Pg. 26: (photo of tv) Scientific American ad, March 1978, p. 151.

Pg. 27: (photo of cowboys) Monaco, Film, p. 65.

(photo of IMAX) "Producing the Imax Motion Picture: 'To Fly,'" (reprint) American Cinematographer, July 1976, p. 12.

Pg. 28 (photo) Stewart Kranz, Science and Technology in the Arts (New York: van Nostrand Reinhold, 1974), p.177.

Pg. 29 (photo) Youngblood, Cinema, p. 353.

Pg. 31 (photo) Product literature, Cinema Products Corp., Los Angeles, CA.

Pg. 43 (photo of author) taken by Mark Polumbo

Pg. 44 (quote) Alan W. Watts, The Way of Zen (New York: Vintage, 1957), p. 174.

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