SLIPSTREAM

A DATA RICH PRODUCTION ENVIRONMENT

by

Alan Lasky

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ABSTRACT

Film Production has always been a complex and costly endeavor. Since the early days of cinema, methodologies for planning and tracking production information have been constantly evolving, yet no single system exists that integrates the many forms of production data. Organization is the key to any successful production; but as filmmaking becomes increasingly complex the organizational task becomes even more intricate. With the current availability of powerful personal computers it is now possible to bring together the different elements of cinematic information in a dynamic multi-media platform. The linking of these elements will create a data rich production pipeline that will pass data between pre-production, shooting, and post production. This thesis will explore the development of this data pipeline for motion pictures, known as the SLIPSTREAM.

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ROOTS

1.0 INTRODUCTION: WHAT IS THE PROBLEM?

"This movie is so complicated, and working with three units, first unit, second unit, and blue screen unit - that the computer in my head cannot contain it all..."

Director Paul Verhoeven
on shooting TOTAL RECALL

Modern motion picture production is a very complex organizational task. When a film is made many separate elements must come together in harmony, or chaos will reign and creative control will be lost. Since the early days of film production a general methodology for controlling the flow of information on motion picture sets has evolved. Specifically scripting, storyboarding, and the use of continuity supervisors all serve to give the creative team some measure of control of the direction of a film, but there has never been a cohesive methodology for integrating the knowledge held by all the individuals contributing to the final form of the motion picture. As film making becomes more complex, driven by the public's demand for bigger, more visually intricate movies the need for a system which supports cinematic control becomes a necessity. Such a system must include a range of media types: pictorial, sound, numbers, text and a range of computing functions. The lack of usable tools for controlling cinematic data flow coupled with the increasing complexity of motion picture production has caused many motion pictures to run grossly over budget and many weeks over schedule.

Although the methodologies for tracking cinematic information work in the limited situations for which they were developed, there is no coherent central structure for film data. Information created during pre-production rarely translates to the set in anything but its most abstract form, and data flow from the set to other areas of the production such as the wardrobe department, art department, or effects unit is, at best, marginal. The artistic vision of a film is shaped by several principle contributors, many of whom are rarely in contact with each other. Without a shared record of data it is impossible to assume that every member of the creative team grasps all the important details of the vision. Data can no longer be isolated to one specific area of a production, for this isolation can cause a "domino effect" of problems due to lack of communication in sharing specific data. The tools used to record cinematic data are as responsible for this isolation as the lack of a cohesive platform for data sharing. Many of the industrial age tools developed in the early days of film making remain standards in today's production environment. A crew member transported from a 1920's motion picture to a set in 1990 would see few differences or little that seemed unusual, and probably could begin working with only minor adjustment. Continuity notes, the backbone of on set cinematic data gathering, are still taken by hand with notebook and paper, and rings of Polaroid photographs provide necessary visual continuity. These recording mediums are bulky and inefficient for data which needs to be compared or passed among many individuals, and they fall seriously short of the ideal tools for handling the requirements of modern motion picture production. A new, more efficient methodology is needed for keeping track of cinematic data if film production is to remain a viable industry in the next century. The SLIPSTREAM is designed to keep track of the myriad of details involved in producing a film and to shape the display of this information coherently for each member of the creative team based on their particular needs.

This need for a new method of cinematic data gathering and dissemination is what sparked the creation of the SLIPSTREAM, a tool for managing the various elements of film production. The rising cost and complexity of motion picture production, coupled with my own experiences in film making, confirmed the need for a management tool like the SLIPSTREAM. During my work on the film TEENAGE MUTANT NINJA TURTLES in the summer of 1989, I witnessed many mistakes that could have been avoided with a more coherent approach to cinematic data flow. The director of the film came from the world of rock video, where the concepts of visual continuity are relatively unimportant, and when confronted with complicated action sequences, he made mistakes which were only discovered many months later when the film was in post-production. Also, as the film was on a very tight shooting schedule, scenes were often split between the first and second units. The first unit would execute as many shots as it could accomplish in a twelve hour day, and often leave the remainder of the work to be "picked up" by the second unit. The frenetic pace of this schedule and the abysmal lack of communication between the units inevitably led to errors of continuity that could not be glossed over, even in the editing room. Two months after main unit production had wrapped, an entire unit had to be reassembled in order to reshoot those elements which were needed to fix the mistakes, all this at enormous financial and temporal cost to the production. This was not an isolated incident; many of the motion pictures I have worked on have been subject to extensive reshooting. While some reshooting decisions are made on purely aesthetic grounds, most are caused by errors in continuity or planning that are found too late. Many of these mistakes are generated by a lack of organization and bad data management. If the first unit of TEENAGE MUTANT NINJA TURTLES had turned over more complete data about what they had shot to the second unit, many of the mistakes could have been avoided. Additionally, if the director had been able to access to a tool with which he could follow the visual continuity of the film more closely as it unfolded, he surely would not have made so many errors. Even very simple cinematic concepts such as screen direction and matching can become a nightmare during the frantic hours of day to day film production. The SLIPSTREAM system addresses these problems by providing an electronic environment in which the wide array of production data can be stored, accessed, compared, and shared.

The potential for such an electronic management tool could only be realized once a flexible computational environment with appropriate video capture and display devices became available. Most cinematic data comes in the form of either text or graphics, and computational environments such as the Apple Macintosh II system coupled with high resolution frame grabbers and display equipment can manage these elements. The SLIPSTREAM utilizes these tools to create a true multi-media platform for what has come to be known as "electronic production." The most important goal of the SLIPSTREAM design is its effectiveness as a tool for control of a film by its director, and many of the SLIPSTREAM's features have been designed with this in mind.

As end users of computer and video systems increasingly become the authors of their own video material, and as remote archives of video data come on line the importance of the SLIPSTREAM becomes more apparent. Out of the development of professional tools like the SLIPSTREAM will come the evolution of tools for the home user. By researching the methods of cinematic data gathering and delivering them into a computational environment we pave the way for the next generation of systems which will be used by multi-media authors of tomorrow. When desktop studios become available, amateur enthusiasts, independent film makers, and industrial clients will surely face the same problems of organization as their professional counterparts; and they will require tools for cinematic data gathering and organization. The SLIPSTREAM will offer an important model in the genesis of these tools.

Looking further into the future when it becomes possible for computers, through the use of artificial intelligence and expert systems, to become the authors of their own cinematic material, the SLIPSTREAM will provide a template for meaningful descriptions of cinematic data in machine readable form. William Gibson, in his science fiction epic NEUROMANCER, describes such a situation:

> "Panther Moderns," he said to the Hosaka, removing the trodes. "Five minute precis."
> "Ready ," the computer said.
> "Go," he said. The Hosaka had accessed its array of libraries, journals, and news services.
> The precis began with a long hold on a color still that Case at first assumed was a collage of some kind, a boy's face snipped from another image and glued to a photograph of a paint scrawled wall. Dark eyes, epicanthic folds obviously the result of surgery, an angry dusting of acne across pale narrow cheeks. The Hosaka released the freeze; the boy moved, flowing with the sinister grace of a mime pretending to be a jungle predator.

Clearly this is still the realm of science fiction, but the time is approaching when computer systems will be called on to dynamically shape cinematic experiences, be they news stories or narrative fiction, and these systems will need coherent descriptions of film data in order to make effective decisions about cinematic structure. The SLIPSTREAM will serve as the basis for these descriptions. However, before we attempt to make this leap into the future let us look back at the history of visual continuity and sequential art, as these are at the root of the SLIPSTREAM model.

2.0 VISUAL PLANNING

"... Yet it indicates the range of possible references in any history of the moving image. For some commentators this history begins as far back as 30,000 BC, with the cave paintings at Altamira in Spain. Certain of these animal drawings, it is argued, can be associated in groups intended as sequential progressions."

John Wyver
THE MOVING IMAGE

In order to understand the concepts on which the SLIPSTREAM system is based, it is important to understand some of the history of sequential art. It is beyond the scope of this thesis to provide a complete history of film, or sequential art, but some background is essential. The development of cinema as we know it today emerged from the synthesis of several elements, both technological and aesthetic. The technological breakthroughs of Edison and Lumiere must share equal importance in the development of cinema with other progressions in artistic thought. John Wyver, in THE MOVING IMAGE, puts it best:

> "The early cinema was closely linked with many of the 19th century's most common forms of comic strips. representation, including theatrical tableaux vivants, documentary photography, magical illusions and The influences of these representations was as significant to the invention of the cinema as the technical breakthroughs of Muybridge, Dickson, Lumiere and the others."

One of the fundamental principles of the SLIPSTREAM, and of film itself, is the concept of utilizing sequential pictures to form a narrative. This system of visual storytelling can arguably be traced back to prehistoric cave paintings, but it is the more modern manifestations that interest us.

One of the leading, and probably least appreciated ancestors of modern narrative film making is the comic strip and comic book. Many of the aesthetic principles of the comic book narrative form have a direct correlation to their cinematic counterparts. The layout of comic strips and comic books shares much with the way motion pictures are planned, shot, and edited, and the SLIPSTREAM itself owes more to the "grammar" of comic books than any other form of representation. This is due to the fact that the comic book format is perfect for depicting sequences of shots in a narrative, and translates well to a graphical computer environment. Will Eisner, creator of the comic THE SPIRIT, and one of the great masters of the comic book form wrote a classic text: COMICS & SEQUENTIAL ART, that has been the veritable bible in the design of the SLIPSTREAM. In the forward of COMICS & SEQUENTIAL ART Eisner nicely sums up comics' place in the history of sequential art:

> "This work is intended to consider and examine the unique aesthetics of Sequential Art as a means of creative expression, a distinct discipline, an art and literary form that deals with the arrangement of pictures or images and words to narrate a story or dramatize an idea. It is studied here within the framework of its application to comic books and comic. strips, where it is universally employed.
>
> This ancient form of art, or method of expression, has found its way to the widely read comic strips and books which have established an undeniable position in the popular culture of this century. It is interesting to note that Sequential Art has only recently emerged as a discernible discipline alongside film making, to which it is truly a forerunner.
>
> The premise of this book is that the special nature of Sequential Art is deserving of serious consideration by both critic and practitioner. The modern acceleration of graphic technology and the emergence of an era greatly dependent on visual communication makes this inevitable."

Although the comic strip has in its ancestry such film-like inventions as the magic lantern and Zoetrope, it can truly be regarded as a unique discipline. The narrative rules developed out of comic strips had a direct relation to the narrative conventions of modern cinema. The comic strip is an American invention, derived from the single panel "editorial cartoons" of the newspapers at the turn of the century. During the 1920's and 30's artists like Winsor McCay, R.F. Outcalt, Frederick Opper and others developed the unique narrative grammar of the comics through presentation and experimentation in the mass media. Much of the groundwork for these "continuity graphics" can be traced to Rodolphe Toppfer, a Swiss mathematician working in the mid 1800's. Toppfer wrote AN ESSAY ON PHYSIOGNOMY, one of the seminal works on graphic representation. His work is the basis for much of modern semiotic theory. Toppfer was also an amateur cartoonist, who drew many picture-stories that could be called primitive comic strips. Countless early American comic book artists were influenced by his work, and his ideas on narrative form carry over to the world of film.

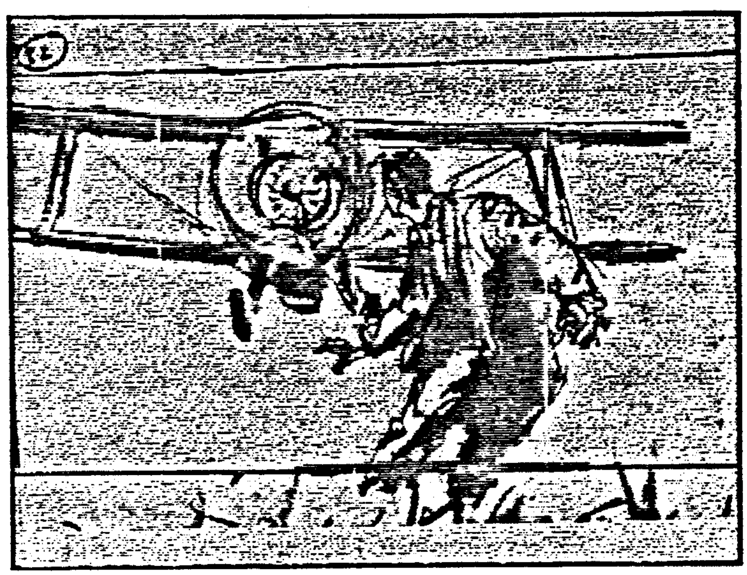


Figure 1: A storyboard from Alfred Hitchcock's NORTH BY NORTHWEST

As films and comics grew up side by side in turn of the century America, many modes of thought passed between the two mediums. The use of story boards is a method that clearly came from comics, however it is unclear who first used storyboarding as a method of shot planning. Story boards (comic style drawings used to visually represent what a shot is going to look like on film) have been a standard method of shot planning in the film industry for decades. The first direct reference to the use of story boards comes from notes about the great Hollywood art director of the 1920's and 30's, William Cameron Menzies. Menzies, a former commercial illustrator, would often make detailed drawings of how his sets should be filmed, specifying lighting, camera angle. and actor positions. He referred to these drawings as "shot boards," and some of the surviving drawings can be seen as the first examples of detailed story boards in the cinema. Menzies was a visionary art director, credited with inventing the title "production designer." He saw the need for detailed production planning if films were to be kept under the control of the studios, and his work helped the film mogul David 0. Selznick keep a tight reign on several of his productions, including GONE WITH THE WIND. One of Selznick's memos included in MEMOS FROM DAVID 0. SELZNICK (edited by Rudy Behlmer) indicates the innovative work of Menzies:

> "When he gets a complete script, he can then do all the sets, set sketches, and plans during my absence, for presentation to me upon my return, and can start on what I want on this picture and what has only been done a few times in picture history (and these times mostly by Menzies)-- a complete script in sketch form, showing actual camera set ups, lighting, etc. This is a mammoth job that Menzies will have to work on very closely with Cukor In short it is my plan to have the whole physical side of this picture handled by one man."

Was Menzies the first to use story boards? It seems hard to believe that directors and cameramen did not use some form of crude sketching to plan shots since the very beginning of the film industry. I believe our first examples of storyboards can be credited to the man who was both a comic strip creator and film animator. Winsor McCay, one of the first comic artists, was also one of the worlds first animators. In 1914 McCay created what is thought to be the first real cartoon character: Gertie the Dinosaur. McCay utilized drawings to represent the key frames of his animations, essentially creating story boards for his film. Since McCay came out of the comic strip world, this form of. story planning was just an extension of his usual artistic medium. Story boarding remains a fundamental tool in animation today. As techniques were passed between the emerging mediums of comics and film, it seems no one thought to herald the use of story boards as anything but a logical development in artistic control and communication.

The use of story boards to plan shots in films illustrates the development of a very sophisticated visual language that is in no way inherent to the medium itself. Film makers at the turn of the century were only starting to realize the potential of cinema as an art form, and at this time theories of visual continuity slowly began to appear. The narrative structure of comics had a very profound effect on those early film makers who possessed sufficient knowledge to utilize it. The concept of visual continuity was not part of early film making, in fact some famous early film makers were never to make the discovery .George Melies and many other film pioneers structured their films as nothing more than stage plays where the camera took a center seat. All the shots were wide proscenium type angles and the action unfolded in front of the camera in scenes. The man usually credited with "discovering the shot" is Edwin S. Porter, an early American film maker working with Thomas Edison. Many other film makers prior to Porter were known to have experimented with the concepts of visual continuity, and it is clear that Porter was aware of at least some of this work. David A. Cook, in A HISTORY OF NARRATIVE FILM states:

> "Sometime after 1901, however, Porter encountered the films of Melies and those of the two British pioneers, G.A. Smith and James Williamson, who had been experimenting with the use of interpolated close-ups in their studio at Brighton."

Wyver, in THE MOVING IMAGE, elaborates on Smith's early experiments with visual continuity:

> "The historian Barry Salt has identified 'the first purely filmic device' in THE KISS IN THE TUNNEL (1899), made by G.A. Smith. Here a studio shot, which is supposedly the interior of a railway carriage, is cut between two exterior shots filmed from the front of a train, the first as it enters a tunnel and the second as it emerges again. There is a clear intention of continuity."

These early explorations of cinematic grammar served as the basis for much of modern film theory. As the early film pioneers discovered many of the principles of cinema, the theory of visual continuity began to emerge. Again Wyver states:

> "But only gradually did film develop visual continuity, to create a narrative which could be readily understood independent of any descriptive text."

As the concepts of visual continuity developed in the early days of cinema, pioneers such as D.W. Griffith, Fritz Lang, and Abel Gance began to explore the boundaries of the medium. These early film makers all came to recognize the shot as the basic element in cinematic narrative. In Russia, Sergi Eisenstein began to explore the potential of "montage," where shots were edited together to create maximum emotional impact as early as 1924. The use of the shot as the single unit of cinematic representation is still the major driving force behind modern theories of visual continuity.

The SLIPSTREAM uses the shot based theory of visual continuity as the basis for the organization of cinematic data. Representing a motion picture as the sum of many separate elements, the smallest of which are shots, simplifies the isolation of potential problems and allows the film makers to envision the narrative as an objective whole. In order to accomplish this effectively, the layout of comic strips is used in the SLIPSTREAM as a format for working with visual data. As will be discussed later, the combination of a graphical computer environment with comic strip layout makes a powerful tool for managing visual continuity. Before the SLIPSTREAM's data management system can be described, a brief description of today's standard for cinematic data gathering and the role of the script supervisor will be given.

3.0 THE SCRIPT SUPERVISOR

> "The script supervisor is the director's right hand... the link of communication between the editor and the director... [He] is objective and highly intelligent... Without the script supervisor, the director can be destroyed... the script supervisor communicates directly with the editor by means of script notes. This is a precise form of communication worked out through many years of effort on the part of the director, the script supervisor and the editor... notes will be the bible for the film editor... a producer or director would be very wise to make sure he hires a top script supervisor. A bad one can add weeks of film editing time... if the film editor has to do all the research himself, it can cost the production an untold amount of extra money, time and grief..
>
> Joseph F. Robertson
> The Magic of Film Editing

In the early days of filmmaking the job structure was much less defined then it is today. The director ran the set and a group of technicians handled most of the other technical crafts, from wardrobe to camera. As the industry grew, the need for certain specialized jobs became apparent to those involved in producing motion pictures. The job of script supervisor evolved out of the editor's need for more information about the day to day shooting on the set. When no script supervisor (also known as continuity supervisor or script girl) was present on the set, no description accompanied the filmed material as it passed from the set to the editing room. Inevitably, this led to hours of searching and logging material by the editors and their assistants; time the film's producers could ill afford. As editors vented their frustration to the producers, a system gradually evolved for annotating shot material on the set. At first all the notation was kept by the camera department. The "clapper board" was an early invention for visually identifying a shot's scene and take number which developed from the association between the early camera and editorial departments. The work of the camera department became more specialized as the industry grew and the need for on set data gathering became even more important and complex. Since camera crews no longer had time to be responsible for the copious notes required by the editing department, a new job category emerged. By the 1920's the script supervisor had secured a place on the day to day crew of the burgeoning film industry. Thelma Preece, one of the first script supervisors and the head of the script supervisor's guild for more than thirty years, was there to see the dawn of continuity supervision in Hollywood. In their book THE ROLE OF SCRIPT SUPERVISION IN FILM AND TELEVISION, Shirley Ulmer and C.R. Sevilla provide an interview with Mrs. Preece that offers an anecdote for the early days of script supervision:

> "Trudy Wellman was working as a secretary at Paramount and RKO for $25 or so a week when someone asked her if she would like to go down to the set and take notes. They would pay her $27 a week, which was a good increase in salary in those days. She accepted the job. There was no formula for work at the time. The emergence of a script supervisor was born of necessity."

As the script supervisor's role on the film set was established, the economic danger of not utilizing a script supervisor became apparent to most producers. The task of continuity supervision evolved along with the film industry, and the theory of film continuity was enhanced through the development of the script supervisor's "formula for work."

The theory of film continuity is based on the principle that motion picture scenes are divided up into a series of single shots that are cut together to represent an action. These shots must give the illusion of spatial, temporal, and motion continuity, regardless of the order in which they are filmed. The final editing structure of the film is the primary directive for the on set production, and this requires an individual will keep track of all the elements of continuity if the film is to flow smoothly on the screen. Ulmer and Sevilla state quite frankly:

> "Screen continuity is based on the premise that during the filming of a motion picture, the screen story evolves independently of the world around it... What happens in reality has no importance."

The early film pioneers such as Griffith and Eisenstein developed shooting and cutting styles that enhanced film grammar and provided many of the first rules of screen continuity. Spatial and motion matching from shot to shot became of utmost importance in building coherent sequences. and the script supervisor was in charge of maintaining this continuity. The major basis for film continuity is seen in Ulmer and Sevilla's description:

> "A film narrative is compiled of continuous visual images. The story is made up of a series of shots which, when put together, comprise a sequence. A series of sequences forms the complete story. The over-all action will flow smoothly from shot to shot only when the individual components meld so that together they depict the picture in a coherent manner."

The fundamental principles of visual continuity are logical extensions of cinematic grammar, and their evolution is parallel. Directors, cameramen, and editors all share the credit for this development with the script supervisor.

Visual continuity can be broken down into three major areas of concentration: Continuity of Motion, Continuity of Space, and Continuity of Time. Many of the major texts on continuity supervision, including Ulmer and Sevilla's. agree on these areas as the most important in maintaining visual continuity. A closer look at all three categories is useful to understanding the design of the SLIPSTREAM system.

Continuity of motion can be interpreted as the coherent use of screen direction. Subjects that enter frame from one side need to maintain a sense of "screen direction" in order for the audience to keep a mental picture of their progress. Chase sequences, one of the earliest forms of parallel cutting, need to establish a direction for the pursuit and utilize it throughout the action if coherence and believability are to be maintained. Film sequences are rarely shot in order, and the script supervisor must be very careful to note all the subtle manifestations of screen direction in a shot. This is particularly tricky when the camera is in motion, as in the case of a dolly or pan, because the movement of the camera often changes the right-to-left and left-to-right relationships of screen direction. In complicated scenes, the continuity of motion elements can easily generate a mistaken description, and one error can render an entire block of shots useless. This happened several times during the production of TEENAGE MUTANT NINJA TURTLES. For example, the karate fighting sequences were carefully storyboarded as groups of quick shots of specific actions. On the set many of the scenes were shot utilizing a moving camera to heighten the sense of action, and hence matching screen direction became very important. When scenes were divided between the first and second unit much of the information about the progression of screen direction in the individual shots was either communicated incorrectly or disregarded by the second unit. Of course, this lack of attention to. continuity created chaos in the editing room as shots of combatants were often mismatched, with fists and weapons constantly flying in the wrong direction. This chaos of motion and spatial continuity could only be solved by extensive re-shooting. Shirley Ulmer and C. R. Sevilla again have the final word on the subject:

> "The importance of maintaining proper screen motion cannot be overestimated. How an actor travels across the frame, where a policeman looks at fleeing robbers, and in which direction an airplane flies when it's heading west are just three examples of what to look for. Special precautions must be taken to ensure continuity in these cases and countless other examples of moving subjects."

Continuity of space, while related to continuity of motion, is more concerned with the camera's (and therefore the audiences') perception of physical space. The camera angles used to "cover" a scene determine the spatial relationships of objects and characters in a space. Once established, these relationships must be maintained in order to prevent spatial inconsistencies that are disturbing to an audience. If the camera establishes a judge looking to his right to address the jury, then all subsequent angles must utilize this spatial relationship. The continuity of space covers abroad range of production situations, and visual as well as narrative logic must prevail if shots are to match in the editing room. The continuity of space is also important to the manner in which an audience is presented the physical layout of a space. If the audience is not given enough visual information about the architecture of a space, they will not be able to build a "cognitive map" of the layout of the set. The perception of the dynamics of a space is important to the audience's understanding of the action in a scene, and the choice of camera angles is the only guide the viewer has to mapping an area cinematically.

A prime example of the power of spatial continuity to effect a viewer's knowledge of an architectural layout can be seen in the phenomena we call "Brady Space." Nearly every adult who grew up watching television has encountered the series THE BRADY BUNCH, and those who consider themselves regular viewers have a surprisingly thorough knowledge of the interior layout of the Brady household.

Many can draw detailed maps of the house showing the location of all the major rooms on both floors, and even the relationships of inside rooms to outside features. Since none of these viewers have ever actually been to the Brady house their specific knowledge can only have come from the camera angles used to cover the weekly actions of the Brady family. By maintaining a continuity of space in the shooting of the Brady house the film makers guarantee that their viewers have a coherent perception of the BRADY BUNCH set. The cognitive map of the Brady house is one of the most complete in popular culture, and it shows how attuned the audience is to these elements of visual continuity.

Continuity of time is somewhat harder to define. In motion picture narrative, time passes according to the plot. and the passage of time can only be traced through the use of tangible visual or aural elements. Ulmer and Sevilla note:

> "Time continuity must be observed through those physical clues which tend to express the passage of time."

The continuity supervisor must take special care to keep the visual clues consistent with the temporal pace of the script. Characters must change costumes and make-up to reflect the passage of time, seasons must change logically, and all other visual cues must be observed if the audience is to accept the film maker's intended perception of time.

Notebooks, paper, a stopwatch and a Polaroid camera have been the traditional tools of the script supervisor for many years. After a film has been scripted and is in the final stages of preproduction the script supervisor is called in to break down the script for continuity. Typically the script supervisor will break scenes down into eighths of pages, and this organization will be maintained throughout production. The script supervisor then reads the script critiquing its content and plot in terms of continuity. Any glaring errors of continuity that are present in the script are usually caught by the continuity supervisor at this time. Robin Squibb, script supervisor on HIGHLANDER, ANGEL HEART, and many other features related the story of how during the breakdown phase of the film ONCE AROUND,. she discovered that a character was written as being pregnant for 13 months. Squibb annotates all the elements relating to continuity that are apparent in the script at this time.

Once on the set the work of the continuity supervisor really begins. At all times the continuity supervisor must be observant of events unfolding in front of the camera, and notate the script accordingly. Major details effecting continuity are marked, and Polaroid photos of major costumes, props, and sets are taken. These are all filed in a manner best associated with each individual continuity person's methods. When questions of continuity arise, the script supervisor can access his/her notes or photographs to provide the needed information. Frequently the script supervisor will be asked by the director to retrieve a continuity Polaroid in order to verify a point of action or visual continuity. At the end of each day the script supervisor turns over a production report and a copy of their notes to the First Assistant Director. The daily production report is used to chart the course of a production in order to maintain proper scheduling and budgetary considerations. The script supervisor's notes are passed on to the editor so that he can have a more accurate description of the material covered by the crew that day.

Accurate continuity notes are the key to an efficient production and successful edit. If the continuity supervisor does not deal effectively with the data generated every day on the set, the film is destined for failure. Pat P. Miller in her book SCRIPT SUPERVISING AND FILM CONTINUITY is moved to state that: "Continuity is the backbone of all motion picture production." A film with a good script supervisor can move from shot to shot with ease and confidence, whereas a bad script supervisor can grind a major motion picture to a halt.

Continuity supervisors have been effectively controlling cinematic data flow for many years, but there are still many horror stories of errors in continuity which resulted in massive cost and schedule over-runs. Editors often complain about the limited notes they are given from the set. Today's films are increasingly complex; visually dynamic scripts are filled with special effects and complicated action, which makes it increasingly difficult for continuity supervisors to keep up. This trend has shown no indication of abeyance and many film makers have recognized the necessity for new tools to aid in the task of continuity supervision.

In the technological evolution of motion picture production there have been many. advances which have helped film makers monitor their productions and control the creative direction of their vision. Recently many of the developments to aid film making have been made in the domain of post production, but over the years a few on-set devices have made their way into the field. One such advancement is video assist, and as it is an important element in the SLIPSTREAM system, a study of its history and development will be beneficial.

4.0 VIDEO ASSIST: HISTORY AND APPLICATIONS

"I love the video tap, it keeps 'em all off me' back."
John Fenner Director of Photography:
TEENAGE MUTANT NINJA TURTLES

It has been said that the concept of video assist was invented by the comic actor and director Jerry Lewis during the production of his film THE DISORDERLY ORDERLY .Lewis, because he was acting in and directing the film, wanted immediate access to takes he had just shot in order to review performance and other factors. He procured a standard production television camera and had it mounted next to his motion picture camera and framed as close to the cinematic shot as possible. Lewis could then record the takes on a standard video tape machine for on set playback. Although Lewis' inventiveness should not be understated, he was not the first to use video as an electronic front end to film making. Russell Campbell, in PRACTICAL MOTION PICTURE PHOTOGRAPHY describes systems in use as early as 1959. The Mitchell System 35, developed by the Mitchell Camera Corporation, and the Electronic-Cam System, developed at Arnold & Richter (later ARRIFLEX), were early video assist systems used for professional applications.

Video assist, or video tap, is a merging of film and video technology which has been steadily gaining popularity since its introduction into film production. Raymond Fielding, in the seminal work THE TECHNIQUE OF SPECIAL EFFECTS CINEMATOGRAPHY, describes video assist:

> "In recent years, some production cameras have been designed or retrofitted to incorporate a so-called 'video tap', a small video camera which 'intercepts' the image formed by the film camera's lens and sends that image to a video monitor off camera, where the camera's field of view can be seen during photography. The image on the video monitor may even be recorded on video tape for subsequent replay and examination. The design of the video tap varies from one camera to another. In most cases a pellicle is inserted into the optical system of the camera. During photography most of the image-forming light passes through the pellicle and exposes the film. However a portion of the light is reflected 45 degrees off the surface of the pellicle and is picked up by the lens of the 'video tap' camera. In a few systems, the video-tap camera picks up the image from the mirror-silvered, front surface of the rotating shutter blades."

When video tap was first introduced, as in the Mitchell System 35, it was designed for situations in which motion picture cameras were being utilized to shoot television productions. The video tap allowed television producers to shoot film as they would any three camera video program. Directors and technicians could monitor what was being shot on each camera and direct the shoot from a standard video production truck. The only feature film ever shot with the Mitchell system was STOP THE WORLD - I WANT TO GET OFF in the early 1960's. When it was first introduced video assist was an incredibly bulky and cumbersome technology. Video cameras were, at the time, not very sensitive to light, and the equipment needed to record video signals was so large that it had to be housed in its own dedicated truck. The technology looked promising, but it added more set up time and cost to productions than it could save.

In the early 1970's as advancements were made in the sensitivity and portability of video equipment. video assist once again was considered as a viable on-set technology. Arriflex and Panavision independently developed systems for video assist that were unobtrusive and reliable. As with many new technologies video assist was only slowly accepted into motion picture production. Commercials were the first area to really make use of video assist as a production technology. The added cost of the video assist system did not appeal to the budget conscious feature producers. but the commercial culture. with their high budgets and strict deadlines. saw video assist as a welcome solution to some of the problems inherent to commercial film making.

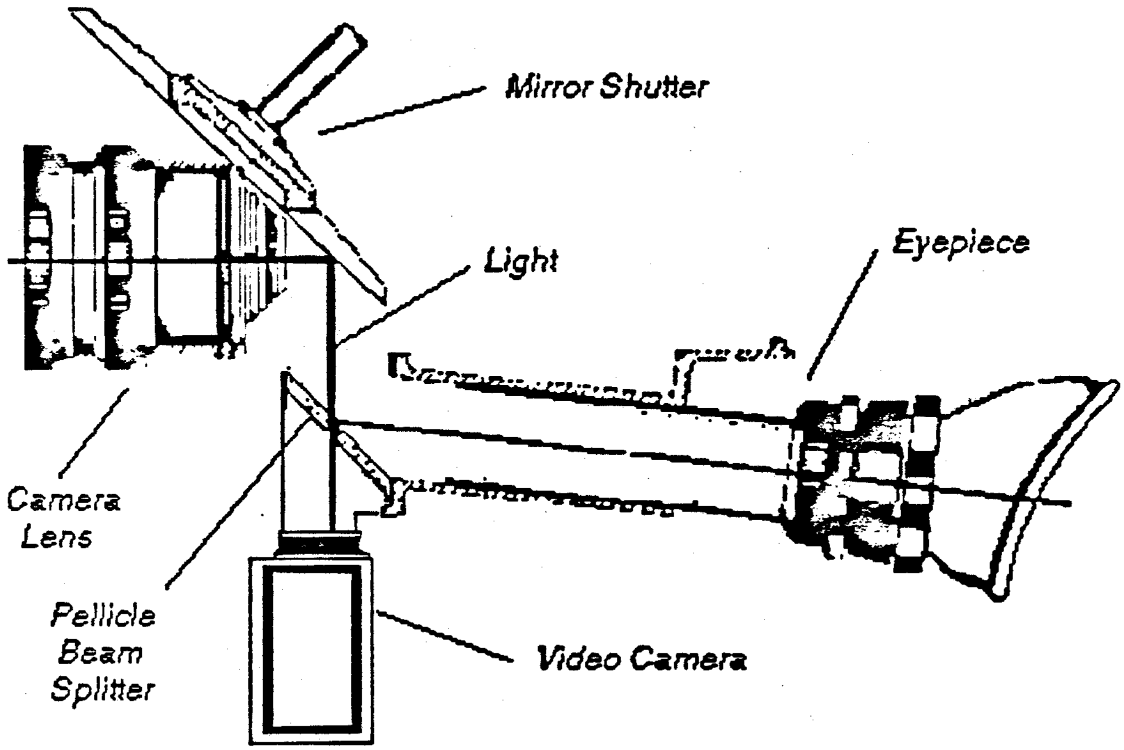


Figure 2: Video Assist Configuration

Because of the nature of commercial production many people on the set are allowed to look at individual shots and comment on such elements as camera placement, lighting, and performance. The clients often "co-direct" commercials by making decisions on the set that must be observed by the crew. Video assist became a tool with which clients could be spirited away from the camera during a commercial shoot, keeping on set pandemonium to a minimum. Because the video assist "sees" exactly what is being shot through the lens, a monitor can be set up far from the working crew for the clients to view. This speeds up production as there are no more long lines of people waiting to look through the eyepiece and comment on the shot. Takes are recorded on a standard VCR for on set playback, giving instant access to shot material.

Motion picture producers began to see the utility of video assist technology in the middle of the 1970's, and soon it had become standard equipment on most larger budget features. The instant access to takes and the availability of a monitor for the director have made video tap a popular tool for most productions.

Motion picture production today has come to rely on video assist as another way of insuring continuity and proper coverage, even to the point that a department has been created for video assist and a union of video assist operators has been formed.

The availability of video assist can be seen as the first step toward a totally "electronic" production system for motion pictures. Several attempts at fully electronic production have been made in the past, some successful, some utter failures. In the next chapter we will investigate some of the more important experiments in electronic production and how they effected the development of the SLIPSTREAM.

5.0: ELECTRONIC PRODUCTION

> "Could one of these SuperPaint machines be designed, or packaged for a very specific purpose, like if we wanted to story board movies? ...That's what I want to do."
>
> Francis Ford Coppola
> from the ELECTRONIC IMAGERY CONFERENCE
> June 20-22, 1980

The technology of film production changed very little in the years after the appearance of sound. Cameras were changed and modernized through reflex viewfinders and on board electrical systems but these advancements came very slowly and were usually met with skepticism by the production community. Only a handful of inventive technicians such as Linwood Dunn, inventor of the Acme/Dunn optical printer, and Ub Iwerks, the man behind Disney's multi-plane camera, were pushing film technology past the status quo.

In the late 1970's film production methods were subject to a period of modernization precipitated by the rapid developments in special effects technology. Young film makers like George Lucas and Steven Spielberg stimulated a technological revolution with films like STAR WARS and CLOSE ENCOUNTERS OF THE THIRD KIND. These films were full of special visual effects that required the development of tools and techniques which, at least for some visionaries, propelled motion picture production into the electronic age. One of the major technological advancements of this period was the development of motion control technology for traveling matte photography. Motion control allows the camera, under computer control, to move during traditional matte photography; this breakthrough ended decades of "locked off' effects shots. Because a computer controls the movement of the camera through the use of stepper motors, any number of "repeat passes" can be made with the camera following exactly the same path every time. Extremely complex visual effects sequences can be realized with motion control systems, such as the "Death Star trench attack" from the original STAR WARS.

The most profound achievement of this era was the acceptance of computers as a practical tool for motion picture production. Film makers were beginning to see computers, video, and other electronic tools as viable enhancements to film production, and their use began to expand throughout the industry. Ulmer and Sevilla give an objective perspective on this period:

> "At present, film production hasn't advanced that far from the early days of the "talkies," outside of special effects. While the equipment goes through constant upgrading, production is slow to follow suit. from computerized film cameras capable of achieving special effects... to the eventual conversion of optical houses to computer technology, equipment will continue to evolve. Eventually, the script supervisor, together with every member of a film crew, will have to adjust their working methods to accommodate the new technology. What all these innovations have in common is that they are not intended to replace film, but to use the advantage of videotape and computer technology to improve film production."

The improvements in production technology were embraced by a core group of young, visionary film makers fresh out of film school who were willing to utilize innovative tools and techniques. One such film maker was Francis Ford Coppola.

Coppola, a graduate of UCLA's film production program, began his career as a sound mixer for Roger Corman's New World Pictures. After a brief interlude as a screen writer, Coppola moved into directing with the low-budget feature, DEMENTIA 13. The young director's style and talent caught on in the 1970's and Coppola's career now spans two decades with such films as THE CONVERSATION, THE GODFATHER, APOCALYPSE NOW and many others. In the early 1980's Coppola built Zoetrope Studios, a production facility unequaled in the history of cinema, and began assembling some of the most radical technology ever created for film production.

Francis Ford Coppola was always an advocate of new production technology, as can be seen in a 1968 interview titled "THE YOUTH OF F. F. COPPOLA" from FILMS IN REVIEW magazine where he states:

> "... We've taken a lot of chances on this picture ---we've had equipment designed and built for us ---and we're suffering in some

> degree. We had a whole blimp designed ---a new silencing system --- and for three days we functioned very inefficiently because no one knew how to work it. The studio is not concerned with the future, they're concerned with doing things the most expedient way."

Coppola's desire to enhance production methods through the use of technology led him to create a system that became the state of the art for what has come to be recognized as 'electronic production.' Electronic production is a term used to describe the marriage of standard film production methodology with video, computers, and other electronic technology to enhance both efficiency and creativity.

In the spring of 1981, as he was about to begin work on ONE FROM THE HEART, Francis Ford Coppola set out to change the very nature of film production. After spending almost a year and his entire personal fortune reshaping APOCALYPSE NOW, Coppola sought to develop a method where he could completely previsualize a motion picture before the first frame of film was shot. Coppola called his idea "the electronic storyboard." Michael Goodwin and Naomi Wise in ON THE EDGE: THE LIFE & TIMES OF FRANCIS COPPOLA describe the origins of the electronic storyboard:

> "But Coppola apparently wasn't worried. He had a plan for ONE FROM THE HEART, a plan that would save millions. To start with, at a time when personal computers and word processors were still relatively rare, Coppola decided to word-process his script, saving all the drafts so he could exchange text between various versions. But that was small change compared with the technological breakthrough he had in mind for the actual film-making, a scheme he knew would change the entire industry. Before the first frame of film went through a camera, every scene would be planned, polished, and perfected by use of a three-stage previsualization technique Coppola called the electronic storyboard. It would employ the latest high tech hardware-- computers, video recorders, editing consoles-- to drag the antiquated filmmaking process into the twenty-first century."

Coppola hired a young technician, Thomas Brown, who had been working at George Lucas' Industrial Light and Magic, to oversee the development of the electronic storyboard. Coppola's system utilized some of the most advanced video and computer equipment available at that time to create a dynamic simulation of every sequence in ONE FROM THE HEART so Coppola could shape the film at every step of production. Pre-production on the film started with the usual script polishing and the creation of a full set of storyboards. After the storyboards were drawn and approved the sketches were recorded into a frame store system through the use of a video digitizer. These images were logged into computer memory so that they could be randomly accessed by Coppola and other members of the production crew. Key cast members were brought into a studio and a "scratch track" of the dialogue of ONE FROM THE HEART was recorded. This recording was then synchronized with the corresponding video storyboards to create a rough "animatic" that could be played on a video monitor. Coppola was able to watch a rough outline of his film to envision how the film would be structured in editing and would make corrections and refinements as needed. Once he was satisfied with the framework of the film Coppola brought all his cast members in to shoot the entire film on video. This video rehearsal would serve as the second stage in the development of the electronic storyboard, and Coppola could again conceptualize how the film would work when it finally made it to the screen. The next stage of the electronic storyboard is best described by Goodwin and Wise:

> "Stage three would take place during the actual filming. Coppola had a shiny silver Airstream trailer built for him in San Diego. Its official title was Image Control, but its real name was Silverfish; Coppola filled it with monitors, telephones, control boards, microphones, dials, knobs, buttons, and switches-- along with a Jacuzzi and the inevitable espresso machine. Even his studio bungalow was filled with monitors. Video cameras would look through Storaro's lenses, sending simultaneous image and sound to the video recorders and screens. Not only would Coppola be able to review instant replays of performances and camera moves, but he could also use his editing equipment to create optical effects, making a preliminary edit while actors, technicians, and lights were still on the set, ready to restage a shot if the video edit indicated a problem. For the first time a movie director would actually see his movie as it was shot."

The use of the electronic storyboard, and especially the Airstream "Image Control" trailer, on ONE FROM THE HEART was met with mixed reviews from both the cast and crew. Several people mentioned their discontent at being directed by Coppola's disembodied voice booming out over loud speakers from the sanctuary of his video center. Teri Garr, one of the stars of ONE FROM THE HEART, was aggravated enough by her "remote control director" that she was moved to say: "It's okay, but we can't talk. Just listen and take direction. We're little puppets." As more of the press were allowed on the set of ONE FROM THE HEART to witness Coppola's Silverfish command center, the film became known as "ONE FROM THE TRAILER."

The concept of the electronic storyboard was a giant step forward for the field of electronic production. Coppola created a functional system for the previsualization of motion pictures that was the foundation for much of the work that was to follow. Fielding, in THE TECHNIQUE OF SPECIAL EFFECTS CINEMATOGRAPHY comments on the suitability of the system for film production:

> "Taken as a whole, the electronic storyboard provides the ultimate machine for previewing the likely 'look' of the finished film. It assists the director in staging the various scenes and in selecting or rejecting particular scenes which are proposed in the script, depending upon their likely dramatic effectiveness in the finished film. It assists the art director, costumer and prop builders in the planning and execution of their work."

Coppola had hoped that the electronic storyboard system would save millions of dollars on ONE FROM THE HEART by streamlining the shooting and editing process. Unfortunately Coppola's style of direction was one of constant transition and the film ended up over budget and behind schedule. Much of the budget was spent on building complex sets of Las Vegas when Coppola refused to shoot the film on location. Because of the negative press heaped on ONE FROM THE HEART and the subsequent financial collapse of Zoetrope Studios, the electronic storyboard system was perceived as another in a long list of the extravagances of Francis Ford Coppola.

To regard the system as a failure, however, would be a mistake. As Ulmer and Sevilla point out:

> "The pioneering efforts of Coppola should not be viewed in any way as a failure. Even though his experiment proved impractical and prohibitively expensive for most companies due to the excessive lead time required, Coppola's system is a truly revolutionary innovation in its infant stage. It was the first successful step toward a grand-scale integration between video technology and film production. A system such as Coppola's which relies so heavily on preparation time may have been more practical in the early days of the big studios when economic pressures didn't playas active a role as today, but at the time, the necessary video equipment was unavailable. Dismissing Coppola's system on the basis of its shortcomings on ONE FROM THE HEART is like dismissing the early attempts at flying when all the inventors lacked was rip-stop nylon and lightweight aluminum. The early flying machines were not so different from today's hang-gliders."

Coppola's system and ideas were very influential in some areas of the film industry. Many film makers took to his concepts of previsualization and some went on to develop systems of their own. Thomas Brown, the man employed to create Coppola's technology, eventually teamed up with documentary film maker Meg Switztable and formed an independent film partnership known as Foresight

Films in order to produce an ecologically based narrative known as PASSING THRU LINDEN. Using his experience at Zoetrope, Brown set up an electronic storyboarding environment for the visualization of PASSING THRU LINDEN. In the June 1989 issue of MACWORLD Stuart Cudljtz. in his article STAR QUALITY tells of Brown's system:

> "For storyboards Brown uses the Mac and an updated version of the electronic storyboarding techniques he first developed for Coppola. Using SuperPaint. his production team places text and notes in the draw level and storyboard pictures in the paint level. They draw pictures on a Summagraphics tablet, but also digitize from tape and scan in images with a desk scanner. By videotaping the storyboards (with the text suppressed} and taping a "radio play'. of dialog and sound effects, Brown and company produce an animatic version of the entire film."

Because Foresight Films is an independent company the use of the electronic storyboarding system allows the film makers to streamline their production and get a better idea of scheduling and budgetary considerations. PASSING THRU LINDEN is being funded through a limited partnership, and the ability to show potential investors a complete electronic representation of the film heightens confidence in the abilities of the company to deliver a product. This also helps secure the backing of a completion bond; a necessary step to begin the production of any independent film.

Electronic production systems are in development at a few other production centers at the time of this writing; most notably at LucasFilm and Universal Studios. Computer technology plays a large role in all of these systems, and they are all being created to enhance the efficiency and creativity of the film production process. The SLIPSTREAM was created with this goal in mind and in part two of this thesis we will look at the design and development of the SLIPSTREAM electronic production system.

PART II:

THE SLIPSTREAM

6.0 FUNDAMENTALS OF THE SLIPSTREAM SYSTEM

"I'm into conceptualization, and I knew a nonlinear system could give me another way to conceptualize --to play with, try out, manipulate concepts."

Director Oliver Stone
on the use of nonlinear editing systems
FILM & VIDEO, July 1990

The fundamental design goal of the SLIPSTREAM was to develop a portable system for the tracking and organization of visual data throughout a motion picture production. In the SLIPSTREAM design, the director was established as the most important user of the system and much of the methodology was conceived with his needs in mind. However, the SLIPSTREAM's functionality is geared to allow for use by many other crew members at all stages of production. The script supervisor, art director, first assistant director, cinematographer and other personnel could all benefit from the data generated by the SLIPSTREAM.

Directors of motion pictures need to visualize the structure of their films as shooting progresses in order to maintain control of the final product. So much visual data is generated on a motion picture that is impossible for an individual to keep track of it all without assistance. Directors continually refer to the storyboards, script, video assist and continuity supervisor to manage the intimidating amount of visual data generated every day of a production. During the frantic hours on the set it is easy to lose sight of a film's comprehensive vision, and when this happens creativity is lost and errors are made. The SLIPSTREAM's ability to track and organize visual data on the set makes it a comprehensive tool for the conceptualization of a film as it is being created. Because the SLIPSTREAM keeps a full graphic record of what has been shot, what needs to be shot as well as other support material in a dynamic platform, a director can constantly update his vision and guarantee that the creative potential of the film is maximized.

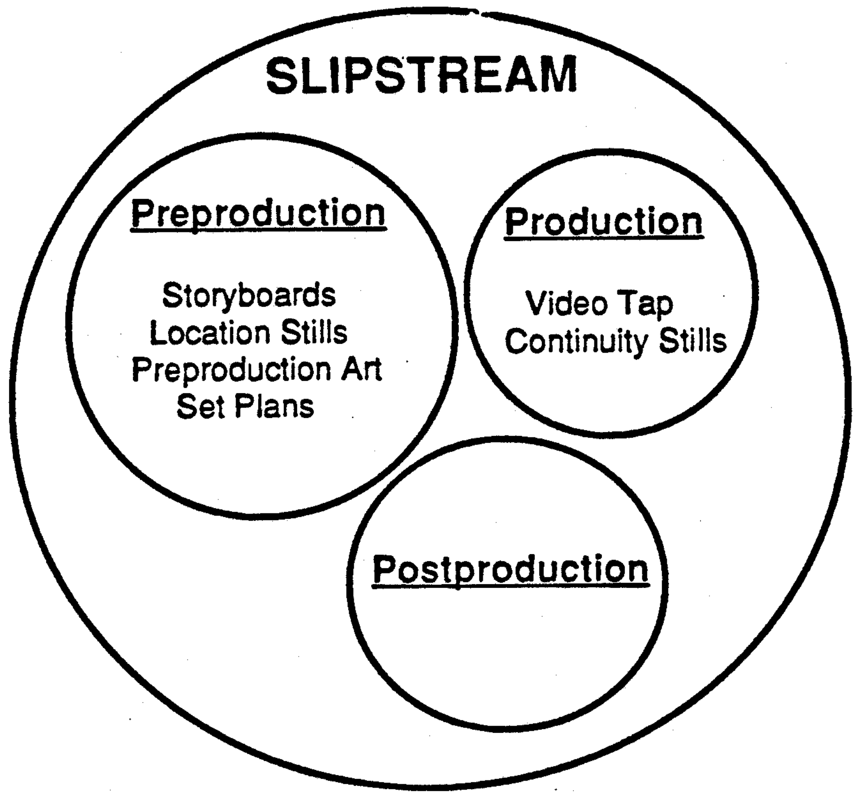


Figure 3: Visual Information Stages of the SLIPSTREAM

Visual data materializes in. many forms on a motion picture, and it is from these forms that the SLIPSTREAM builds its pictorial database. During preproduction storyboards, location stills, preproduction art and production design illustrations are all collected into the SLIPSTREAM. The script is also entered into the SLIPSTREAM during preproduction and linked with associated images from the database. During the actual shooting of a motion picture the SLIPSTREAM gathers continuity stills as well as key frames from the video tap. This visual data is all stored in the database for later recall in the SLIPSTREAM's dynamic multi-media environment.

Before the SLIPSTREAM's specific modules can be described, it is important for the reader to grasp the research goals of the SLIPSTREAM system. Early in the development of the SLIPSTREAM Professor Glorianna Davenport and I had a series of design meetings that fleshed out the major objectives of our electronic production environment. An understanding of these design objectives will allow the reader to more completely evaluate our final solutions for the SLIPSTREAM system.

The first, and possibly most important goal of the SLIPSTREAM system was portability. The SLIPSTREAM would constantly be moving from one location to another and from place to place on a film set. Coppola's Silverfish trailer was viewed as an example of a system that failed partly due to its size and complexity. Standard sound mixing consoles and video assist stations are mobile platforms that require little set-up time when moved, a characteristic the SLIPSTREAM would need to retain. We designed the SLIPSTREAM to fit in a standard rack-mount assembly that could easily be moved and was self contained enough to allow for rapid set up. If the SLIPSTREAM failed to be portable and efficient to use it would never be considered for professional on set applications.

Powerful graphical navigation in the electronic environment was the second major design goal of the SLIPSTREAM system. Picture and text had to be coherently structured to allow for flexible retrieval by any individual involved in production. The system had to adapt to the users and their specific on set problems, as typical queries could come from the director, continuity supervisor, art director or anyone else needing production information.

It was clear in the early stages of design that the graphical navigation environment would need to capture and display elements from a variety of electronic sources. In order to deal with the dynamics of such a system in the context of its implementation on a film set, I devised a two monitor configuration for the SLIPSTREAM. The two monitor system would greatly facilitate graphic operations and allow for a logical design of the environment's dynamics. In the two monitor configuration one monitor is designated as the "workspace monitor" and the other as the "pallet monitor." All of the digitization functions and graphical set up would take place on the workspace monitor while the pallet monitor would be used for the representations of sequences through storyboards and frames from the video tap, along with continuity stills and other elements.

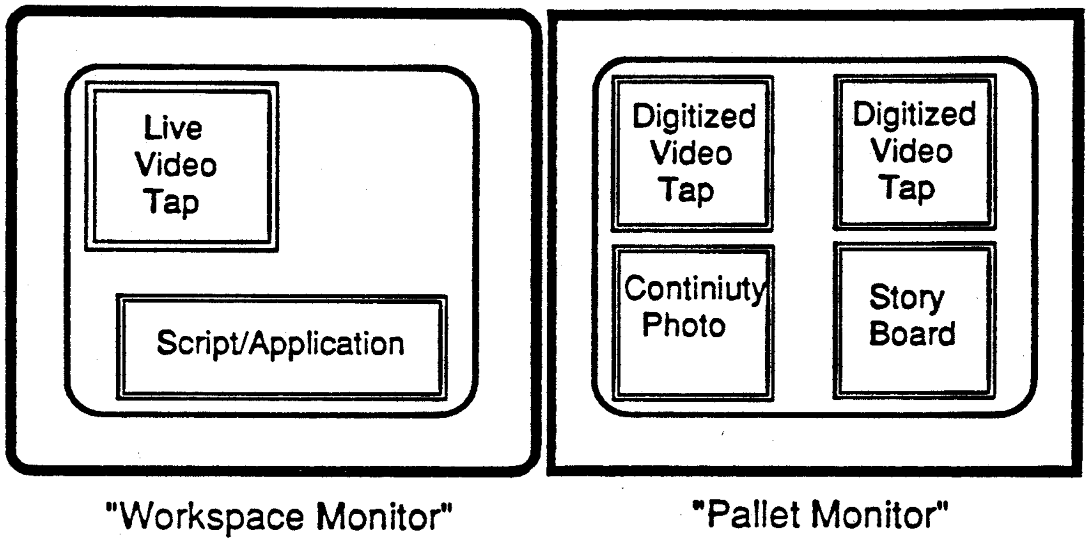


Figure 4: SLIPSTREAM 2 Monitor Configuration

In the computational environment where elements from the SLIPSTREAM's visual database would be manipulated, the format of comic strips was chosen as the model for graphic layout. This mode of visualization would be presented on the pallet monitor, and would conform to the methodology used in film planning and sequential narrative structure. When storyboards are created they are laid out as groups of sequential drawings which function as narrative strips, showing the shot to shot progression of each scene. The graphical navigation environment of the SLIPSTREAM allows the user to arrange the scanned storyboard frames in different sequences to maximize coverage. Location photos and preproduction art would be linked to these storyboards on the shot pallet in order to more accurately plan the production of the scene. On the set key frames from the video tap would be digitized in real time. and delivered into the shot pallet in order to better conceptualize the coverage of a scene. Our design goals specified that the digitized video tap frames could be mixed with storyboards in the shot pallet, creating a dynamic platform for visually illustrating the coverage of a sequence. By blending grabbed images from the video tap with the preproduction storyboard sketches a scene can be visualized as it unfolds, greatly enhancing creativity and efficiency. Continuity stills taken on the set and digitized would also be brought into the shot pallet offering increased insurance against mistakes in visual continuity.

The third major design goal of the SLIPSTREAM was to interface with the continuity supervisor and create a logical relationship with the methodology of script supervision. The SLIPSTREAM was never designed to replace the continuity supervisor; rather our goal was to augment and enhance the common procedures of script supervision so that, given the complex world of modern film production a considerable portion of the data management or collective memory could become more accessible and malleable as necessary while still retaining accuracy. The SLIPSTREAM had to work in conjunction with the script supervisor by accepting her input and expediting the task of maintaining visual continuity. For the SLIPSTREAM to be successful it must not be interpreted as a threat to any crew member's job. Powerful unions such as the International Alliance of Theatrical and Screen Engineers {I.A.T.S.E.) control much of the film production in the United States. and any technology perceived as a menace to members of these unions stands little chance of survival.

In order to meet our design specifications for the SLIPSTREAM a powerful computational system was needed. To understand the current functionality of the SLIPSTREAM it is important to review the hardware base used for the system and the way in which the hardware was procured in the context of a Media Lab research project. In the next chapter we shall track the development of the SLIPSTREAM through a study of its hardware evolution.

6.1: SLIPSTREAM HARDWARE

When we set out to build the hardware base for the SLIPSTREAM it was clear that a computational environment capable of handling large amounts of high resolution graphical data was needed. The Macintosh II was selected as the platform for the SLIPSTREAM due to its relative portability, graphical interface and ability to manipulate and display visual data. As the Macintosh alone could not execute all the digitization and display functions, research was conducted to ascertain the best combination of capture and display devices for the SLIPSTREAM system.

I had always envisioned the SLIPSTREAM as a two board, two monitor system. Two frame capture and display boards, along with a scanner would be necessary to collect and manipulate the various kinds of visual data generated on a motion picture. One digitizer would be dedicated only to displaying and "grabbing" live video from the video assist camera on the set. The digitizer for this task had to be able to run live video in window on the Macintosh screen and digitize key frames in real time. As the SLIPSTREAM operator would be watching the video tap live on the screen he had to have the ability to grab frames from the on set source at the touch of a button. Interactive Cinema had been utilizing the Mass Micro Color Space II and Fx digitizer board combination for The Elastic Charles and other multi-media projects, and their capabilities were close to what was needed for the SLIPSTREAM. When research began on the SLIPSTREAM project the Mass Micro boards were used to test design considerations. Later, when it became clear that a "live video in a window board" dedicated to the project was needed we chose the Orange Micro 'Personal Vision' capture and display card for the digitization ofvideo assist frames. The Orange Micro card was a low cost solution that in hindsight can be viewed as insufficient for the task. The Personal Vision board proved quite unreliable; when used under MultiFinder it had a tendency to crash the operating system, rendering it almost useless for the SLIPSTREAM. The SLIPSTREAM system was conceived as a combination of software and hardware that could pass data between separate areas of the program seamlessly, a task impossible to accomplish with the Orange Micro card. Also, the Personal Vision's analog to digital converter was quite sensitive to fluctuations in the video signal; any deviance in the incoming video would create an error in the board that was passed through the NuBus essentially freezing the system. The Personal Vision's acute sensitivity to incoming video could not be tolerated, as one can imagine a range of scenarios on set which would guarantee fluctuations in the video signal such as the disconnection of the video tap or electrical current black outs. The tendency of the card to crash the Macintosh made demoing the system a nightmare in the early days of the SLIPSTREAM as we had to pamper the Orange Micro board or be faced with embarrassing consequences. In the configuration of the SLIPSTREAM that is working at the time of this writing we have replaced the Orange Micro card with the RasterOps 364, which will be discussed later.

As was mentioned earlier, the SLIPSTREAM was designed as a two capture and display card system. Images from the video tap were to be grabbed a dedicated sub-system, but location photographs, continuity stills and other images would be channeled to their own capture environment. As detail is of overwhelming importance to continuity stills, the standard eight bit dithered resolution of both the Orange Micro Personal Vision Card and Mass Micro Color Space II/Fx combination was not sufficient for the imaging demands of the SLIPSTREAM. 24 bit "true color" was necessary if the SLIPSTREAM was to be used in any professional situation. As we researched the true color systems available for the Macintosh many issues were explored relative to both the technological and economic feasibility of these systems for the SLIPSTREAM. Most 24 bit true color systems are combinations of display cards with dedicated monitors, and most lack the ability to capture incoming video. While the search for the true color platform continued we employed the Personal Vision and Color Space cards for our capture and display requirements. As will be discussed later, when true color finally did materialize, it came in a form we did not expect, but one that was perfect for the SLIPSTREAM.

Rounding out the image capture hardware of the SLIPSTREAM is a standard desk scanner. Flat artwork such as storyboards and line drawings are more efficiently captured through the use of a scanner, and the 300 dpi resolution available on most commercial systems is of higher quality than that of video capture devices. In researching scanners for the SLIPSTREAM I was able to test two systems available at the Media Lab. The Apple Scanner was the first system

I tested and I found it to be unsuitable for the needs of the SLIPSTREAM. The Apple Scanner produces an adequate picture, but the software is hard to manage and the lack of standard picture formats in which to save scans renders the system useless for our needs. The Visible Language Workshop's Hewlett-Packard "Scan-Jet" scanner proved to be a viable tool for the image capture needs of the SLIPSTREAM. The Scan-Jet supports high resolution capture and the software is adaptable to many scanning situations. All of the scanning operations needed for the SLIPSTREAM were carried out with the Scan-Jet.

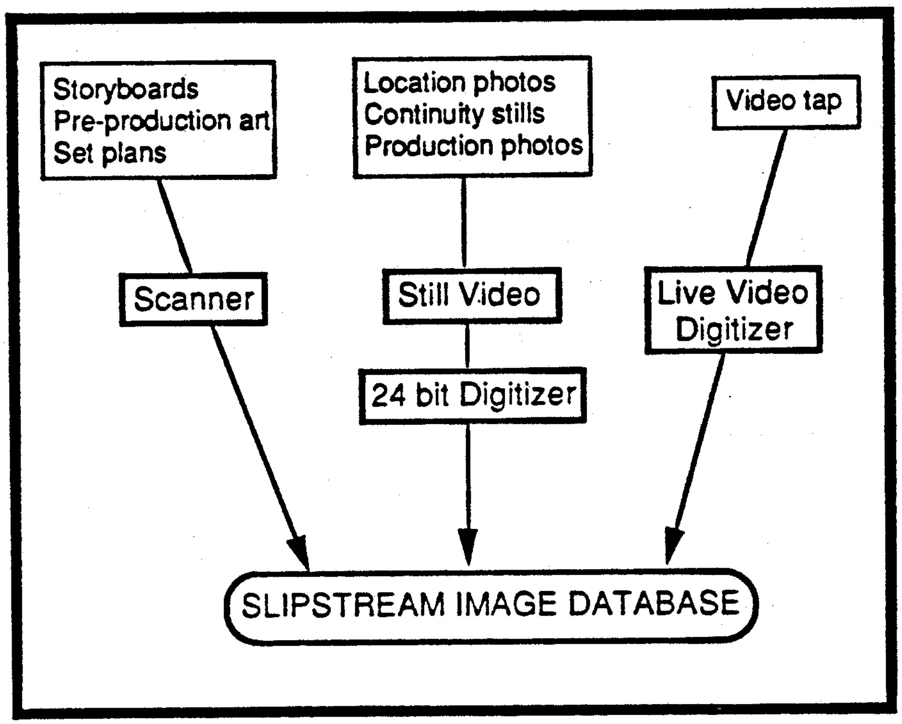


Figure 5: Environment for Image Capture in the SLIPSTREAM System

When I first began to envision a system for electronic continuity supervision it was clear that some mechanism was needed for the capture of continuity stills. location photographs. and other production imagery. These images would then be digitized by the 24 bit system for use in the SLIPSTREAM image database. During my work on TEENAGE MUTANT NINJA TURTLES I became aware of the availability of Still Video. a relatively new technology for the capture of still frames of video with instruments that were hybrid crosses between standard SLR cameras and video camcorders. Several Japanese companies had collaborated on the creation of a standard format for the image data of Still Video and were releasing products in several test configurations. The technology was seen to be more applicable to industrial applications, but a few consumer Still Video products had made their way into the American market. I purchased a SONY Pro-Mavica MVC-C1 Still Video camera at the end of the summer in 1989 and brought it back to the Media Laboratory to research the possibilities of using Still Video for the SLIPSTREAM system. The SONY Pro-Mavica proved to be an excellent tool for capturing images for later digitization. Still Video, as its name suggests, provides a still frame of video along a normal composite NTSC channel. As most digitizers for the Macintosh do not grab video in real time, the ability to produce a stable signal of one frame of video information makes Still Video an efficient solution for high resolution image capture. Once we had worked out the peculiarities of the sync signal on the Still Video channel, the most important image capture tool for the SLIPSTREAM was established.

After using the SONY Pro-Mavica still video camera with the Orange Micro Personal Vision and Mass Micro Color Space III/Fx boards for digitization we found that an upgrade of our Still Video technology would enhance the SLIPSTREAM system. I contacted SONY's Still Video division several times requesting information on their professional line of Still Video equipment and asking if SONY would be interested in sponsoring our project with an equipment loan or donation. My correspondence eventually led to SONY extending an invitation to Professor Glorianna Davenport and I to attend Digital '90, a conference on digital photography held in Washington D.C., where we met with several members of SONY's Still Image Systems Division. At the conference we discussed the SLIPSTREAM concept over tea with Mr. Takagi of SONY Japan and Mr. Seijiro Tomita of SONY's Park Ridge Center, and as a result of this meeting SONY's park ridge research center decided to support this project with an equipment loan. A few weeks later we received a package of equipment that included the MVC-5600 Pro-Mavica Still Video Recorder/Player, MVC-2000 Still Video Camera, UP-5000 Color Video Graphics Printer and a high resolution monitor.

This equipment added a new dimension of capabilities to the SLIPSTREAM system. The MVC-2000 Still Video Camera provided an upgrade in image capture over the fixed focal length consumer model due to its zoom lens, field and frame recording modes and enhanced shutter. The MVC-2000 was used to capture all of the continuity stills, location photographs and other images except video tap frames, and proved to be a reliable and high quality system. Currently on motion picture sets the script supervisor uses a standard Polaroid instant camera to take the stills which are used to maintain visual continuity, however these stills are of very low resolution and often times fail to show important details in costumes, sets and props. The SONY Still Video camera can record 430 lines of video resolution in the frame mode, giving a much clearer image that can be stored and displayed electronically. Utilizing the MVC-2000 camera in the field to record continuity stills is a clear improvement over the existing Polaroid method.

In order to display the images captured with the SONY Still Video Camera the recording disk must be installed in some form of player device. From the beginning the MVC-5600 player/recorder which we tested was designated for this function, but the wide array of additional features quickly demonstrated that the MVC-5600 could playa more dynamic role in the operation of the SLIPSTREAM. The MVC-5600 operates as a "video recorder" for Still Video images, providing a flexible environment for image capture and display. Images can be recorded to disk from live video, computer display and other NTSC, RGB or component sources. The image quality is superb and the system is quite easy to use. Because Still Video is an analog format, bottlenecks associated with digital storage are nonexistent. In the SLIPSTREAM system the Still Video recorder/player can function as a low cost archiving device for high quality images that do not require database archiving. When images did need to be digitized from Still Video for storage in the SLIPSTREAM's image database the MVC-5600 provided the video input to the 24 bit capture device. The Hi-band signal produced by the player guaranteed very high quality images from the digitization procedure. The MVC-5600 also provides a standard RS-232 control interface, and at the time of this writing we are attempting to create the drivers to control the Still Video player/recorder from the Macintosh desk top in order to increase its functionality within the SLIPSTREAM system.

Without hard copy of the images stored in the system the usefulness of the SLIPSTREAM would have been severely limited. SONY's UP-5000 Color Video

Graphics Printer solved this problem by providing high quality print out from a variety of sources. The UP-5000 is a video printer capable of producing a 5"X8" printed image from Still Video, video tape or the Macintosh display. The printer can scale and multiply images on a print as a single image; or both a 4X4 composite of images, or a gxg composite. This feature is useful for creating prints with several location photographs, continuity stills or other images structured for specific departments of a film production. Again, the images are of higher quality than the standard Polaroid photographs currently used for continuity supervision on feature film productions, in addition the UP-5000's ability to produce multiple copies of a picture allows for distribution of images to all required crew members. The UP-5000 can be controlled via the RS-232 port and we are currently writing drivers for this purpose in the Macintosh environment.

Clearly, the arrival of the SONY Still Video marked a giant step toward realizing the design goals we set forth for the SLIPSTREAM. However, a system for the capture and display of 24 bit true color still eluded us. Late one night while we were engaged in SLIPSTREAM research two gentleman, William J. Warner of AVID Technology and Carl Calabria of Truevision, came to Interactive Cinema hoping to get a tour of the building. I obliged and we showed Mr. Warner and Mr. Calabria around the lab and demoed the SLIPSTREAM for them. As it turned out, this random visit proved instrumental in securing 24-bit capture and display for the SLIPSTREAM. Because it is my nature to let people know what is on my mind I made it clear to Mr. Calabria that the SLIPSTREAM would function much better with the 4 Megabyte NuVista card manufactured by his company. I also stressed that Truevision would benefit from support of the SLIPSTREAM project because of its expected high visibility in the film industry and the obvious advantages of association with the Media Laboratory .Apparently some of what I said must have had an impact on Mr. Calabria for 5 days after his visit I received a Federal Express package containing a NuVista 4 Megabyte Card, a VIDI/O box and software.

Since its arrival the NuVista card has become the single most important component of the SLIPSTREAM configuration. It is an entire graphics processing subsystem on a card utilizing the Texas Instruments TMS34010 32-bit graphics microprocessor and 4 megabytes of on board fast video RAM.

Truevision provides an encoder/decoder system, known as the VIDI/O box, as the video interface to the NuVista card. The VIDI/O box is a stand alone video converter that will encode component RGB video into NTSC or V/C S-Video, and decode NTSC and S-Video into their RGB components. Any video signal routed to the VIDI/O box is converted into an RGB signal for capture by the NuVista's powerful 32 bit digitizer. All of the Still Video stored in the SLIPSTREAM's image database is digitized through the combination of the NuVista card and VIDI/O box. The image quality of the NuVista digitizer is the best of any system on the market, and its 32-bit real time capture function is efficient and easy to use. Since the NuVista and VIDI/O box can also be used to drive a video display, the NuVista became the card that controls the pallet monitor in the SLIPSTREAM graphical navigation environment. The ability to convert graphics from the RGB format to standard NTSC allows the NuVista's output to be displayed on a standard NTSC monitor, a feature which allows the material presented on the pallet monitor to be transmitted to the director's monitor on the set. Although the NuVista card now serves as the most important component in the SLIPSTREAM's graphical environment, I believe we have barely scratched the surface of the board's capabilities.

Rounding out the current graphical environment of the SLIPSTREAM is the RasterOps 364 24-bit capture board. The RasterOps 364 runs live video in a window on a standard Macintosh 13" monitor and captures frames in real time. In looking for a replacement for the Orange Micro Personal Vision, I visited the MacWorld Expo in San Francisco where I compared most of the live video digitizer boards available and found the RasterOps was most suited to our needs. The 364 not only displays video in a window from a standard composite source but also converts the Macintosh color monitor into a full 24-bit display. In the SLIPSTREAM environment the 364 board is used to control the workspace monitor, and the ability to have both the workspace and pallet monitors display 24-bit color greatly increases the productivity of the entire system.

With a firm grasp of the technological mechanism used to drive the electronic environment the reader can better understand the SLIPSTREAM as a tool for film production. In the next section we will explore the SLIPSTREAM system as it performs the task of tracking and organizing the visual data on a film production and look at the first test of the SLIPSTREAM in an on set environment.

6.2: SLIPSTREAM ON THE SET

As the academic stage of SLIPSTREAM research is now complete and a functioning SLIPSTREAM unit has been built and tested, we can review the relative merit of the system as a tool for film production. The SLIPSTREAM system in existence at the time of this writing is a powerful and efficient instrument for the tracking and organization of visual data on a motion picture production. The SLIPSTREAM has met many of its initial design specifications such as portability and seamless integration with the current method of script supervision, but it is the SLIPSTREAM's graphical capability which finally makes it so powerful. Visual data captured and stored in the SLIPSTREAM's image database can be manipulated in a variety of sub-modules designed to increase efficiency and enhance creativity on a film production. In order to assess the functionality of the SLIPSTREAM it is important to understand the relationship between these sub-modules and scenarios for on-set cinematic problem solving. The three major sub-modules we will examine are: the "smart continuity" environment, the "smart coverage" environment, and the "coverage mapping" system.

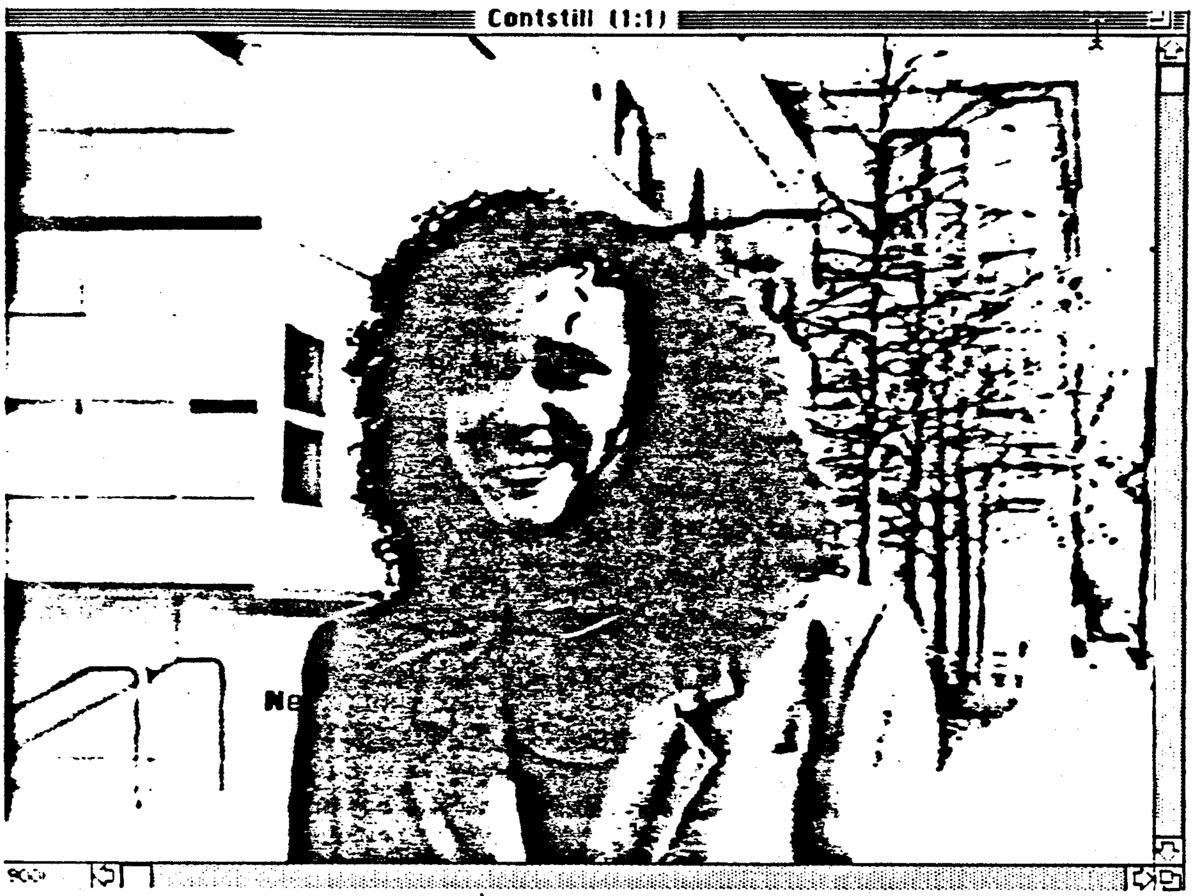


Figure 6: A digitized actor still in the "smart continuity" environment

As seen in the above picture digitized stills of actors can be brought into the "smart continuity" environment to check details of hair. make-up and wardrobe. In the "smart continuity" environment any continuity still in the database can be displayed on the SLIPSTREAM's pallet monitor based on individual queries. The 24-bit still can be exported to a paint program for annotation with information important to visual continuity. Different departments can identify the elements they consider significant to the maintenance of continuity. The image can be channeled to the "director's monitor" on the set for fast access to continuity material, or shown privately to individual crew members on the pallet monitor without disturbing on-set monitoring functions. The continuity still can also be printed from the "smart continuity" environment and distributed to the appropriate crew member, department, or unit.

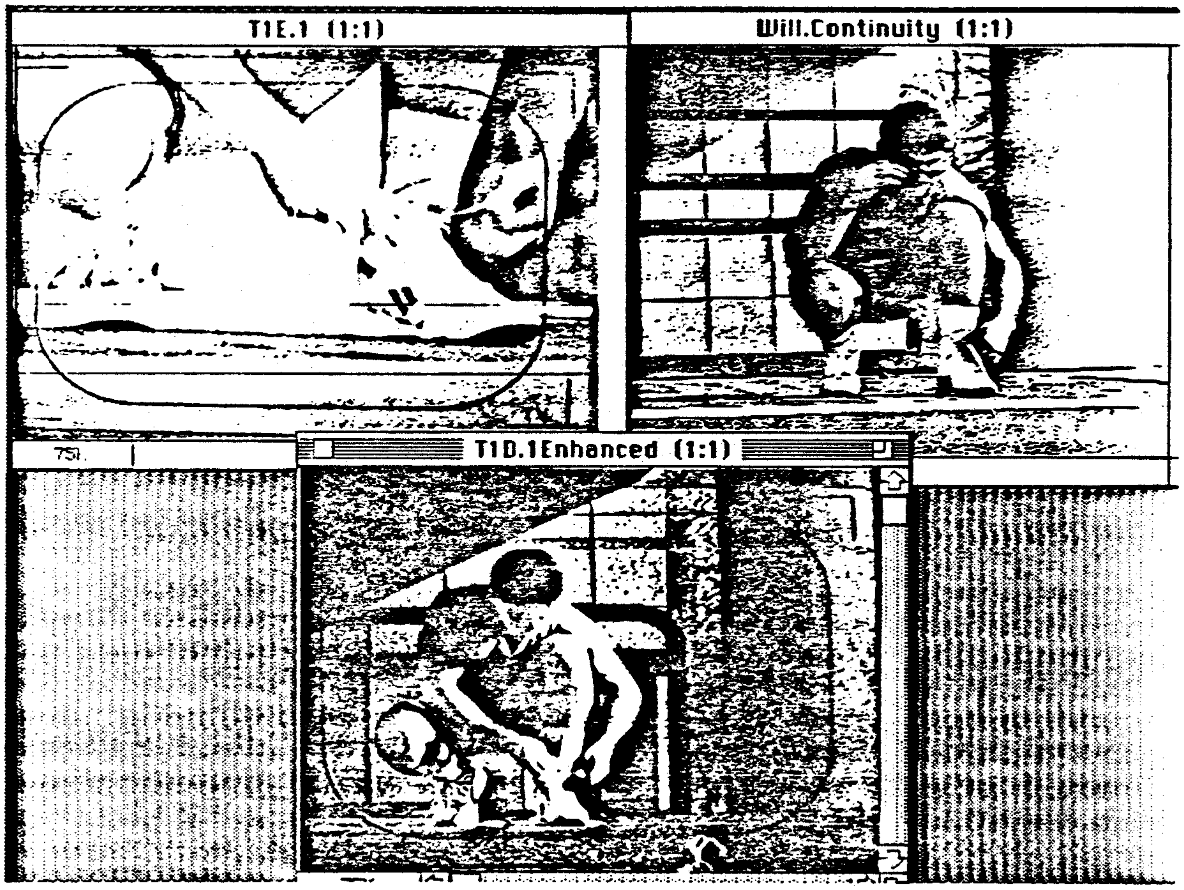


Figure 7: An actor continuity still mixed with digitized video assist frames in the "smart continuity" environment.

In the above image frames from the video tap are being matched with digit!zed continuity stills on the pallet monitor in order to check elements of continuity from shot to shot. Here a medium shot of the actor tying his shoe and a close up of the same action are compared with a continuity still to provide an accurate match of leg and foot positions between the shots. Set up time between these two shots can be anywhere from a few hours to a few days, and details of continuity are easily forgotten without a visual record. The "smart continuity" environment provides real time dynamic access to continuity material in a multi-media setting, so that any images in the database can be displayed on the on-set monitor providing immediate visual responses to questions of continuity. The flexibility of the "smart continuity" environment allows unlimited combinations of images to be compared in order to check elements of visual continuity. We feel that this enhanced form of continuity supervision will benefit the script supervisor by organizing the detail intensive continuity elements into an efficient, accessible environment, allowing the script supervisor to concentrate on the higher order concerns of narrative continuity.

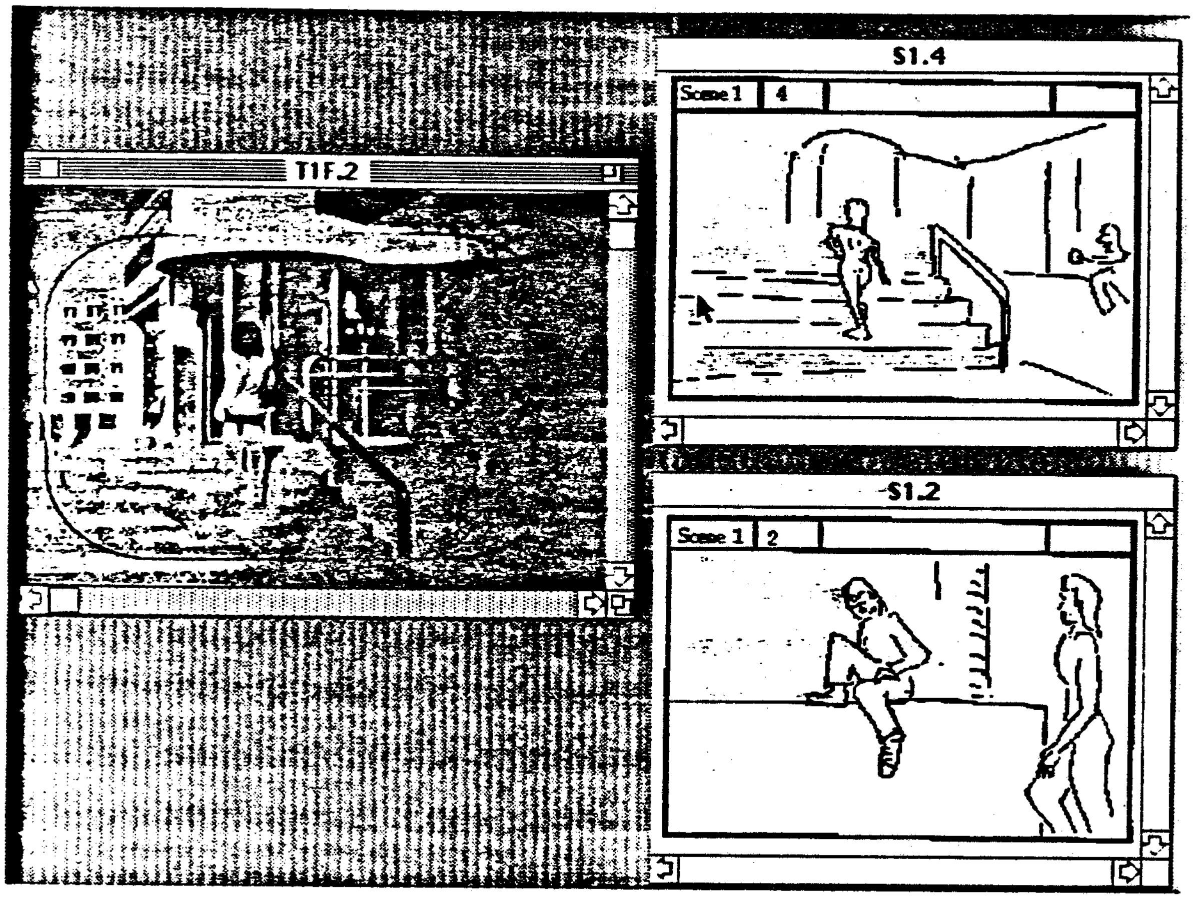


Figure 8: A digitized frame from the video tap is compared to scanned storyboard pictures in the SLIPSTREAM's "smart coverage" environment.

When the shooting of a motion picture is planned the first assistant director, second assistant director and script supervisor usually break down the script into scenes and occasionally further divide the scenes into groups of shots based on the storyboards or input from the director. As the schedule is created the scenes are grouped by the days on which they will be shot and this information is transferred to the assistant director's "strip board." The strip board is a representation of the scenes that are scheduled for each day of shooting. These strip boards very rarely show the logistics of how the scenes will be shot once shooting commences. On the set as decisions are made to complete the necessary coverage of a scene it is difficult to keep an objective perspective on the shot to shot logistics of a scene. When shooting out of sequence, shots that are from similar camera positions should be grouped together, in order to reduce the time spent resetting the camera, lights and actors. In the SLIPSTREAM's "smart coverage" environment key personnel have instant access to the storyboards, digitized video tap frames and other support material so that a decisions can be made on the set as to the most efficient plan for scene coverage. In the example image a storyboard from the image database and its matching frame grab from the video tap are compared to a storyboard in the sequence that represents a similar camera position. By scanning the storyboards in the "smart coverage" environment the director can see that the shot of the girl, walking by the wall can be shot from on or about the same camera position as the girl walking up the steps. By simply panning over to the wall and changing the focal length of the lens the shot can be covered with minimal set-up time. The storyboards and video tap are displayed on the pallet monitor, or fed to the director's monitor on the set. The "smart coverage" environment can also be used to track elements of spatial continuity as a scene is being shot. In the field many factors determine the framing of a particular shot, and shots are rarely exact matches to their associated storyboards. In the "smart coverage" environment frames from the video tap can be reviewed with the appropriate storyboards in order to dynamically track screen direction, eye line and other visual elements. This method of visualization will dramatically increase efficiency in shooting while decreasing errors of continuity and coverage.

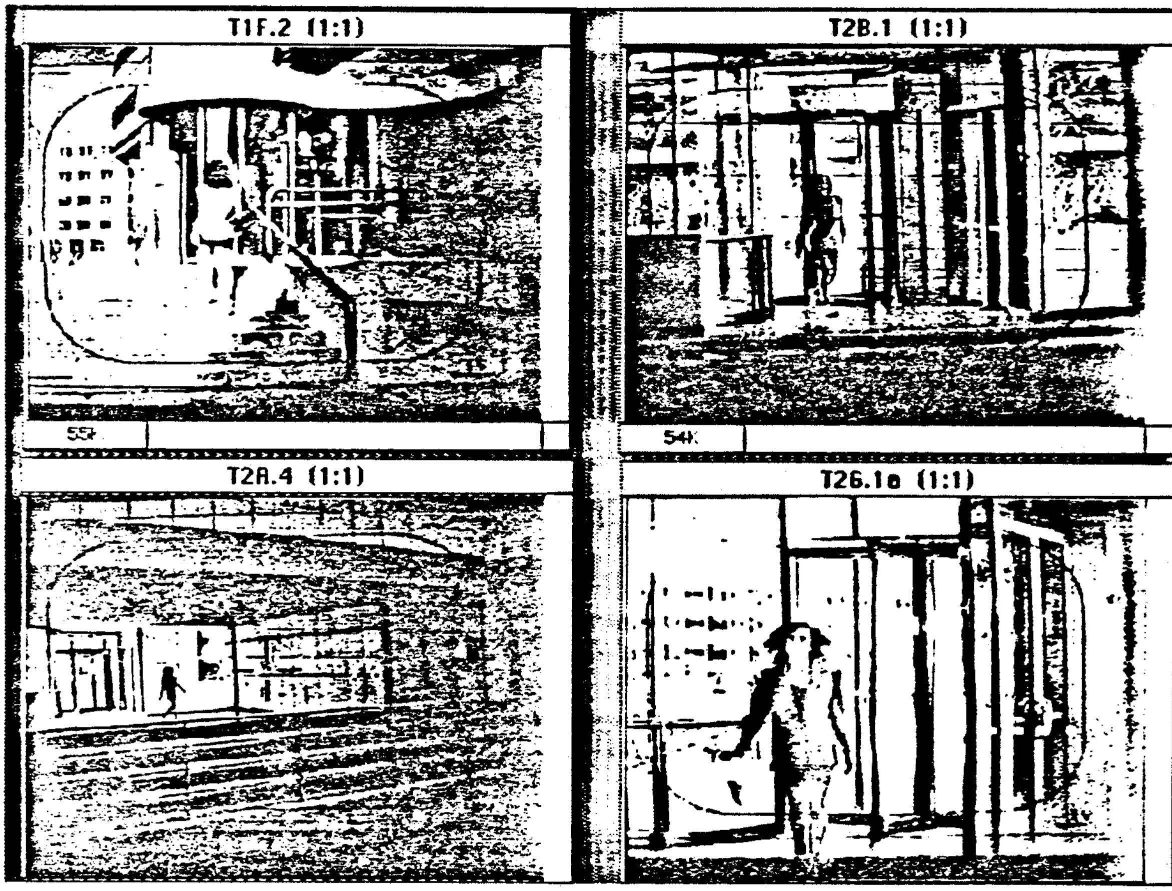
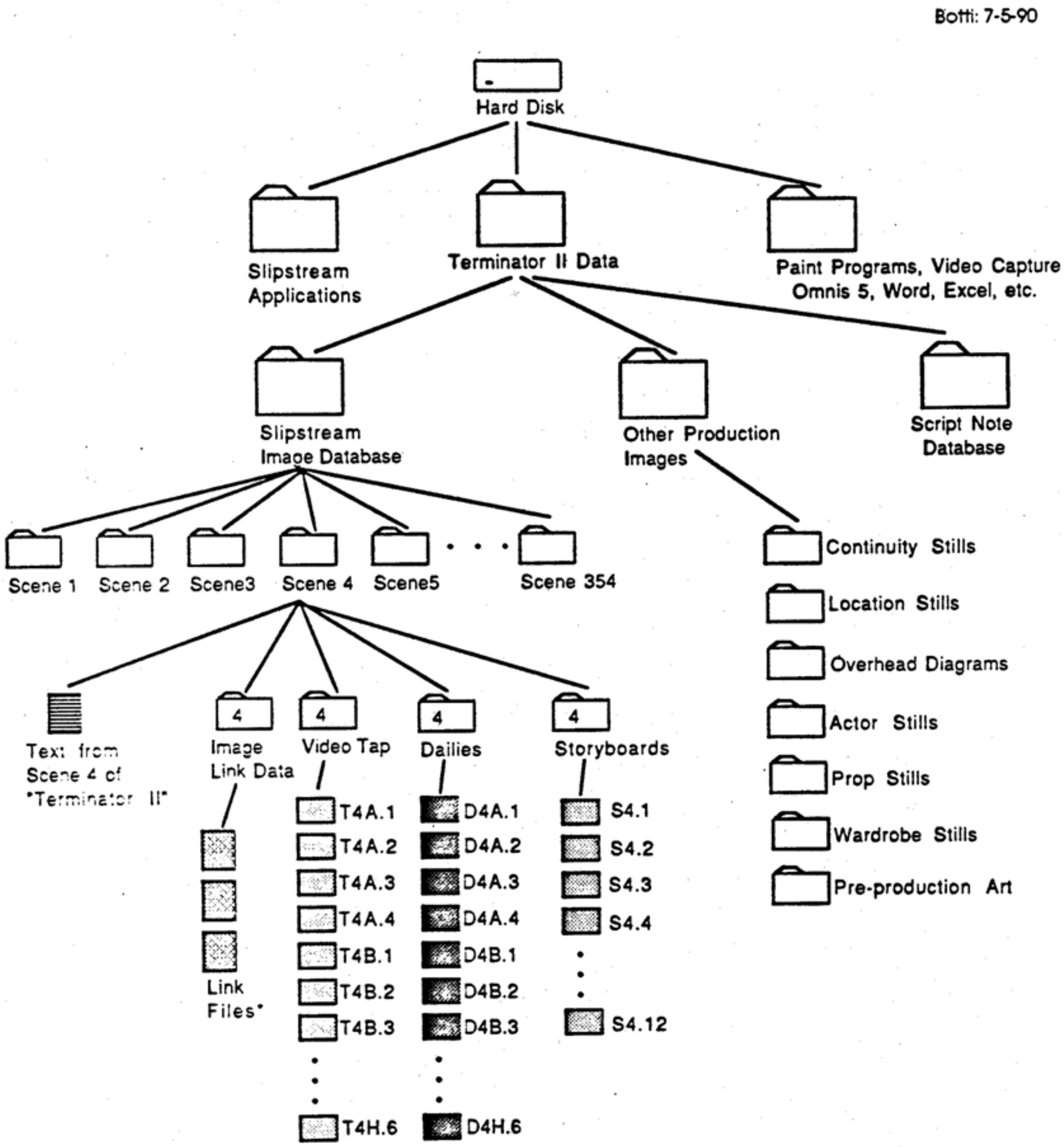


Figure 9: Four frames from the video tap are arranged in comic strip formation in the SLIPSTREAM's "coverage mapping" environment.

As stated before one of the most important design goals of the SLIPSTREAM was to be a tool for the visualization of a film's coverage as it is being shot. The "coverage mapping" environment meets this goal by providing access to digitized frames from the video tap in a reconfigurable layout. By arranging digitized frames from the video tap in sequential groups the director can study the shot to shot progression of a scene, visualizing editing dynamics while still on the set. This form of mapping allows the director to see if any additional shots are needed to insure complete coverage, and to spot any potential editing problems between shots. A visual representation of all the shots in a scene is the most efficient way for a director to review his cutting options. Because this is done on the set in real time a director can choose to shoot more material for a scene while all of the production elements are still in place. Prints of entire sequences can also be sent to the editing room to augment the notes taken by the script supervisor, this gives the editor the advantage of seeing all the coverage shot for a sequence prior to cutting.

On any motion picture the visual database of the SLIPSTREAM used to drive these environments will be very large, and for the system to succeed this data must be organized efficiently. None of the standard database programs for the Mac were sufficient for the SLIPSTREAM task. The most serious limitation of these programs is their inability to handle 24-bit image files. No database available for the Macintosh can store a 24-bit file as field for immediate access; only records relating to the image can be stored in these systems. This limitation renders these databases useless for our purposes as the time spent in actually retrieving an image file from these databases would be intolerable by production standards. We decided to organize the SLIPSTREAM's hard disk to match the method used to track information on a motion picture. The video tap frames, storyboards, continuity stills and other information are stored in folders dedicated to each scene of a motion picture. While this does not offer an easy way to sort or do multiple queries. it does facilitate quick access on a scene to scene basis which is the most common form of query. On the next page the hard disk layout of the SLIPSTREAM image database is graphically represented.

The "smart continuity," "smart continuity," and "coverage mapping" environments all serve to track and organize the large amount of visual data generated on a motion picture production. During the course of our research it was clear that we were going to have to test the SLIPSTREAM system in a "live fire" situation to prove that it was a viable system for on set production. In the next section we will look at the actual test of the SLIPSTREAM on a motion picture shoot.



*Link Files for each scene hold dynamic data links to the script and other production imagery. For Special Effects Shots, each composite element is linked to the shot as the individual effects are completed.

Hard Disk Layout

Figure 10

6.3: THE HIGHTOP SHOOT

In April of 1990 we decided to test many of the concepts of the SLIPSTREAM system in a real on-set environment. Obviously we had neither the time nor money for an actual feature film production so the commercial format was chosen as the production situation for the SLIPSTREAM. My affinity for high top sneakers led to the creation of a script for a commercial marketing a new style of high top. After the scripting process was complete we had a full set of storyboards drawn which were immediately scanned and stored in the SLIPSTREAM's visual database. Location photographs of our chosen shooting site (the Media Lab), were taken with the still video camera and also digitized for storage.

The SLIPSTREAM system required testing under conditions which closely matched those of a real motion picture. A 35mm motion picture camera with a high quality video tap was essential to the success of the HIGHTOP experiment. Armed with our storyboards, script, location photographs and support material about the SLIPSTREAM John Botti and I went to Boston Camera Rental Company to see if they would be interested in supporting our project. Brian J. Malcolm, the manager of Boston Camera, spoke to us in detail about the project and agreed to supply the photographic equipment for the shoot at a substantially reduced cost. When it came time to shoot Boston Camera provided us with an Arriflex 35BL IV camera, a video tap and all the necessary accessories.

Before shooting began we had to build a prototype SLIPSTREAM system that would be portable enough to allow for location filming. At the time of the HIGHTOP shoot we had not yet procured the NuVista card or the RasterOps 364, so we decided to utilize the Color Space fx/IIci configuration for our on set digitization and display. The Macintosh used for the Elastic Charles was borrowed on the day of the HIGHTOP shoot and put on a standard mobile audio-visual cart. The two monitor configuration of the Color Space system was similar to what I had envisioned for the SLIPSTREAM workspace and pallet environments. A standard VHS videotape recorder was put onto the cart in order to record takes from the video assist. The still video recorder/player and the still video printer were the final elements added to the SLIPSTREAM prototype for the HIGHTOP shoot. All of these devices were connected by a simple switcher in order to pass data along to the digitizers, monitors or other environments.

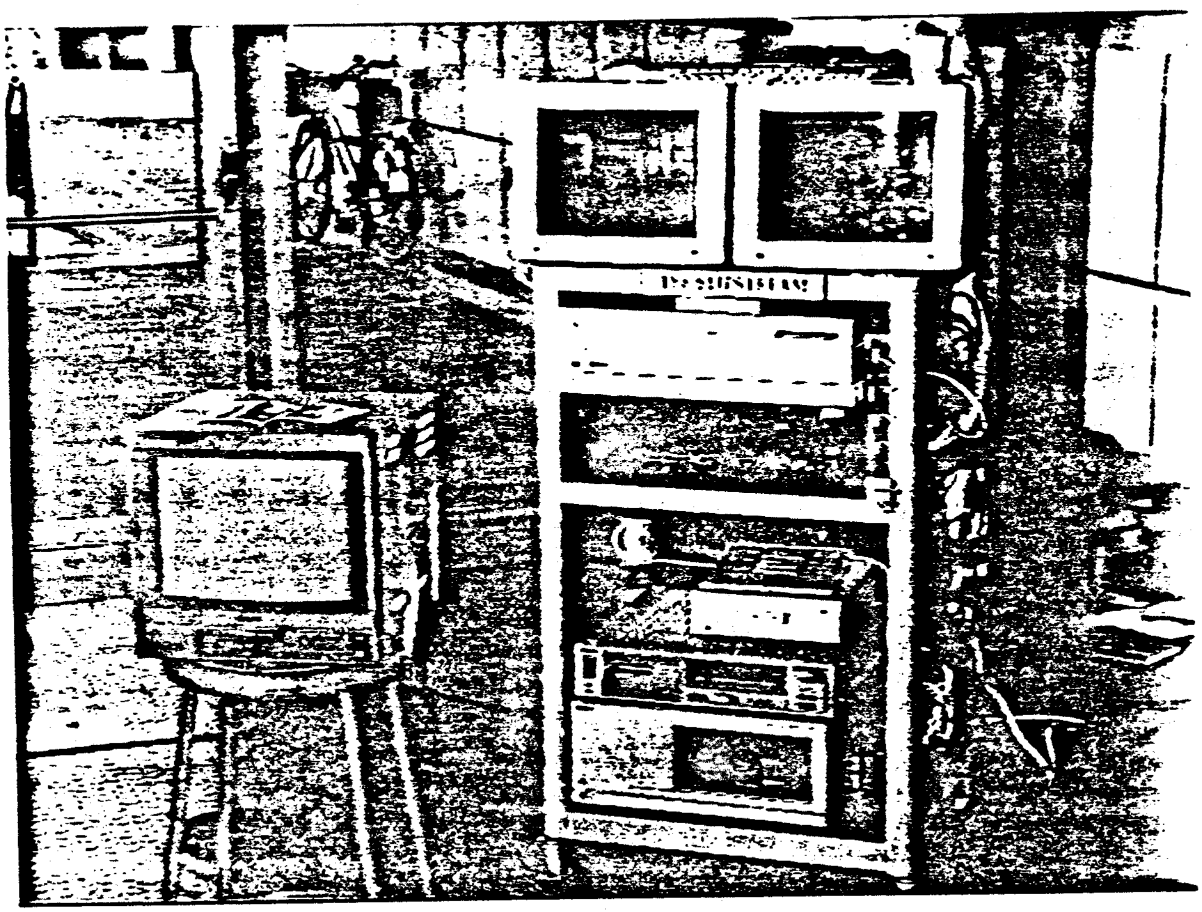


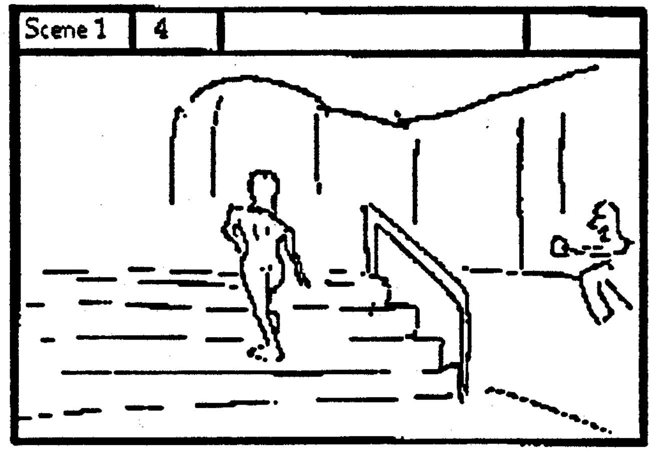
Figure 11: The prototype SLIPSTREAM system used on the HIGHTOP shoot.

When the day of shooting arrived we assembled a crew from the various departments of the Media Laboratory. The crew, most with no on-set experience, performed admirably under the stressful conditions of a real production. The SLIPSTREAM worked much better than we had expected and it proved to be a real asset to the production. Our shooting schedule required that we finish the entire commercial in one day, a task many believed was impossible. We not only finished all of the shots on our list. but actually covered several more that were invented on the set. Miraculously we were able to shoot 40 set-ups in one full day of work, a task almost unheard of in normal production.

Figure 12: The HIGHTOP shoot (clockwise from top) : the crew at work in the lobby of the Media Lab; the Arriflex BL-IV; SLIPSTREAM operator Joel Wachman with the prototype SLIPSTREAM; Director John Botti checking a take outside the Media Lab with the SLIPSTREAM system.

The SLIPSTREAM was operated by Joel Wachman (MSVS 1990) from the electronic publishing group, and he should be commended for his professionalism and dedication to the task. On the set the SLIPSTREAM not only accomplished its data gathering functions but also helped to track the visual continuity and coverage of HIGHTOP as it was shot. The ability to instantly access key frames from the video tap was especially helpful to the shooting of HIGHTOP. In one sequence. an actor runs up to an elevator just as its doors are closing and touches off with his arm before stepping back to review his options. When we shot the original angle, we failed to note which arm he used to touch the elevator door, so when we came around to shoot the reverse angle of the same action we were faced with a continuity matching situation. Joel had grabbed a key frame from the video tap at just the right moment and when he called up the frame from memory we could instantly see the position of the actor's arm. The SLIPSTREAM was able to provide many on set solutions like this during the HIGHTOP shoot and the experiment was deemed a great success.

On the next several pages are the storyboards and some of the frame grabs from the video assist of the HIGHTOP shoot.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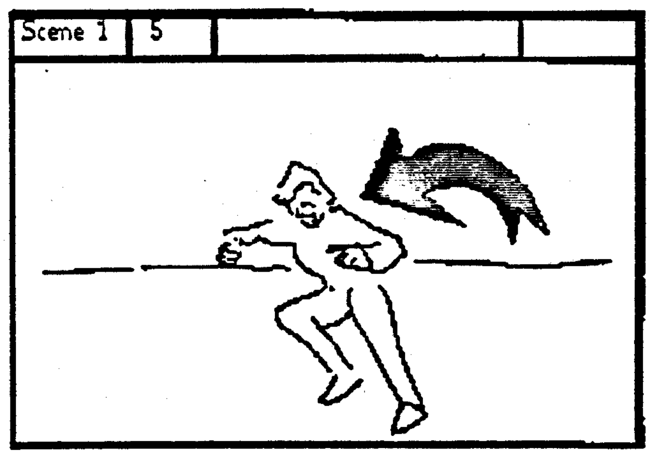
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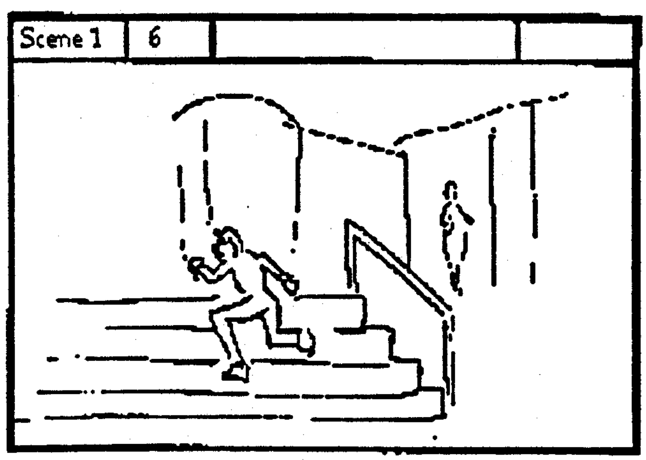
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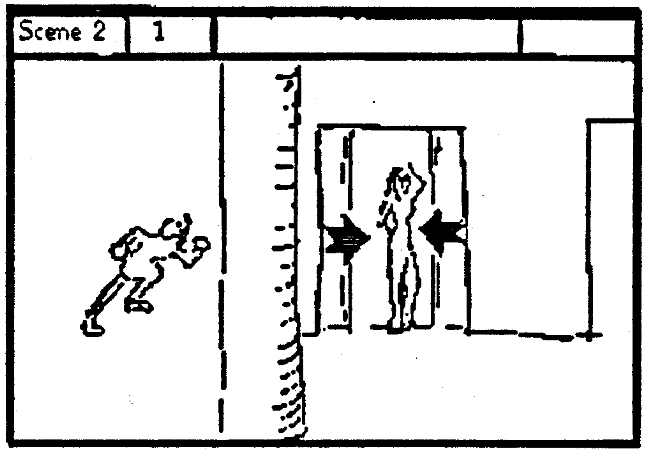
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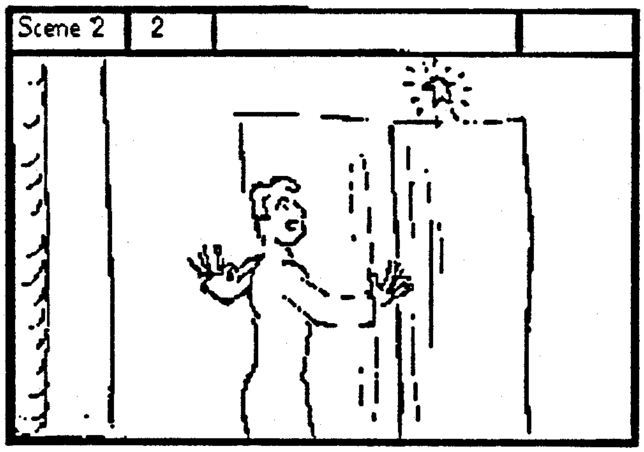
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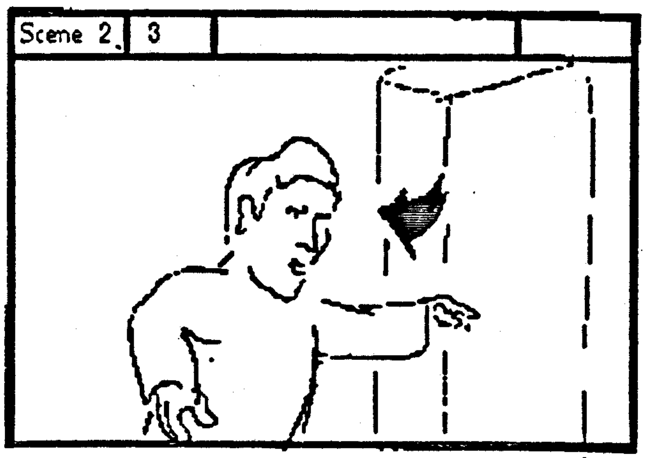
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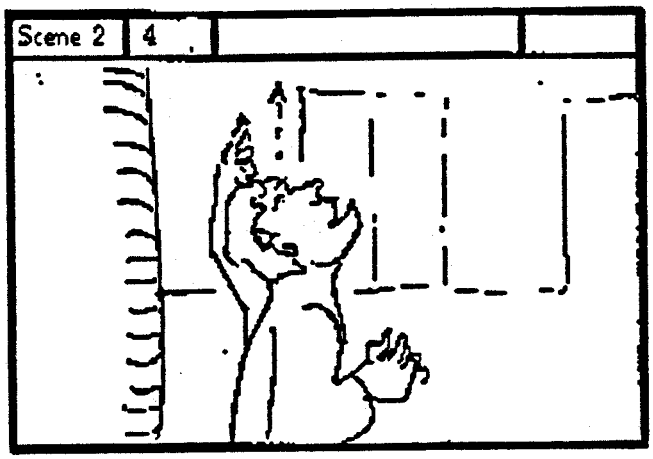
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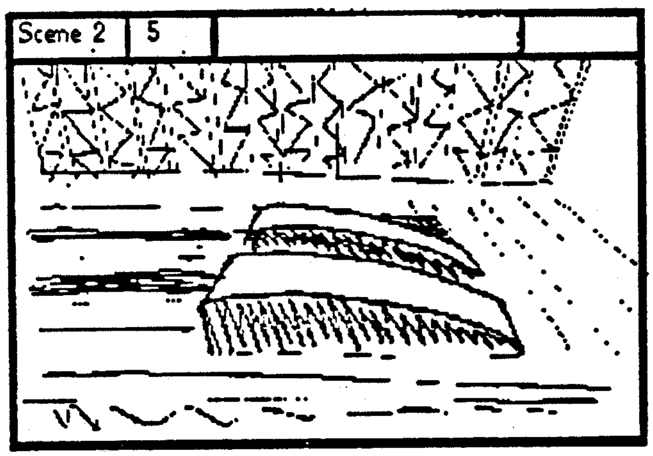
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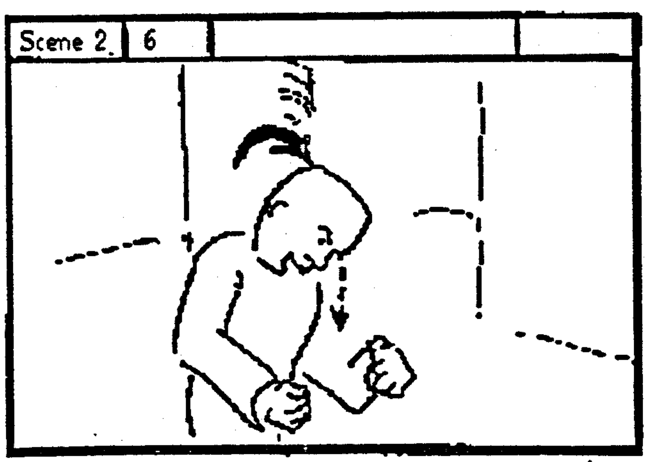
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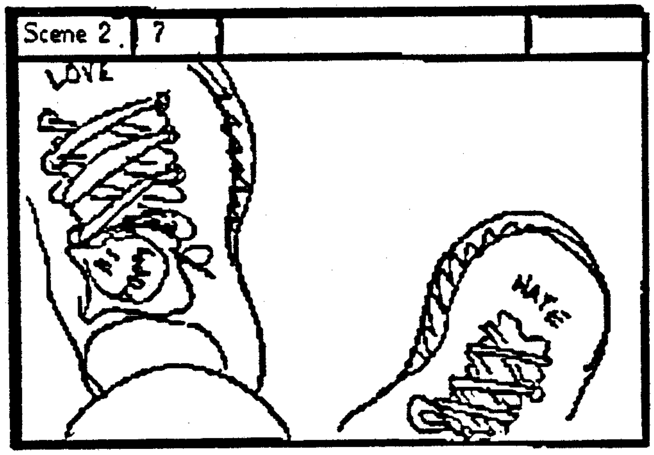
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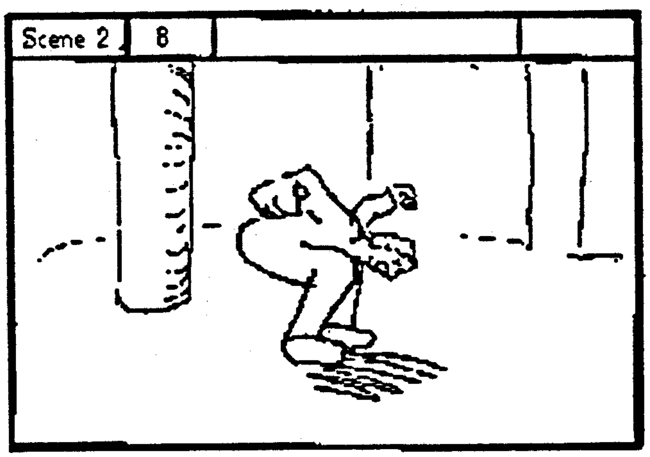
LOVE
HATE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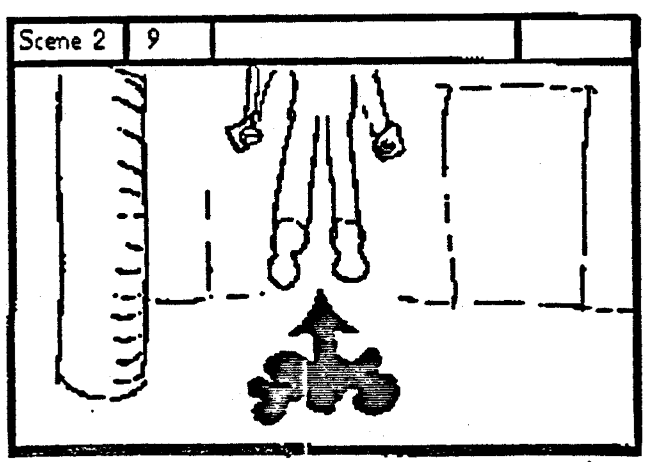
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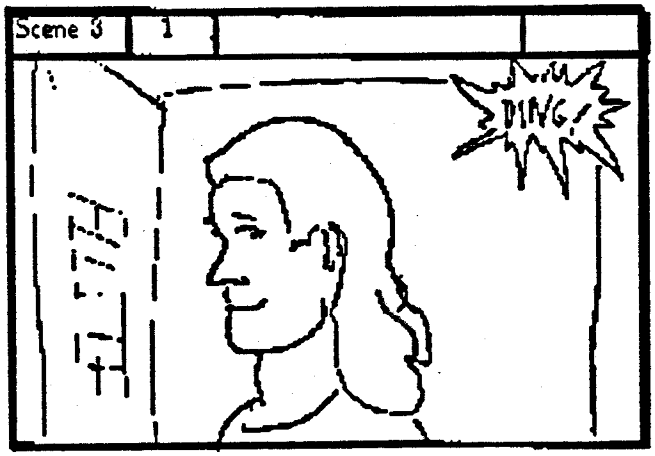
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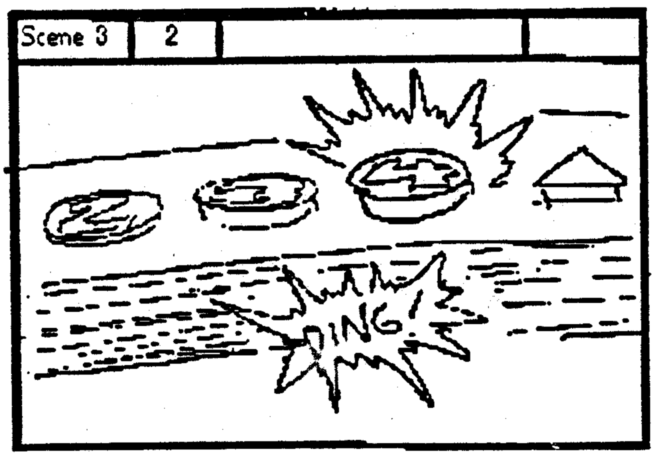
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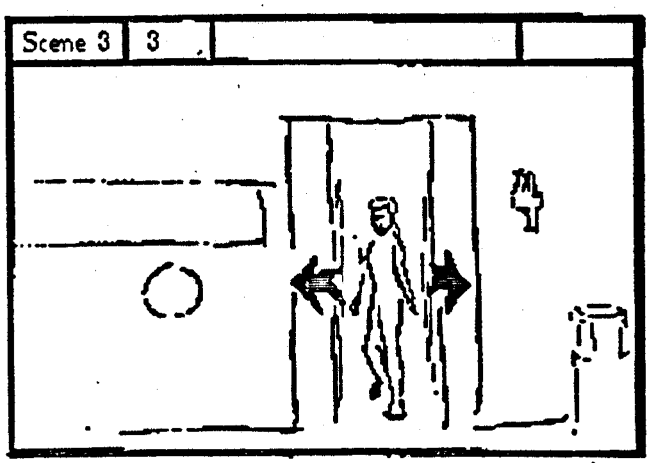
DING!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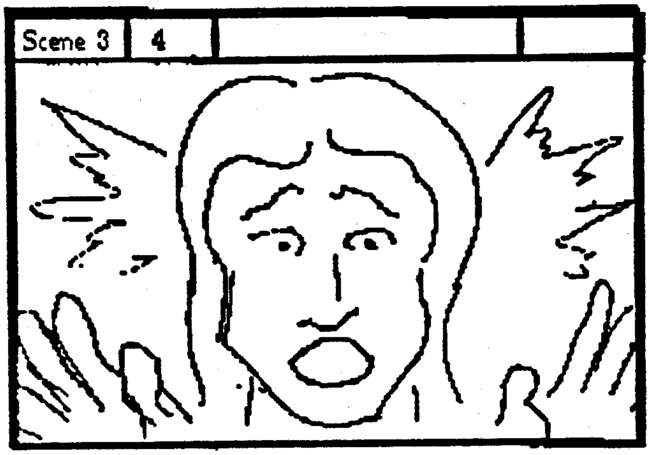
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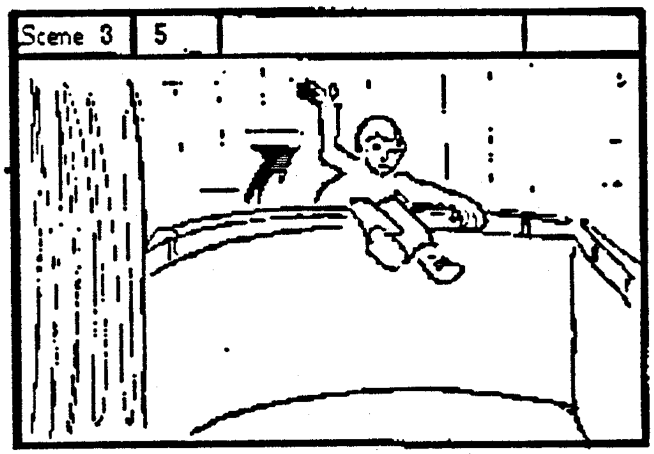
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Scene 3
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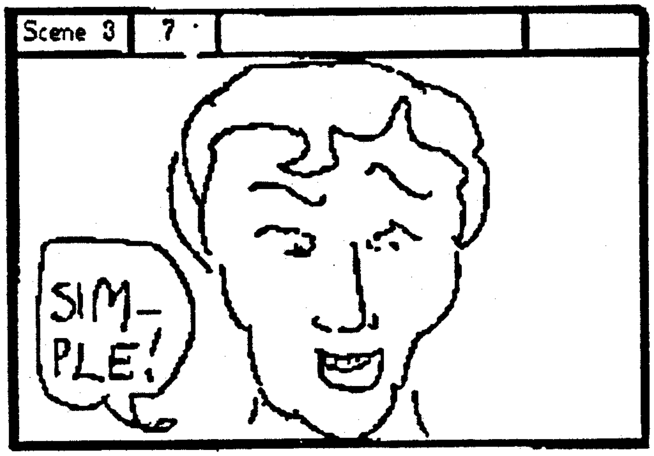
HOW DID YOU DO THAT?!


Scene 3
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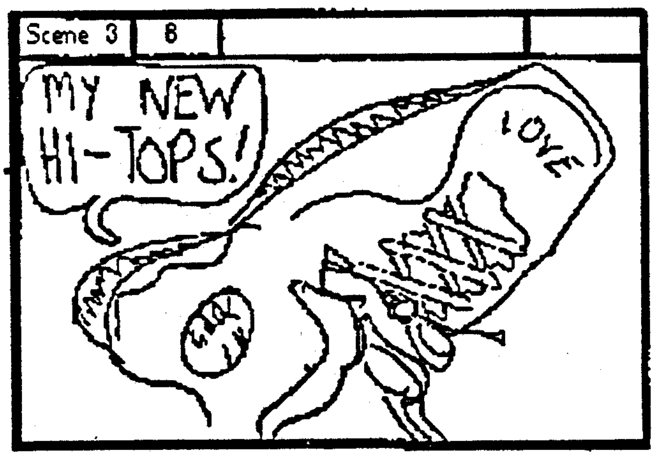
SIM-
PLE!


Scene 3
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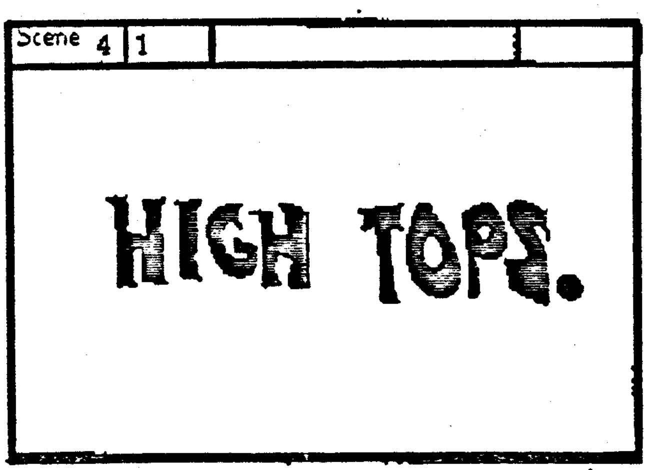
MY NEW
HI-TOPS!
LOVE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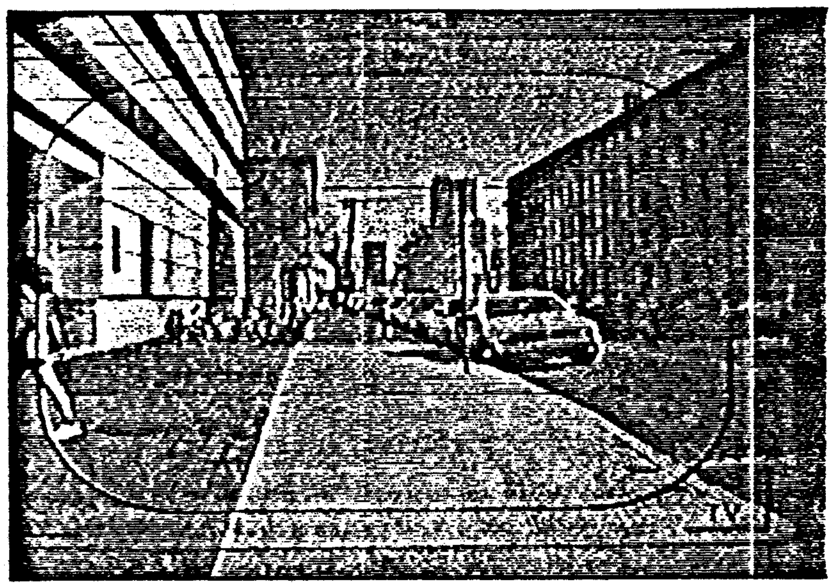
HIGH TOPS.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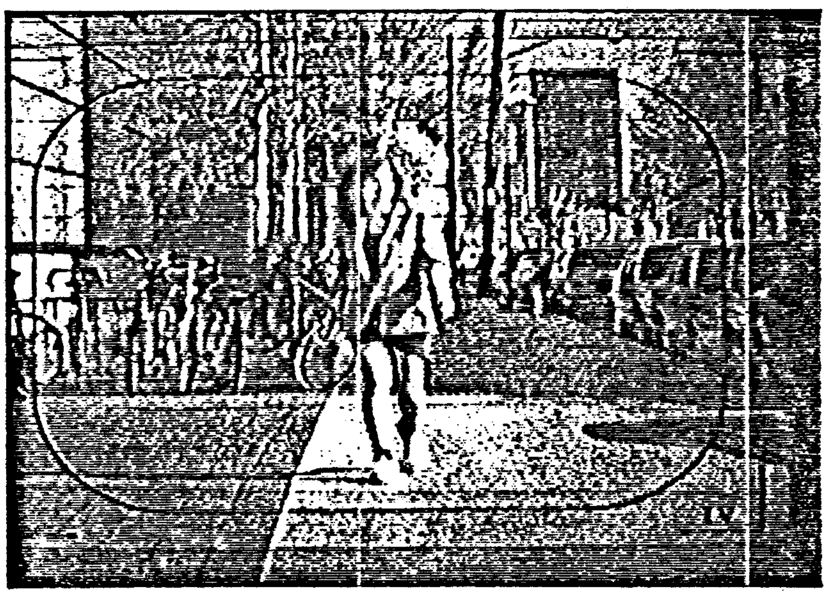
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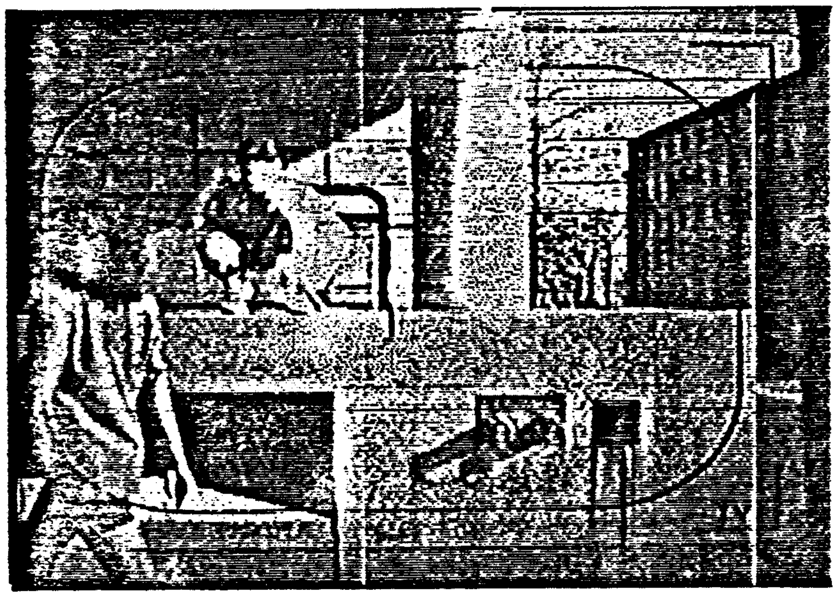

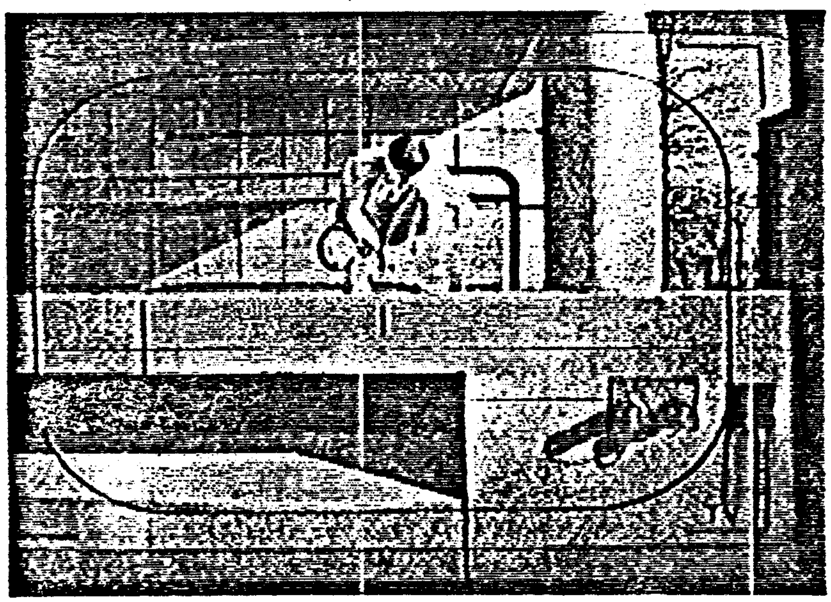

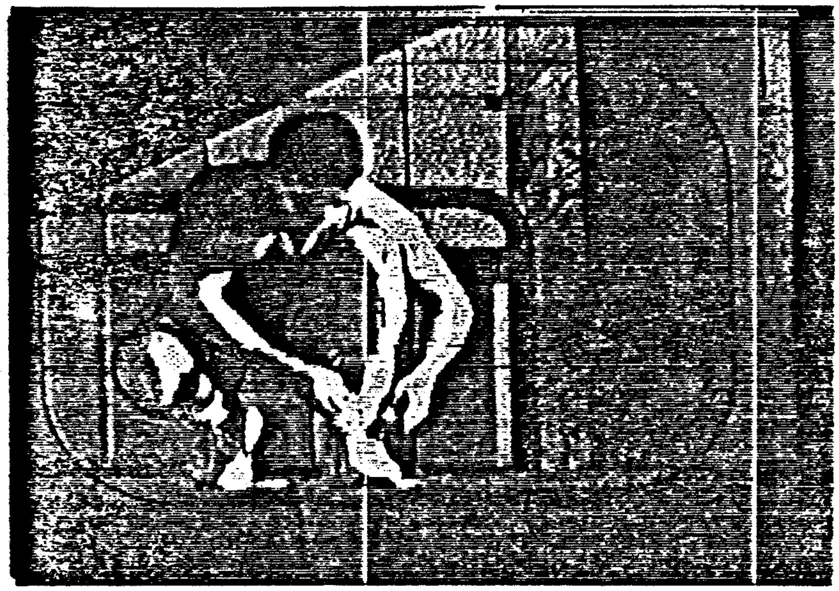

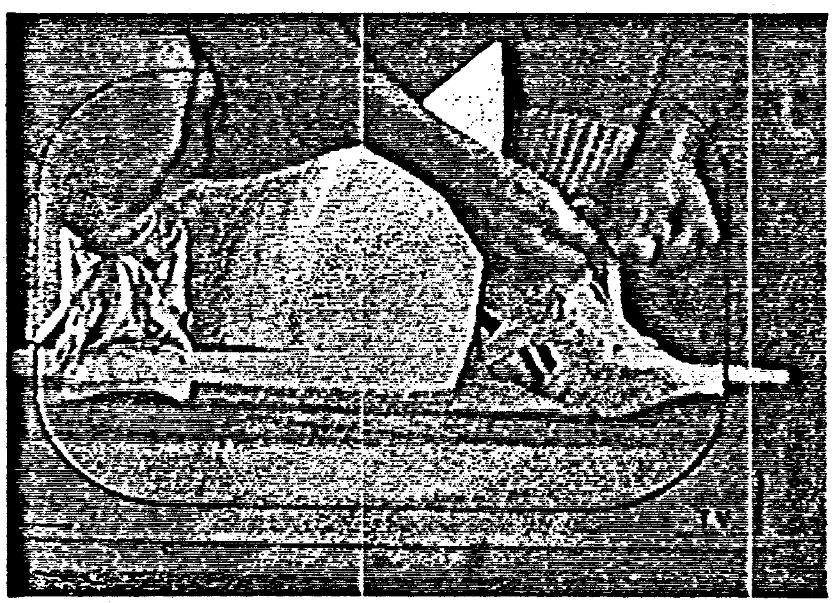

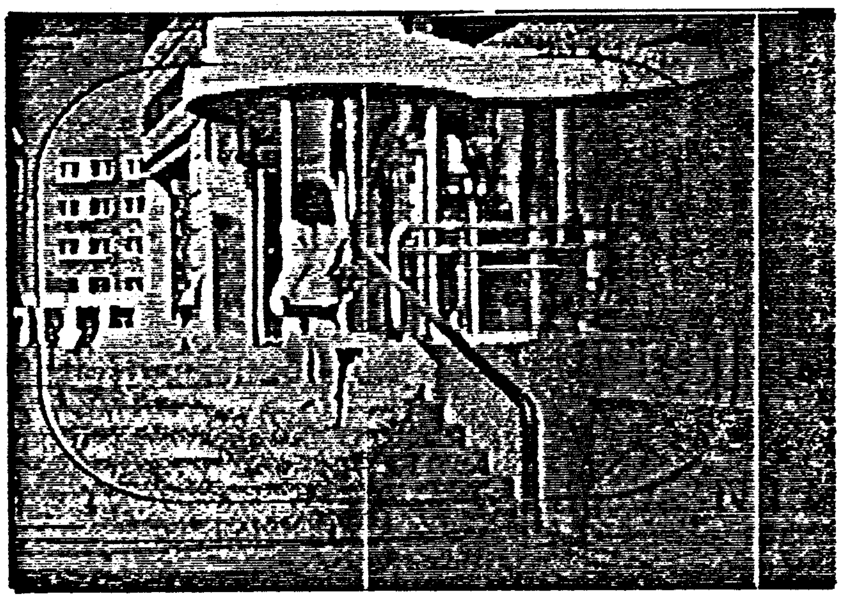

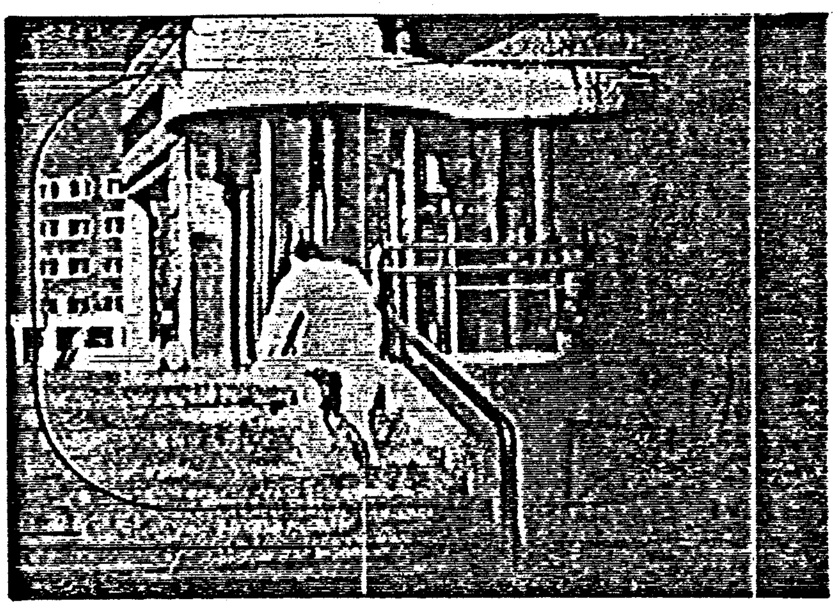

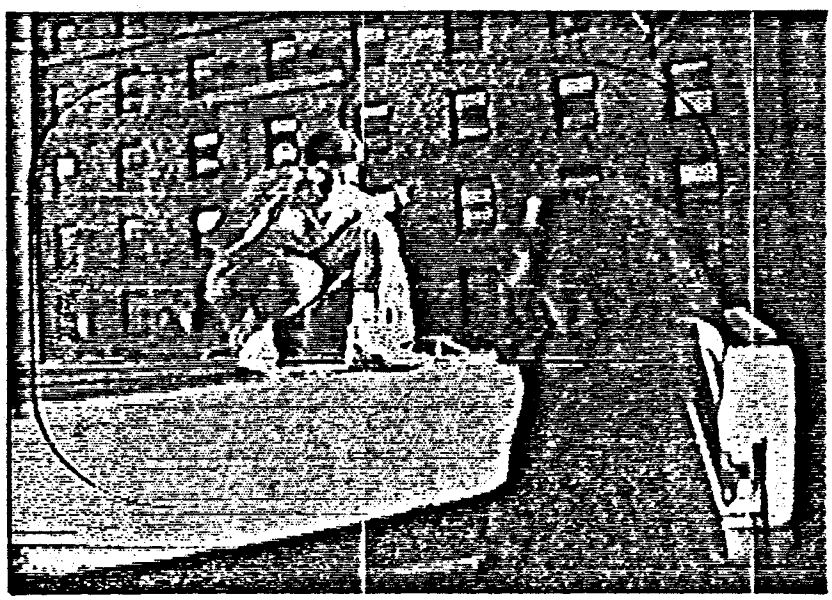

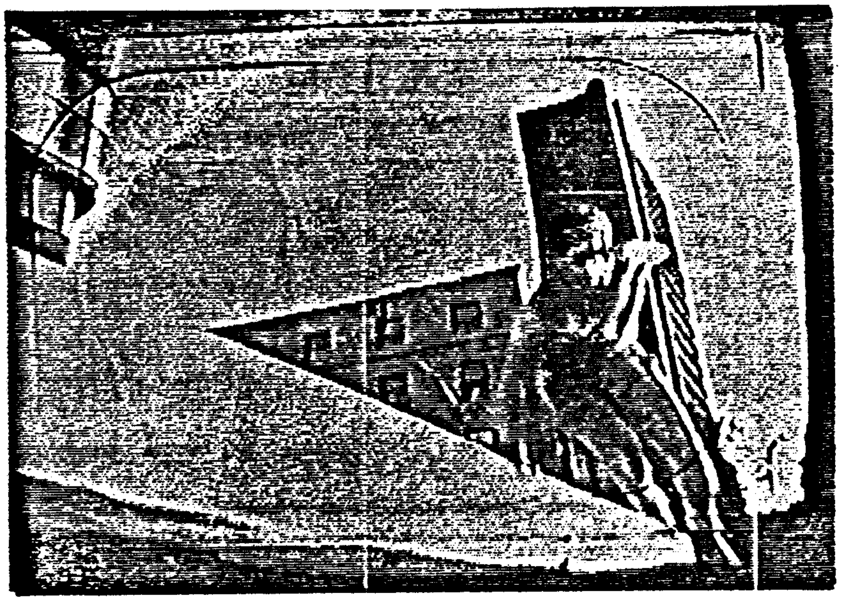

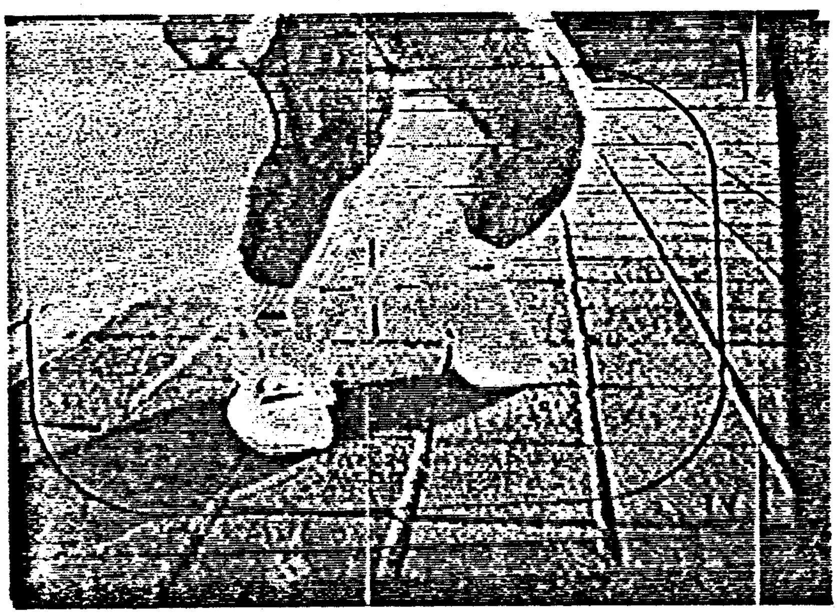

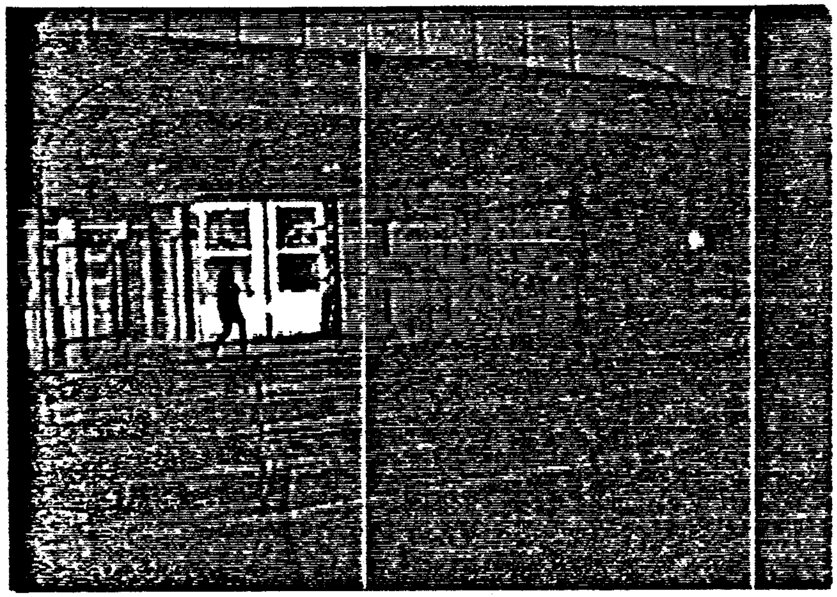

7.0: CONCLUSION AND FUTURE DIRECTIONS

"Build a better mousetrap and the world will beat a path to your door"

-- Unknown

Inventions in cinema technology have almost always been developed by someone working in the field who is frustrated with the status quo. Examples of technological advances created in this fashion abound: crystal sync, video assist, reflex viewfinder systems, and upgrades in film stock. As a film maker, movie lover, and professional motion picture technician I became disillusioned with the amount of mismanagement present in modern feature production. Making a film is a large organizational task, but as Joel and Ethan Coen (directors of RAISING ARIZONA, BLOOD SIMPLE, and MILLER'S CROSSING) once said: "Each individual element taken separately is not overwhelming." The time and money wasted due to lack of planning and organization in the film industry was one factor that led me to take a sabbatical from production. When I came to the Media Lab I was sure that I could find a "better way," and the creation of the SLIPSTREAM was born out of this obsession.

From our research we can draw several conclusions about the SLIPSTREAM and other electronic production systems. It is clear that the SLIPSTREAM or systems like it are going to be necessary tools for the production of motion pictures in the near future. Simple economics demands it! If film production is to survive as a medium in the next century , it must change to meet the challenges of the electronic age. Although it is a high technology heralding the future of production, the SLIPSTREAM was successful in part due to a grafting with the roots of cinema. These roots are reflected in the powerful role model used to guide the development of the system: the continuity supervisor. The continuity supervisor has always been the crew member who understood the most about production logistics; the methodology of script supervision has served the industry for almost a century. Utilizing the continuity supervisor as a guide for designing the SLIPSTREAM system offered us a viable methodology for translating our ideas into a working system. We can also see that the visual continuity system of the SLIPSTREAM; with its "smart continuity," "coverage mapping," and "smart coverage" environments, will move the grammar of film making as it has been discussed for the last 50 years into the electronic arena. The potential of technology to enhance creative endeavor is limitless, and to those few who strive to create real tools for the makers I can give one piece of firm advice: "If you don't know the past; you can't.see the future."

Looking beyond the SLIPSTREAM research, the experience of the Media Lab as a whole has provided many lessons. At its best the Media Lab is a place where people of different disciplines and expertise can come together with the common goal of creating something new from the synthesis of their experience. Although this ideal is not always easily lived up to at the Lab, the exposure to so vast an array of ideas and technologies can be truly inspirational. If you have a clear idea of yourself and your goals, there is no more exciting place to pursue your education. Positioned at the cutting edge of technology the Lab's reputation can help gain access to the appropriate available technologies and ideas necessary to the pursuit off any defined research endeavor. I learned a great deal about the corporate world of high technology, and about communication in general, by "jumping in" and making my intentions known. I would recommend that any graduate student do the same.

The future of the SLIPSTREAM itself looks bright, as we have now already had several meetings about putting the technology on a professional film. The future of the SLIPSTREAM research could go any number of ways. Without a doubt at some point in the future users of digital video systems will want to trace images from the SLIPSTREAM back to the original data. This will require a transparent data base, research that would insure the SLIPSTREAM's functionality in multi-media environments. When film production finally does accept computer technology as a tool for enhancing efficiency a networked system would be the most important goal. All the departments on a motion picture could be passing data into a central hub, creating an efficient tool for the management of a production. If all departments were linked the possibility for errors would be greatly decreased and the information sharing would greatly expand the capabilities of film crew. Editors have always complained about the data that is passed to post production from the set, and more research in needed to find the best method fro passing the data generated by the SLIPSTREAM through to editorial. Finally, the SLIPSTREAM itself will be enhanced and upgraded by its use in the field. The technology will evolve based on what it will be asked to accomplish on a real production, so it is now time to start the second phase in the development of the SLIPSTREAM.

BIBLIOGRAPHY

Behlmer, Rudy, ed. *Memo from David 0. Selznick.* New York: Viking Press, 1972.

Benton, Mike. *The Comic Book in America: An Illustrated History.* Dallas: Taylor Publishing Company, 1989.

Bordwell, David, and Kristin Thompson. *Film Art: An Introduction.* Reading, Massachusetts: Addison-Wesley Publishing Company, 1980.

Campbell, Russel, ed. *Photographic Theory for the Motion Picture Cameraman.* London: Tantivy Press, 1974.

Cook, David A. *A History of Narrative Film.* New York: W.W. Norton and Company, Inc., 1981.

Cudlitz, Stuart. "Star Quality." *MACWORLD,* June 1989, pp. 117-123.

Dager, Nick. "The Nonlinear Revolution Has Begun." *Film & Video,* July 1990, pp. 33-44.

Eisner, Will. *Comics and Sequential Art.* Tamarac, Florida: Poorhouse Press, 1986.

Electronic Images Conference: Final Report. *Proc. of a conference sponsored by Zoetrope Studios.* 20-22 June 1980. San Francisco, 1980.

Fielding, Raymond. *The Technique of Special Effects Cinematography.* London: Focal Press, 1987.

Gibson, William. *Neuromancer.* West Bloomfield, MI: Phantasia Press, 1986.

Goodwin, Michael, and Naomi Wise. *On the Edge: The Life and Times of Francis Coppola.* New York: William Morrow and Company, Inc., 1989.

Koszarski, Richard. "The Youth of F.F. Coppola. *Films in Review,* November 1968, pp. 529-536.

Miller, Pat P. *Script Supervising and Film Continuity.* Boston: Focal Press, 1986.

Murray, Will. "In the Catacombs of Mars. R. *Starlog,* August 1990, pp. 45-48.

Ulmer, Shirley, and C.R. Sevilla. *The Role of Script Supervision in Film and Television.* New York: Hastings House, 1986.

Wyver, John. *The Moving Image: An International History of Film, Television, and Video.* New York: Basil Blackwell, Inc., 1989.