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INTEGRATING COMPUTER GENERATED ANIMATION AND VIDEOGRAPHY

Using a computer animation and paint box system, the intention of this thesis is to combine digitized video input and computer generated imagery for the production of a performance animation.

The material contained within this thesis reflects exercises illustrated on the accessible equipment in The Rochester Institute of Technology's Computer Graphics Design and Videographics Departments' 1986-1987 academic year's installation.

Approvals

Advisor:
Robert Keough ______________________ 7-14-92
Date

Associate Advisor:
James Ver Hague ______________________ 7.24.92
Date

Associate Advisor:
Charles Werberig ______________________ 8/14/92
Date

Special Assistant to the Dean for
Graduate Affairs: Phillip Bonarth ______________________ 8/24/92
Date

Dean, College of Imaging
Arts and Sciences:
Dr. Margaret Lucas ______________________ 8.24.92
Date

I, ______________________, Annemarie Incorvia (a.k.a. Annemarie Incorvia Roeder), prefer to be contacted each time a request for production is made. I can be reached at the following address.

28070 Andorra Drive
North Olmsted, Ohio 44070
(216) 777-0490

Date: ______________________

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Introduction

"In the first place, art is always independent of the medium through which it is practiced. The domain in which something is to be deemed art has nothing to do with how it was produced."[1]

"Art is a process of exploration and inquiry. Its subject is human potential for aesthetic perception. It asks: How can we {be} different? What is other?"[2]

Eventually, most media will be digitized, synthesized or integrated as a movement in the progression of a collaborative media. As alternative sources and combinations of media are explored and defined, new and evocative media will emerge. As conventionality relaxes, these manifestations will develop, out of insight and experimentation. In turn, these developments, will create fresh options and new precedents.

In the past, art and technology (sciences) have been mutually exclusive. It is no longer true. Today, technology makes it possible to create and combine text, imagery, and graphics without the use of conventional methodology. Electronic compositioning offers flexible approaches to image manipulation. Often, the speed, dynamics, and special effects offered the artist by the computer are otherwise unattainable in traditional practices. "This is not to say there is no room for traditional skills. Instead, computer graphics will increasingly automate the mechanics of graphic design, further enhancing the need for good designers."[3] When viewed as an alternative approach to effective imaging, computer graphics technology will truly be a designer's tool.

"One of the most interesting and far-reaching offshoots of all electronic information processing is the distinctions between film, video and print media are becoming less and less important. Designers who once specialized in one or two aspects of the graphic arts find their talents are more universally useful."[4]

As evolutionary design methods are fostered by technical advancements, general applications increase. Increasing applications, in turn, generate an expanding interest in experimental exploration. This process, in effect, is self-perpetuating and generates continuous possibilities.

Interests in the development and expansion of communication technologies brought me to Graduate Computer Graphic Design at Rochester Institute of Technology (RIT). These interests, in addition to the technology exposed to me at RIT, brought me to pursue a thesis which was both technical and exploratory. As a body of work, this thesis evolved into a series of explorative applications in technology and creativity.

Stage I: Thesis Proposal

Initially, the first discussions with my thesis committee generated a list of potential guidelines for the shaping of the thesis. Primarily, issues were raised concerning the need to explore the mechanical limitations of combining computer animation and videography, using available equipment. Secondly, it was recommended that I focus my intentions early and set my objectives in relation to computer time restraints as well as the academic year's end (1986-1987).

The committee speculated that my concept "to incorporate videographic and computer generated imagery to facilitate rotoscoping effects in the design of an animated background for a performance art piece," while ambitious, was overly inclusive and probably beyond my current capabilities. In examination, the objectives of my statement were isolated for simplification. This "concept simplification," in turn, identified three areas in need of closer review.

A. The Performance Art Piece

"Theatrical: a theatrical event is one which represents an action through the medium of performers on a stage for an audience."[5] However oversimplified, a performance piece involves the presentation of one act, or narrative, by one actor on a stage, constructed or improvised, for another.

The production of a performance art piece requires resources and educated expertise. Uneducated in theatrical mandates, there were several important issues I needed to consider.

1. Theatrical Advisory Staff

The complex mechanics involved in successfully producing a cohesive performance art piece required skills which I did not possess. Assembling these resources or acquiring these skills would result in the diversion of my limited thesis hours from computer graphics exploration toward the academics of theater arts.

2. Facilities

The production of a live performance coupled with a computer animated background required a large screen video projection system and a physical setting. I had neither access to a theatrical stage nor large screen video production facilities.

3. Performers

With the computer animation serving as a background, my initial intention was to incorporate live, contemporary dance in the foreground of the performance art piece. To facilitate this, Thesis Chairman, Robert Keough, and I attempted to persuade The Bucket Dance Theater of Rochester, New York to act as participants. However, Garth Fagan, Choreographer of The Bucket Dance Theater, declined the invitation.

As an alternative, a resource limited decision was made to seek a prerecorded performance piece for computer graphic applications. In this manner, academic emphasis would remain on computer graphics techniques without reducing the initial intent. Presentation, instead, would be limited to a color monitor rather than a theatrical stage. Therefore, the visual product would shift from a live performance art piece to a prerecorded production, (i.e. eradicating the 3-dimensional theater-in-the-round and producing a 2-dimensional video presentation).

Since the equipment under consideration, the Genigraphics and the Artronics, were capable of outputing

visual information directly onto a 3/4" video tape recording, my thesis presentation would be designed to conform to this format.

B. Rotoscoping

In 1918 Max Fleischer devised a method of filming live actors to produce a reference guide for animators. This system, known as rotoscoping, yielded gestures and mannerisms which could never be invented.[6]

Rotoscoping originates as a technique to combine live-action and animated images. By feeding light to the film through a ninety degree rotoscope prism, the process involves projecting a piece of live-action film, frame by frame, onto a surface. By tracing the projections, a new series of drawings can be created and eventually inserted into the original live-action footage. From this plot, artwork and moves can be planned together. Maintaining perfect registration, the drawings are then transferred to animation cels, so that both the animation and live-action can be combined on a single strip of film.[7]

Traditionally, a synthesis of the cel drawings and the live-action film is created with an animation stand. This is achieved by rephotographing each frame of the live-action film rear-projected at the compound surface along with the corresponding cel from the animation sequence. An alternative technique is to photograph the animation sequence alone and then combine it with the live-action footage in a process involving mattes and double-printing techniques with an optical printer.[8]

However, I intended to simulate the traditional effect with an unconventional approach. Instead of using film and live-action as a base, I decided to use video and computer generated imagery as the primary sources. In addition, the synthesis of the material would be achieved with a video special effects generator in an editing suite (see Appendix A:B).

1. Genigraphics

My original application involved the rotoscoping of several minutes of video footage. I intended to introduce sequentially spaced video keyframes into the Genigraphics system. Using the Genigraphics Paint Program's "Grab" function and a video camera, each keyframe would be input individually.

As an extension of the console operating system, keyframes are incorporated in the Genigraphics animation software package. The artist creates the keyframe artwork and indicates command entries in an animation table to reflect desired changes to the artwork. The computer calculates the changes between the first keyframe and the next keyframe in order to automatically generate all the intermediate frames.[9]

The Grab Function is a capturing technique incorporated into the Paint Program of the Genigraphics Video Upgrade Package. Frame grabbing an image inputs it into the computer system where it can be enhanced or modified. This function requires 1/30 second and is also known as a "flash scan." The image can be black and white or color. It can be a photograph, a transparency, a three-dimensional object, or, for special effects, a moving image. Once in the system, a frame grabbed image can be moved, bordered, painted, or combined with other real or synthetic images.[10]

The Genigraphics 1986 Video Upgrade Package enables the console operator to generate sophisticated, high quality images which combine object-based images with pixel-based images. Vector imagery, or object-based imagery, use basic geometric shapes, or equations, to define the individual components of an image. Pixel imagery, on the other hand, is constructed from "picture elements". Pixels, are the smallest display unit to which color or texture, can be assigned by a computer system.[11]

a. Vector Animation

In order to understand the following modifications, the reader should be aware that the Genigraphics animation package operates on vector principles.[12] However, any "grabbed" imagery introduced through the 1986 Video

Upgrade Paint Program would exist as pixelized representations. For this reason, any grabbed imagery could not be animated while it existed in pixelized form.

However, with the Genigraphics 1986 Video Upgrade Software, a grabbed, pixel image could be traced as a series of points to create a vector based representation for animation. In order to take advantage of the Genigraphics interpolation feature, each object targeted for manipulation must have the same number of vector points from one keyframe to the next, and each vector point must be positioned precisely (in relation to each other) from one keyframe to the next. In any other presentation, it is unlikely the animation sequence would be anatomically correct.

I assumed, by designating the sequentially spaced keyframes as start or end points, the Genigraphics would automatically generate the "in-between" frames accurately. In actuality, the rhythmic deviations of the Genigraphics interpolation function were strictly mathematical (Illus. 1). I was animating life forms. This logically tempered progression was unlike the complex fluid motion of a live performer. The rigid applications of the interpolation function were unsuitably rigid for my animation.

b. Frames

Since the complex motion could not be duplicated through interpolation, the rotoscoping process would have to be generated traditionally as single frame constructions. At this point, it is important to understand the number of frames involved in simply tracing one minute of live-action video tape.

The central principle of video equipment is that an optical image must be converted into an electrical signal which can be transmitted and then reconverted into an optical image for viewing. When the signal is received, it can be reassembled on a screen as a visible image. All visible images may be thought of as variations of light and shade. In order to be converted into electrical signals, images must be broken down into a large number of dots, ranging from black through gray to pure white, which are arranged as a series of slightly slanted horizontal lines on screen.[13]

In order to convey the illusion of motion, each of these lined "pictures" must last no more that 1/30 second. In practice, however, even this very brief duration would flicker when viewed. Therefore, each picture of action is scanned twice by a tube generating a series of interlaced lines. When combined, the interlaced lines produce a complete picture (Illus. 2). This is known as "field frequency" and is double the frame frequency.[14]

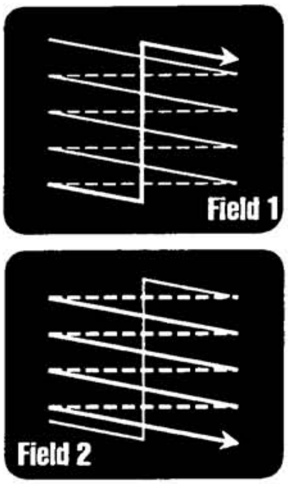
Basically, frames can be measured in terms of time-units. As hours can be measured in terms of minutes and minutes in terms of seconds, in animation, seconds are again broken down into another unit of measure. This unit of measure is the frame. Frames, in turn, can be broken down into fields. As explained, in video there are two fields per frame and 30 frames per second. Therefore, in order to rotoscope one minute of live-action video, a series of 1,800 frames must be generated:

1 minute = 60 seconds x 30 frames per second = 1800 frames.

The process of rotoscoping, frame by frame, is time consuming.

Illus. 1: From keyframe to keyframe, the software compares and calculates the distance between each vector point. Therefore, when generating each "in-between" frame, vector point number one in the start keyframe would transform toward and into vector point number one in the end keyframe.

Start Frame 1 | *In-between Frame 2* | *In-between Frame 3* | *End Frame 4*



Illus. 2: The first scanning process only 'samples' half of the field, in stripes, in preparation for a second pass. It then returns to the top for a second 'field'. The second scanning, or field, takes care of the remaining alternate stripes in the next fraction of a second (1/60). The total frame together, composed of two fields, is now complete, without visible flicker.

Suppose it takes only three minutes to grab, trace, and create each frame for composition. The computer time required to prepare one minute of live-action footage for rotoscoping would equal 90 hours:

1 minute = 1800 frames x 3 minutes
= 5400 minutes = 90 hours

While it is unlikely that it would only take three minutes to generate each new frame, time constraints are further complicated by the fact that the entire process would be limited to the availability of the Genigraphics 100D-plus system specifically.[15]

c. Storage

For this thesis, however, time was not the only issue considered. Provided time was available, the pixel imagery would require storage on special "firm-ware" known as a Bernoulli Boxes.[16] The cost of which (in 1987) equaled approximately $80.00 each. Each Bernoulli Box, in turn, would be capable of storing approximately six to 19 images. Therefore, under these conditions, the production of one minute of rotoscoped imagery would require a minimum of 90 hours on the Genigraphics 100D-plus system at a storage cost between $7578.94 and $24000.00:

- 1 minute = 1800 frames ÷ 19 = 94.74 boxes x $80.00 = $ 7578.94
- 1 minute = 1800 frames ÷ 6 = 300 boxes x $80.00 = $24000.00

While the Genigraphics offered some very special imaging effects, realistically, cost limitations and practicality forced me to explore other alternatives.

2. Artronics

The Artronics equipment was capable of accepting video input for frame captures, or grabs, as well as provide direct video output. While the amount of time required to grab a single frame would be approximately between 15 and 20 minutes as opposed to the 1/30 second flash scan of the Genigraphics 1986 Video Upgrade grab, in 1987 the thesis time demand on Artronics equipment was far less restrictive. In addition, the cost of storage on floppy diskettes was fairly inexpensive when compared to the cost of Bernoulli Boxes. Due to digital storage inconsistencies, information created on the Artronics could not be integrated with the Genigraphics information. Therefore, any imagery created and stored on the Artronics system could not be introduced into the Genigraphics system without incorporating an interim step(s). The interim step(s) would result in visible quality loss. Furthermore, aside from the cycle paint function, the 1986-1987 Artronics Paint software did not offer an animation feature.[17]

Technical considerations for these elements of incompatibility revolved around the assembly of the final piece. Feasibly, the animation could be divided to allow separate scenes to be generated on one system and the video output of each analogically combined with an editing controller (see Appendix A:A:1). Capitalizing on the dissimilarities of the two systems to heighten the rotoscope delivery, an intermixing of visual effects could be possible. However, for rotoscoping, image registration was critical and would be excessively complicated by the introduction of two systems during composition.

With registration, time, and cost considerations reviewed, upon the conclusion of the first formal thesis meeting it was suggested I singularly use the direct video input/output capabilities of the Artronics system for use throughout my entire thesis body. With the use of a video input cable, the video could be transmitted from a Video Tape Recorder (VTR) to the Artronics (Illus. 3). Several video images, or frames, could be captured with the Artronics Grab software. Once captured, these images could be stored, electronically painted, and output on videotape for composite with the performance videotape.

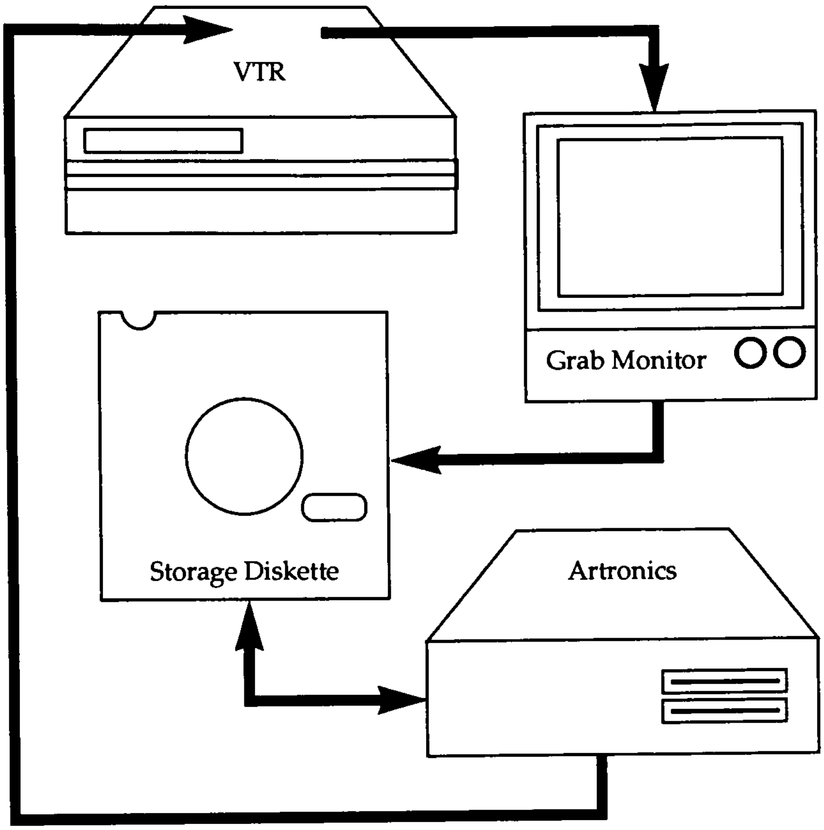
a. Color Grab

In color video, the camera has to analyze each point of an image for luminance and hue. In addition, hue

is subanalyzed for three color components: red, green, and blue. Red, green, and blue are the primary colors and strategically placed midway and at either end of the visible spectrum. By scanning these three key components and producing them in various constructions, it is possible to produce the visible color spectrum. While, the tint of a particular color is referred to as a hue, it is modified by its degree of brightness in the direction of either white or black. This direction, known as luminance, affects the degree to which a color is light or dark. Together, these are referred to as the degree of saturation in that color. In other words, in video, the compound addition of red, green, and blue produce hue. Hue, in conjunction with luminance, correctly saturate colors to a degree of brightness. These components are all that is needed in order to represent an object's correct color.[18]

Unlike a black and white grab on the Artronics, the process of capturing a color image requires three independent scans of visual information. The digitizing camera surveys once for each red, green, and blue color component. In order to avoid the visual interference of the scan line (see Illus. 2), I would need to grab the image while the video tape was in play.[19] However, the durations of a triple scan process compounded by the continuous progression of the tape in play left insufficient time for the three scans to be completed. Therefore, in order to successfully capture all the information of each frame grab, the process would be restricted to monochrome.

Unfortunately, without use of SMPTE Time Code (see Appendix A:A:3), I was unable to grab a consecutive sequence of frames for linear manipulation. This resulted in a method which was completely random and unpredictable. Compounded by the extremely poor resolution of video, the individual frames could not be acceptably rendered for reassembly in a cohesive fashion.



Illus. 3: With the use of a video input cable, the video could be transmitted from a Video Tape Recorder (VTR) to the Artronics. Several video images, or frames, could be captured with the Artronics Grab software. Once captured, these images could be stored, electronically painted, and output on videotape for composite with the performance videotape.

3. Rotoscope Length

A third alternative involved limiting the duration of the rotoscope effect. Rather than rotoscoping an entire animation, the animation itself could be broken down into workable sections or scenes. The rotoscoping could then be applied to the sizeable portion where it would create the greatest visual impact. Subsequently, the remaining sections or scenes of the animation would have to be approached in alternative fashions.

C. An Animated Background

I intended to superimpose the animated background as the stage

Illus. 4: *Keying is a system which permits any hard-edged portion of one input to entirely replace the other input on the screen. Keying is an effect using luminance as a variant; it works best when altering solid white or solid black.*

setting, or backdrop, to the video performance occurring in the foreground. During the video performance, the background was to support and strengthen the tone of the event. If the feeling of the production was to be light and airy, the animation was to visually reflect the same message to the audience, consciously as well as unconsciously. The animation was to remain subordinate to the foreground activity.

The intersection of the background and foreground was the compound surface where the computer generated animation was to be composited with the live-action video performance. On the suggestion of my Thesis Advisor, Charles Werberig, I attended a lecture given by Russel Lunn, a Teacher's Assistant in the Videography Department at RIT. Lunn introduced the concepts of keying and chroma keying effects to create a mask-like composite of computer/video animation.

Briefly, keying is a system which permits any hard-edged portion of one input to entirely replace the other input on the screen (Illus. 4). Keying is an effect using luminance as a variant; it works best when altering solid white or solid black. Alternately, chroma keying can be used to replace all the parts of one scene of a particular color. Chroma keying is a hue variant; when including human subject matter, a certain blue background is recommended due to the near exclusion of its value from human flesh tones (see Appendix A:B:3).[20]

While I questioned the applications and effects of this format, I was especially interested in the superimposition capabilities offered by the special effects generator (see Appendix A:B). After a demonstration, I was convinced keying and chroma keying were the direction in which to proceed.

Outline

Stage II: Reexamination of Original Intent

Stage II: Reexamination of Intent

Once the major components of the idealized thesis intent were isolated and examined, the immediate technical and physical limitations of each component were exposed. Reexamined and focused upon, the first major directional changes in the thesis developed.

A. The Prerecorded Piece

Once the concept of a performance art piece was abandoned, the single greatest obstacle was the selection of the video source material. The selection of a video source had to be the one with the greatest flexibility, visually and technically. Eventually, many limitations of the final synthesis would be predetermined by the limitations of the original source.

The selection of a contemporary dance ensemble for subject matter evolved not only out of personal preference but also from its adaptability to free-form and conductive expression. Contemporary dance was universally adaptable to my prerequisites. While The Bucket Dance Theater declined to supply a videographic recording, The Lakeland Civic Dance Company of Mentor, Ohio, was very cooperative. I was supplied with a 1986 duplication of a live performance no longer in production. Ideally, I would have preferred to record a live performance or at least obtain an original master tape for usage. Unfortunately, these options were unavailable.

I viewed the tape for several days before I determined the specific selection I would choose for this animation. During my original discussion with Russel Lunn, it was recommended that I choose a dance projecting the actors against either a solid white background, matte black background, or specific blue background. This would provide the best atmosphere for most keying and chroma keying effects.

As mentioned earlier, keying effects such as these operate by subtracting visual component information from the videographic image. Eventually, I selected a dance segment where the performers were cast against a blue curtain, and the background contained very few property elements. I determined this would be the most suitable for chroma key effects.

The selection of this dance sequence became the foundation of my thesis. The product of this thesis reflects exercises illustrated upon The Lakeland Civic Dance Company of Mentor, Ohio's production entitled "The Jellicle Ball" based upon the Broadway musical Cats and the original poems of Thomas Stearns Eliot's Old Possums Book of Practical Cats (Illus. 5).

B. Rotoscope Length

After limitations were discovered during stage I, I decided to reduce the rotoscoping effects to workable time frames. I also decided to reconstruct the animation with the new restrictions in mind (see Stage I:B:3)

In order to arrive at a logical breakdown of the animation segments, I repeatedly listened to the music and catalogued the actions of the video performance. By recording durations between the changes in audio and choreographic treatment, I developed the time tables for my animation storyboards (see Table 1 on page 10).

C. The Animated Foreground

Keying and chroma keying effects were applied to portions of the animation video and prerecorded, live-action footage. A composite assembly was made with the aid of three video tape recorders, an editing controller, and a special effects generator.

Illus. 5: A scene taken from The Lakeland Civic Dance Company of Mentor, Ohio's production entitled "The Jellicle Ball" based upon the Broadway musical Cats and the original poems of Thomas Stearns Eliot's Old Possums Book of Practical Cats.

Unfortunately, these initial experiments revealed that the backgrounds of the selected prerecording were not lighted evenly enough to incorporate keying and chroma keying effectively. This prevented the complete subtraction of the background elements. While the special effects generator permitted the mixing of some videographic imagery with portions of the computer generated imagery, the union was not satisfactory.

Disappointed by the first composite videographic and computer generated effects outlined, a third modification to the original thesis intent was introduced. This modification involved the creation of the computer generated animation on a solid blue background. This would permit chroma keying effects but with a different perspective. Instead of the performance being superimposed over the animation, the animation would be superimposed over the foreground.

Next, an aesthetic decision was made. The animation should not conflict or contrast with the actions of the performers. For this reason, the animated foreground would generate support and direction for the activities of the performers but remain subordinate to their activity.

D. Assessment

In summary, with these three major changes outlined, the emphasis of the thesis was redirected. First, a conscious decision regarding the presentation format shifted from a live performance art piece to a prerecorded performance. Second, instead of rotoscoping the entire performance, a decision was made to restrict the technique to a workable section of the animation due to time limitations. Finally, the composite treatment of the computer generated animation and videographic footage would shift from an animated background to an animated foreground.

At this point, it appears the technological aspects of this art form, have been recognized only as barriers. However, it is important to recognize that it is the adaptability of the technology which has brought this medium to its present form. The development of this thesis is compounded by its mechanical flexibility. I believe this technological tool in juxtaposition with creative applications, is the evolution of this medium. Complete computer integration, in art, media, science, etc., may be fully realized through experimental applications.

Animation	Choreography	Music Start	Music End	Time
Alley Cat Opening Animation	Cat Silhouette	0:00:00	2:08:26	2:08:26
Keyboard & Flower Sequence	Cats Entrance	2:09:26	5:14:12	3:04:86
Starburst	Line Sequence	5:14:13	5:28:21	0:14:08
None	Synchronized	5:28:22	6:58:01	1:29:79
Running Cat & Leaves	Transient Cats	6:58:02	8:27:23	1:69:21
None	Exits & Entrances	8:27:24	9:04:08	0:76:84
Rotoscope Sequence	Cat Duet	9:04:09	11:11:25	2:07:16
Dancers	Group Sequence	11:11:26	12:43:08	1:31:82
Credits	Cats Frenzy	12:43:09	15:21:23	2:78:14

***Table 1:** A log of the music and choreography helped develop an animation time table for storyboards.*

Outline

Stage III: The Storyboards

Stage III: The Storyboards

Escaping technical properties, the creative aspects of this thesis were explored during storyboard development. Mentioned earlier, the thesis was broken into several workable sections (see Stage I:B:3). To obtain the greatest flexibility, each section of the animation table was developed independently. Provided the synthesis of the parts was cohesive, I determined it was not necessary to apply the same visual effects throughout the entire piece. Instead, the treatment of each scene was determined by the qualities which would offer it the greatest visual impact. Each technique was evaluated by what it could offer to the independent scene as well as to the overall performance. Continuity of form, however, would supercede all other considerations.

A. Subject Matter

T.S. Eliot published Old Possum's Book of Practical Cats on October 5, 1939. In this book of collective poems, Eliot depicted cats very much like human beings. "Each poem is a precise and accurate definition of a particular kind of cat, but Eliot appears to be satirizing the cats' owners, and the English society in which they live."[21]

The stage design of the original Broadway production of Cats, by John Napier, was an environmental space designed to entice the audience into a lyrical, feline world energized by elements of imagination and fantasy. Conceived as a giant playground for cats, John Napier visualized a place where cats might congregate together.[22]

B. Storyboard Development

I developed the storyboards linearly. While the performance of The Lakeland Civic Dance Company illustrated the events of the narrative, the chronology of the music was catalogued by audible deviations. From this, animation time tables could be accurately generated (pg. 10, Table 1). Determined by the choreography of the dance or intensity of the music, some sections were animated while others were left untouched.

1. The Opening Scene

While the original book of poems is a collection of individual descriptions, the Broadway performance of "The Jellicle Ball" is an explosive dance illustrating the "height of cats' passion through their most private, energetic and anarchic rituals".[23]

From the start, I amplified the personification of the cats by juxtaposing human elements with elements of cat genre. The scene opens in a traditional alley oddly illuminated by an iridescent blue light. Simultaneously, entrances and exits of the prerecorded performance were alternately intermixed with those of the animated cats. Sections of the performance and animation are faded in and out of view while others are superimposed upon each other. The theme is indicated by the blatant introduction of the title "The Cat's Dream." When the exits of the animation and the performer coincide, the viewer is invited into the dream by a simulated recession of the animated alley into the surface of the monitor (Illus. 6).

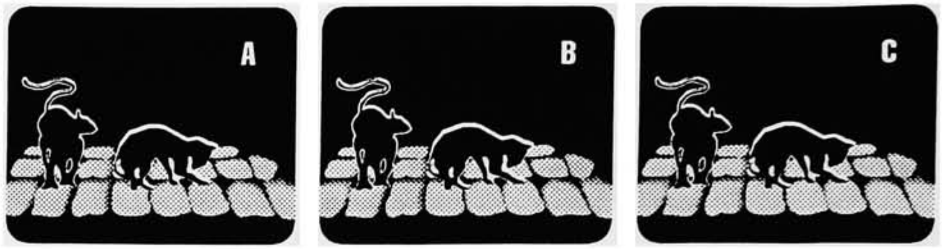
a. The Horizon Line

The first problem encountered was the inconsistency between the horizon line of the animation and the prerecorded performance. In the prerecorded performance, the appearance of a stark visual horizon was generated by the planar meeting of the stage and the backdrop.

In order to avoid confusion, intermixing the computer animation and

Illus 6: Computer animation scenes from "The Cat's Dream".

Illus 7: By cutting object-based artwork from the display and pasting it to a canvas, a synthetic image is converted to a pixel-based image. Returning a pasted image from the canvas onto the the display, by creating a panel, reserves space on the artwork list. A panel is an object and, therefore, takes up one object on the artwork list



A: On Display, this illustration represents several objects on the artwork list.
B: Cutting these objects from Display and pasting them on the Canvas converts the object-based artwork to pixel based artwork.
C: Returning the converted image to Display, produces only one object, the panel, on the artwork list.

the prerecorded video required the uniform display of orientational elements such as the horizon line. In response to this need, a series of horizon lines were traced from video display to acetate overlays for registration of future storyboards.

b. Animal Locomotion

In order to generate a realistic representation of feline movement, I was referred to a photographic study of animal locomotion by Eadweard Muybridge.

Muybridge noted: "In terrestrial movements, the instant that the foot strikes the earth the resistance is great and the arrest complete. The resistance of the air and the water is so much less than that of the earth. In the animal moving on the surface of the ground, the foot being brought to rest, an absolute break occurs between the beginning of the act of recover and its completion, the time which would be required to describe the interval and thus to complete the union corresponds to the period that the foot is on the ground."[24]

Using Muybridge's notes and studies as a guide, I generated a series of cat locomotion cels on a traditional animation inking board. At the same time, I copied Muybridge's photographic record for use later in the thesis. The drawings were input on the Genigraphics system by affixing an Acme peg registration mount to the surface of the graphics tablet. In this manner, careful registration could be maintained.

Unfortunately, the number of vertices accumulated by the collective cat drawings surpassed the Genigraphics table of limits. However, a workable solution could be achieved by generating pixel files, known as canvases, from the vector files and, in this process, eliminating the problem of excessive vertices.

c. Canvases and Panels

The applications of the canvas are specific to the 1986 Video Upgrade System residing on the Genigraphics 100D-plus (at RIT's 1986-1987 installation). The canvases are the work areas where pixel-based imagery is contained for eventual use on the display.[25] The pixel-based imagery can be viewed and animated on display only through the process of creating panels. To the viewer, panels contain bit-mapped information, however, the 1986 Video Upgrade System recognizes panels as synthetic, or vector-based, rectangles. These synthetic rectangles contain only five vertices, the four corners and the center. For display and animation purposes, the process of creating pixel-based files from complex vector-based files reduces the number of vertices the system recognizes while displaying the same visual information (Illus. 7).

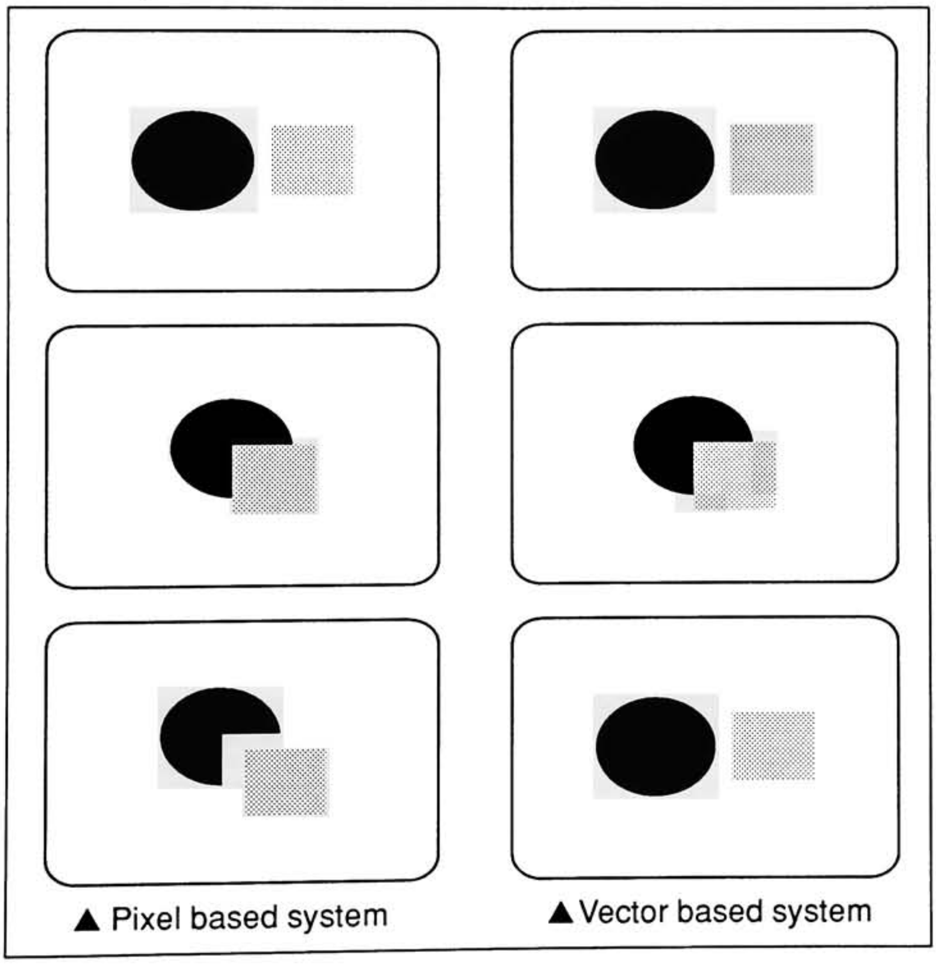
Fortunately, the availability of canvases offered me a workable solution. It should be noted, however, the quality of a vector-based

file is defined as the maximum resolution of the output device. The reproduction quality of a pixel-based file, on the other hand, is limited by the input device. This file transgression, from vector-based to pixel-based, resulted in the limitation and loss of resolution quality upon output.

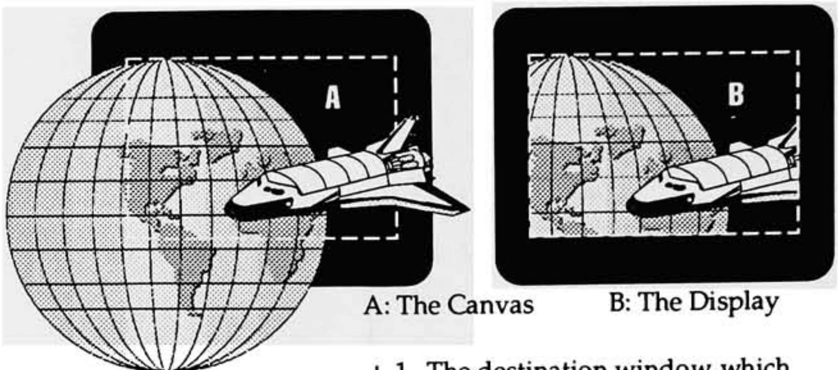
In addition, vector imagery can be stacked on top of each other and still retain the integrity of each form. Pixelated imagery is not hierarchical, however, and cannot be overlapped while retaining the independence of the original forms. For example, pixel systems are often referred to as "paint box systems." If a square is painted over a circle, only the information of the square remains since the circle has been physically replaced. However, if a square is stacked on a circle on a vector system, each object retains its original attributes (Illus. 8).

Due to the degree of registration required for animal locomotion, on the Display, the cat illustrations would need to overlap each other. To reduce the number of vertices, the cats underwent a vector-to-pixel transgression. This means the cat illustrations were moved to the Canvases and converted to pixelized forms. Since they were pixel images, they could not be overlapped.

For this reason, a clear understanding of the application of panels is important. "When you transfer a pixel image from a canvas to the display, the display 'sees' that pixel image as a vector object. The display image is known as a panel. Looking at a panel is like looking through a rectangular tunnel with one opening on the display and the other opening on a canvas (Illus. 9). Each panel has two "windows":



Illus 8: On a pixel based system, when two objects are overlapped, they occupy the same space and become one. On a vector base system, when two objects are overlapped, they are stacked one one top of the other and remain individual elements.



Illus. 9: Viewing a panel on Display is analogous to the two sides of a window. One side of the window shows the Display and other side of the window shows the Canvas.

1. The destination window, which appears on the display
2. The source window, which appears on the canvas"[26]

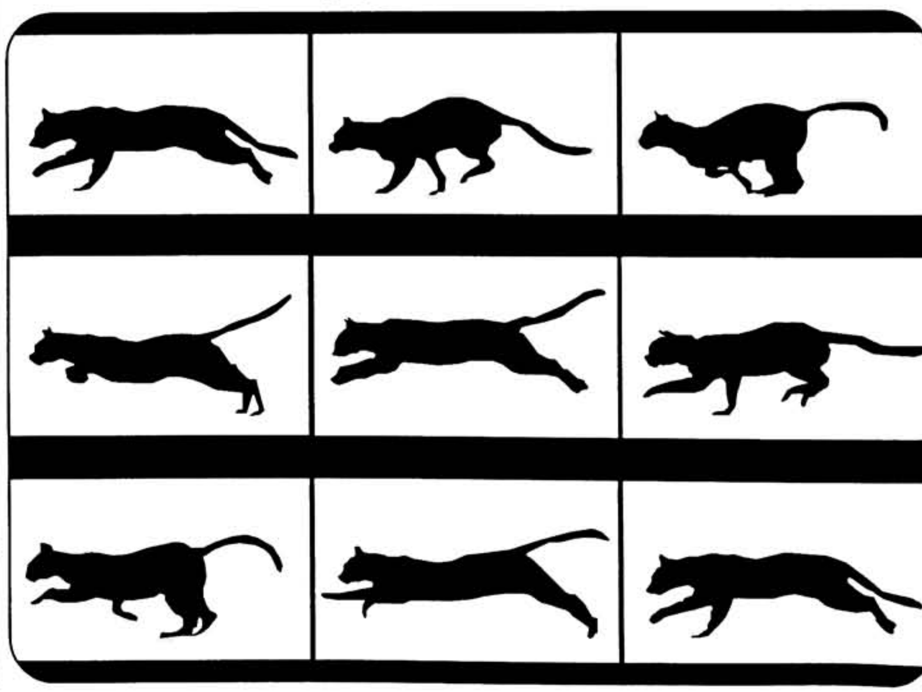
The Genigraphics 1986 Video Upgrade System provided three independent canvases all capable of containing pixel information. Although I could not overlap the imagery, I had the freedom to locate the source and destination windows. This freedom enabled me to develop the following registration system.

A uniform frame, or reference rectangle, was drawn and placed in position around a cat illustration on the display. In turn, an identical frame was drawn around each pixel illustration on the canvas, in registration to the one on the display.

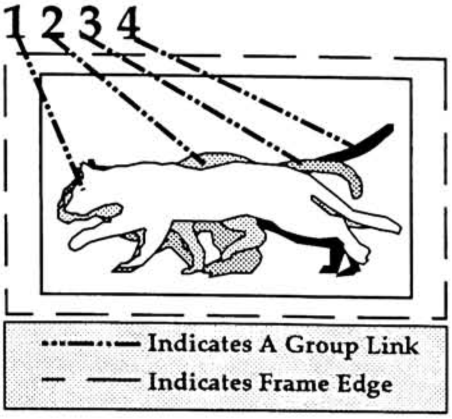
The framed illustrations, could then be rearranged on the canvas to avoid overlapping while maximizing available space. Next, panels were created using the newly drawn frames to describe the source window for each illustration. Each source window was then assembled, in registration, over the original frame already positioned on the display. To avoid detection, once assembled, the original reference frame was deleted from the display. In this manner, as vector imagery, each cycle of the cats' movement overlapped one another on the display but did not overlap as pixel imagery on the canvases (Illus. 10).

It should also be noted that when each image is completely overlapped on the display in this manner, the rearmost objects in the stack could not be easily selected. As a solution, when each illustration was brought to the display, it was literally numbered on the display. Residing outside the visible video frame, each number was created as a separate object and linked to its corresponding illustration as a "group."

A group is a collection of two or more objects which can be linked



Illus. 10: At right, framed pixel illustrations as they appear without overlapping on Canvas. At top of next page, the overlapping panels as they appear in registration with the reference rectangle on display.



together in order to maintain a fixed unit. When it was necessary to animate an illustration independently of the others, I selected the number grouped to the image I desired to animate. By this process, both the number and corresponding image were easily accessed for animation purposes (Illus. 11).

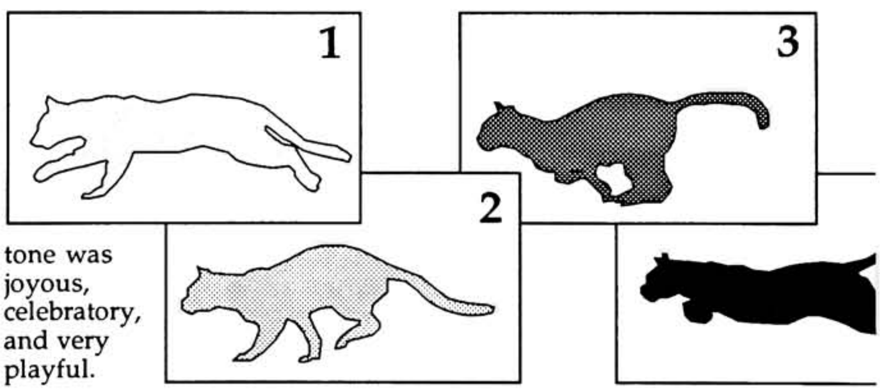
Unfortunately, while creating the imagery in precise registration, the canvases quickly ran out of space. My original storyboard called for the simultaneous animation of three cats in an alley. However, all three canvases were utilized to animate just one cat. Eventually, I had to reduce the amount of information I animated at one time. Therefore, the final composite reflects two cats animated separately, one as panel-vector imagery and the other as solely vector imagery. In addition, the activity of each cat was limited by either the canvas space available or the number of vertices allowed by the Genigraphics table of limits. The third cat remained static throughout the opening scene.

d: Background Strobing

Background strobing, otherwise known as a visual shutter, appeared in the first series of animal locomotion tests. Strobing usually occurs when a pan, or sweeping lateral motion, is not correctly calculated.[27] As explained, in video, one second of animation requires thirty frames (1 second = 30 frames). Each cycle of the cat was animated on fours but the background was panned on ones. In other words, each phase of the cats movement was photographed four times before changing to the next phase; but, the equal movements of the background were photographed only once before changing to the next lateral position. Although the cats appeared to move smoothly, the environment appeared to violently shift forward and backward, creating a disturbing visual image. The strobing was corrected by consistently animating the cats as well as the background on four exposure counts each.

2. The Piano Keys

In the next scene, the musical accompaniment of composer Andrew Lloyd Webber burst out of a subtle, intriguing melody into a vibrant dance emphasized by the piano. The music seemed to inspire a catharsis in the performers. For several choruses, the choreography featured a series of bounding, acrobatic performers intercrossing the length of the stage. The tone was joyous, celebratory, and very playful.



Therefore, this section of the storyboard was developed to reflect the spontaneity and spirituality of the music. Warped piano keys streamed across the screen while a luminous geometric plane intercepted it. A second set of playing piano keys were introduced at the bottom of the frame in head-on perspective. Finally, the keys evolved into a repetitive series of sprouting orange blossoms. When the animation was composited with the prerecorded video, the performers were to appear as if

Illus. 11: Objects overlapped by other objects are difficult to capture. However, grouping obstructed objects with unobstructed elements (in this case, the numbers which have been displayed out-of-view) provides a selection alternative

dancing on the keyboard and leaping among the flowers (Illus. 12).

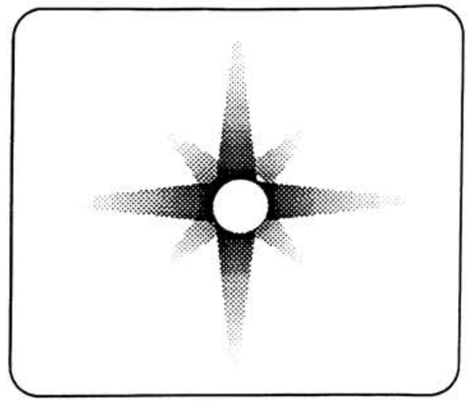
After the initial composite, this section did not encounter many modifications. Primarily, the animated elements had to be directionally shifted in order to avoid collisions with the moving performers. In addition, some of the objects had to be resized due to a close-up camera angle in the prerecording.

3. The Starbursts

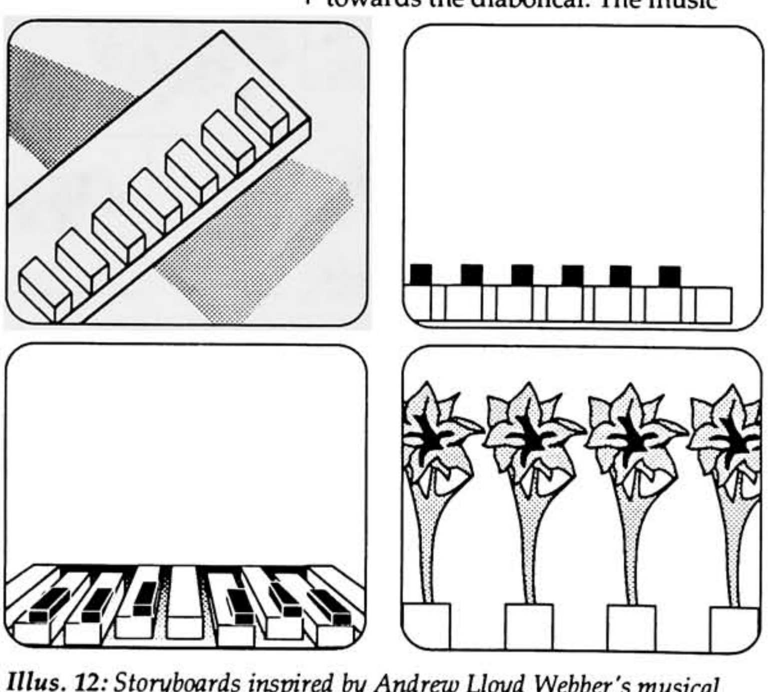
The starbursts were a short animation designed to reflect the energy radiating from the celebration of the Jellicle cats. At the suggestion of Thesis Advisor, Jim Ver Hague, the final version was repositioned to explode from an isolated spotlight projected in the background of the prerecorded video (Illus. 13).

4. The Leaves

After pausing for a dramatic a solo in the prerecorded performance, animation was again introduced. The tone of the music shifted away from the celebratory and, instead, edged towards the diabolical. The music evoked a message of urgency, yet, one of controlled nervousness.



Illus 13: The starburst animation was designed to illustrate energy.



Illus. 12: Storyboards inspired by Andrew Lloyd Webber's musical composition for "The Jellicle Ball."

I decided to incorporate elements of horror show genre into the storyboards, primarily black cats and stormy weather. Flying leaves tossed by the wind filled the screen. As the leaves cleared, they revealed a single black cat, full frame, anxiously running to or from something.

In order to create the running cat, I returned to Muybridge's photographic records. By tracing selected frames, and stringing them back to back in a cyclical fashion (1-2-3-4-1-2-3-4-1-etc.), the cat could continue to run indefinitely (Illus. 14). Unlike my first encounter with animal locomotion (see Stage III:B:1:b,c), only one cat was animated and less transitory phases were involved in this sequence. This allowed the animation to remain singularly vector based (without the additional vector-to-pixel based transgression incorporated during the opening animation sequence).

5. Rotoscoping

This phase of the performance was the most climactic. The intensity of the music accelerated. The dancers cleared the stage while two primary figures challenged each other in an energized duet. The choreography was filled with strength and emotion. I decided this was the place to introduce the rotoscoping; limited in length but emphasizing in treatment

and relation to the entire piece.

The duration of this segment was approximately forty-four seconds. Again, every second of video animation required the construction of 30 frames. In order to construct 44 seconds of rotoscoped animation, 1320 individual frames would have to be generated:

44 seconds x 30 frames (number of frames per second) = 1320

However, following a procedure outlined in an article published by *HOW* magazine entitled "Animating for Music Video," I opted to generate images according to a patterned ratio: 2:3 for every 5 frames of video.[28] In other words, for every five frames of video I would need to rotoscope two frames and leave three unmanipulated (Illus. 15). This ratio was developed for dual image reconstruction, on a mutual plane, where the rotoscoped segments would be imposed upon the originally recorded material. Next, the video performance and rotoscoped cels would be recorded simultaneously. The voids created by the absence of rotoscoped imagery (three frames per every five frames) were intended to facilitate a real/non-real illusion. This new ratio meant the generation of twelve rotoscoped frames per second, leaving 18 frames of video material. Therefore, the amount of material required would still involve the creation of several hundred images, but the total was significantly less than originally suspected.

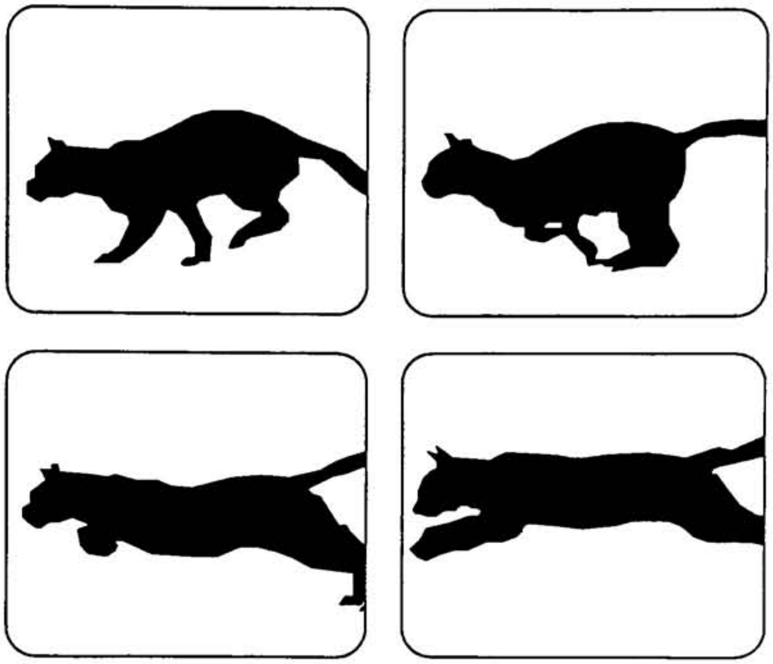
a. Primary Registration

Since the synthesis would reside on video, I had to insure that the recomposited images were sized and registered to each other. This was facilitated with the aid of Christopher Wright, a graduate student enrolled in The School for American Craftsmen (SAC) at Rochester Institute of Technology.

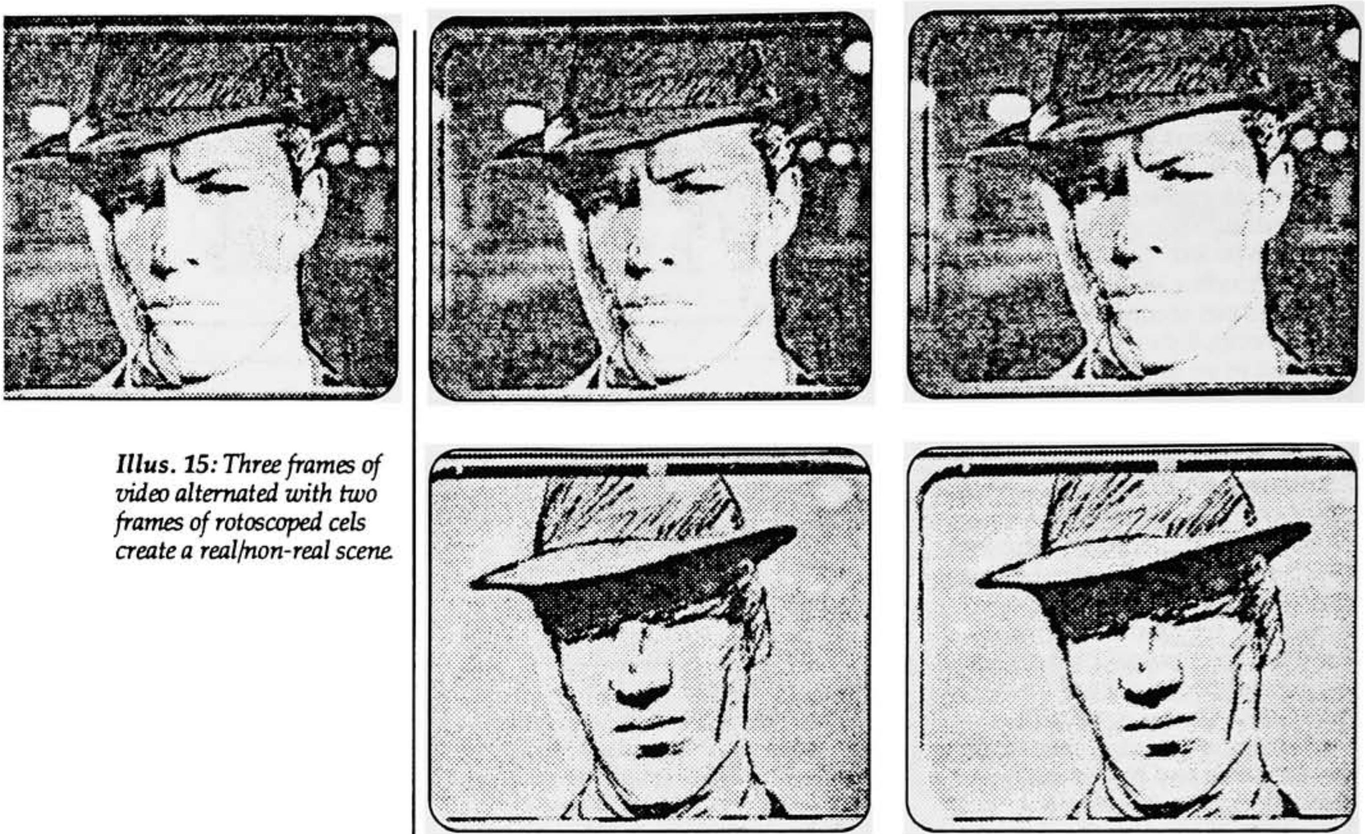
Wright designed and built a box which would accept a monitor within its dimensions. This box was specially created to allow the monitor to be tipped on its back without damaging the cathode ray tube. This device enabled me to trace the video output of the prerecorded source directly from the monitor where the newly created images would eventually be displayed for output. Thus, by using careful registration, the images would be properly sized and positioned for final compositing.

In order to precisely access two sequential frames out of each five, it was necessary to number the frames. This process can be achieved with the aid of a time code generator. An editing controller was utilized to generate a form of time code known as SMPTE (see Appendix A:B:1,5). By writing SMPTE Time Code to audio channel 2 of the prerecorded performance, I could then use the editing controller to read and freeze each frame I needed to trace for rotoscoping.

Originally, I expected the flat surface of the anti-glare screen attached to the output monitor would be an excellent surface for registration. However, the surface of the anti-glare screen was situated approximately 5/8" above the surface of the monitoring screen itself. This complicated the registration process. Unless I could maintain my exact perspective throughout the entire tracing pro-



Illus. 14: Using Muybridge's photographs, a single black cat runs in a continuous cycle.



Illus. 15: Three frames of video alternated with two frames of rotoscoped cels create a real/non-real scene.

cedure, the images would appear to shift in relationship to my eyes and the screen's surface. This is known as parallax. Therefore, it was necessary to remove the anti-glare screen and work directly on the convex surface of the monitor screen. Unfortunately, the registration mount could not be affixed to the convex surface of the monitor. Alternately, the images were registered, as closely and consistently as possible, by securely placing them in the upper left corner of the monitor.

b. Tracing, Inking, and Painting

The tracing, inking, and painting process of rotoscoping is more than a time devouring, mechanical maneuver. This is the stage where aesthetic decisions take place. The amount of information each traced representation must contain as well as the artistic treatment of the image is all determined during this process.

Due to the amount of cels needed, I traced the images as gesture drawings. Retaining the liberal quality of gesture drawings, I loosely inked and painted the cels. In order to increase the visibility of the rotoscoped imagery upon composite assembly, I restricted my color palette to include colors with highly luminous values (Illus. 16).

c. Secondary Registration

When the newly created images were input into the Genigraphics system, they again had to be carefully registered in order to avoid unsynchronized movement. This secondary registration was achieved by again affixing the Acme peg animation mount to the flatbed surface of the video camera stand. Once the image was grabbed and displayed on the Genigraphics display, it was output directly to the video display monitor. In addition, the primary registration cel and a carefully traced representation of the original frame were affixed to the output video display monitor. When all were in registration, each rotoscoped frame was individually scanned into the Geni-

graphics system for the purpose of outputing each on a video recording (Illus. 17).

d. Introduction to the Genigraphics

Each cel was scanned into the Genigraphics system separately with the aid of a Camera Control Unit (CCU), an Ikegami Camera and the 1986 Video Upgrade Grab Function. As mentioned earlier (see Stage I: B:1:c), the amount of storage space required to save these images would have been massive and expensive. Therefore, the images were never digitally stored. Instead, the only record of these drawings remained on the surface of the acetate cels. By grabbing the imagery and immediately bringing the results onto the Genigraphics screen, the images could be recorded directly on video.

Generally, from the Genigraphics, imagery is recorded on 3/4" video by creating an animation table and initiating the taping procedure. Fortunately, the editing controller also possess the ability to manually record "hold frames." These frames do not require the recording of an animation table. Initiating the manual procedure can be done at the editing controller keypad, causing the controller to record directly from output display. Whatever appears on the output display, will also be recorded on the video tape. Therefore, it is necessary to remove any visible, unwanted information from the display.

With the 1986 Video Upgrade Grab Function and a Camera Control Unit, each cel was scanned into the Genigraphics system using the Ikegami camera which was mounted to a camera stand. Once the image was regenerated on both the Genigraphics and video display monitor, it was immediately recorded manually at the editing controller. While the material was recorded with the aid of a video camera, graphics system, and editing controller, in essence, this procedure is very similar to the film recording of traditional animation.

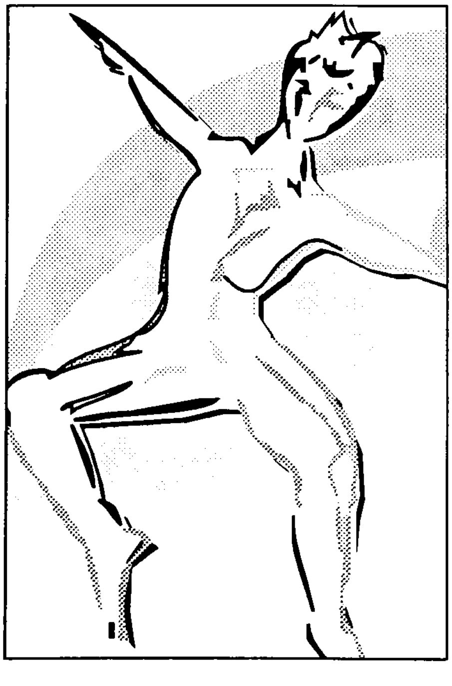
To maintain synchronization with the live action prerecorded performance, each frame was recorded sequentially with three blank frames alternately placed between every two rotoscoped frames as described by the ratio index (see Stage III:B:5). In addition, it should be noted, that when following this procedure, for recording purposes it was necessary to enter the "Use Brush" function in order to remove the Genigraphics menu from the visible recording area.[29]

e. Image & Scene Management

Since the imagery was never electronically stored, the rotoscoped cels were chronologically labeled. As each frame was traced its corresponding SMPTE time code number was recorded on the acetate cel (see Appendix A:A:5).

Next, a cross reference filing system was developed. Firstly, each cel was filed chronologically according the time code number assigned it. Secondly, when it was recorded on video output, each cel was also documented with the corresponding frame and scene number assigned by the 1986 Video Upgrade Software.

Therefore, when reviewing a scene, the associated frame numbers of any unsatisfactory elements could be identified by requesting its particular para-

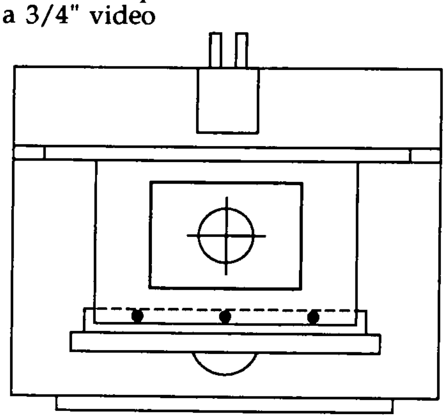


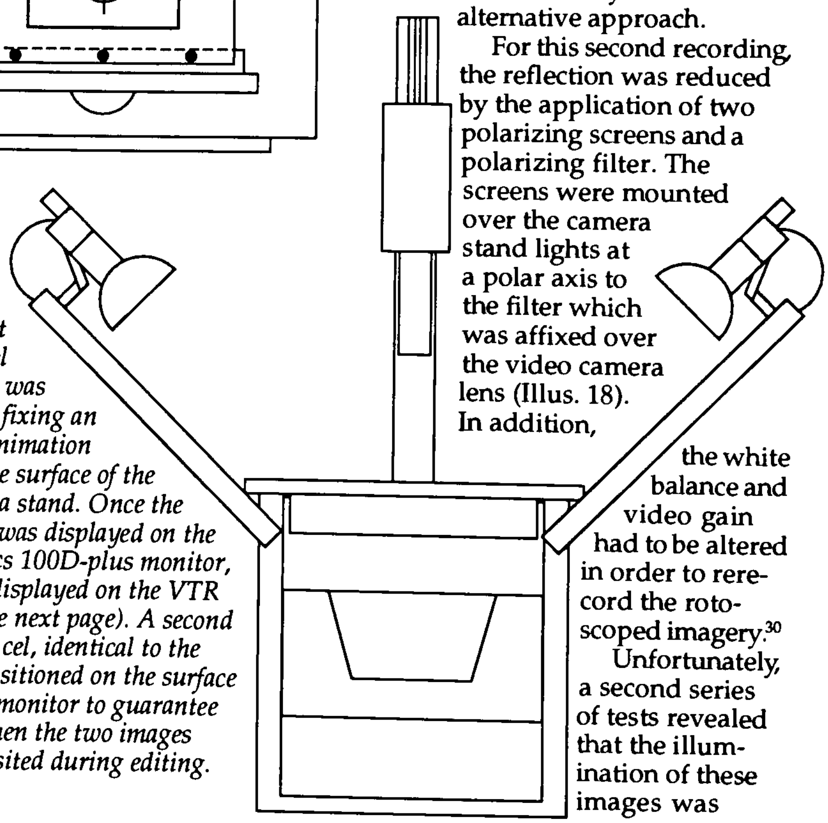
Illus 16: Gesture drawings were developed to mimic the complexity of movement and motion dynamics displayed by the performers.

meter information from the editing controller. The parameter information provided the video frame and scene number I previously recorded on each acetate cel by hand. By cross referencing the scene and frame number with the SMPTE Time Code number, specific cels could be located. Once modified, selected cels could be rescanned and viewed on the video monitor. The new images could then be rerecorded in there correct frame position by entering it at the editing controller keypad.

f. Video Output

It was necessary to output all the information, both vector animation and rotoscoped animation onto a 3/4" video recording for the purposes of later composite through the available special effects generator (SEG). The composite animation would be assembled using a video editing technique known as an "A/B Roll," where each "A" and "B" are independent video sources. These two sources are then simultaneously edited onto a single tape titled "C". In this case, "A" would represent the vector and rotoscoped animation, "B" would include the prerecorded video material, and "C" would be the final composite animation. Therefore, to succeed, all animation would need to reside on 3/4" video to accommodate the available SEG.





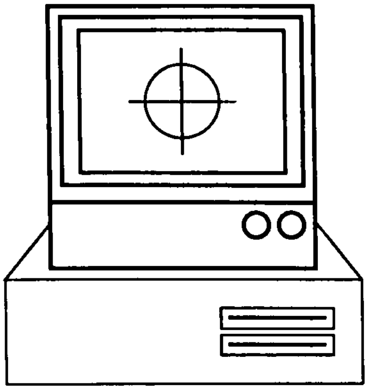
Illus. 17: Displayed above and at right, the cel registration was achieved by fixing an Acme peg animation mount to the surface of the video camera stand. Once the grabbed cel was displayed on the Genigraphics 100D-plus monitor, it was also displayed on the VTR monitor (See next page). A second registration cel, identical to the first, was positioned on the surface of the VTR monitor to guarantee accuracy when the two images were composited during editing.

g. Glare

After reviewing the initial composite, a reflection from the acetate cels created a severe hot spot on the video recording. Confusing and distracting, the reflection was a visual annoyance. In order to record the material without the reflection, it was necessary to find an alternative approach.

For this second recording, the reflection was reduced by the application of two polarizing screens and a polarizing filter. The screens were mounted over the camera stand lights at a polar axis to the filter which was affixed over the video camera lens (Illus. 18). In addition, the white balance and video gain had to be altered in order to rerecord the rotoscoped imagery.[30]

Unfortunately, a second series of tests revealed that the illumination of these images was



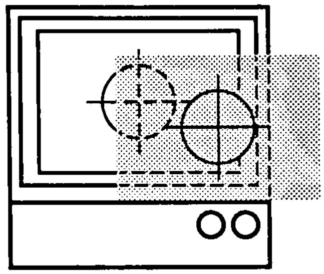
Genigraphics Monitor Display

insufficient to produce a discernable reproduction. The recording was too dark to be separated from the background through the keying process. Again, the images would have to be recorded in another format.

For the third recording of the rotoscoped material, the acetate images were mounted to a light background and illuminated from underneath, otherwise known as backlight. The modified background in addition to the backlight provided sufficient lighting for reproduction, however, since the original images were created with opaque inks they were now represented as silhouette drawings. Unfortunately, while the forms lacked their intended coloration, the illustration of the dance remained comprehensible.

6. The Credits

The audio breakdown of the animation revealed a section where the music entered a period of degeneration. This section was positioned after the climax and very near the end of the piece. It was a logical point to introduce the credits. Since their primary function would be to highlight specific people and specific functions, they would be treated as typographic and thematic illustrations. I felt for the first time in this production, the animation would not have to be subordinate to the prerecorded performance.



VTR Monitor Display &Registration Cel

For this reason the credit storyboards tookon a very different look from the remainder of the thesis. These were generated as full frame designs with complete backgrounds and a hard-edge, graphic treatment. They were not composited with the prerecorded video (Illus. 19).

This portion of the thesis moved extremely fast. All eight keyframes were designed in one day and computer generated shortly thereafter. The animation was timed and planned from keyframe to keyframe in a very methodical progression. Fortunately, no problems or modifications were encountered throughout the production of the closing credits.

C. Additional Techniques

The following exercises were initiated, however, they were abandoned due to the lack of remaining time before the thesis show. While they were excluded from my final production, I would like to include them in the written body.

1. Real Time Animation

Real Time Animation is the animation of objects without encountering a prolonged pause for each frame regeneration. In "conventional computer animation," each frame is generated individually and recorded frame by frame. In contrast, however, real time animation is generated and recorded in the same passage of time as that of when it would be viewed.

Using video as an example, in conventional computer animation, one second would require the calculated creation, display, and recording of 30 individual frames. This creation

may take several hours or even days to generate and record while they would be consecutively reviewed in one second. However, in real time animation, all 30 frames of that one second would be generated and recorded in one second.

The display of the Genigraphics system requires a process known as regeneration in order to illustrate the created imagery. During the regeneration process, each created object is reproduced one at a time in the hierarchical order in which they are overlapped. If the designer planned carefully, the objects could be overlapped in such a visual array as to construct an animation by simply regenerating the display.

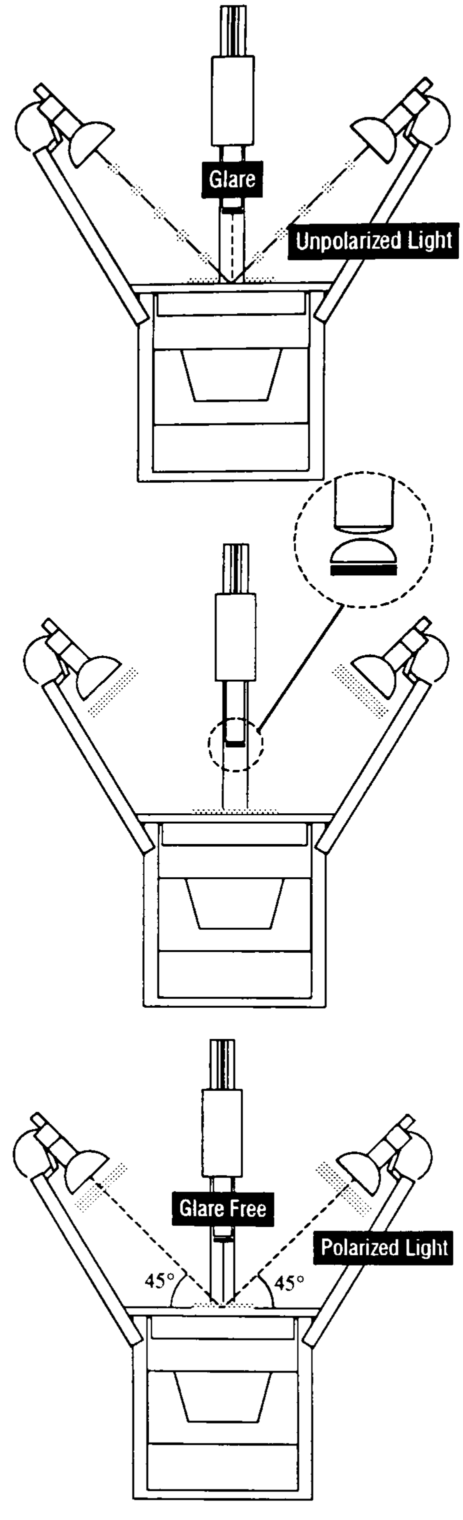
As described earlier, the "hold frame" function of the editing controller permits the manual recording of whatever currently resides on video display (see Stage III:B:5:d). If the manual recording could be initiated during the regeneration process, real time animation would be recorded. Since it would be difficult to precisely start and end the manual recording process in synchronization with the beginning and ending of the regeneration,it would be necessary to record longer time lengths. This extra recording length would then be edited out in post production phases.

These two processes, the hold frame of the editing controller and the regeneration of the Genigraphics display, in conjunction with each other would, in effect, constitute a real time animation.

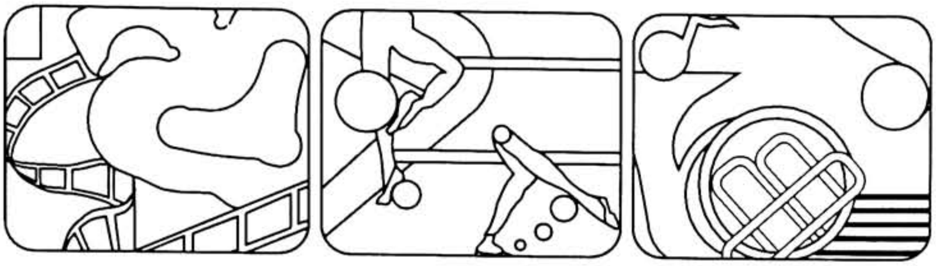
2. Electronic Frame Painting

Originally, I intended to incorporate this technique rather than gesture drawing for the illustration of the rotoscope scene. However, this technique was an incredibly timely process. While the Rochester Institute of Technology's 1987 Genigraphics installation could not directly accept an isolated video input cable, I found a crude but alternative method for introducing video to the system.

Again using the monitor box created

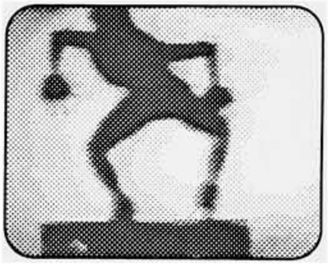


Illus. 18: Glare can be reduced by the application of two polarizing screens and a polarizing filter.



Illus. 19: The credit storyboards were created as full frame graphic designs. They were not composited with the prerecorded video performance.

by Chris Wright (see Stage III:B:5:a), I was able to place a monitor on its back on the flatbed of the camera stand. Through the compounded use of the Camera Control Unit, Ikegami video camera and the Genigraphics 1986 Video Upgrade Grab function, I could capture video imagery while the video cassette remained in play. Unfortunately, I could not guarantee which frame I would capture nor exclude the interference of the continuous video scan line. However, with the aid of the editing controller, I could use the SMPTE Time Code to address a particular frame, pause the image on display, and capture a particular frame (see Appendix A:A:5). Once scanned, the grabbed image would reside on a canvas and could be enhanced through the applications of the Paint Package (Illus. 20).



Illus. 20: Images grabbed with Ikegami video camera are electronically painted and enhanced with the aid of the Genigraphics 1986 Video Upgrade Package and output with the aid of an editing controller.

Outline

Stage IV: Editing & Composite Assembly

Stage IV: Editing & Composite Assembly

Once the footage for a program is recorded, the process of building the narrative really begins. Editing is generally a two- stage process. The first stage usually includes the cataloguing of raw footage from the original master. From this catalogue, the desired segments are organized into what is known as an editing script. The editing script indicates the location and duration of each segment intended for the final product assembly. Using the editing script, the rough-cut is assembled, usually without effects, titles or graphics. Stage two is the fine-edit, in which the master tape is edited to create the final product. Generally, it is at this stage that the full capabilities of computerized editing systems are applied and special effects are introduced.[31]

In order to provide a basic understanding of some general video editing principles, Appendix A: "Basic Editing" has been assembled for the benefit of the reader. If a question concerning the recounted procedures or equipment used in this stage, please refer to this Appendix for more information.

A. Assembly Production

Compositing the computer generated imagery with the video imagery was more difficult than anticipated. For the first editing session, I brought the raw footage of the prerecorded performance and the newly generated computer animation. Additionally, I brought a detailed editing script including time code schematics, a special effects script, the original sound track from Cats, and a 3/4" broadcast quality video cassette prerecorded with black burst, color bars, and SMPTE Time Code. In order to guarantee a successful edit, the recordings were genlocked through the editing controller, the signal checked with the waveform monitor, and the color bars corrected with the vectorscope.

1. Color Correction

Among other adjustments, when the two video sources, labeled "A" and "B" were brought to the editing session, they were monitored for signal stability and color compatibility.

The color bars recorded on each source were displayed and synchronized with the aid of the vectorscope. However, when I created the animated imagery on the Genigraphics, I determined the color visually from the display monitor. At the time, I was unaware that the color generated on the display monitor was modified to simulate the visual results desired by individual animators using the system. For synthesis applications, I was restricted to true color. Therefore, the generated animation had to be modified to reflect true coloring.

This was achieved by keyboarding color into the Genigraphics according to the numeric values supplied in the Genigraphics User's Manual. In addition, the video output monitor was visually corrected by displaying color bars with the aid of the color encoder and making the adjustments manually. For future applications, I recommend this procedure to any individual intending to output Genigraphics imagery on video.

2. Audio

The original album sound track was recorded on both audio channels of what would become the composite master. By recording the original album sound track onto the video, it became a second generation sound track. The recording used to generate a music log for the original development of the animation storyboards

was also second generation. The music provided on the prerecorded video performance, however, was fourth generation.

Once the original album sound track was composited with the prerecorded video performance and the computer generated animation, a discrepancy was evident. While the length of the animation almost equaled the second generation sound track, the sound track outlasted the prerecorded performance by almost 40 seconds.

Next, I was informed that each of the three sound tracks, the original album; the prerecorded video performance; and the tape cassette used to generate the music log for the computer animation, should have been played on the same source, at a fixed speed (not battery powered), in order to increase the chances they would coincide in duration.

At this stage, it was too late to create new animation time tables. It was also not recommended to reproduce the fourth generation sound track (of the prerecorded video performance) onto the composite master tape thus making it an even lower-quality, fifth generation sound track.

As limited as the options appeared, another alternative existed—manipulating existing imagery. This included somehow lengthening all prerecorded video and computer animation to equal the duration of the new sound track.

Equality was achieved by modifying the editing and special effects script. Portions of the special effects script were altered to include fading out the prerecorded performance while fading in the computer generated animation. When the prerecorded performance was faded out, it was rewound to an earlier point and reintroduced at a suitable position. Another modification included a repetitious editing of a cyclical choreographic movement to provide the appearance of several leaps by a performer when only two actually existed. Finally, in order to lengthen the computer generated animation, it was also repeated in a cyclical fashion.

3. Image Collision

Compensations for sound track deviations resulted in the displacement of storyboard elements when superimposed on the prerecorded material. In order to alleviate the visual disturbance, some computer generated animation was excluded while other portions were "mixed" with the prerecorded information. As time conscious decisions, these modifications were introduced and incorporated in the editing suite.

4. Rotoscope Alignment

As described earlier, the rotoscoped material now resided as silhouette imagery. Prior to the synthesis, the imagery had an individual characteristic. Upon composite, however, the effect completely lacked substance. It was confusing and unreadable. While trying to resolve the situation, the rotoscoped imagery was accidentally offset against the prerecorded performance. A strobing effect was produced when the original ratio of two superimposed rotoscoped frames against three unmodified video frames was unintentionally dissolved (see Stage III:B:5). In addition, the rotoscoped silhouettes appeared to be dancing with their prerecorded counterparts. With the addition of some special effects, the composite editing produced an illusion of four synchronized performers where only two originally resided. Far from idealized, the final rotoscoped synthesis produced the real/non real illusion .

5. Safe Area

While the credits of the animation were designed within a specified video safe area, they pressed the extreme boundaries. When a title or graphic is recorded, it is necessary to to take into consideration that no two monitors frame in exactly the same way. An image that is perfectly centered on one monitor may appear slightly to the left on another. Accordingly, titles or graphics must have adequate space around them so that the edges do not disappear into the monitor frame. But with slides, photo-

graphs, and other all-over graphics, the reverse is true. The part of the image shown has to be smaller than the whole, especially on the narrow dimension.[32] Upon composite playback, several credits, designed as full frame imagery, extended beyond the safe areas and out of viewer sight.

In order to correct this, I returned to the Genigraphics and reduced the sizes of each affected image. The results were then rerecorded and successfully insert edited onto the composite master.

EVALUATION

This thesis developed as a personal exploration in the compositing effects of computer generated imagery, traditional cel animation, and videography. Through trial, great error, and much modification, this collaboration evolved. As a product of transition and progression, it can be said, it echoes the absolute design process.

In order to create a visually aesthetic ensemble while incorporating several techniques, each exploration was to support the whole in its depiction. Personal aesthetics and technical limitations determined the inclusion or abstraction of any particular approach, and to what degree, if any, that it would be used, modified or manipulated. Finally, these decisions were based upon the desire to support, strengthen, or emphasize the prerecorded performance.

Weakness

The greatest individual weakness of this thesis, was a poor foundation. As outlined in Stage II:A, a major consideration of this thesis was one of source material.

1. The selection of a source had to be one which offered the greatest visual adaptability.
2. In addition, the mechanical adaptability of the original source would be a major factor in producing the final synthesis.

Primarily, deterrents to the composite product reflected poor initial source selection. The use of a third generation, prerecorded, out-of-production performance introduced the major technical limitations which plagued the remainder of the project.

Strength

The strength of this thesis was its ability to adapt and modify. Collisions between idealized and realized were, obviously, more frequent than desired or anticipated. However, out of these contrasts, alternatives and new processes were developed. Processes which, had the intended symbiosis been reached, would otherwise have gone unrealized. In retrospect, the obstacles encountered provided the new insights and precedents I sought. Therefore, however modified, the evolution of experimental exploration was challenged through the limitations of the original thesis intent.

Outline

Appendix A: Editing Basics

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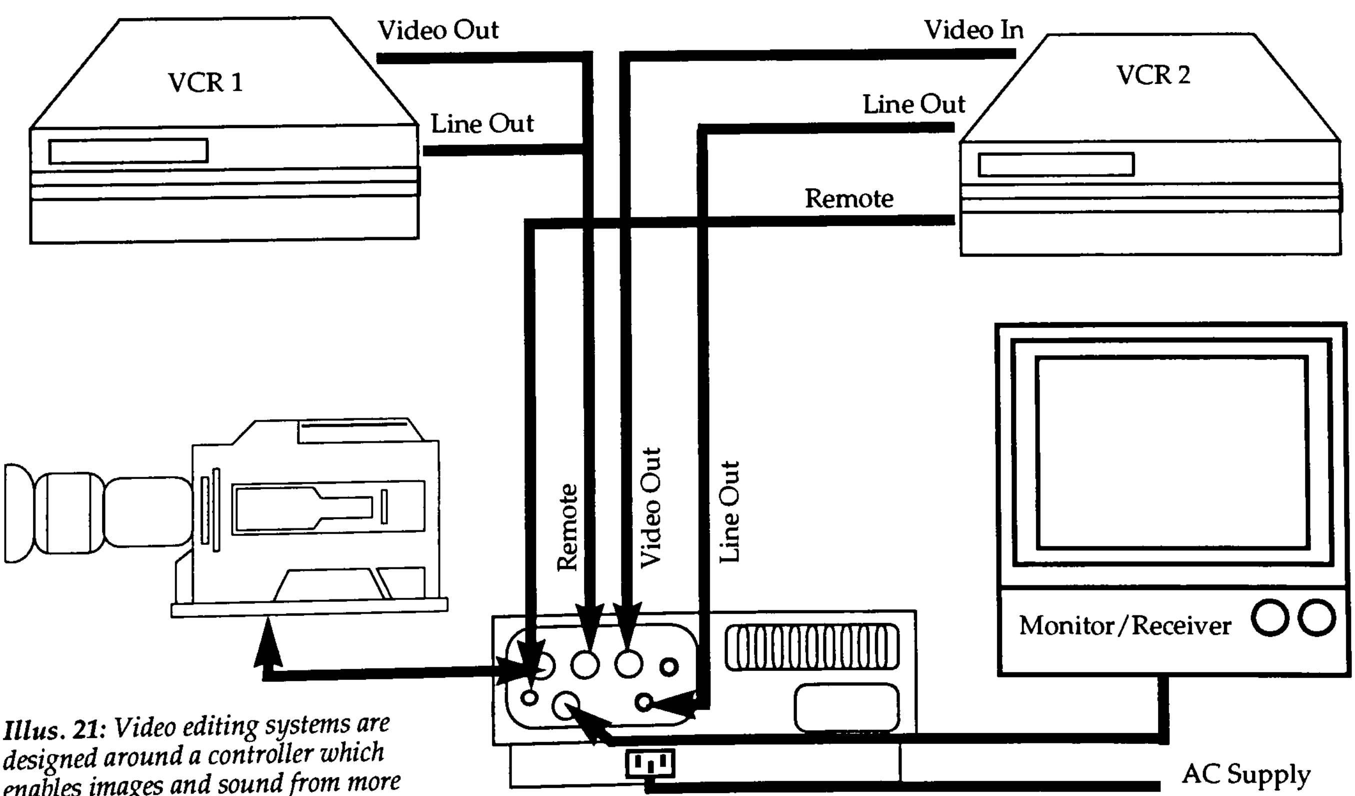
Video tape editing is the rearrangement of images and sounds from one tape onto another, enabling unwanted material to be discarded and new alignments made. The tape originally recorded is known as the master tape. When this tape is edited onto another machine, the second tape is known as the "composite master,"and referred to as a second-generation recording.

A. Editing

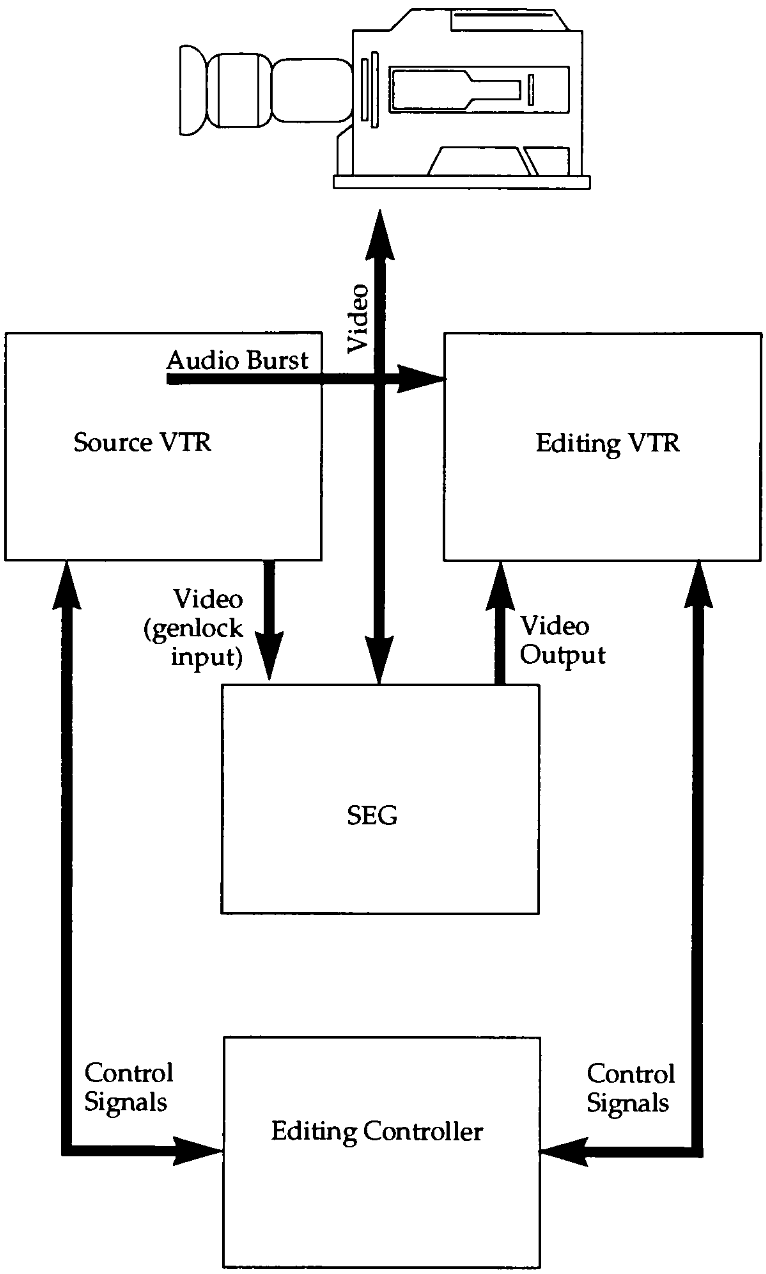
In order to provide a basic understanding of some general video editing principles, this Appendix has been generated. The material outlined on the next few pages has been primarily derived and consolidated from three sources: The Video Manual, Convergence Corporation ECS-90 Series: Preliminary Installation and Operations Manual, and Professional Video Production. In order to avoid a cluttered and disruptive narrative, the sections entitled "Editing," "Special Effects,"and "Monitoring Equipment" will be inclusively footnoted at their conclusions.

1. The Process

The object of a simple edit is to place each new segment on the edit master so that the first frame of the new material will start at precisely



Illus. 21: Video editing systems are designed around a controller which enables images and sound from more than one source to be assembled.



Illus 22: SEGs make transitional effects between cameras and auxiliary devices possible.

the point at which the last desired frame of the previous segment on the master ends. The composition, speed, and direction of movement in one shot will either glide into the next or collide with it. The visual result of the interface between the two segments is the primary objective.

Two machines are involved in editing: the "record" machine and the "replay" machine. The replay machine contains the originally recorded master tape. The second machine, known as the record machine, holds the compositing tape and must be capable of producing splices from one shot to the next without interference or frame roll.

2. The Editing Controller

Video editing systems are designed around a controller that enables the images and sound available at one or more source decks to be assembled onto a master tape. The controller is in part a remote control, and in part a dedicated computer, with its inputs, logic circuits and outputs entirely dedicated to the performance of editing operations (Illus. 21).

The controller's counter uses control track, both to regulate speed and to determine an edit point. In a two-machine edit, the editing controller regulates the replay machine and the record machine. By comparing times of the control tracks on the source and record decks, or replay and record decks, the controller can measure the difference in timing between the decks and generate a differential signal. By providing this signal to the capstan servo of the editing video tape recorder (VTR), the latter can be slowed or sped up by the required fraction until the vertical intervals of the two decks are perfectly matched. This prevents a disturbing frame roll.

3. Initializing a Tape

A new or blank video tape, by definition, contains no information on it. An initialized tape has a control track laid upon it for frame-by-frame recording and editing purposes. To initialize a tape, it must be prerecorded with either a black video signal or color bars over the entire length of the tape.

4. Black Burst

As described, editing requires a control track. Often control tracks are initiated through black burst. Black burst includes the entire television raster, with horizontal sync, color

burst and vertical sync in addition to control track. When a tape with black burst is run, the particles on the tape are organized into a black-level raster, with stable sync. Without a control track, a blank tape is not suitable for editing.

4. The Control Track

The video image is controlled by two sync pulses: line sync and field sync. Every videotape, in addition to the video picture and audio channels, contains a series of regularly spaced pulses on a control track. The control track is a signal consisting of one pulse per frame. If the pulses are irregularly spaced, a break-up of the picture, or frame roll, will result. The pulses are used to track the relative tape location, monitor the speed, and guarantee that edits are executed at the correct points. In addition, the pulses are also used to perform searches, prerolls, and previews.

5. SMPTE Time Code

During an editing session, control track pulse counting is not completely accurate. Occasionally a pulse is lost and can not be read. Therefore, it is often necessary to employ time code. SMPTE Time Code is the name given to the form of time coding developed by The Society of Motion Picture and Television Engineers. Time coding is control track information generated in digital form to give each frame on a video tape a permanent identification in terms of its position in minutes, seconds and frames from the tape head. It is recorded on an audio channel (on 3/4" recordings it is on a time code address track located in the vertical blanking interval). This extra signal carries an encoded number for each frame. Since the recorded numbers are permanent, once the tape moves up to full speed any previously undetected pulses are recounted.

6. Assembly Editing

The most basic form of editing is known as an assembly edit. Assembly mode is used to lay down black and sequentially construct separate segments of one tape onto another tape. If raw stock or a video tape without a continuous control track is used, assembly mode must be employed to achieve the edit. Assembly editing involves writing over the entire master tape, including the video picture, the control track information, and all audio tracks.

As discussed, two machines, or video tape recorders (VTRs) are involved in editing. The master tape resides on the VTR known as the replay deck and the compositing tape resides on the VTR known as the record deck. First the record deck is cued to an appropriate starting point, then the desired segment on the master tape is found, rehearsed, and precisely indicated to the editing controller. Next, a preroll is initiated, and the replay machine is set into motion. When the chosen entry point is reached the record machine begins taping. At the end of the section required for that episode, the pause is enabled on the record machine and the replay machine is used to find the next sequence on the master.

7. Insert Editing

Insert Editing requires much more sophisticated equipment and involves the insertion of audio and video (or video alone) on a previously recorded tape. Insert operations involve the insertion of selected parts of a program over prerecorded video material by using the existing control track as a timing reference. The prerecorded material is normally black burst. In this mode, it is possible to insert video only, without disturbing the existing audio; to dub one or another of the audio tracks separately without disturbing the existing video, or other audio tracks, and any combination thereof. Today, the insert mode is the primary mode used in editing.[33]

B. Special Effects

While the camera and the deck record the image, they are not unique to the editing suite. Special Effects Generators (SEGs), or switchers, are essentially editing devices that operate in production as well as post-production. In production, SEGs make trans-

itional effects between cameras and various auxiliary devices possible. A small range of special effects that may be achieved include: fades, mixes, wipes and keying (Illus. 22).

For an SEG to create transitions among the different images generated by two or more pieces of equipment, the images must arrive at the SEG on the same "time base." That is, they must be perfectly synchronized, so that the sync intervals of the lines and frames generated by each piece of equipment all start at the same instant.

To do this in production, all the devices used as image sources are "genlocked," or enslaved, to the sync provided by one source, such as the sync from one of the cameras, or from a sync generator. If a videotape recorder is used as an image source in a studio, however, then either the sync recorded on the tape is used as the genlock source, or the VTR must be equipped with a time base corrector (TBC). Whatever source provides the sync, all the video equipment used at one time must operate on the same time base.

1. Fades, Mixes, and Superimposition

A fade is a gradual increase or reduction in exposure. SEGs have separate faders for each camera. These act in the same way as volume controls on a sound mixer, and regulate the video gain of each input. For example, if camera 1 is selected as the output camera, the image from that camera can be faded up, or down to black and the effect may be observed on the output monitor. Alternatively, as camera 1 is faded down, camera 2 may be gradually faded up. The effect here is a dissolve, or mix, between one camera and another. The mix of the two inputs may be held at any given stage to produce a sustained superimposition. This can be used for a variety of effects.

2. Wipes

Wipes are essentially graphic devices, made when one image is transformed into another along the edges of a pattern. A wipe differs from a mix in that the incoming image occupies an ever-increasing area of the screen, and a hard line separates the incoming from the outgoing image. The wipe may be a straight-forward vertical or horizontal line. Alternatively, it may be a square, an iris, or any number of other variations. The direction and speed of the wipe can be controlled through the faders and through the controls on the SEG.

3. Keying

Keying is an electronic relative of wiping. Keys bring in the new image in specified areas, defined by luminance or chrominance. The keyers in most SEGs are luminance keyers. These are used, for example, to create the television subtitles which are generated against a black background and superimposed upon the action. The black background is ignored by the keyer, while the bright letters supercede the image where they appear. Where the luminance of the keyed letters is equal to that of the image, the letters become unreadable if they are not bordered.

Video also offers the possibility of chrominance keying, which is done by means of a chroma keyer that uses a specific hue to key an image. Traditionally, a central blue (chroma key blue) has been used for this purpose, because this color contains a minimum of flesh tones.[34]

C. Monitoring Equipment

Aside from editing controllers, video tape recorders, and special effects generators, editing suites usually include a variety of sensitive equipment in order to monitor the quality of the production. Some of the instruments used provide a means for identifying signal distortion, stability while other equipment provides structural compensations for signal inconsistencies.

1. The Waveform Monitor

A video waveform monitor is an oscilloscope designed to display the video signal as a linear trace, in formats standardized for television wave-

forms. It is designed to be used by video technicians to evaluate the amplitude and timing as well as the relationships between signals, but can also be read on a less technical level, to determine the electronic integrity of the image that is being, or has been recorded.

2. The Vectorscope

Vectorscopes are designed to check the color, or chrominance, relationships within a television image. As mentioned, color has two aspects, hue and chroma, which describe the actual color (hue) and its intensity (chroma, or chroma level). In production, vectorscopes enable the producer or technical director to match or "balance" two or more cameras, and to check that the signal recorded displays both correct chroma and correct hue.

Matching cameras involves checking that each is set for the same color relationships. If the two cameras are matched, the differential between the two can be minimized or eliminated entirely. However, when they are not, the entire scene will look off-color whenever there is a switch or dissolve from one camera to another.

In post-production, the vectorscope is also used to check color, primarily the color bars that should have been recorded at the head of each tape during production. The color bars will then indicate precisely how much color phase adjustment is necessary to provide a color-correct master. In dubbing, the vectorscope can be used to check the color bars on the master to make correct color dub.

3. Time Base Correctors

Video signals recorded and played back through VTRs are degraded. While first generation quality is acceptable, when edited, each generation amplifies the abberation. A time base corrector (TBC) adjusts the timing of the video signal. Primarily, this adjustment involves the time that each line starts, lasts, and is blanked. To do this, a TBC stores one or more lines of video at a time, comparing the duration of the blanking and sync for each line to a correct reference interval. If a line is a fraction early compared to the reference time, it is delayed by the fraction and then released. If late, the line will be delivered earlier.

Time base correctors also provide manual adjustments for hue, in terms of color phase, and chroma, in terms of chroma level. However, since color is affected by time base error, some improvement in color occurs automatically with time base correction. Manual adjustments therefore need not be made until the unadjusted output is observed.

NOTES

1 Gene Youngblood, "A Medium Matures: Video and the Cinematic Enterprise," in The Second Link: Viewpoints on Video in the Eighties, comp. The Walter Phillips Gallery of The Banff Centre School of Fine Arts (Banff, Alberta, Canada: The Walter Phillips Gallery of The Banff Centre School of Fine Arts, 1983), p. 9.
2 Ibid.
3 Charles R. Berg, "Fundamentals of Computer Graphics for Artists and designers," in Computer Graphics '84, Proc. of the Fifth Annual Conference on Computer Graphics, 13-17 May 1984 (n.p.: National Computer Graphics Association, 1984), I, p. 525.
4 Ibid.
5 Gerald Kahen, Jacques Callot: Artist of the Theatre (Athens, Georgia: The University of Georgia Press, 1976), p. x.
6 Christopher Finch, The Art of Walt Disney: From Mickey Mouse to the Magic Kingdoms from 1983 ed. (New York: Harry N. Abrams, Inc., 1983) pp. 192-193.
7 Kit Laybourne, The Animation Book (New York: Crown Publishers, Inc., 1979) p. 149.
8 Ibid.
9 Genigraphics Corporation, The Animation Products User Guide (n.p.: n.p., n.d.), p. 1-7.
10 Genigraphics Manual, The Video Upgrade Products User Guide (n.p.: n.p., 1986), p. Intro-3.
11 Ibid. p. Intro-2.
12 Basic geometric shapes, points, and lines define vector based imagery in point-to-point constructions. Pixel imagery is illustrated as bit-mapped configurations where the smallest unit possible, the picture element, is the foundation of image assembly.
13 David Cheshire, The Video Manual (New York: Van Nostrand Reinhold Company, 1982), p. 16.
14 Ibid.
15 During the 1986-1987 academic year, the one Genigraphics D plus graphics computer was the only system operating with The Video Upgrade Package. Graduate students were required to fairly divide the number of hours available on the system between the number of students requiring its services.
16 Bernoulli Boxes are removable-cartridge firm-ware devices designed for large storage capacities of digital information.
17 Cycle Paint is a real-time animation function of the Artronics Paint Package. It repeated shifts a specified range of colors from the palette forward by a specific number at determined time intervals.
18 David Cheshire, The Video Manual (New York: Van Nostrand and Reinhold Company, 1982), p. 21.
19 "In a video camera, the image coming through the lens is focused onto an electronic "signal plate", coated with photo-electric material. A very narrow scanning beam of electrons, emitted by a cathode, reads the resistance of the material into an electrical signal. This scan beam traces across the entire picture on the signal plate passing through a deflection coil which pulls the beam in horizontal and vertical directions. The deflection coil focusses the scanner in a continuous pattern until the entire picture has been scanned." Edward A. Kramer, "Analog to Digital Conversion: A History of Video Animation" in Computer Graphics '87. Proc. of the Eighth

Annual Conference and Exposition on Computer Graphics, 22-26 March 1987 (n.p.: National Computer Graphics Association, 1987), II, 366.

20 David Cheshire, the Video Manual (New York: Van Nostrand Reinhold Company, 1982),p. 175

21 Trevor Nunn, 2nd ed., "'We are fascinated by cats...'" in Cats:Souvenir Brochure comp. Mary Williams (London: Dewynters LTD, 1983), n. pag.

22 Gillian Lynn, "'a giant playground for cats'" in Cats: Souvenir Brochure comp. Mary Williams (London: Dewynters LTD., 1983), n. pag.

23 Ibid.

24 Eadweard Muybridge, Animals in Motion (New York: Dover, 1955), p. 39.

25 Genigraphics Corporation, The Video Upgrade Products User Guide (n.p.: n.p., 1986), p. 1-3.

26 Ibid. p. 1-4.

27 Tony White, The Animator's Workbook (New York: Watson-Guptill, 1986), p. 51.

28 Bruce Nesbitt, "Animating for Music video," HOW, May/June 1986, I, No. 4, 46-53.

29 The Use Brush function of the Paint Menu in the Genigraphics Video Upgrade Package calls up the current canvas, ready for painting. The menu will scroll away to give maximum work area. Genigraphics Corporation, The Video Upgrade Products User Guide (n.p.: n.p., 1986), p. 2-18.

30 White Balance is the system for calibrating color balance on a domestic color camera.
Gain is the degree of amplification of an electrical signal.
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