CATALOG / DIALOG

Paul Paternoster

B.F.A., The Cleveland Institute of Art, 1980

Submitted to the Department of Architecture
in partial fulfillment of the requirements of the
Degree of Master of Science in Visual Studies
at the Massachusetts Institute of Technology

June, 1984

Author: _____
Paul Paternoster May 11, 1984

Certified by: _____
Muriel Cooper, Associate Professor of Visual Studies
Thesis Supervisor

Accepted by: _____
Nicholas Negroponte, Chair
Departmental Committee for Graduate Students

Rotch

Catalog / Dialog

by Paul Paternoster

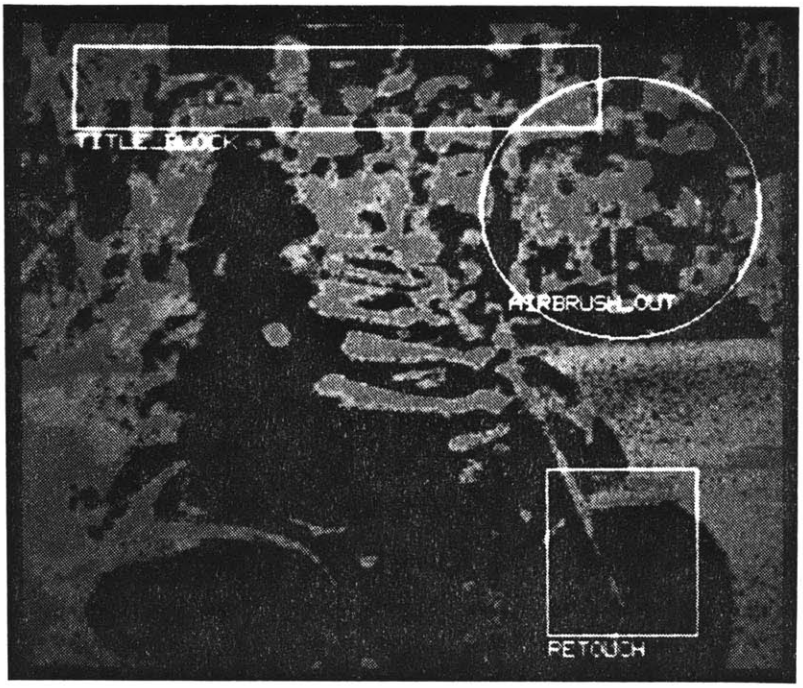
Submitted to the Department of Architecture in partial fulfillment of the requirements of the degree of Master of Science in Visual Studies at the Massachusetts Institute of Technology
May 11, 1984.

ABSTRACT

The organization and archival storage of visual records takes a variety of forms, from the family photograph album to the large picture files maintained by the news media. Common to all systems is the problem of the location and retrieval of particular images, to serve any purpose from page layout to illustrating a story.

The thesis will examine ways to personalize the cataloging of large bodies of visual data. Single frames of an optical videodisc will provide the storage mechanism and computer control of the disc will facilitate search procedures. Manipulation of a database associated with the disc frames allows the development of more than one way to order this sea of information, whether by a card catalogue system like the picture file or some personal chronology like the photograph album.

Thesis Supervisor: Muriel Cooper
Associate Professor of Visual Studies



DISC SEARCH is a system for the retrieval, organization and annotation of images that resulted from the research outlined in this thesis document.

CONTENTS

1: PICTURES AND PICTURE FILES

Black Bull.
c. 15,000-10,000 B.C.E.
Lascaux, France.
Janson, 1962

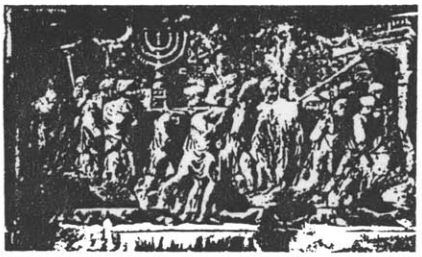
The earliest records left by human beings are visual. Over 20,000 years ago people were leaving significant marks that were not only a representation of the world around them but the expression of a wish. The wish for a successful hunt

Cave paintings.
c. 15,000-10,000 B.C.E.
Lascaux, France
Janson, 1962

or the perpetuation of their people.

Venus of Willendorf.
c. 15,000-10,000 B.C.E.
Janson, 1962

Images contained the narratives of both actual and ritual histories.



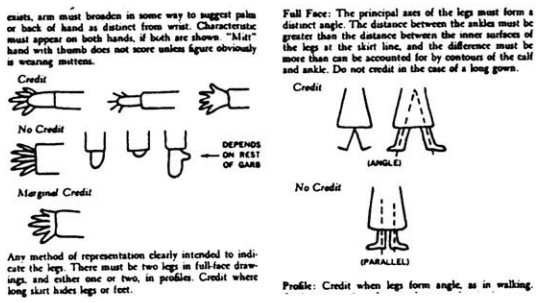
Spoils from the Temple in Jerusalem.
81 A.D., Rome.
Janson, 1962.

Guernica.
Pablo Picasso, 1937.
Janson, 1962.

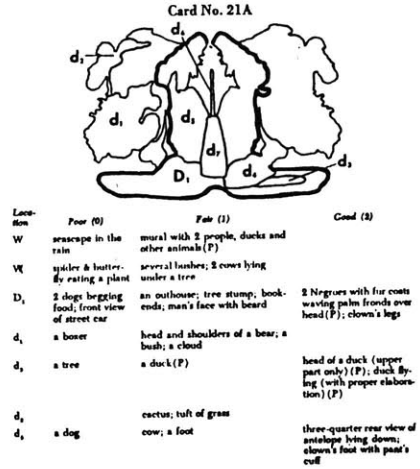
The Battle of Hastings.
from the Bayeux Tapestry, c. 1073-83.
Janson, 1962

The Annunciation.
Master of Flemalle, c. 1425-28.
Janson, 1962.

The study of the communicative power of images and the translation of the messages they convey concerns the archaeologist, art historian, psychologist, educator, designer, and the marketing analyst trying to sell a product in a new way.



Goodenough Draw-a-Man test interpretation chart.
Harris, 1963.



Inkblot interpretation card.
Holtzman et al., 1961.

Underground signage.
London.
Gombrich, 1982.

Donis Dondis in A Primer of Visual Literacy examines the types of messages that are contained in images in an attempt to discover an underlying visual vocabulary. She divides information encoded in images into three parts:

> "Visual data has three distinctive and individual levels: the visual input, which consists of myriad symbol systems, the representational visual material we recognize in the environment and can replicate in drawing, painting, sculpture and film; and the abstract understructure, the form of everything we see, whether natural or composed for intended effects." (Dondis 1973)

This attempt to break down the image and extract the correspondence to its verbal identity is part of a long history of image analysis. Ancient peoples believed that to name a thing was to control it. Naming a picture gives it a dimension and a place in relation to other pictures.

PICTURE FILES

Not only is this a visual culture but it is a visual culture based on the photographic image. Photographic images that attempt to persuade are found on packages, in advertising and on billboards. Images that inform (and sometimes persuade) are found in newspapers and magazines. In my pocket I carry three small images of myself that identify me more convincingly than a verbal declaration. And all of these purposes and more are fulfilled by the images broadcast on television. The pervasiveness of the photographic image even a century ago is summed up by John Berger as follows:

> "The camera was invented by Fox Talbot in 1839. Within a mere 30 years of its invention as a gadget for an elite, photography was being used for police filing, war reporting, military reconnaissance, pornography, encyclopedic documentation, family albums, postcards, anthropological records (often, as with the Indians in the United States, accompanied by genocide), sentimental moralising, inquisitive probing (the wrongly named 'candid camera'), aesthetic effects, news reporting and formal portraiture. The first cheap popular camera was put on the market, a little later, in 1888." (Berger, 1980)

What happens to the billions of images produced? How are they organized, stored and retrieved? I focused on three different systems of the many that

exist for the organization of visual records when I began thinking about picture storage and retrieval. All three are shaped by both the end uses perceived by the designer and by the quirks introduced in a development process that took place over a period of years. The three systems are: a family photograph album, a stock photo file, and the picture collection belonging to a news publication.

THE PHOTO ALBUM

The family album that I studied is one that I know very well, since I have been looking at my grandmother's photograph collection for two decades. These images have had meaning for me that is tied up in the objects and people they portray plus my own sense of connection with the history they document. Berger summarizes the role of these images as follows:

> "The private photograph - the portrait of a mother, a picture of a daughter, a group photo of one's own team - is appreciated and read in a context which is continuous with that from which the camera removed it." (Berger 1980)

These photographs were organized in the following way: An initial selection was made with each photograph, whether to add it to the bound photograph albums or not. The photograph albums are organized chronologically, beginning with a wedding portrait of my great grandparents from 1885. The largest numbers of images document events of the 1930's through the 1950's and they then taper off in quantity ending with the early 1970's. There is a structured format: all photographs are presented in a linear array and are

captioned with white ink on black pages.

These are the formal albums and the subjects and identifiers are short, listing only the people in the photograph, sometimes the place or event and the date. History is seen as a list of pictures and labels. Still, the personality of the maker is evident. The photographs were selected because they were important to an individual, for reasons that are sometimes unclear to me because of their non specific captions. As an example, there is a group shot of about forty small children wearing adult formal dress whose caption reads only "1929".

However, over half of the total number of photographs did not make it into the albums but were sent to the other branch of the family picture library, a large tin. These images were also organized but under different criteria. Some are loose and include photographs too large for the albums or subjects not interesting (a photograph of a lawn chair or a thumb over the lens). The rest are in small envelopes, sorted by criteria such as type of camera used, period of time taken, or subject (several generations of an aunt's dogs). It is in examining these and the notes written on both back and front that I have found some interesting pictures of short histories that were important enough to keep but not important enough to enter into the formal albums. The

following two snapshots are in an unmarked envelope:

The backs of both are stamped by the processor with the year, 1946. The one on the left has no inscription, but the one on the right has written on the back "This is the first photograph Aunt Polly has ever taken!" By examining who's missing from this photograph I can identify Aunt Polly. I can also make some guesses as to her involvement with media technology by the inscription.

It is the combination of factual with personal information that makes this photo album a successful picture library, well suited to its purpose although for a limited audience.

Barbara Norfleet, a photographer and an historian of photography, has examined photographs taken by studio photographers in an effort to uncover a larger story about the history of American social life. Her approach to organizing and interpreting the same kinds of images that I reviewed from my grandmother's collection is quite different. With no personal connection to the subjects, she is more free to draw

general conclusions about the circumstances surrounding each image. In this way the image with her translation becomes a map describing middle class American life. In the same way my grandmother's photographs provide a map but of different terrain. My involvement with the images and the additional information provided by captioning provide a base of information that is unique to me, with the same images interpreted differently by another viewer.

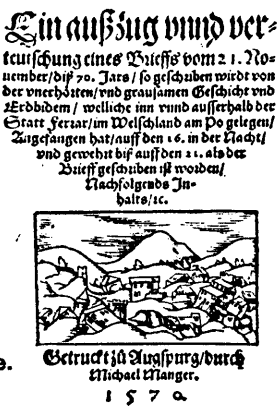
The interdependence of photographer, subject and viewer are summed up by Norfleet in the introduction to her book The Champion Pig:

> "It is possible to analyze a photograph as a work of art or for its information on material culture because all the information you need is in the photograph, but to interpret the picture's meaning requires information outside the photograph. Like the historian, who edits his raw material, the photographer chooses his subject, frames it to include and exclude, and at the moment he sees fit, clicks his shutter. The result of this interaction between a person with a camera and a subject at a particular time and place is then seen by the viewer who also edits the photograph as he filters it - unconsciously - through his frame of reference." (Norfleet, 1979)

STOCK PHOTOS

I will only briefly discuss my experiences with stock photography files. Both systems were unsatisfactory but proved another perspective on the problem of image organization.

Stock photographs are intentionally bland in character, meant to serve multiple purposes in a variety of applications. Large files of generic images are kept by institutions or by private companies who make their picture libraries available to a customer. The practice of substituting stock imagery for a depiction of the real thing is not new: below are shown two examples of the precursor to the newspaper, the broadsheet, publicizing different natural disasters with the same illustration. (Gombrich, 1982)



Ein außzug vnnd ver-
teutschung eines Briefs vom 21. No-
vember/diß 70. Jars/ so geschriben wirdt von
der vnerhörten/vnd grausamen Geschicht vnd
Erdbidem/ welliche inn vnnd ausserhalb der
Statt Ferrar/im Welschland am Po gelegen/
Angefangen hat/auff den 16. in der Nacht/
vnd gewehrt biß auff den 21. als der
Brieff geschriben ist worden/
Nachfolgends In-
halts/ꝛc.

Getruckt zů Augspurg/durch
Michael Manger.
1570

The Ferrara earthquake. 1570, Sammlung Wick. Gombrich, 1982.

Warhafftigeerschrecklí-
che Beschreibung der Newenzeitung
vnd grausamen Wasserflutt/ welche sich am 12.
tag Augusti/ dieses 1573. Jahrs angefangen im
Voigtlande/ vnd herumb daselbs vmb im
Meyssnerlande/ an Menschen/ Viehe/
Gebäwen vnd Getraide/ einen
vberauß grossen schaden
gethan.
Mit einer Christlichen Vermanung
an den Leser/ Durch H. F. E.

Lucæ/ 21.

Gedruckt zu Nürmberg durch
Hans Koler.

A catastrophic flood in the Voigtland. 1573, Sammlung Wick. Gombrich, 1982.

The first stock image file I used extensively was maintained by the art school I attended. It was intended to be used like the school's collections of stuffed birds and animals or plaster casts, as a source of models for the students. While the plaster casts had become studio decorations and the stuffed animals were disintegrating, the picture file was continually being used, edited and expanded.

Over the one hundred years of the school's existence it had grown to the extent that it filled two rooms with file cabinets. No one, however, approached the file with a specific image in mind because it would never be found. It was better to browse for a few hours and hope that something usable would surface. In this manner the system adjusted the researcher's request to what was available rather than accomodate the original desire.

Ostensibly, there was a system to the filing. Pictures were identified as to their content, similar images being grouped together and then filed alphabetically by this label. However, with a century of librarians and student employees doing the filing without any published guidelines, labeling became worse than idiosyncratic - it became completely

obscure. For every file given a succinct label such as "French tapestries" or "whales" there would be a file whose title was so unique to the person who did the filing that it was useless to anyone else. An example was the file "Noses, large" that contained photographs of people or portraits featuring large noses.

This problem was solved partially by a major reorganization where all of the unusual files were scrapped and their contents redistributed either to other, more general files or to the trash. Now the problem was the creation of large files with titles like "Birds". Again, the specific images were often lost in the new groups of hundreds. A compromise between the general and the unique had not been reached.

The Boston Public Library uses a similar classification system for organizing the approximately 125,000 images in their circulating picture file. An initial division was made based on patterns of use. Two hundred twenty file drawers hold pictures organized by subject and one hundred eight file drawers hold pictures organized by geographical locations.

Pictures can be located either by browsing through the file drawers or by checking a card catalogue that

lists picture categories, a category representing a manila folder containing pictures related by subject matter. There is no listing of individual images but the categories are specific enough that there are no more than about fifty pictures per category. A minimal amount of cross referencing is done, usually to more general related categories rather than more specific.

As a designer, I have had experience with commercial stock photo houses when looking for images to use in advertising or publications.

To generalize, stock photo houses organize their images into broad categories based on content. The categories are given names like "children" or "cities". These categories are in turn broken down into smaller groups that are given slightly more specific titles, like "New York". There is little or no cross referencing and at this point the only way to make selections is to start looking at all of the pictures in a file. While this is more efficient than the idiosyncratic file names mentioned earlier, it has the same problem as the file "Birds" - in an effort to present the images in categories that are easily understood by the most people, the qualities of individual images have been ignored. Without a way of cross-referencing or making notes about particular images, again there is not a compromise between the

general and the unique, making the search for particular images time consuming.

TIME INC. PICTURE COLLECTION

A commercial picture file that has attempted to solve many of the problems listed above is the Picture Collection of Time Inc., an enormous archive serving all of the corporation's news publications.

This picture filing system has also evolved over a number of years. Unlike the art school image file, it was realized early on that a structure would have to be imposed on the filing and cross filing of images numbering in the hundreds of thousands to keep them in a usable order. A comprehensive manual outlining filing and retrieval procedures is available, I used the most recent addition, updated in 1980.

Time Inc.'s picture collection system has evolved to meet changing needs in the corporation, with changes being carefully documented and worked into the overall system. Some of their solutions to particular problems bear study when considering the design of any method for cataloguing hard to define materials.

A filing language has developed within the Picture Collection department and has been recorded in the Glossary section of the manual. Its entries give

some clues as to the history of the system and are also examples of how the personal habits of the employees helped to determine its form. Some examples of Glossary items are:

> "CHERRY: (This procedure was discontinued in October 1976) A cherry is another word for a temporary card. The Life black and white temporary card is bright pink or cherry-colored and was filed behind cards for Life black and white fully cross-referenced sets. Although they weren't pink in color, we also called temporary cards for the Time sets.....etc.
>
> PFs: Stands for Personality File. We generally refer to agency pix which file under a personality name as PFs. Cross-reference cards classified to personality are also called PFs.
>
> TAKE: Group of photos within a set that cover a particular phase of the story.
>
> V-SETS: Restricted sets. "V" (for verboten) appears before the set number."
> (Picture Collection manual, 1980)

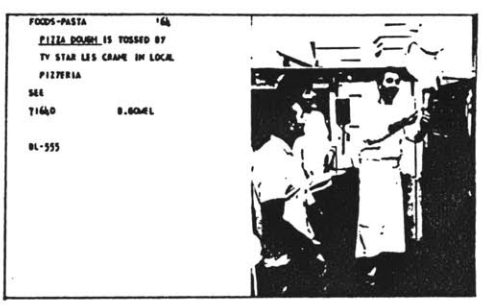
An unusual feature of the Picture Collection is that certain divisions were made in the materials that were based on criteria other than a label of image content. The photographs are grouped under three main headings: Agency pictures (pictures purchased by Time Inc. from one of the photo agencies or another publication), color sets and black and white sets. In turn, the Agency section is itself divided into two separate files: the personality file and the subject file.

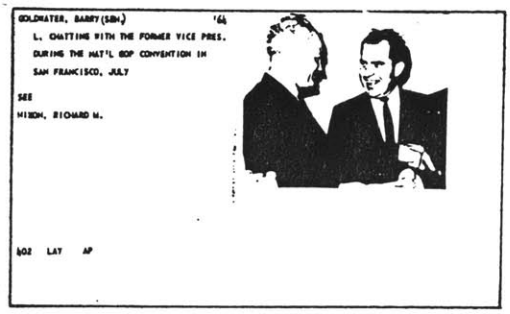
The groupings represent a difference in function. Color and black and white sets are commissioned by

Time Inc. to work with a specific concept for a specific issue. They are not often refered to after their initial publication and are filed together as sets under the overall classification of whatever the original assignment topic was. They are occasionally pulled and used individually, but not often.

The Agency file is the working image vocabulary of the Picture Collection. Time Inc. purchases thousands of images from the agencies based on whether they might prove useful in the future as well as whether they fulfill a current need. The pictures that are not used immediately are sent directly to the Picture Collection, to be referenced, extensively cross referenced and filed. Now a library has been developed so that if a person or subject becomes newsworthy, a check of a few categories could provide an editor with an instant visual accompaniment to an article.

Black and white sets in addition are identified in the reference files by cards called photo crosses. A representative shot from each set is attached to one side of the index card, giving a visual indicator of the contents of the set as well as the text descriptors:





If the Chinese saying "One picture is worth a thousand words" is true then each of these cards tells the searcher an entire story about the picture sets. The simultaneous display of an image with its text descriptor and the development of categories based on information other than a description of image content are the two most important qualities of the Time Inc. Picture Collection's filing system that set it apart from the systems described previously.

All of these systems for picture filing illustrate different ways of interpreting visual/verbal information relationships. What is distinctive about image bases when compared to other database types is that this relationship becomes a factor at all. The verbal information to some degree is seen as a translation of the visual information and the key that gives the image a context for evaluation. Some information heirarchies are designed to accomodate specific review procedures, like the elaborate filing system of the Picture Collection. In this instance,

the image base leans strongly in favor of the verbal identifiers. Because of the origin of the images and the established pattern of their use, the images are subordinate to some news item that they represent. This specific mode of identification requires that a user have a certain level of prior knowledge in order to track down particular images. The prior knowledge is obtained by using a manual. There really aren't any naive users to be considered as all requests are handled by a staff trained for that job.

Others picture filing systems like the photograph album are based on completely personal visions of what is significant information. The photograph album leans more toward the purely visual organizational scheme. Verbal tags are minimal and images are arranged chronologically in the formal albums. A curious anomoly is that these images were intended to preserve an historical record yet without the verbal description of a guide the history is lost. Even participants in some of the portrayed events now don't know the reason for taking the photographs in which they appear. This picture system requires not only a high level of prior knowledge but a perfect memory as well.

The stock photo collections and the library collections fall somewhere in the middle. They are not so strongly verbal in their organization, but

even more general verbal labels require some prior knowledge of the overall structure. For an image collection maintained by an art department library, some knowledge of the way the history of art is currently categorized is helpful. Stock photo houses base their organizational system on divisions that they think are useful to the advertising industry.

The project part of my thesis demonstrates one way of combining the personal notations of the photograph album with the more accessible subject categories of the other file types. These are not the only file types that exist. The image files of museums may follow slightly different criteria for the organization of images or artwork such as creator of the image in question or historical significance rather than a description of image content, but the basic mechanism is the same. In all cases, an external structure is imposed on the body of visual materials that requires the cooperation of the researcher as passive user rather than creative participant. There exists a body of literature in the field of library science that discusses the problems of picture filing systems, but the approach is one of listing subject headings appropriate to the nature of the picture file rather than an investigation of user interaction. A natural development of the search

systems described earlier would be the addition of a mechanism for allowing researcher input in the form of useful annotations and alternative filing categories natural to the specific application. DISC SEARCH resulted from my investigation of this idea. Since an integral part of this filing system is the introduction of an optical videodisc as the medium for image storage, a discussion of that technology follows.

VIDEODISCS

Developing media technologies make available options for changing traditional forms of visual record storage. All of the filing systems described earlier require keeping quantities of paper records on hand. These records can occupy great amounts of space, be difficult to duplicate, and are vulnerable to damage or loss. All of these things define an information system that is tied to an environment, a system that requires the user to come to it and use it on its own previously defined terms.

An alternative currently available and just starting to be utilized is the optical videodisc. The videodisc was developed and introduced to the commercial market as an entertainment medium. At first it was used to distribute theatrical films, later products included instructional materials like the First National Kidisc (© Optical Programming Associates).

What is inherent in the structure of the optical videodisc that makes it a suitable medium for mass storage of documents? The source of information that

is stored on a videodisc master is a standard video signal. This signal, after some conversions and filtering, is used to control the movement of a laser focused on the surface of the master, a glass disc that has been coated with a photosensitive resin. As the disc spins, the video signal causes the laser to etch pits into its surface. The length of the pits corresponds to the pulses of the signal and in just one revolution of the master, all of the information necessary to produce a single video frame is stored. A standard half-hour disc can accomodate 54,000 frames of information. The master is plated and used to stamp out plastic duplicates which are coated with a reflective material. Now when a laser beam in the disc player is focused on tracks in the disc, the deflections of the beam as it is reflected by the pits can be measured and used to reconstruct the original video signal.

One of the earliest projects that took advantage of the single frame nature of information storage in an optical videodisc was the mastering of the Slidathon disc by the Architecture Machine at MIT. The majority of the disc's 54,000 frames are made up of images from slides in the Rotch Library's slide collection. Since each disc frame also has encoded the disc frame number, individual frames can be

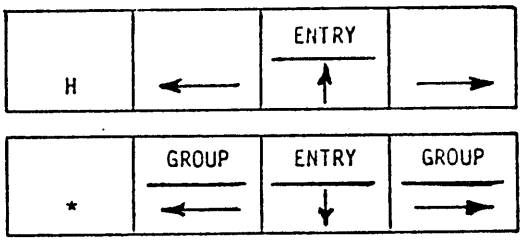
accessed randomly and displayed. When this capability was tied to software controls for driving the disc and an associated database that related text information with each disc frame the optical videodisc's applications grew from the linear presentation of film sequences to the dynamic archiving and retrieving of visual data - the electronic file drawer. Research is also underway to develop the videodisc as an incredibly dense medium for the storage of digital data.

Videodiscs have none of the disadvantages of paper records when considered for archival record storage. Discs are compact - one disc can be thought of as the equivalent of 54,000 sheets of paper. They can be stamped out in multiple copies. Once a document is stored by encoding it into a disc frame it is locked there forever, eliminating the danger of lost records. Driven by computer and with an associated database the optical videodisc is a storage system that is portable and plastic. Of course a video image can not replace the vellum folio of an illuminated manuscript or the weight and texture of a well crafted volume. However, for almost all applications its resolution and information carrying ability are acceptable and its portability and information density are superior.

Although examples of videodiscs being used for record storage are continually being introduced, their

numbers do not accurately represent their range of capabilities.

A pilot project completed in 1980 by the Public Archives of Canada is the first step in their plans to store their active holdings on videodiscs. They have calculated that the total amount of this information is approximately 7,400 parabits (one parabit equals one million million bits) which could be stored on approximately 19,000 discs. The pilot disc that they have produced has the interesting combination storage of both digital and visual data. Designers of the disc also attempted to solve the problem of displaying large format documents with very high resolution such as maps by considering them a matrix of separate frames that can be "roamed" by using the special function keypad shown below: (Mole, 1981)

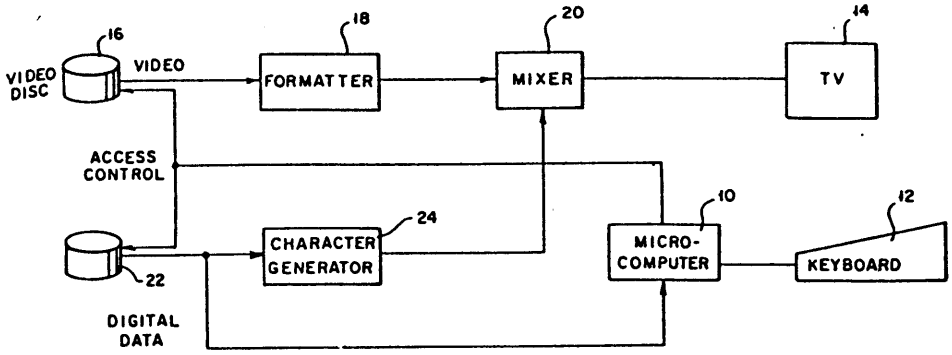


Special frame-manipulation keys. Mole, 1981.

The National Library of Canada followed this project by producing their own pilot disc in 1982. On two sides they chose to store four productions: a promotional film titled Canada's National Library, a slide show Canadiana, a History of 'O Canada' (The

Canadian national anthem), and another promotional film Walk Through the National Library. While the content of the final product is not innovative or interesting, the article written by the project manager for Special Libraries is an instructive history of a project where every beaurocratic aspect of mastering a disc caused problems, from the use of outdated materials to bilingual requirements. (Sonneman, 1983)

IBM has recently published their design for a video disc dictionary system. By using a video disc to supply visual information such as diagrams or short animations and audio information as an aid in pronunciation, its developers hope to amplify the text information stored on a digital data disc. Use of a video mixer will allow the simultaneous display of text and images. A diagram of the system's components is shown below: (Cohen and Herbst, 1983)



Video Disc Dictionary System: Hardware configuration.
Cohen and Herbst, 1983.

My project was to explore the use of this medium

as an image archive in the context of the Visible Language Workshop at MIT. The development of my picture file system, DISC SEARCH, built upon these appplications and the picture file systems described earlier.

2: THE PROJECT: DISC SEARCH

THE LABORATORY ENVIRONMENT

The Visible Language Workshop is a multi-use graphics research laboratory at MIT, a part of the Media Technology Laboratory and Department of Architecture. Central to the Workshop is an interactive computer graphics system with software tools for image processing (SYS), page layout (PAGER) and page management. In addition the laboratory functions as a new studio environment for artists investigating the applications of new technologies to the visual arts.

Currently, five methods are used for the storage of the images produced or employed by these systems. They are:

1. Storing the image in memory in the picture directory.

2. Images can also be stored in one of the several levels of the substructure called Big Picture in SYS.

3. Images that are not currently being used are saved on magnetic tape or video tape.

4. Before the image is loaded on tape, generally 35 mm slides are made.

5. For a very few images, 8 X 10 or 20 X 24 Polaroid prints are also made. These last two options should be considered as documentation of the image, not as storing the image itself.

There are problems inherent in each of these methods for some applications. While the picture directory offers a simultaneous visual review of all stored images, the total number of full screens that can be stored is only sixty. Loading a full screen image is also a slow pixel by pixel process. The long delays in loading a series of images make it difficult to make visual comparisons between full screens or to do any sequencing.

Magnetic tape offers a way of storing high quality images but with no possibility of visual review. To see what is stored on tape, it has to be loaded first into an available slot in the picture directory and then loaded into the frame buffer and sent to the screen.

Introducing an optical videodisc into this environment will increase the speed of retrieval, volume and flexibility of image storage. Tens of thousands of full screens of information can be stored on single frames of a disc that occupies the same physical space as a reel of magnetic tape that can hold sixteen images. Each of these frames can be accessed randomly by the computer and and each can be sent immediately to the screen. This speed of

retrieval allows rapid comparison between images, an aid to examining alternative selections or pagination sequences and facilitates planning and editing of the materials used by the other systems.

As important as the increase in volume of images that a videodisc allows is their plastic nature. Since these images are video signals and not physical objects like those in the picture files of part one, they can be manipulated or "marked" through the use of a video mix without losing the original image. Also, their order can be changed by a reassignment of sequence numbers in an associated database without changing the absolute order represented by their disc frame number. These two qualities make possible the creation of a variety of image files from the same source material without altering that source.

HARDWARE

The hardware configuration required by DISC SEARCH is centered on a 32 bit general purpose mini computer, a Perkin-Elmer 3220. The operating system is MagicSix, developed at the Architecture Machine and similar to Multics. Programs were written in PL/1.

Two user interface devices are used, a terminal and a graphics tablet with puck. Two monitors are also used, a color monitor and frame buffer manufactured by Grinnell Systems and a auxiliary black and white monitor for displaying menus and other information.

The videodisc player employed is a Pioneer VP-1000, chosen because it has the capability of reading frame number information encoded in most discs, allowing single frame viewing.

THE DISC

The disc I chose to use is manufactured and leased by FirstVision. It is a collection of stock photographs on single frames and was conceived as a tool for graphic design and illustration.

This disc was chosen because it provided a broad spectrum of image types. It also has been organized into thirty eight categories that make the creation of a global database containing information about the disc frames possible. The picture categories are:

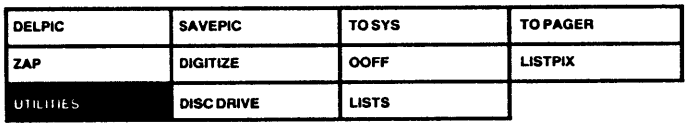
> abstracts, accidents, agriculture, air/atmosphere, aircraft/airplanes, America, amusements, animals, art/crafts, automobiles, babies (1st year), beverages, buildings, business, cemeteries, children, couples, dance, ecology/environment, energy, family, food, health/physical, highways, holidays, industrial/people working (in), luxury statements, men, music and entertainment, natural disasters, parades, people, religion, scenics, seasons, sports, women, world places.

These are the components of DISC SEARCH. A walk through the menu and a description of a possible use scenario will clarify the current form of the project.

THE MENU

At the first level of the menu, the user is presented with three choices representing three options for using the disc. These are: UTILITIES, DISC DRIVE, and LISTS.

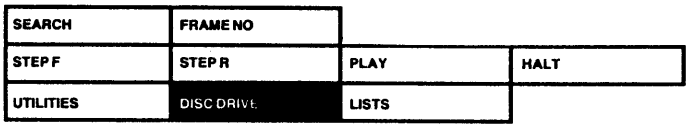
Choosing UTILITIES branches to a next level of eight functions that relate to image storage and manipulation, the end uses for the images selected by DISC SEARCH.



These functions are: ZAP, which clears the screen, OOFF (overlay off), which clears only the overlay planes of the Grinnell, and DIGITIZE, which will allow video input from the disc player to be grabbed and read into the frame buffer. To save an image in the picture directory installed in the VLW system, LISTPIX allows the user to check if there is room to save anything by listing this directory, DELPIC deletes pictures if necessary to make room and

SAVEPIC will assign whatever has been digitized a space in the directory. This facility to save images is what gives DISC SEARCH practicality when used in the context of the VLW. The last two choices at this level, TO SYS and TO PAGER, branch to the image processing system SYS and the page layout system PAGER where images chosen by DISC SEARCH and stored in the picture directory may be employed as source materials.

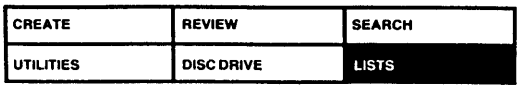
The next branch at this first level of the menu, DISC DRIVE, allows the user an unstructured browsing of the frames on the disc.



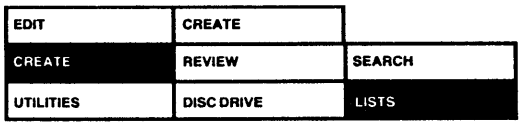
Here the purpose is to get an idea of what types of images are on the disc without the framework of a particular task. Choices in this branch are: STEP F which advances the disc one frame, STEP R which steps back to the previous frame, PLAY which displays consecutive disc frames at the rate of 30 frames per second, HALT which stops disc play, SEARCH which will display a frame whose number is specified by the user, and FRAME # which will display the current frame's number.

The last of the three initial choices, LISTS, is where the most interesting options for using the disc are located. This branch contains the systems for

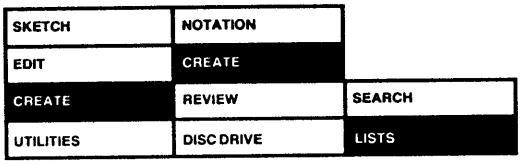
searching, selecting and marking disc frame images.



After choosing LISTS, the next level also presents the user with three choices. They are: CREATE which accesses systems for creating groups of selected images, REVIEW which allows the viewing of image files that have already been created and SEARCH which allows the location of particular images.

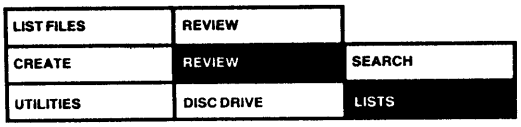


Two different tactics are contained within the action CREATE. They are: CREATE which allows the creation of a new picture file from scratch and EDIT which by allowing the editing of an existing image file creates a new one.



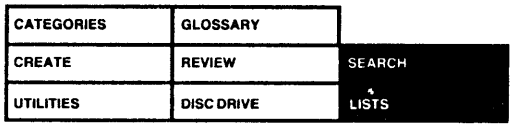
I wanted to demonstrate two different methods for creating image files in DISC SEARCH. What both have in common is the association of marks made by the user, hopefully with some significant meaning, that can be displayed on top of selected disc frames. The quality of these marks takes two forms. In the one

called SKETCH, the marks are made as if by an electronic wax pencil - the user can sketch freehand on top of the image on the display, storing information about these marks and the image's disc frame number in a file with a name and descriptor given by the user. The other marking system, called NOTATION, is meant to store more formally constructed information. Areas on the images can be outlined with circles or rectangles and then captioned with a text label. As in the SKETCH procedure, the outlines, text labels and disc frame number are stored in a file for later review. These two systems are a step towards creating a personal picture file from a general source.



The other tactic for creating picture files, EDIT, provides the user with three functions. They are LIST FILES which provides a list of all picture files created to date, DELETE FILE which allows the deletion of an entire picture file and EDIT which allows the insertion or deletion of particular frames and associated notes in an existing picture file.

REVIEW, the second branch of the LISTS triad, has a function similar to the browsing facility of DISC DRIVE. Selecting it branches to LIST FILES, which again will list all picture files and REVIEW which once a file has been selected will play back each image in that file and any markings associated with that image.



SEARCH is the last of the LISTS branches. I have provided the user of DISC SEARCH with two different methods for locating particular images on the disc other than the random viewing permitted in DISC DRIVE. These methods are called GLOSSARY and CATEGORIES.

CATEGORIES provides the most straightforward approach to searching for an image. A global database has been constructed that identifies images on the disc by a description of general content, like conventional picture file systems. There is however an addition: each frame is also associated with morphological data about the image. The information I have chosen to save is color and primary orientation (horizontal or vertical). These categories of labels can then be selected and all pertinent frames can be pulled and examined.

GLOSSARY also locates images that match user-chosen categories, but draws on a different library of information. Each time an image was selected by either of the systems NOTATION or SKETCH, the user was prompted to provide a text identifier associated with that particular image. These identifiers were stored in their own library, a glossary of word/image associations that can now be opened and examined. As in CATEGORIES, glossary entries can be selected and the associated frames viewed.

SCENARIO FOR USE

How might this system be employed? A designer comes to the system with a task that involves the selection and gathering together of a number of images, whether they are ilustrations to be used in a layout or key frames of an animation sequence. An optical videodisc provides the source file of images.

A global database providing general information classifying these images by content and morphology is available to the operator allowing a 'first pass' at the disc frames: say the task is to find images suitable for a promotional brochure for a utility company. General topics to be explored might be 'air/atmosphere' for images of electrical storms, 'industrial' for images of the facilities and equipment being discussed, or 'family' for images of the domestic consumer of the client's product. All of these topics are part of the global database, narrowing down the number of images to be reviewed by a significant amount.

To further narrow down the search, these subgroupings of images could also be searched on the

basis of morphological information that is also stored in the global database. Without yet viewing a single frame, the operator could mark all images that are vertical or black and white.

Once this first pass has been done, this initial grouping of images can be examined and selections made using the 'notation' and 'sketch' systems that are currently installed. Production notes useful to the designer can be drawn on top of the disc frame images and stored along with the frame number- essentially this is an electronic wax pencil. Now whenever this particular file of images is opened, the notes made by the operator can be viewed on top of the images, just as they were drawn.

What about images that fall between the cracks of the initial classification system? Every application or meaning evoked by an image could never be anticipated by the creator of the original database. This is where the GLOSSARY database fits in, by providing a growing library of personal cross references.

3: THE BIGGER PICTURE

DISC SEARCH attempts to expand the standard vocabularies of image organization by basing its systems on the three catagories of image content defined by Dondis and quoted earlier in this paper. Her divisions are:

visual input - symbol systems
representational material
abstract structure

The glossary made up of user-chosen identifiers corresponds to a symbol system where a significant word or phrase represents the image. The global database corresponds to the remaining two categories. Representational material is the same as the disc category names that are an abbreviated identification of image content. Abstract structure is named by the morphological data included in this database, the color or orientation of the image.

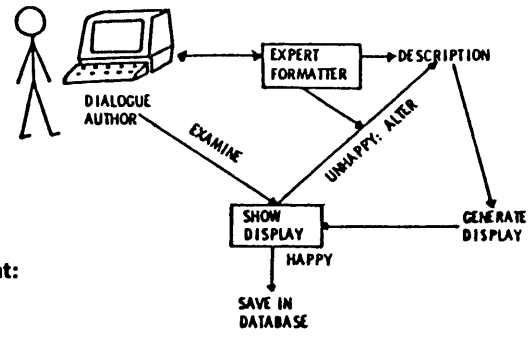
One other feature of DISC SEARCH, the systems for marking disc frame images, points to another issue in computational research, the personalizing of computation processes. As computers proliferate in both professional and consumer markets, personalizing

computation processes becomes an increasingly important issue. Attempts to make the exchange between operator and device comfortable and familiar can be seen in a variety of applications ranging from the 'pages' of videotext publications to the cluttered windowed desk tops of personal computer systems to the rapid interaction of video games. Many of these employ the power of the visual image to condense data and introduce the ability to 'edit' this image whether by manipulation of the image itself or a change of position.

Recent advances in hardware technology make possible more complete sensory involvement of the operator, such as the gesture tracking and voice recognition of the Media Room, also at the Architecture Machine, MIT. In this environment, both verbal commands and gestures made by the operator can facilitate actions, making communication between user and device more natural. (Negroponte 1981) Paralleling these developments, advances in artificial intelligence and computation research are making possible systems that are 'personal' in the sense that they mimic the behavior of a skilled assistant to the user, the expert systems.

One example is the Visual Design Consultant being developed by Roach, Pittman, Reilly and others at Virginia Polytechnic Institute. The goal of the

research was to develop a system that could operate as a graphic designer, accepting specifications and producing sample displays. This was accomplished by encoding rules of 'good' design based on principals of balance, sequence, emphasis, grouping, proportion and unity and constructing solutions within that framework. A diagram of of the system structure is illustrated below: (Roach et al. 1982)



Visual Design Consultant: system structure.
Roach et al. 1982

While it seems impossible to imagine defining a structure called 'good' design, let alone creating a system that would use these rules to create visual materials, the current incarnation of the system illustrates the problems inherent in imposing computational processes on an activity that is usually defined as defying computation. The Visual Design Consultant examines ways of thinking about problem solving, not about design.

Recent advances in videodisc technology relate directly to some of the issues addressed by the development of electronic media. Interactive

videodisc systems, those that allow more than a linear presentation of frames, fall into three categories. Level One systems use only the basic functions of a consumer disc player such as step forward, search or chapter functions. Level Two systems, the 'industrial' players, allow the encoding of branching sequences. These systems are currently being described as interactive but the rules of operation allow only sharply defined activities. Level Three systems, which now exist primarily in the laboratory, treat the videodisc player as a computer peripheral that can be used in a variety of ways as varied as the available software allows. (St. Lawrence 1984)

The Level Three system DISC SEARCH can offer a form of dialogue with the user. The use of a general catalogue for locating images is like the stock photography files described at the beginning of this paper - a user is constrained to use a structure that already exists and can not be altered to suit changing preferences. However, with the introduction of a glossary of word/image pairs and the introduction of notes displayed with the image, both made by the user for their purposes, the system begins to communicate information other than a tag identifying content. By examining files created by the user, personal connections can be made between images that might

suggest other possibilities. Now a user who liked a picture they marked before can open that file, find that image and view others in its category to look for additional material.

Another capability that would increase the dialogue is the ability to store images along with any ways they might have been used, providing an ongoing history for reevaluation and inspiration. Write-once videodiscs have already been introduced, allowing the creation of more organic image libraries than allowed by the normal disc mastering process. With these devices, video input controls a laser beam that melts pits into the surface of a plastic disc that can be immediately replayed. This ability to include visual records made 'on the fly' is a valuable tool for image archiving, book design, animation, making storyboards or any investigation of serial imagery. Alternative sequences of frames can be recorded and are available for instantaneous review. NHK has announced this year that they have developed a re-recordable videodisc that uses a magnetic material, allowing thousands of reuses of the same disc. (Funkschau, 1984) Now the sketchpad of the recordable videodisc has the additional flexibility of pages that can be thrown away and not reduce the total number of pages available.

The write-once disc would also increase the

flexibility of search strategies like the ones in DISC SEARCH. By using a recordable disc in tandem with a source disc of images, files could be created by recording images from the source disc in sequence, increasing the speed of locating these images, simplifying the required data storage and creating the operator's own image library.

This technology is also a candidate for a new form of the family photograph. As home video equipment becomes more commonplace, the substitution of the disc for the album becomes more plausible.

Finally, to completely free the system from obvious structures that would limit its use, the introduction of image recognition capabilities would eliminate the use of an established catalogue of image identifiers. Now the user could say "I want to see all the pictures that have a tree on the left side of the frame.", possibly by making a sketch illustrating that request, and images could be scanned and matched within a reasonable range of variance to the desired goal.

The title of this thesis, CATALOG / DIALOG, expresses not only some of the characteristics that I hoped DISC SEARCH would posess but also the object of the development of media: the creation of environments that talk to the participants, reminding

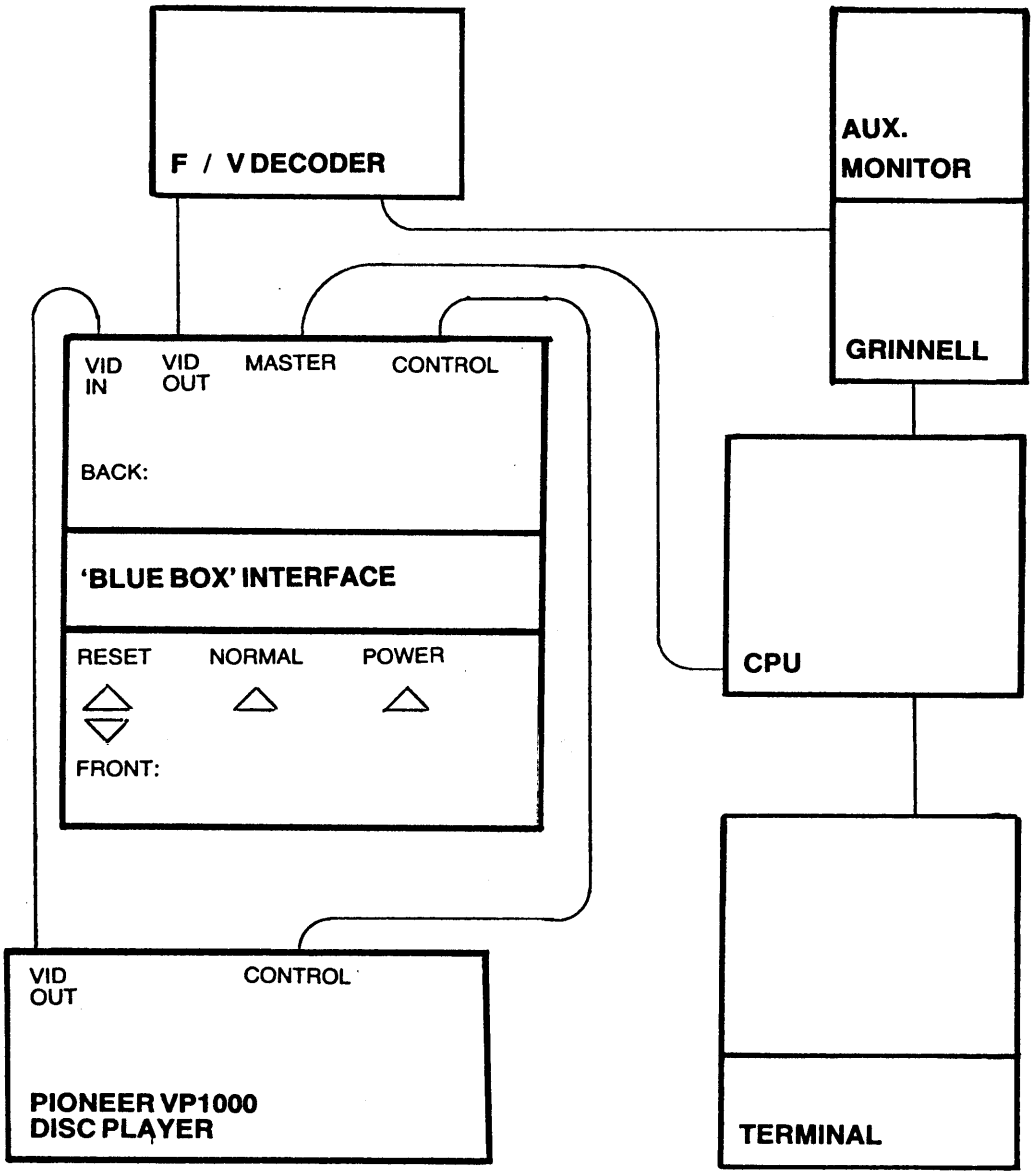
them of where they have been and making suggestions to the future.

4: APPENDICES

APPENDIX A:

HOW TO

The following diagram outlines the hardware configuration required to run DISC SEARCH. To use the system, type "use disc_search" from command level in >u>pvp>thesis.



APPENDIX B:

DATASTRUCTURES

DISC SEARCH both utilizes and creates a variety of permanent and temporary databases. They can best be described by dividing them into categories based on their use by different branches of the system.

GLOBAL

Global databases are utilized by the CATEGORIES search strategy in the SEARCH branch of DISC SEARCH. These databases are located in the directory >u>pvp>thesis>databases>global. The database employed by CATEGORIES is an array of disc image categories created by the manufacturers of the disc together with dimensional information: the frame number of the first frame in the category and the total number of frames in the category. The datastructure is as follows:

```
1 global_index_structure based(file_ptr),
     2 total_items fix,              (total categories)
     2 item [1],                     (category array)
          3 word char(32) vary,      (category name)
          3 total_frames fix,        (total frames in category)
          3 frameno fix(31);         (starting frame number)
```

The contents of this database may be listed by running >u>pvp>thesis>info>globindexlist.

The search strategy CATEGORIES creates a temporary database recording operator selections in its own segment in >u>pvp>thesis>databases>glossary that is deleted after the operator has viewed the selected items. The datastructure is:

```
1 glindex_structure based (temp_ptr),
     2 total_items fix,              (total no. of selections)
     2 item [10],                    (array of selections)
          3 word char (32) vary;     (name of category)
```

Category names from this temporary database are compared to category names from the global_index and whenever a match is encountered the disc is sent to the appropriate section of frames for viewing.

Data is being entered for a larger database containing morphological data relating to individual frames to allow the location of images based on different criteria for selection. To speed the review of this amount of data, each disc image category's data is stored in a separate segment in >u>pvp>thesis>databases>global. The datastructure for each is:

```
global(category #) based (ptr),
     2    total_items fix,          (total frames in cat.)
     2    item [1],                 (array of frames)
          3    frame fix (31),      (frame number)
          3    name fix,            (sub category key)
          3    orientation fix,     (orientation key)
          3    color fix,           (color key)
          3    flag bit(1);         (flag to indicate selected
                                     frames)
```

Keys correspond to the following information:

name:	each category has its own set of sub categories.
orientation:	0 = null 1 = horizontal 2 = vertical
color:	0 = null 1 = red 2 = yellow 3 = green 4 = blue 5 = brown 6 = black and white

This information can be reviewed by running >u>pvp>thesis>info>check_global.

GLOSSARY

Information in the glossary database is used by the search strategy GLOSSARY_CHOOSE. Every time a frame label is entered by the operator creating a picture file, that label is sent to the glossary of labels with this data structure and located in >u>pvp>thesis>databases>glossary:

```
1 glossary_structure based(file_ptr),
     2 total_items fix,              (total glossary items)
     2 item [1],                     (array of items)
          3 word char(32) vary,      (item name)
          3 total_frames fix,        (total frms w. same nm)
          3 frames [50],             (array of frames)
               4 frameno fix(31);    (frame numbers)
```

This information is utilized by GLOSSARY_CHOOSE the same way as the global_index described earlier. Operator selections from this glossary are stored in a temporary database also in >u>pvp>thesis>databases>glossary that is deleted once these items are viewed. The data structure of this temporary image file is:

```
1 glosschoose_structure based (temp_ptr),
     2 total_items fix,              (total selections)
     2 item [10],                    (array of selections)
          3 word char (32) vary;     (glossary item)
```

The glossary items chosen by the operator are checked against the gossary and if there is a match then all of the frames with that label are viewed.

NOTATION

The frame marking system NOTATION stores information in segments whose names correspond to the picture file names given by the operator. These files are located in >u>pvp>thesis>notation>databases>notation and have the following data structure:

```
1 notation_structure based(file_ptr),
     2 descriptor char(32) vary,     (additional file info)
     2 total_items fix,              (total frames in file)
     2 newtotal_items fix,           (used in editing file)
     2 item [1],                     (array of frms in file)
```

```
        3 item_descriptor char(32) vary,
                                  (frame label: entered
                                   in glossary)
        3 item_number fix,        (sequence number of item)
        3 frame_number fix(31),   (frame number of item)
        3 total_circles fix,      (total number of circles
                                   superimposed by user)
        3 circle [1],             (array of circles)
            4 circle_definition char(32) vary,
                                  (label displayed with
                                   circle)
            4 center_x fix,       (<= information for
            4 center_y fix,        <= drawing
            4 radius fix,          <= circles )
        3 total_rectangles fix,   (total number of rects)
        3 rectangle [1],          (array of rectangles)
            4 rect_definition char(32) vary,
                                  (label displayed with
                                   rectangle)
            4 bot_lef_x fix,      (<= information for
            4 bot_lef_y fix,       <= drawing
            4 top_rt_x fix,        <= rectangles
            4 top_rt_y fix,        <=            )
```

This information is used by REVIEW and EDIT.

SKETCH

The frame marking system SKETCH stores information in segments whose names correspond to the picture file names given by the operator. These files are located in >u>pvp>thesis>notation>databases>notation and have the following data structure:

```
1 sketch_structure based(file_ptr),
     2 descriptor char(32) vary,   (additional file info)
     2 total_items fix,            (total number of items)
     2 newtotal_items fix,         (used in editing)
     2 item [5],                   (array of items)
          3 item_descriptor char(32) vary,
                                   (item label,entered
                                    in glossary)
          3 item_number fix,       (total number of items)
          3 frame_number fix(31),  (frame no. of item)
          3 total_dots,            (total number of points
                                    drawn by operator- used
                                    to set limit for playing
```

```
                                  them back)
    3 dot [500],                 (array of dots)
          4 size fix,            (<= information for
          4 color fix,            <= drawing the
          4 x fix,                <= sketches
          4 y fix;                <=          )
```

This information is used by REVIEW.

APPENDIX C:

CODE

DISC SEARCH is run by using a menu system developed by Nardy Henigan for the Visible Language Workshop. The structure of the menu can be viewed by printing >u>pvp>thesis>disc_search.menu. All of the programs called by this menu are contained in one of four bind files determined by use. Programs contained in each bind file are run in their own address space. All code used by DISC SEARCH is located in >u>pvp>thesis. A review of the object code contained in each bind file follows:

disc.bind

This group of programs contains all code used in driving the videodisc player and creating the image files as well as a few utilities used in displaying the menus. They are:

button.....menu utility, lights up or turns off the menu buttons.

circlev.....circle drawing utility, draws circles to overlay planes, courtesy of lino.

draw.....used by sketch, allows user to draw to overlay planes.

draw_circ.....used by notation to draw circles with captions on the overlay planes.

draw_menu.....used by sketch, allows viewing of disc frames and selecting them for annotation.

draw_rect.....used by notation, allows placement of rectangles with captions on the overlay

planes.

mark_menu.....used by notation, allows selection of types of marks to be made by the user on a selected frame.

notation.....creates a database for storing frame numbers and associated annotations.

notation_init.....initializes everything to zero or null in the database created by notation.

notation_list.....lists all databases created by notation.

notation_menu.....used by notation, allows the selection of disc frames for annotation.

playback_notation...plays back information stored by notation together with associated frames.

playback_sketch.....plays back information stored by sketch together with associated frames.

search_frame.....shows frame whose number is furnished by user.

sketch.....allows creation of a database with disc frames and associated freehand annotations.

sketch_init.....initializes all values in database created by sketch to zero.

sketch_list.....lists all databases created by sketch.

sketch_menu.....used by sketch, allows viewing of frames and their selection for annotation.

upcase.....accepts character string and returns all caps, courtesy of jht.

vdisk.....videodisc utility: calling the following entry points affects the following functions:

init-initialize interface device
play-play the disc regular speed

```
pause-halt play and black out
      monitor
laud-toggle left audio
raud-toggle right audio
stepf-advance disc one frame
stepb-retreat one frame
halt-halt disc play
frame-toggle frame number display
advance-slow forward disc play
retreat-slow play reverse
search-accepts argument of fix(31)
       frame number which is
       located and displayed
scanf-scan forward
scanr-scan reverse
```

search.bind

This file contains all code used by the SEARCH branch of DISC SEARCH.

```
global_choose.......used by CATEGORIES, scrolls a list
                    of the disc image categories
                    defined by the manufacturer of the
                    disc.  Allows the selection of
                    multiple categories, creates a
                    temporary database storing these
                    selections.

global_display......Uses the temporary database
                    created by global_choose and
                    displays the selected items.

glossary_add........Used by NOTATION, this procedure
                    enters the frame descriptors
                    created by the operator into the
                    glossary database.

glossary_choose.....used by GLOSSARY, scrolls a list
                    of the disc frame descriptors
                    created by the operator.  Allows
                    the selection of multiple items,
                    creates a temporary database
                    storing these selections.

glossary_display....Uses the temporary database
                    created by glossary_choose and
```

displays the selected items.

glossary_list.....Lists all glossary items and all frame numbers of images that have been given the same identifier.

utilities.bind

This file contains code for the functions that relate DISC SEARCH to the other systems on line at the Visible Language Workshop.

delpic.....Deletes a picture from the picture directory >pix.

gtest.....Digitizes video input on Grinnell monitor.

listpix.....Lists the picture directory >pix.

off.....Clears the overlay planes on the Grinnell.

savepic.....Stores whatever has been digitized by the Grinnell in the picture directory >pix.

to_pager.....Branches to page layout system PAGER.

to_sys.....Branches to image processing system SYS.

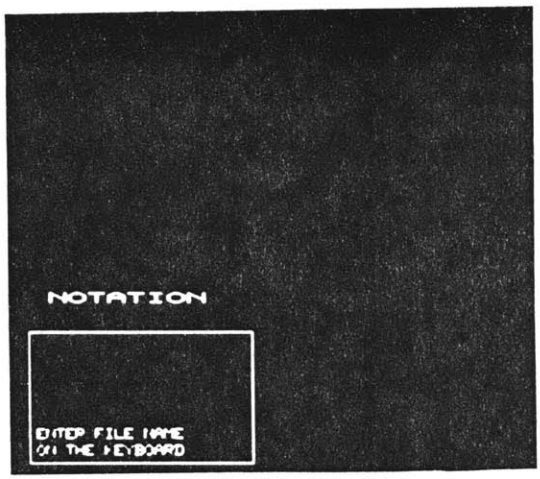
zaps.....Clears the Grinnell monitor.

APPENDIX D:

ILLUSTRATIONS

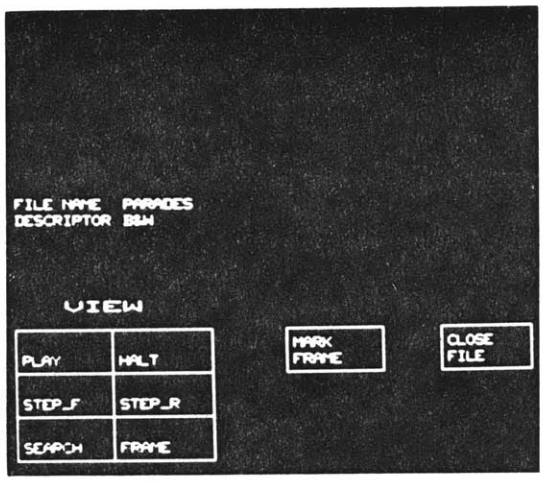
NOTATION

AUXILIARY MONITOR



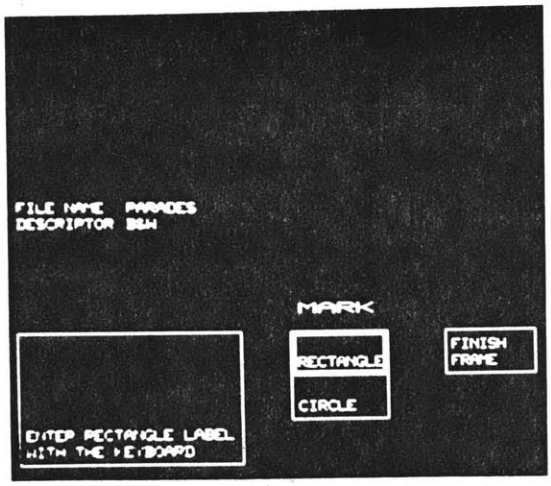
Prompt for file name.

AUXILIARY MONITOR



View disc frames and select for annotating.

AUXILIARY MONITOR



Choose type of annotation.

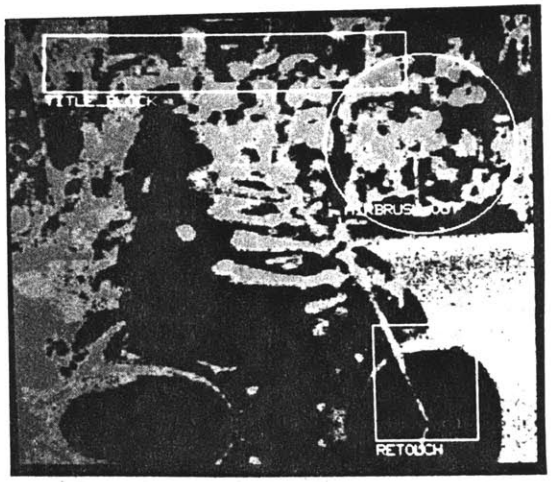
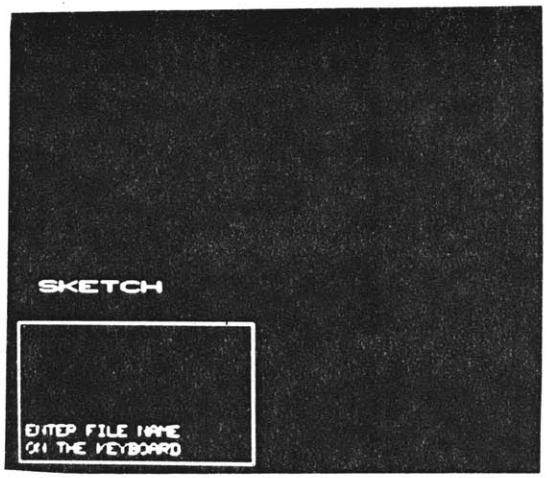


Image with annotations.

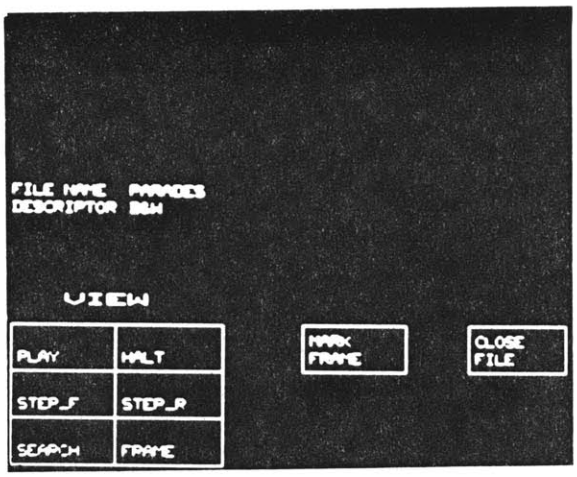
SKETCH

AUXILIARY MONITOR



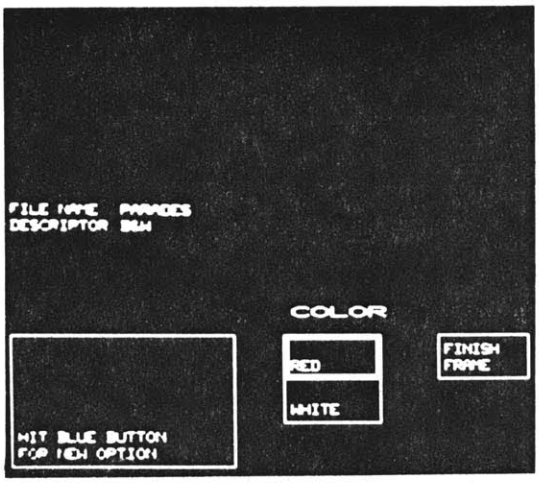
Prompt for file name.

AUXILIARY MONITOR



View disc frames and select for annotating.

AUXILIARY MONITOR



Choose type of annotation.

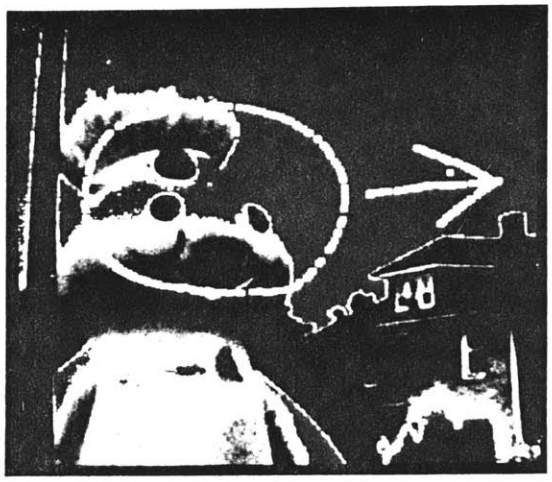
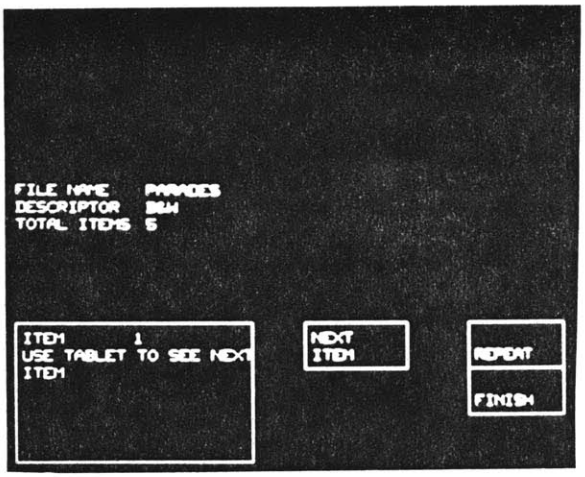


Image with annotations.

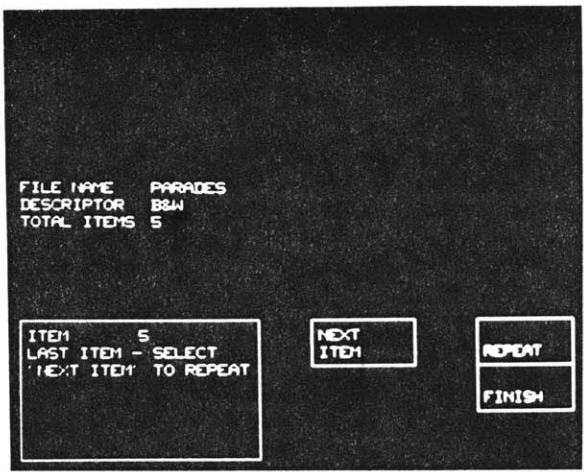
REVIEW

AUXILIARY MONITOR

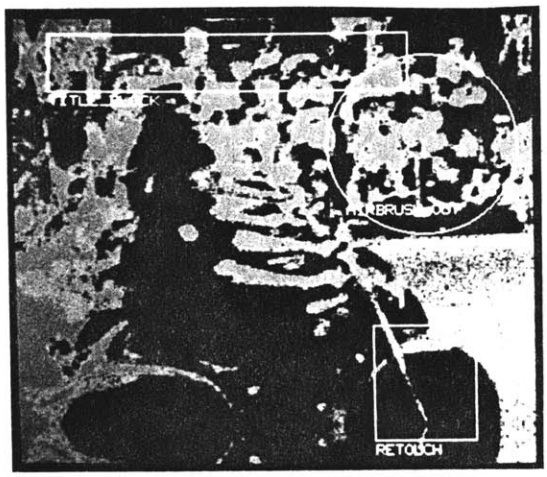


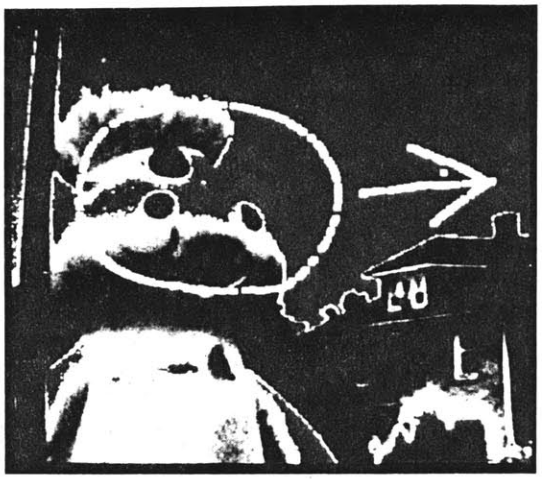
First item.

AUXILIARY MONITOR



Last item.

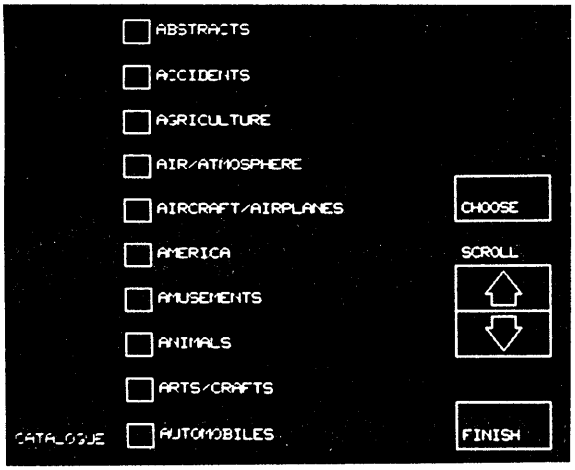




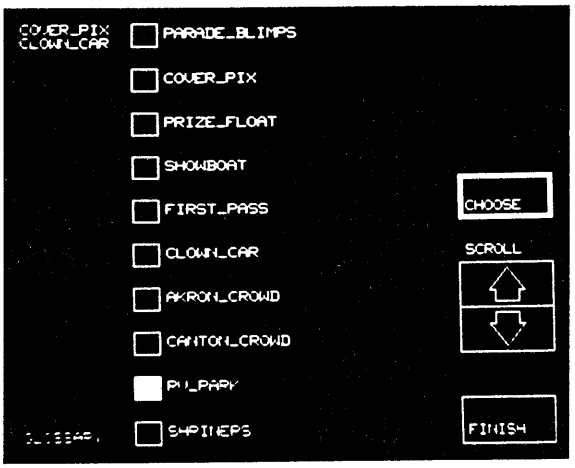
View frames with annotations.

GLOSSARY

AUXILIARY MONITOR

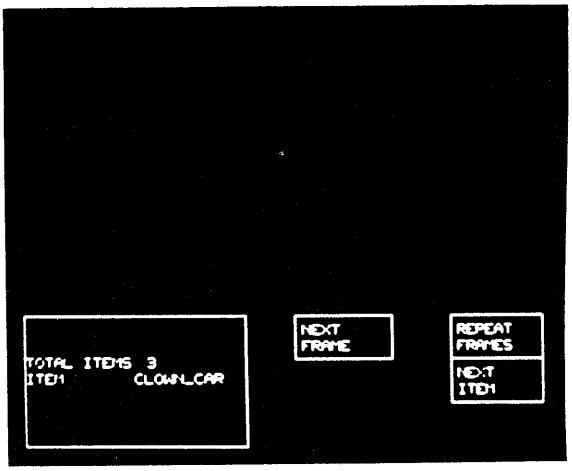


AUXILIARY MONITOR



Scroll and choose glossary items.

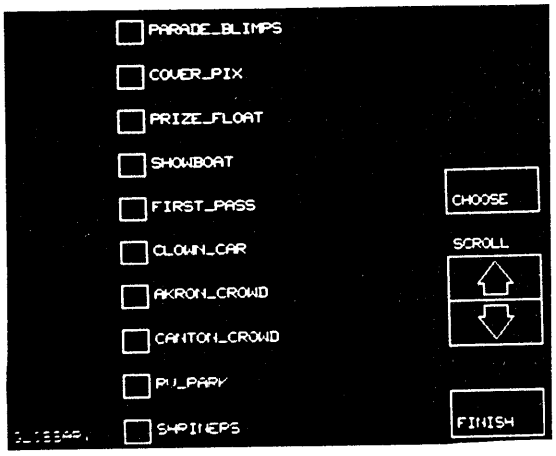
AUXILIARY MONITOR



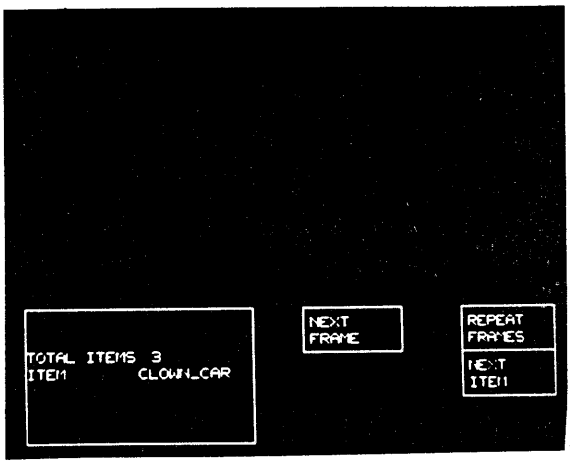
View selected items.

CATEGORIES

AUXILIARY MONITOR



AUXILIARY MONITOR



Similar to glossary.

5: BIBLIOGRAPHY

Arnheim, R. Art and Visual Perception A Psychology of the Creative Eye. University of California Press, Berkeley, California. © 1974.

Berger, J. About Looking. Pantheon Books, New York, New York. © 1980.

Black, M. "How Do Pictures Represent?" Art, Perception and Reality. The Johns Hopkins University Press, Baltimore, Maryland. © 1972.

Cohen, P., Herbst, N. "Videodisc dictionary system." IBM Technical Disclosure Bulletin, vol. 25 no. 8 January 1983.

Dane, W. The Picture Collection Subject Headings. The Shoe String Press, Inc., © 1968.

Date, C. J. An Introduction to Database Systems. Addison-Wesley Publishing Company, Reading, Massachusetts. © 1974.

Daynes, R. "The Videodisc Interfacing Primer." Byte, June 1982.

Evans, H. The Art of Picture Research A Guide to Practice, Procedure, Techniques and Resources. David & Charles Inc., North Pomfret, Vermont. © 1979.

Glenn, A., Kehrberg, K. "The Intelligent Videodisc: An Instructional Tool for the Classroom." Educational Technology, October 1981.

Gombrich, E. H. Art and Illusion A Study in the Psychology of Pictorial Representation. Princeton University Press, Princeton, New Jersey. © 1960.

Gombrich, E. H. The Image and the Eye Further studies in the psychology of pictorial representation. Cornell University Press, Ithaca, New York. © 1982.

Harris, D. Children's Drawings as Measures of Intellectual Maturity. Harcourt, Brace & World, Inc., New York, New York, © 1963.

Holtzman, W., Thorpe, J., Swartz, J., Herron, E. Inkblot Perception and Personality. University of Texas Press, Austin, Texas, © 1961.

Janson, H. History of Art A Survey of the Major Visual Arts from the Dawn of History to the Present Day. Harry N. Abrams, Inc., New York, New York. © 1962.

Kircher, G. "Simon Fraser University Videodisc Project: Part One: Design and Production of an Interactive Videodisc for Elementary School Children" Videodisc/Videotex, vol. 1 no. 3 1981.

Kribs, H. "Authoring Techniques for Interactive Videodisc Systems." Educational Technoloy Systems, vol. 8(3) 1979-80.

Moberg, D., Laefsky, I. "Videodiscs and Optical Data Storage." Byte, June 1982.

Mole, D. "The Videodisc as a Pilot Project of the Public Archives of Canada" Videodisc/Videotex, vol. 1 no. 3 1981.

Negroponte, N. "Media Room." Proceedings of the Society for Information Display, 22(2), 1981.

Neimat, M. K. Search Mechanisms for Large Files. UMI Research Press, Ann Arbor, Michigan, © 1981.

Norfleet, B. The Champion Pig Great Moments in Everyday Life. David R. Godine, Publisher, Boston, Massachusetts, © 1979.

Norfleet, B. Wedding. Simon and Schuster, New York, New York, © 1979.

Pogue, R. "The Authoring System: Interface Between Author and Computer." Journal of Research and Development in Education, vol. 14, no. 1, 1980.

Roach, J., Pittman, J., Reilly, S. A Visual Design Consultant. IEEE © 1982.

Sonnemann, S. "The Videodisc as a Library Tool", Special Libraries, vol. 74 no. 1 January 1983.

Sontag, S. On Photography. Farrar, Straus and Giroux, New York, New York, © 1973.

St. Lawrence, J. "The Interactive Videodisc." Electronic Learning, vol. 3 no. 7 April 1984.

Winston, H. P. "Learning by Creating and Justifying Transfer Frames." Artificial Intelligence: An MIT Perspective Vol. I. Winston, H. P. & Brown, R. H. eds. The MIT Press, Cambridge, Massachusetts, © 1979.

ACKNOWLEDGEMENTS

While I am grateful to dozens of people for their help and advice at various stages of this project, I would like to thank Pamela Sussman Paternoster for her financial, intellectual, editorial and emotional support during the last two years. All other contributions pale in comparison.