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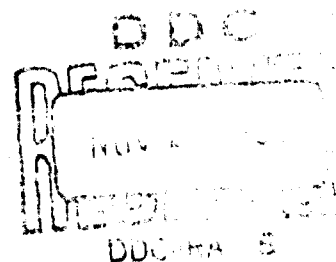
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COMPENDIUM OF STORAGE AND RETRIEVAL DEVICES AND TECHNIQUES

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FOREWORD

Condensed data on available information storage and retrieval capabilities is compiled in this report, which is intended for Air Force use, especially in organizations involved with information handling.

The authors express their sincere thanks to the personnel of the organizations, both commercial and governmental, who contributed to this compendium.

ABSTRACT

The contents of this compendium have been selected for the purpose of indicating existent hardware capability for information storage and retrieval. As such, this compendium is intended as a guide and future reference in applying storage and retrieval capabilities for satisfying Air Force data handling requirements.

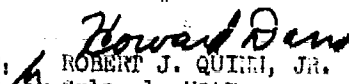
In compiling this information, particular attention has been directed toward devices and associated techniques of the special purpose type, and applicable for the mass storage of textual and graphic information. Most of these equipments have some degree of uniqueness, such as a particular type of storage medium or storage medium format. In order to minimize repetition, multiple entries of similar items, such as tape units, magnetic discs, and magnetic drums, have been excluded. Thus, this report emphasizes the different types of equipment available rather than the varieties within each type.

This compendium has been compiled primarily from information obtained by formal request from commercial organizations. It has been supplemented by documentation available within the Information Processing Branch at RAIDC. However, because of a lack of cooperation from many commercial organizations, this collection of information is not as complete as possible or as desired.

PUBLICATION REVIEW

This report has been reviewed and is approved.

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TABLE OF CONTENTS

INTRODUCTION	1
SECTION I. CHEMICAL STORAGE	2
SECTION II. MAGNETIC STORAGE	4
A. Magnetic Card Storage	4
B. Magnetic Disc Storage	9
C. Magnetic Drum Storage	10
D. Magnetic Tape Storage	10
SECTION III. PHOTOGRAPHIC DIGITAL AND/OR IMAGE STORAGE	16
A. Microfilm on Aperture Cards	17
B. Microfilm in Card Form	18
C. Roll Film	23
D. Unitized Photographs	32
E. Unitized Photographs—Film Strips	45
F. Photographic Plate Storage—Sheet or Scroll	46
G. Photographic Plate Storage—Disc	49
SECTION IV. SURFACE PERFORATION STORAGE	52
SECTION V. SURFACE DEFORMATION	56
SECTION VI. STORAGE FILES	57
SECTION VII. SPECIAL DEVICES	62
MANUFACTURER INDEX	65
SECTION INDEX	68
APPENDIX I. COMMERCIAL ORGANIZATIONS SOLICITED FOR INFORMATION	69
APPENDIX II. APPLICATIONS CHART	74

INTRODUCTION

Probably the most common and most elementary form of a storage and retrieval system is the standard file drawer. When this proves to be inadequate, the next resort may be a card-indexing technique similar to the library Card Catalog. If this technique still leaves much to be desired, then several avenues of approach are available. These include the use of microfilm, manual files, and different forms of storage using mechanical, electro-mechanical and electronic contrivances.

However, through all these levels of sophistication, one important factor is present—that the relationship between the elements of a storage and retrieval system and how they are applied is still determined from past experience and trial-and-error. This situation prevails because of a lack of a general theory of information on storage and retrieval. As a result, each system has to be evaluated on its performance in the application for which it was specifically designed. This situation has encouraged the development of equipments for each particular type of application and has, therefore, provided the many devices and techniques available today.

As the state of the art in this area has progressed, the tendency has been to attain greater access speed for large-capacity files through various degrees of random access, the condition in which the storage location is approached directly without first referring to other locations. In contrast, sequential storage, approaching a storage location after proceeding from another location, is generally considered slower and is used predominantly in less active files. However, by using various combinations of indexing, coding, file organization, storage media and storage formats, the capability and operating characteristics of a system employing random access or sequential storage can be varied extensively. Since each form of storage is available in various equipment configurations, the equipment characteristics, not the storage concept, become critical when considering capability. This is illustrated by the fact that it is possible to select several sequen-

tial access storage systems that are superior to certain random access systems in a specific operational environment.

Therefore, although recent developments are, in many instances, considered advances in the state of the art and promise faster access time and greater storage density, just what is required is still determined by systems analysis and past experience. The selection of appropriate equipment characteristics is now complicated by the multitude of equipments available. It is hoped that, in this respect, this report will be of help.

The items in this compendium have been described according to an established format which was selected so that most of the pertinent data on each equipment or technique is provided in paragraph form. Indicated in outline form for each entry is the following:

- Name of equipment
- Status
- Military Sponsorship (If none, the developer)
- Agency
- Contract Number
- Contractors
- Date available and/or delivery time
- Cost

The subject content of this compendium includes storage files, and equipments and techniques that utilize one or more of the following storage methods:

- Chemical
- Magnetic
- Photographic
- Surface Deformation
- Surface Perforation.

SECTION I

CHEMICAL STORAGE

PHOTOCHROMIC MICRO-IMAGES

Status—Successful feasibility model

Developer—The National Cash Register Company

Date Available—Not available

Cost—Not available

Description of Equipment

The NCR photochromic micro-image process provides the capability of high-density document storage by utilizing both microfilm and photochromic materials. The advantage of this technique is that image reductions on photochromic materials are erasible and, therefore, convertible before final recording on microfilm. Using this method, linear reductions of 200:1 are feasible for an operational situation handling normal business documents.

A micro-image system would include the following elements:

- **PCMI Camera/Recorder**—This device will reduce micro-image from 35mm microfilm onto photochromic film.
- **Off-line refrigerated file**—PCMI master plates will be stored in this file until required for updating.
- **Contact printer**—This unit will produce micro-image cards from the micro-image master film prepared by the PCMI Camera/Recorder.
- **Micro-image viewer**—For viewing micro-image cards.
- **Hard copy printer**—For hard copy print-out of enlarged micro-images.
- **Micro-image card file**—For storage of micro-image cards.

Operating Characteristics

The NCR photochromic materials consist of a molecular dispersion of light sensitive dyes. When exposed to radiant energy in the visible or near-

visible portions of the spectrum, they exhibit a reversible spectral absorption effect. In using this effect, these dyes can be made to retain two-dimensional patterns or images which are optically transferred to their surface. NCR photochromic coatings can be coated on the same type of substrates as photographic emulsions and can exhibit excellent resolution capabilities. Also, both positive-to-negative and direct-positive transfers are possible. These coatings are completely grain-free, have low gamma, and exhibit inherently high resolution. When exposed, the image is immediately visible with no development process required.

The image appears with photochromic materials where the individual molecules are switched from either the colored or the colorless state of radiation by light of the proper wavelength. All of the NCR coatings now in use switch to the colored state when near-ultraviolet light is used. A colorless state is achieved by using either heat or visible light.

The life of photochromic images is dependent upon the ambient temperature of the coating. At room temperature, image life is only a few hours but, as the temperature is lowered, life can be extended to months and even years.

Because the semi-permanent characteristic of photochromic images prevents their use for archival storage, NCR has devised a system which includes the transfer of photochromic micro-images to a high-resolution photographic film for storage. In using this concept, NCR has taken advantage of the resolution, reversibility and immediate image capability of the photochromics and has combined this with the permanency of the silver halide emulsion.

Mechanization of the NCR PCMI process requires that the original document be first transferred to high-quality conventional microfilm. Properly filtered, near-ultraviolet radiation is then directed through the transparent microfilm and into the micro-image optics where it is focused on a photochromic plate. This forms a miniature image on the photochromic coating such that up to 2625 micro-images could be placed on a 3" x 5" photochromic plate. This plate will then be used for producing duplicate micro-

image cards on photographic film for dissemination at a reduction ratio of 200:1. Four hundred of these 3" x 5" cards could contain a file of one million documents.

This NCR PCMI system has been designed for applications requiring the original document or its

facsimile in the form of either microfilm or micro-image and high-density storage. Since this system's characteristics are compatible with numerous micro-filming techniques and equipment, it is adaptable for use with various input and output media configurations.

SECTION II

MAGNETIC STORAGE

Because of its desirable characteristics, magnetic storage has been utilized extensively in information handling. Most appealing are its erasability and freedom from processing, allowing instant use of information after recording. Such characteristics have encouraged the development of many forms of magnetic storage for various applications. The forms considered here are:

- Magnetic Card
- Magnetic Drum
- Magnetic Disc
- Magnetic Tape

The most common form of magnetic storage is magnetic tape. It is relied upon by the computer industry for bulk storage and, even with recent developments, is still the most economical form of erasible storage available. Its use has been challenged in various applications because of the development of faster random access type devices, such as magnetic discs and drums. However, due to the increased cost of these, tape storage is still extensively used. A common practice is to use tape storage in combination with some form of random access device. In this manner, a compromise is reached between access speed and cost. Files of up to 100 million characters can be stored on discs and any larger files on magnetic tape. In this concept, the more active portions of the file data are recorded on the magnetic discs while the less frequently used data is placed on magnetic tape.

The use of large magnetic drums, magnetic tape strips, and magnetic discs for random access was introduced as early as 1955. However, there were limitations on reaching an ideal system due to speed, capacity, and cost. Also, large drum or disc systems become unwieldy when a considerable number of units are required on-line.

Such difficulties have encouraged the development of cartridge units which attempt to combine the random access capabilities of magnetic discs and the practically unlimited storage capacity of magnetic tape. Basically, these devices have appeared in two

types. In one, discs are removable and can be replaced as reels of tape on a tape unit. The other form utilizes magnetic strips or cards which are contained in removable magazines.

Considering operating speeds, magnetic cores and magnetic film with access times in the order of microseconds are much faster than drums or discs. The current disc files have access times of 100-250 milliseconds while magnetic drums vary from 3-100 milliseconds. Magnetic card or strip is also in the millisecond region with an average access time of about 250 milliseconds.

Because of the cost per bit, magnetic cores and magnetic film are not currently practical for mass storage applications. Consequently, equipment employing these forms of storage will not be included in this section.

A. Magnetic Card Storage

Information storage and retrieval requirements cannot in most cases be defined to the extent that exact equipment characteristics can be specified. As a consequence, manufacturers usually try to include as much flexibility as possible in their equipment designs. Requirements for mass storage emphasize capacity and, in many cases, erasability. Initially, magnetic tape was the only storage medium that could economically provide these storage characteristics. However, magnetic tape was dependent upon the roll storage concept which proved to be ineffective in handling large files unless sequential access or considerable batching was employed. Consequently, it became evident that magnetic tape storage lacked several characteristics desirable for mass storage.

Unit record storage, in contrast to roll storage, is applicable to operations which require considerable flexibility in file organization and information manipulation. In recognition of these characteristics, attempts have been made to combine the storage advantages of both magnetic tape and unit records. The results of these efforts have been the present magnetic card handling devices.

CRAM

Status—Available

Developer—The National Cash Register Company

Delivery Time—3 to 6 months

Description of Equipment

Card Random Access Memory (CRAM) is a magnetic card handling device in which coded information is recorded on a .005 inch, oxide-coated Mylar Card, 14" long by $3\frac{1}{4}$ " wide. Each card has a set of binary coded notches at one end to permit automatic random selection of any one of the 256 cards contained in a magazine. Data is recorded on these cards in 7 tracks of 8 bit channels each. Blocks in lengths of up to 3100 characters may be written on each of the 7 tracks. This arrangement allows up to 21,700 characters to be recorded in a single CRAM card. Since there are 256 cards in a magazine, the total capacity of each CRAM unit is 5,555,200 alphanumeric characters. When required, a CRAM magazine can be interchanged with off-line magazines in 30 seconds.

A CRAM system can consist of up to 16 CRAM units tied to a C-315 computer. Using this configuration, more than 88 million alphanumeric characters can be available at a maximum access time of 200 milliseconds. In addition, the number of off-line decks per CRAM unit is unlimited, providing the potential for handling a considerably larger file of information. During operation, a CRAM system is capable of transferring data at the rate of 100,000 alphanumeric characters per second.

Operating Characteristics

A card is accessed for read or write operation by first releasing it from its position in the card magazine and allowing it to be pulled on to a rotating drum. A vacuum holds the card firmly as it is accelerated to the surface drum speed of 400 inches per second. As the card reaches the write and read heads, the region of the card passing the heads leaves the drum and is held closely to the heads by a vacuum surrounding the heads. Once each portion of the card has passed the heads, it is brought back into contact with the drum. The card may then be returned to the magazine or it may be recirculated on the drum for additional read/write operations.

The release and suspension of CRAM cards in the magazine are accomplished by using eight selection

rods and two gating rods. Notches at the top edge of the cards have tabs protruding on either the left or right side that permit the card to be held or released by the selection rods. The tabs indicate binary ones or zeros and represent the edge coding that gives CRAM its random filing feature. When a card is selected, all other cards are supported by at least one of these tabs. This method is sufficient to control selection of 255 cards. Gating rods support the cards at the edges and allow the use of an additional card representing binary zero.

This card handling procedure requires that the cards be separated and free to fall while the magazine is in-line. Separation of the cards is accomplished by a relatively low-velocity stream of air injected from above. The air stream is passed through a nozzle containing 256 separators and then into the cards. In general, a state of equilibrium exists so that each card is under a separator. This method results in the cards dropping slightly faster than that which would be due to gravity alone.

For changing magazines, a cartridge is attached to the magazine so that the cards hang inside it. With the air jets off, the cards are compressed first, by hand, and then further, by a spring in the cartridge. The cartridge is then slid to the right along the guide bar until the cards are off the rods and the cartridge is removed from the guide bar. This complete operation takes approximately 30 seconds.

CRAM has many of the operating characteristics of magnetic tape file, with the added flexibility provided by the unit record feature of the CRAM card. Use of CRAM should be considered in applications that require large files, frequent updating, rapid accessibility, and a large data transfer rate.

MAGNACARD INFORMATION STORAGE AND RETRIEVAL SYSTEM

Status—Available off-the-shelf

Military Sponsorship

Government Branch—U.S. Air Force

Agency—Rome Air Development Center

Contract Number—AF30(602) 2133

Contractor—The Magnavox Company

Delivery Time—12 to 18 months

Cost—400K to 750K

(depending on system configuration)

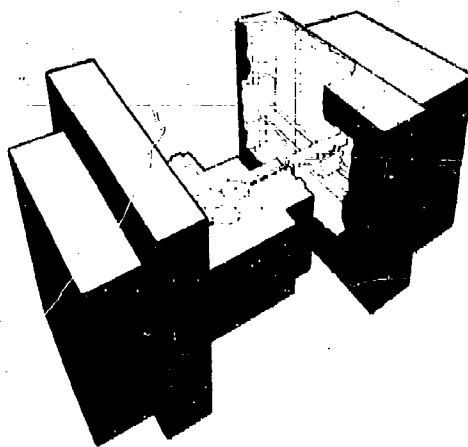
Description of Equipment

Magnacard is a general purpose, electronic information-processing system, able to store, search, and update large masses of information at very high speeds. Magnacard's unique file storage method provides rapid and automatic access to magnetically coded information. This concept utilizes small magnetic cards as the basic medium of storage. The cards are manipulated within the system at high speed—up to 90 cards per second—for typical sorting, merging, and file processing operations. The Magnacard System consists of the following:

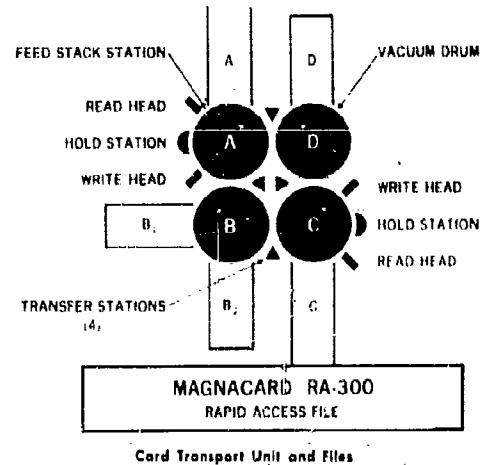
a. Control Unit—Receives and interprets signals from the Data Processor, transmits appropriate signals to the Card Transport Unit, receives the information signals from the Card Transport Unit, and relays them back to the Data Processor.

b. Card Transport Unit—Manipulates the magnetic cards by reading, writing, stacking, holding, and feeding functions. It is composed of four vacuum drums and five feed-stack stations with transfer valves.

c. Rapid Access Piles—Contains 300 magazines in a matrix of 20 magazines high by 15 magazines wide. A selection mechanism capable of holding two magazines operates under program control to bring magazines of magnetic cards to feed stations and to put magazines away from stack stations. File capacity



Magnacard RA-300, Showing Card Transport Unit and Vertical File



is 681,000,000 alphanumeric characters in 900,000 magnetic cards.

d. Vertical File—Contains 10 magazines in a vertical array operating similar to an elevator. The array moves all 10 magazines up or down, stopping at various levels for selection or retraction of magazines under program control. File capacity is 22,680,000 alphanumeric characters in 30,000 magnetic cards.

Operating Characteristics and Capability

Inputs into this system can be from the Magnacard reading stations on the Card Transport Unit at the rate of 5400 cards per minute, from a high-speed tape reader, or from tabulating cards and magnetic tape. The input information is recorded on the 1" x 5" magnetic card which has essentially the same magnetic qualities as magnetic tape. Recording and reading are accomplished without contact, thereby contributing to the long life of the magnetic cards. Using a recording density of 100 bits to the inch, each magnetic card has a total capacity of 56 alphanumeric characters, plus a three character check sum.

The same concepts that are employed in the Magnavue system are used to store and handle the magnetic cards. The Magnacard file contains 300 magazines of 3000 cards each. One transport unit can handle two such files, providing the system with a storage capacity of 10¹⁰ bits. Using vacuum drums which rotate at the rate of 300 inches per second, the



Magnacard System

transport unit can search magnetic cards at the rate of 90 cards per second and achieve system retrieval rates that vary from 10 milliseconds to 30 seconds depending on file organization and the method of batching inquiries.

The handling technique for the magnetic cards provides the speed and protection to the magnetic cards required for reliable operation of the Magnacard system. The basic unit in this handling technique is the Card Transport Unit consisting of four vacuum drums, five feed-stack stations, four transfer stations, two hold stations, two read heads, and two write heads. The magnetic drums are the fundamental means of transporting magnetic cards. Two continuous slots in the periphery of each drum continually exhaust air. A magnetic card brought close to the drum is sucked into its surface and carried around it. Cards are transferred from one drum to another through the use of pneumatic valves and from/or to the drums by the feed-stack stations. The feed-stack stations connect the drum unit with the storage files, thereby completing the channel for information flow.

Output from the Magnacard system can be in the form of punched cards, punched paper tape, high-speed printout or a magnetic tape recording. These outputs are similar to those of any EDP system using magnetic tape as the basic storage media. However, Magnacard combines many of the advantages of magnetic recording with those of unit records, providing substantial freedom in the selection of file arrangement and indexing.

MONROE CARD SYSTEM

Status - Available off-the-shelf

Developer - Monroe Calculating Machine Co.

Delivery Time - 6 to 9 months

Cost - 36K to 39K

Description of Equipment

The Monroe Card System uses magnetic cards of standard tabulating size for storing recorded information. Magnetic cards with the capacity for 800 or 1500

digits are handled by a card unit which can transfer data from the cards to a computer or eject and enter a new card for reading. The card unit can operate with automatic external feeding, or the card can manually be inserted or removed from the input and output stations. Utilizing magnetic recording, the system has several of the same characteristics and applications of a magnetic EDP system.

A Monroe Card System consists of a Monrobot X1 Computer, a Monroe Processing Card Unit and the Monroe Magnetic Cards.

Operating Characteristics

For operation, magnetic cards are inserted in the input hopper of the card unit. From the input hopper, cards are read or recordings made by moving the card forward underneath the read/write heads. The correct location for positioning is determined by the use of sector holes which are on the card. When reading or writing is completed, the card is removed, placed in the output bin, and the next card from the input bin placed under the read/write heads.

Operation of the card unit is controlled by a computer which, in this system, can receive input from typewriter, punched tape, edge-punched cards, 80-column cards, teletypewriter, and numeric keyboard. With this system configuration, storage and retrieval rates are 20 characters per second for the computer and 34 characters per second between the computer and the card punching unit.

RANDOM ACCESS MASS MEMORY SYSTEM

Status—R&D

Developer—Radio Corporation of America

Military Sponsorship—

Government Branch—U.S. Navy

Agency—Military System USN/BuShips

Contract Number—Nobsr 89430

Delivery Time—1st unit due September 1964

Cost—Not determined. Specific proposals will be made on request.

Description of Equipment

The Mass Memory System (MMS) accepts data from the Computer one word at a time and stores the

data on magnetic cards at a location specified by the Computer. When interrogated by the Computer, the data is transmitted from the mass memory to the Computer one word at a time. Each data word is stored on the card as part of a block of 875 words. Every block of 875 words on a card may be randomly accessed. The data block length is arbitrary and may contain a minimum of one word or a maximum of 875 words. Access to words in a block is serial. Every card and block within the memory may be randomly accessed. The cards are contained in magazines which may be removed and replaced with other magazines. The magazine containing the cards and the mechanism for selecting cards and recording or reading them, along with the necessary logic circuitry and power supplies, are contained in a single unitized structure.

Card Characteristics

Card Size	4 1/2" x 16"
Channels	128
Bits/Channels	8750
Recording Density	625 bits/inch
Card Capacity	1,120,000
Card Material	Magnetic oxide coated Mylar

Operating Characteristics

Storage Capacity and Density—The RACE File consists of oxide coated Mylar cards 4 1/2" x 16" and 256 of these cards are placed in a magazine store. The 256 cards in each magazine store as much data as 2 1/2 reels of magnetic tape so that a total of 64 magazines are equivalent in capability to 160 tape stations.

Capacity	36 Bit Words	Information Bits
Block	875	30,900
Card	28,000	1,008,000
Magazine	896,000	32,256,000
16 Magazine Unit	14,336,000	516,096,000

Indexing Coding

Word Formats—Four different word formats are utilized in the MMS: the Instruction Word, First Data Word, Error and Status Word, and Data Word.

Of these, the fields of the Instruction Word (IW), first data word and the Error and Status Word (ESW) are in multiples of three bits, so that each number, operation and address can be designated in octal form.

Instruction Word Format—The Instruction Word (IW) contains 3 bits for the instruction or operation code, 18 bits for the address, 6 bits for block count, and 9 spare bits.

The 18-bit address consists of three 6-bit fields designating magazine, card and block. There are 32 blocks per card, 32 cards per magazine and 32 magazines so the most significant bit of each field (bits 5, 11 and 17) are ignored.

The first data word of each block contains the number of words within the block. There is a maximum of 875 words per block so the word count will be from 0000 to 15553. A word count of 0000 of 0001 will record only this first data word within the designated block.

Data words 2 through 875 are not decoded or used by the MMS so their format is at the discretion of the programmer.

Data Transfer Rate

25,000 36-bit words per second instantaneous

Retrieval Rate

Access Time:

- | | |
|---|--|
| 1. Access to a data block on any single card (in any of 32 magazines) | Minimum: 185 msec.
Maximum: 280 msec. |
| 2. Access to any data block on a card at Read Station | Maximum: 60 msec. |

B. Magnetic Disc Storage

Magnetic disc units are available in two basic types, often referred to as first and second generation devices. Various models of each type have been developed and are currently in use. However, since magnetic discs are considered to be general purpose storage devices, detailed descriptions of these models will not be included in the following:

An IBM 1405 Disc Storage Unit is an example of a first generation random access storage device which,

with less storage capacity, was used in the IBM 305 RAMAC systems. In this unit, a stack of 25 or 50 discs is mounted on a single access arm. For reading or writing, the arm moves vertically to the appropriate disc and horizontally across the disc.

More advanced or second generation equipment is represented by the Bryant 4000 and the IBM 1301. The major improvement in this file type over their predecessors is that a group of access arms, one for each disc, is used. All of these arms move in unison, with mechanical motion limited to the plane parallel to the disc surface. Use of multiple heads has reduced head positioning time by a factor of four to six.

The comb-like access mechanism has changed disc file organization concepts. Since all read and write heads move in unison, the same track position is located on each disc simultaneously. Therefore, all data at this position on each disc can be accessed without further head repositioning. Consequently, optimum organization of a user's files can eliminate a considerable amount of access time by allowing processing of sequentially arranged records.

In operation, record locations on magnetic discs are addressed by dividing each track into sequentially numbered sectors. In most cases, each sector has a fixed data capacity. For addressing, tracks are numbered sequentially, with the disc and disc unit also having identifying numbers. A complete address then would consist of numbers designating a sector, track, disc and disc unit. These addresses are frequently too long to be placed directly into the computer instructions. In this case, they are placed in core memory with their locations contained in the computer instruction.

Recent disc files, although promising improved performance, have been plagued by head positioning problems and damaged surfaces due to head contact. In combatting these problems, disc manufacturers have made use of the floating head principle in which the head floats on a layer of air generated by the rotation of the disc or drum. Some types use solenoids to retract the head when the disc or drum falls below a specified revolving speed.

Some current disc units are the following:

1. The G.E. M640A Disc Storage Unit uses separately positioned access arms with eight read/write heads for each of the 16 data discs. However, only one of the 16 access arms can be repositioned at a time.

2. The Burroughs Disc File System which uses a head for each individual data track. All lateral head movement is eliminated with this approach and the access time is reduced to 0-40 milliseconds. The cost of storage is competitive even with the large number of read/writer heads used.

3. The Anelex Model 80, still undergoing refinement, uses interchangeable cartridges called disc kits. Each kit contains six discs and stores up to 3,900,000 characters. By using seven binary clutches in simultaneous operation and a disc surface of two zones with 100 tracks each, this unit achieves a constant head positioning time of 75 μ sec. The tracks are accessed by an arm containing two heads, one for each zone on the disc surface.

4. The Bernoulli Disc, manufactured by LFE, utilizes the Bernoulli principle to stabilize a thin flexible magnetic disc. In this concept, air is pumped between the disc and headplate such that the hydrodynamic forces of air and the dynamic and elastic forces on the disc are maintained in a stable equilibrium. The recording and reproducing heads are rigidly mounted in a fixed headplate and require no adjustment during operation. In use, the flexible magnetic disc is rotated close to the headplate and separation is maintained automatically between the headplate and the rotating disc. These discs are available in storage capacities that vary from 82,500 to 777,200 bits.

5. The Anelex 800 has a storage capacity of 160 mega-bits and a maximum access time of 125 milliseconds.

6. The Anelex 4800 is a larger disc file unit having a storage capacity of up to 624 million bits. This unit is available with as many as 48 recording discs each with a capacity of 13 million bits. Track accessing is controlled by position addressing with primary and fine movements executed simultaneously and in parallel. The Anelex 4800 is rated as having an average access time of 65 milliseconds.

7. The IBM 1311 could be made available in a militarized version having two disc drives, each containing 50 million bits. Each disc drive contains eleven 14-inch diameter aluminum discs. Four disc drives can be controlled by a control unit which would provide 200 million bits for this 1311 Military Disc System Configuration.

8. The Model dp/f-5035 Discfile, manufactured by Data Products Corporation, can accommodate from 460 to 520 million bits. Like the Model dp/f-5020 Discfile, this unit has separate positioners for each data disc and, in addition, has a dual accessibility feature that allows two computers to be used. The Model dp/f-5035 is available with one or two 32-disc units.

9. The Librascope prototype discfile system under development utilizes 48" diameter discs with 256 tracks on each surface. An access time of 33 milliseconds is attained, using a single-zone, single-frequency operation and fixed-position flying heads. Current applications of this system are contemplated in military command and control operations.

C. Magnetic Drum Storage

Magnetic drums are available in many sizes with varying access speeds. Although used as storage devices, they are considered to be of the general purpose type and are predominantly used in computer systems. As such, magnetic drums are not of primary interest in this report, and, consequently, will not be discussed in detail.

The average magnetic drum uses read/write heads for each track. Access time is then the period required for the drum to rotate such that the desired data is below the reading head. Two drums of this type are the IBM 7320 and the Univac FI-880. Such drums are usually used for systems programs, segments of operating programs or where a fast response is required, rather than large storage capacity.

Some drums, such as the Univac Randex Drum, use a movable access mechanism which reduces the number of read/write heads required. The Univac Fastrand Drum uses a single mechanism to access data on two drums located in the same cabinet. In this unit, 32 read and write heads are used for each drum. Each head serves 96 tracks and, by moving horizontally in unison, has a positioning time of 57 milliseconds. This head arrangement allows 688,128 characters to be accessed at any given position of the access mechanism.

D. Magnetic Tape Storage

Although magnetic tape is used extensively in

computer configurations, several small-scale, special-purpose devices have been developed that also use magnetic tape storage. In order to increase searching speed and access time, these equipments were designed for searching on index information. Stored data is organized such that a minimum of tape reels and tape searching is required. This approach attempts to provide an optimum use of available storage capacity and searching capacity. Furthermore, use of peripheral equipment is also held to a minimum, with just an electric typewriter and paper tape input and output usually required. In production, such devices could cost less than 100K and provide a flexible storage capability. Included in this section are the Document Data Indexing Set, AN/GSQ-38 and the G.E. Search Comparator.

In contrast to these index searchers and compar-

ators, the Video File represents large-scale special-purpose equipment primarily designed for the storage and retrieval of documents. A system installation would have a medium-to-large scale computer and considerable peripheral equipment.

DOCUMENT DATA INDEXING SET AN/GSQ-26

Status—Successful feasibility model

Military Sponsorship—

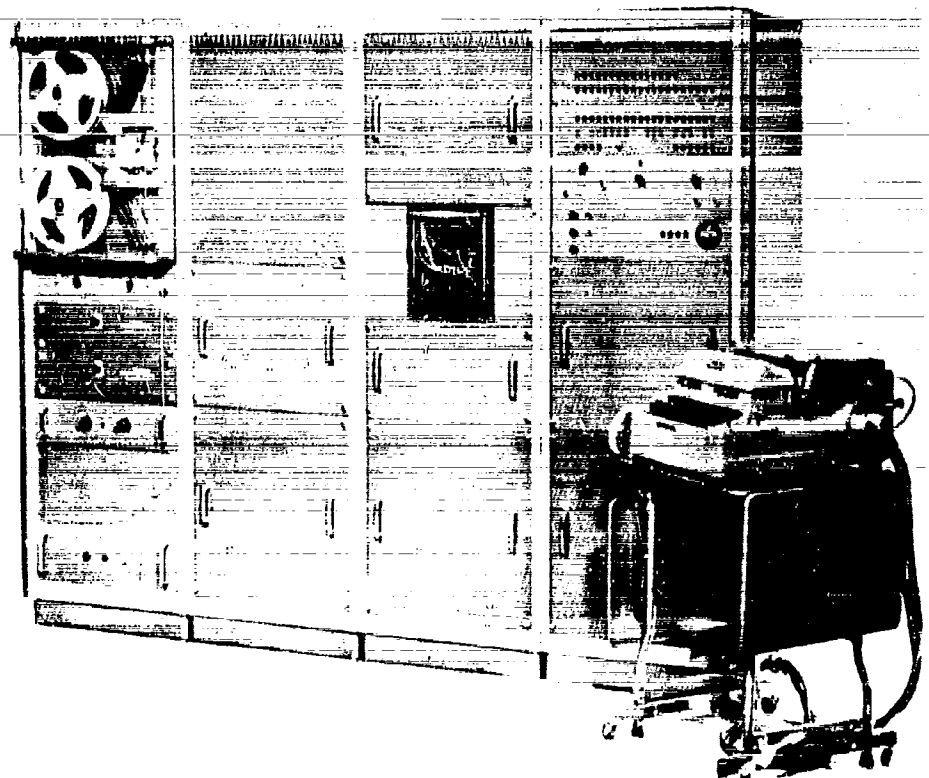
Government Branch U.S. Air Force

Agency—Rome Air Development Center

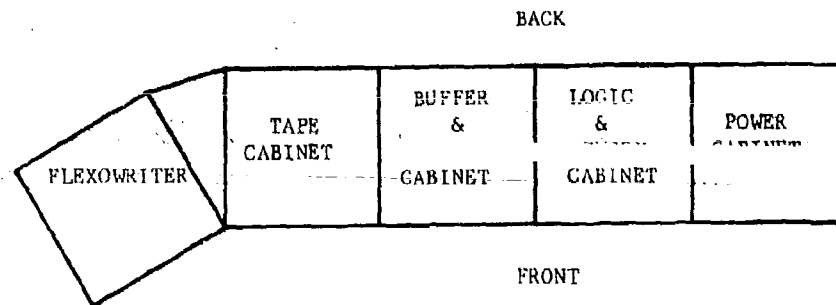
Contract Number AF30(602) 1834

Contractor—Computer Control Company

Cost—140K for experimental model



Document Data Indexing Set An. GSQ-26



AN/GSQ-38 Equipment Layout

Description of Equipment

This device is a special purpose digital computer to search index terms of clear text. A 2400 foot reel of one-inch magnetic tape is the storage medium. It is possible to store on the magnetic tape documents consisting of index terms and an abstract or clear text. Using a plugboard to wire in logical relationships among descriptors, it is also possible to search the file using as many as twenty descriptors at one time. The logical relationships of equality, greater than, less than, greater than or equal to, less than or equal to, are available for comparison during a search.

The Document Data Indexing Set has a word length of 42 bits. Thirty-six bits are used for data, the other six are used as a tag. The maximum document length is 156, 42-bit words. As designed, the machine accepts paper tape input using a special seven-level code. The output is in the form of document accession numbers or the complete document. Using a 2400-foot reel of tape, it is possible to store approximately 40,000 documents on one tape. At a searching rate of 110 inches per second, it is possible to search the entire 2400-foot reel of tape in 4½ minutes. Input and output on this model were limited to ten characters a second because a flexowriter was used for all input output operations.

This special purpose computer could be used in any library-type function where it is desirable to search on index terms at high speed.

Design of this computer to accept words of varying length provides direct access to the question memory, and elimination of plugboard wiring would make this device a desirable piece of operational requirement.

COMPUTER SET, ELECTRONIC ORDER OF BATTLE AN/GSQ-38

Status—Successful Experimental Model

Developer—Aeronutronic Division of Philco Corporation

Military Sponsorship—

Government Branch—U.S. Air Force

Agency—Rome Air Development Center

Contract Number—AF30(602)-2020

Cost—250K

Description of Equipment

The Computer Set, Electronic Order of Battle (AN/GSQ-38), is an experimental model of a unique digital system for searching and retrieving information which meets a predetermined set of requirements from magnetic type files. This special purpose, digital computer uses BLAX logic elements to perform high-speed comparisons and evaluation at full magnetic tape speeds.

The interrogation system consists of an inquiry station, the logic evaluator, and a magnetic tape unit. The inquiry station contains an electric typewriter which permits keyboard entry for the generation of interrogation criteria and the typewriter output for the recording of records (abstracts) which satisfy these criteria. The logic evaluator contains storage to hold the statement of criteria, records which satisfy the criteria, and the logic necessary to operate the system. The magnetic tape unit provides a means for reeling the abstracts or records which are to be searched. These abstracts are stored on reels of magnetic tape.

which are searched at full transport speed in the magnetic tape unit.

The GSQ-38 system permits a search and examination of the magnetic tape file. The file consists of a sequence of abstracts that are grouped in data blocks of 1092 alphabetic or numeric characters. The logical

manner that this system may be used with tape files of complex formats. Also, the basic concept of the computer is flexible enough to permit the more difficult evaluation on ordered abstracts. The unordered abstracts take the form of brief descriptions of technical papers or reports. The search criteria, in this case, would be the appearance of certain key words in the description.

The design of the logic evaluator allows the operator to type the inquiry criteria directly onto punched paper tape. The tape is then read into the memory of the logic evaluator. Stored in the memory of the logic evaluator, the characters which represent the logical equation of the evaluation are the actual characters of the logical equation itself. No translation of this logical equation to operational steps is required. This obviates the need for using the general purpose computer to execute a sophisticated translational program. This further assures that a minimum execution time is required to evaluate more complex logical equations.

SEARCH COMPARATOR

Status—Successful feasibility model

Manufacturer—General Electric Company

Delivery Time—35 weeks

Cost—60K to 80K depending upon equipment features and configuration

Description of Equipment

This equipment is considered a small, single-tape-drive-computing device, used primarily to search for index information recorded on magnetic tape. A recording density of 556 bits/inch provides a storage capacity of 16,680,000 characters in a single reel of tape 2400 feet in length. This tape can be searched in 4.7 minutes. Output is a standard electric typewriter with a listing printer available as a separate option.

The Search Comparator has characteristics that

make it applicable in index searching files which refer to documents or specific items of information.

Operating Characteristics

The current model of this device requires that tapes be updated or prepared by a computer. A

input in 15-30 minutes, depending upon the processor and equipment complement. Shortly, a tape preparation unit will be available allowing this process to be completed at the Search Comparator.

File queries are input by typewriter using natural language. Such operation requires that no special indexing or coding be mandatory, thereby allowing it to be dependent upon user preference.

MAGNETO-OPTICS SYSTEM

Status—R&D item

Military Sponsorship

Government Branch—U.S. Navy

Agency—Office of Naval Research

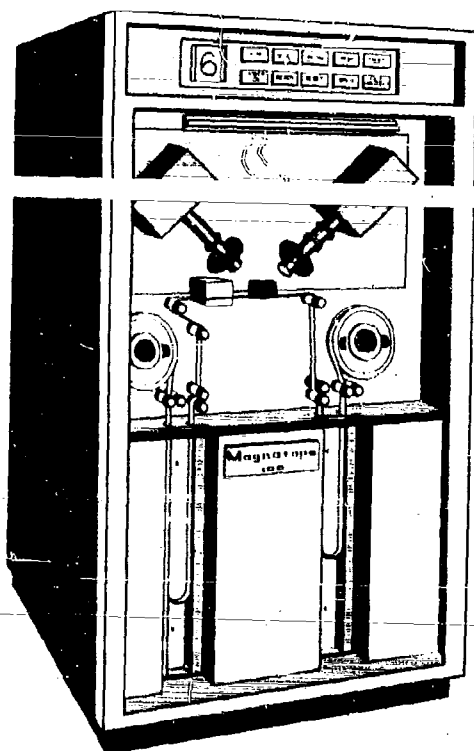
Contractor—The Magnavox Company

Delivery Time—18 months for feasibility model

Description of Equipment

This development will utilize polarized light for readout of magnetically coded data which has been recorded at high densities. A tape transport employing this technique is expected to have the following functional characteristics:

- Recording Format
 - Method—NRZ
 - Transverse Recording—200 bits to the inch
 - Longitudinal Density—1000 bits to the linear inch
 - Density Store—200,000 bits to the square inch
 - Read Transfer Rate— 2×10^6 bits/second
 - Write Transfer Rate— 2×10^6 bits/second
- Tape
 - Width—1 inch
 - Length—1000 feet



Proposed Magneto-Optic Tape Unit—Magnatape Model 100

- Thickness—1.5 mil
- Reels—7 inches in diameter, NARTB hub with file protect ring
- Tape Speed
 - Read/Write Forward—0 to 100 inches per second forward
 - Read Reverse—0 to 100 inches per second
 - Normal Tape Speed (Read)—100"/second
 - Normal Tape Speed (Write)—10"/second
 - High-Speed Rewind—Accomplished in less than 1.5 minutes from end of reel. The speed will be controlled with $\pm 5\%$.
- Start Time—10 microseconds (maximum)
- Stop Time—10 microseconds (maximum)

Equipment using this tape transport would be capable of very high speed reading of stored magnetic data in the form of digital, analog or video recording.

VIDEO FILE

techniques

Developer: Radio Corporation of America

Delivery Time: 18 to 24 months

Cost: 3.8 million dollars for a large scale system

Description of Equipment

The Video File is a document storage and retrieval system which utilizes RCA Video Recording techniques developed for the television industry. Documents up to 10" x 12" in size are recorded on 2.25" x 2" frames of video tape which is stored on reels of 7200 feet lengths containing up to 36,000 documents. Each frame contains, in addition to the document image, a control track, index time track and an index track for index information to be used for scanning in the high speed search mode of up to 300"/sec. The capacity of these tracks is limited to 300 characters of index information.

The principal Video File Units are:

- Camera—Converts document images to composite video signals capable of being stored on magnetic tape by the Video File Recorder.
- Recorder—The video recorder stores on magnetic tape document images produced by the camera or transferred from another recorder. The recorder can also reproduce in video form stored images, erase images and write over previously erased frames.
- Printer—The printer employs the electrofax system to obtain hard copy printouts of images stored on video tape.
- Merge Control Unit—The control unit is used to simultaneously address and control two recorder units during the merging video tape's operation.

Operating Characteristics

During operations, the input camera uses an electro optical scanner, in combination with a fiber

optical bundle, to illuminate the line of paper of the incoming document being scanned. Photo multiplier tubes detect the reflected light from the document page and transfer this signal to a video recorder where the document images are stored on magnetic tape along with associated index information. The recorder unit can then be used to search on this information and transfer it to another recorder or edit it. During the interrogation mode, requested documents are transferred by the recording unit to an output tape

for subsequent transmittal to the electrofax printer for hard copy output.

The Video File System is controlled by paper tape input prepared by the RCA 501 computer. In system operation, it utilizes current input and output techniques with the associated peripheral equipment, i.e., paper tape and magnetic tape units, print reader, etc., that allow for considerable system operating flexibility.

SECTION III

PHOTOGRAPHIC DIGITAL AND/OR IMAGE STORAGE

Photographic systems have been used for quite some time for information storage. In most of these applications, the prime purpose for microfilming was to conserve space. Recent developments, however, have altered this practice to the extent that photography is now recognized as a means for providing more accessible information as well as compact storage. Photographic storage is now available in configurations that satisfy current information requirements as compared to the archival type of storage for which microfilm was used in the past. This condition has evolved from advancements in the state of the art of photographic emulsions and films, lens systems, and mechanization.

Photographic films are now capable of being exposed and developed in extremely short periods of time. Furthermore, dry process films have been developed which further simplify the processing requirements. One of these, diazo film, requires exposure to ammonia for processing, while the other, Kalvar film, is processed by heat. With such simplified processing, production of imagery can now be accomplished in many cases "on line", eliminating considerable delays in the use of photographed information. Such practice has resulted in equipment design that provides duplicate information while never removing the original photography from the master files. Dissemination to the user is consequently quicker and can be more extensive without disturbing the functioning of the original file.

As film emulsions and processing have improved, so has film quality. When combined with better lens systems, greater reductions and resolutions have resulted. As a consequence, storage densities have increased for microphotography and microfilm is now being used to store aerial photography. Currently, it is possible to store as much as 106 document pages in one cubic foot.

Although greater reductions have been desired due to the resultant storage densities, there are also several disadvantages. In almost all cases, microreduction requires some form of mechanization to attain desired operating speeds. Frequently, mechanization is necessary to provide adequate protection for

the recorded images. Furthermore, additional equipment is required for viewing the reduced images and for providing a usable output. Consequently, increased microreduction is not free of ramifications and should be considered with respect to the additional equipment support it requires.

The microfilm industry has produced numerous film formats and equipments to handle current storage and retrieval requirements. Among the unit record formats are microfilm jackets, microtape, microfilm cards, microfilm chips, aperture cards, and microxerographic cards. In using the first two, microfilm jackets and microtape, the recorded information is on roll film which is cut in the appropriate sizes for mounting on prepared cards. The others usually represent a frame of a microfilm roll which was either cut up or duplicated from a master record. With many of these formats, information can be stored in either coded or alphanumeric form. In most cases, index information is recorded in a specified area and serves as the search criteria from which the associated document or document page can be selected from file. In other configurations, index information is recorded on a separate medium such as magnetic tape or a microfilm roll and is searched separately in responding to a query. This arrangement requires that an additional selection be made once the index search has identified the portion of the stored information desired.

Each form of microfilm, whether a card, strip, plate roll or chip, has a variety of equipment with which it can be used. This equipment would include use in both large and small scale operations. This section will concern itself only with those devices that are directly involved with the storage and retrieval of the microfilm. Exceptions are made when a complete system, specifically designed for microfilm and storage and retrieval, is discussed.

Unlike magnetic storage systems, there are microfilm systems that can be completely manually operated. We can find such systems in operation, as well as systems that employ as much automaticity as the current state of the art is capable of providing. Between these two extremes are several other levels of

system sophistication, each with its own selection of equipments. Besides those mentioned in this section, these include cameras, duplicators, processors, hard-copy reproducers and viewing consoles. There are many models of each type which can be used with similar storage media. The problem facing the system designer is to evaluate the capabilities of each type with respect to the storage media and application being considered.

A. Microfilm on Aperture Cards

Aperture cards are cards that have one or more "windows" on which microfilm images can be mounted or printed. Use of such cards facilitates handling small microfilm records but still retains the miniaturization and standardization advantages of microfilm.

Aperture cards are available in many different formats. A common type is an IBM aperture card that can be handled by standard punched card equipment. Other aperture cards are available with edge-notched coding, with jacket windows for inserting microfilm, with diazo or Kalvar film for duplicating images and in forms to be compatible with specific filing techniques such as the VISI record concept. Currently, most aperture cards are used for containing frames of 35mm or 16mm film.

The extensive use of aperture cards for data storage has encouraged the development of numerous equipment for their production, duplication and handling. Such equipment is available in various degrees of capability, size, and sophistication for satisfying practically all aperture card data handling requirements.

Aperture cards cost \$25 to \$70 per 1000 cards, depending on the quantity and card type and the cost information received from the following manufacturers:

Film Sort—Minnesota Mining & Manufacturing
Langan Corporation
Microseal Corporation
Photostat Corporation

This sub-section includes information on
ACSTRAC
RASTAR.

ACSTRAC

Status—Available

Developer—Atek Corporation

Delivery Time—Not available

Cost—Not available

Description of Equipment

ACSTRAC is an Aperture Card Storage and Retrieval and Copying System, which is available in both a semi-automatic and fully automatic form. Aperture cards are stored in capsules which in turn can be stored in magazines or trays.

In the semi-automatic form of the system, the module is essentially a conventional mechanized elevator file. The tray containing the requested capsule is automatically brought to retrieval position by manually keying in the capsule number indicated on a punched control card. The capsule can then be manually retrieved from the tray.

The file module in the automatic version is basically a rotary indexing conveyor system which conveys the tray or magazine requested by the control card to a retrieval and refile position via the shortest route. The trays retain the capsules in such a manner that capsule selection and return can be performed automatically.

Operating Characteristics

Input requests to the ACSTRAC system are in the form of drawing numbers. In the semi-automatic system, drawing numbers and their assigned addresses in file are obtained from an Autoindex. This information is then punched into control cards which are sorted into address number sequence and distributed to the various files for retrieval of the requested aperture cards. Color coding on the control cards dictates which retrieved master cards are to be routed to the file maintenance station and which are to be routed to the copying equipment. Retrieval of the desired capsules is then indicated by the control cards, and the capsules are transported from the file location on a conveyor system.

In the automatic system, the input media may be tapes, cards, or manual keyboard. The requested drawing numbers and their related file address are automatically obtained by the Autoindex and used to activate a retrieval mechanism. This mechanism

deposits the desired capsules in an electronically controlled transport system which transfers the capsule to either the copying or the file maintenance equipment.

Output for both the semi-automatic and automatic systems can be either a duplicate or a hard-copy print. For duplicards, a card punch, a high-speed contact printer, and a processor are used to achieve a reproduction process with less than a 10 percent loss in resolution. Hard-copy output is achieved by use of a conventional projection printer.

RASTAR

Status—Prototype Model

Developer—Photo Devices

Delivery Time—Not available

Cost—Not available

Description of Equipment

The RASTAR system employs electromechanical techniques for the storage and retrieval of microfilm images. Items are stored around the periphery of a drum in unit record form and held to its circumference by mechanical clamping. Using this storage concept, 100,000 tabulating or operative cards can be stored in a ten-drum console 48" long, 50" wide, and 40" high. Each drum within the console is connected to a driving mechanism which can be activated by entering a location number into the system from a computer, punched card, paper tape, or manual keyboard input. Retrieval requires four digits to identify a particular item, a fifth digit identifies the drum within its console and a sixth or seventh digit, if necessary, will identify the specific console. A total of 3.6 seconds is the maximum time required to locate and lift from file any item which can be in the form of a card, aperture card, film chip or microfiche.

Operating Characteristics

In order to properly identify a single card in the file, it is necessary to attach to each card an identifying tab located in a staggered fashion from one to ten, and this sequence is repeated continuously. In retrieving, the first digit of the four-digit drum identification number will start the drum rotating at a speed of one revolution per second until the proper thousand area is located. When this position is

reached, the drum will be slowed down to one-tenth the previous speed until the hundredths area is located, at which point the drum is slowed down again to one-tenth the previous speed until the ten area is located. At this point a selector arm is positioned across the width of the card identified by the last digit, spreads apart the two adjacent cards and removes the item from file. After verification, the card is fed into the pointing station where a diazo or Kalvar duplicate is made. The two cards are then separated and the file copy returned to its original storage location. Total time for this complete procedure from initiation of the first search cycle to delivery of a duplicate copy of the desired item is 14.6 seconds.

B. Microfilm In Card Form

Microfilm cards are produced in many different sizes and formats and on different film stock. Some have been designed for specific applications such that a single card can contain all the information associated with a particular subject. Others have been selected as a compromise between ease of handling and storage capacity. Also, some cards have been selected because they are amenable to mechanical handling.

Microfilm cards, like aperture cards, are unit records and provide flexible filing and storage at various degrees of complexity. File organization and manipulation are currently accomplished by both manual and automatic means. In many instances, effective file organization and card arrangement have enabled manual systems to compete successfully with their automated counterparts.

The latest addition to the capability of this area has been the development of microxerography. This recording concept provides the facility of instant micro-recording of an image onto a microform and further provides the means for successively adding micro-images to the carrier at any point in time. A micro-image of an original document is recorded directly to the carrier and additional documents can be recorded onto the same carrier or "added on" whenever documents applicable to the subject are received. The DARE system employs this technique for recording images on FAM cards.

This sub-section will include information of the following:

- DARE System
- Docuform
- Microcard
- Microfiche
- Mosler Document Retrieval Equipment
- Large File Document Retrieval System
- Graphic Data Storage and Retrieval System

DARE SYSTEM

Status—Available

Developer—Bell & Howell Company
Xerox Corporation

Delivery Time—Not available

Cost—Not available

Description of Equipment

The DARE is a document microimaging device employing the xerographic process. Documents ranging from 6" to 9" in width and 9" to 11" in length are handled automatically. Images of the documents are reduced one-third and placed on EAM cards at the rate of 2000 per hour. These cards are then handled by standard card equipment and can be used in many applications that formerly required aperture cards.

Operating Characteristics

For microimagery, documents and pre-batched cards are placed in their respective input trays. The documents are then fed automatically into the document-holding drum while the cards are fed through a card track near the bottom of the device. In a few seconds, completed image-bearing cards are being stacked in a holder at the rear of the machine. When the required number of cards have been prepared from a document, an end-of-batch signal on a punched card causes the first document to be stripped from the drum and the next document to be attached.

If a document should fail to feed properly, the device stops. However, controls are arranged so that all documents in some stage of the reproduction process will be allowed to continue through the machine. The DARE normally operates unattended

and requires only developer powder to maintain operation.

DOCUFORM

Status—Available off-the-shelf

Developer—Documentation, Incorporated

Delivery Time—2 to 90 days

Description of Equipment

Docuform is a development using a single flat transparent sheet of film which permits over 100 pages of standard-size documents to be stored and reproduced from each 5" x 8" unit. Each film sheet has a color-coded tab along one edge to facilitate selection from storage files that can be ordinary cabinet drawers. Document pages are stored adjacent to one another at a reduction ratio of 18:1 and at a resolution that is above 100 lines/mm.

This particular microfilm record is compatible with many currently available reader-printers, thereby eliminating the necessity for procuring special equipment for its use. It has been designed primarily to provide compact manual storage of document type information.

MICROCARD

Status—Available off-the-shelf

Developer—The Microcard Corporation

Delivery Time—2 to 90 days

Description of Equipment

Microcards and microfiche are similar except that Microcards are printed on paper instead of the transparent film used for microfiche. Since Microcards are opaque, they can be printed on both sides and viewed or reproduced by the use of reflected light. Available in several sizes, such as 3" x 5" and 5" x 8", Microcards can contain complete documents recorded at reduction ratios ranging between 15:1 and 20:1.

Microcard images are always positive because they are normally used for direct viewing rather than as an intermediate for reproduction of enlarged copy. For this purpose, the positive images will appear identical to the original material.

MICROFICHE

Status—Available off-the-shelf

Developer—The Microcard Corporation

Delivery Time—2 to 90 days

Description of Equipment

The Microfiche is a transparent unit record of either silver halide, diazo, or Kalvar film stock for recording document pages of textual or graphic data. For a normal 8½" x 11" material, reduction ratios ranging between 15:1 and 20:1 are used. Microfiche is available in several sizes; 3" x 5", 4" x 6", and 5" x 8" cards are the most popular. The 5" x 8" card has sufficient capacity for 84 document pages reduced 18 times.

Microfiche is recommended for primary use as an intermediate for the reproduction of full size pages. In most cases, the Microfiche is negative to reproduce positive full size copies. In this form, Microfiche is ideal for compact storage and dissemination of stored information.

MOSLER DOCUMENT RETRIEVAL EQUIPMENT

Status—Available

Developer—The Mosler Safe Company

Delivery Time—6 months

Cost —\$15,000 for standard model

Description of Equipment

The Mosler equipment retrieves at command a specific document or specific group of documents from a file, such as a file of aperture cards, multiple-image film cards, or related documents in card form. The cards are stored in a drum file which consists of fifty pockets containing 100 cards each. For in filing, each card can be returned to file at random within the pocket of 100 cards for which it came.

This equipment is available in three models each with a different level of sophistication. The standard model, Cardomatic, is the basic storage and retrieval unit. The Visomatic unit has the same features as the Cardomatic, but, in addition, has the capability to



Mosler Retrieval Unit

automatically retrieve, place in a viewing platen and return to file a stored item. For applications involving multiple image film cards, the Selectomatic model, which operates as the Visomatic, except that it can also select the required image from a group of images on a card is used.



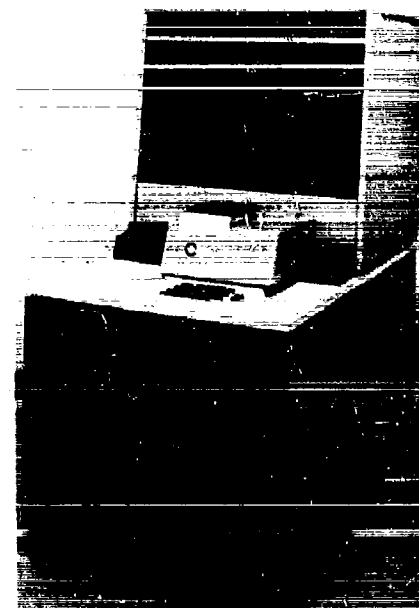
Retrieval Unit Showing Card Output Station and Keyboard

Operating Characteristics

Retrieval of a card in the Cardomatic unit is initiated by keying in the appropriate card accession number. This four-digit number designates the drum pocket and the card within that pocket of 100 cards. Edge-notched coding is used on each card with the last two terminal digits determining the card to be selected.

In retrieval, depressing the last key for any code number automatically initiates the search mechanism and the complete retrieval cycle. The drum file revolves to position the appropriate pocket at the retrieval and infiling location where the appropriate card is elevated for easy extraction by the operator. Retrieval in this manner can be accomplished in 4 to 7 seconds for any of 5000 cards.

The Cardomatic unit stands desk top high and has overall dimensions of 32" high, 40" long, and 15" wide. It is capable of handling all standard $3\frac{1}{4}$ " x $7\frac{3}{8}$ " cards and can be modified to handle other sizes.



Master Retrieval Unit with Viewer-Printer

LARGE-FILE DOCUMENT RETRIEVAL SYSTEM

Status—Proposed R&D effort

Developer—North American Aviation, Inc.
Space and Information Systems Division

Delivery Time—12 months

Description of Equipment

This system is a proposed R&D effort with off-the-shelf equipment. It is designed for document retrieval in large files where conventional numerical computer systems, because of restrictions imposed by their register capacity or logical processing configuration, cannot process descriptor index files efficiently. Included in this system are the following:

FIRE (Fast Information Retrieval Equipment) is an implementation of the search function. Its speed is comparable to that of a high-speed digital computer,

although its main components are relatively low cost electro-optical and mechanical equipment.

FACE (Fast Access Card Equipment) is an implementation of the locate function. It is a fully automatic, random-access, storage and retrieval device that locates a specified card, selects the card and feeds it to peripheral equipment. For a file of 1 million cards, average retrieval time on the order of .2 seconds is feasible.

FUSE (Fast Updating System Equipment) is used to update the term card file. The updating is performed by generating marks on predetermined positions on the term cards.

Operating Characteristics

The Large-Document Retrieval System would have two types of cards: Document cards and term cards. The document cards are the microfilm copies of the documents in the document file while the term cards represent the terms or key words indexed from the document file. In storing index information, each document number is assigned a particular position on every appropriate term card such that the assigned position is the same for all cards. Both sets of these cards are then stored in FACE.

A request to the system consists of a set of terms. FACE accepts the input, locates the corresponding term card, and feeds it to FIRE. When the last term card related to the request has been fed, FIRE scans the cards simultaneously, searching for those positions containing the largest number of marks, and lists the corresponding document numbers. These are used as an input to FACE, and the proper document cards are located and fed to appropriate peripheral equipment. During the time interval that FIRE performs its scan, FACE accepts updating input, feeds a term card to FUSE for marking at the proper position, returns the card, and feeds the next.

Of the sub-systems, the most firmly established in design is the FACE. This is a storage device containing a servo-mechanism capable of retrieving stored cards and feeding them to an input and output magazine. Cards are stored along the periphery of a drum-type storage arrangement and retrieved by a centrally located arm. Each storage unit consists of a stack of several hundred slots, each slot capable of storing an individual card. When a card is requested by means of a keyboard, the servo-mechanism moves the arm in

a position corresponding to the slot. The mobile card receptacle at the extremity of the arm advances slightly to assure close contact with the card slot and the card is pulled by vacuum into the card receptacle. The arm then moves to the input/output position and ejects the card into the input/output magazine.

PROPRIETARY INFORMATION

GRAPHIC DATA STORAGE AND RETRIEVAL SYSTEM

Status—Available

Military Sponsorship—

Government Branch—U.S. Navy

Agency—BuWeps U.S. Navy

Contract Number—NDW63-0765-f

Contractors—GPI Division, Aerospace Group

General Precision, Inc.

Mosler Safe Company

Date Available—March 1964

Cost—\$0K

Description of Equipment

This system allows for the storage and automatic retrieval of 5000 aperture or all-film cards. The cards are stored in a drum file and are selected by means of keyboard input. After the selection, the cards are automatically removed from file and placed in position on an X-Y Platen for TV scanning. From any one of many remote positions it is then possible to view the card images on a high Resolution Monitor (1000 lines), control its magnification up to 250:1, regulate the X and Y orientation, control the image brightness, polarity and contrast and return the card to file.

This system consists of the following major units:

Storage Drum—Stores cards and allows for automatic retrieval of cards.

Microtelevision—Provides variable magnification over a linear range of 30:1 or 900:1 in area.

X-Y Platen—Allows for moving the card so that any portion may be viewed.

High Resolution TV—High quality TV system (1000 lines resolution) allowing for remote viewing of selected image.



OPL Graphic Data Storage and Retrieval System

Operating Characteristics

Inputs to this system are paper aperture cards or all-film cards of the standard EAM size ($7\frac{3}{8}'' \times 3\frac{1}{4}''$). Each card or image has a unique numerical address which is known to the operator and which he places into the keyboard for automatic retrieval of the desired information. The cards are stored in the drum file, which consists of fifty pockets containing 100 cards each. Each card within the pocket is uniquely notch-coded to allow for its retrieval upon request. Average retrieval time for any card is four seconds. However, in this particular system, the output would be a video image of the card's contents. A hard-copy output, although not part of this system can be provided, as well as means for duplicating the desired image on aperture cards.

The storage media can be of almost any material which meets the approximate physical characteristics of EAM cards, so that although the present system is intended to store microfilm type information, it is quite possible to store oxide coated materials for the

purposes of storing and retrieving digital information in magnetic form. Currently, programs are in progress to extend this system's capability for Microwave Link, Computer Tie-in, Project IV and Hard-Copy output at remote locations.

C. Roll-Film

Roll-film storage offers the advantages of microfilm, but requires serial searching to obtain access to the recorded information. Attempts to shorten the search time have concentrated on electronic means of scanning and, in some cases, on using shorter length rolls of film. In some systems, the index information is recorded in digital form as small, clear, and dark areas beside the document image area. Another practice is to record the index information separately. Consequently, in roll storage, the basic intent has been to increase search speed by reducing the length of film to be searched, by increasing the searching speed, or by a combination of both.



OPL System Illustrating TV Scan of Aperture Card

Roll-film storage, however, forces the use of information in a fixed physical arrangement. File updating and reorganization can only proceed by extensive splicing or by complete recopying. In many applications, these restrictions cannot be endured even though mechanization is utilized to increase searching speed. For such situations a unit record concept is usually employed. However, due to the ease of manipulating roll film in contrast to unit records, mechanization of roll film storage can be attained in many cases at lower cost. Under such conditions, roll storage should be considered if any possibility exists that its relative file inflexibility can be endured.

This sub-section will contain information on the following:

- Filesearch
- Flip
- Fostic II

- Miracode
- Radio
- Rapid Selector
- Video Film Converter
- 70mm Roll Film Selector

FILESEARCH

Status Available

Developer F.M.A., Inc.

Delivery Time 4 to 6 months

Cost \$170,000

Description of Equipment

Filesearch is a textual and graphic material storage system that uses 35mm roll microfilm of up to 1000 feet in length as the storage media. This system is



Filesearch Units and File



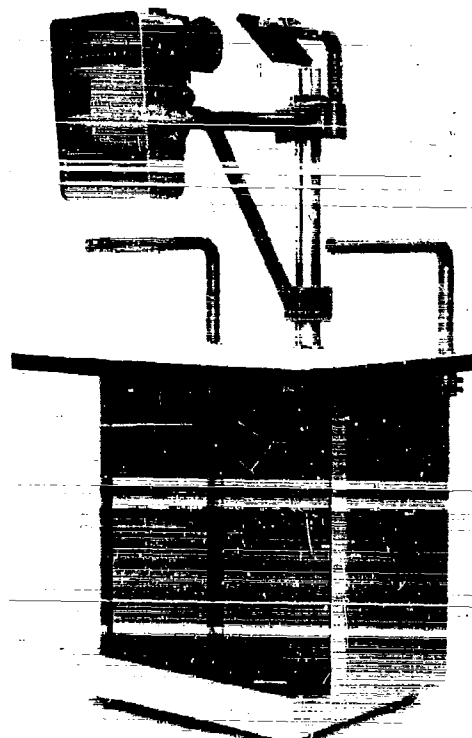
Filesearch Record

composed of two major units: a Recording Unit which consists of a camera, lights and worktable; and a Retrieval Unit which searches the 35mm roll microfilm and includes a viewer, printer, and a copy camera.

A standard Filesearch configuration uses a reduction ratio of 25:1 which enables 32 legal size pages to be recorded on each foot of microfilm. The document area is 310" x 560" and the selection code area is 280" x 160". Each frame of microfilm, in addition to the document area, has a code area capable of containing up to 56 alphanumeric characters of coded index information. If required, additional frames can be used to record index information.

Operating Characteristics

Input to the Filesearch equipment is achieved by creating a punched card for the index information of the document or item to be recorded. The punched card is then placed in a reader which activates the

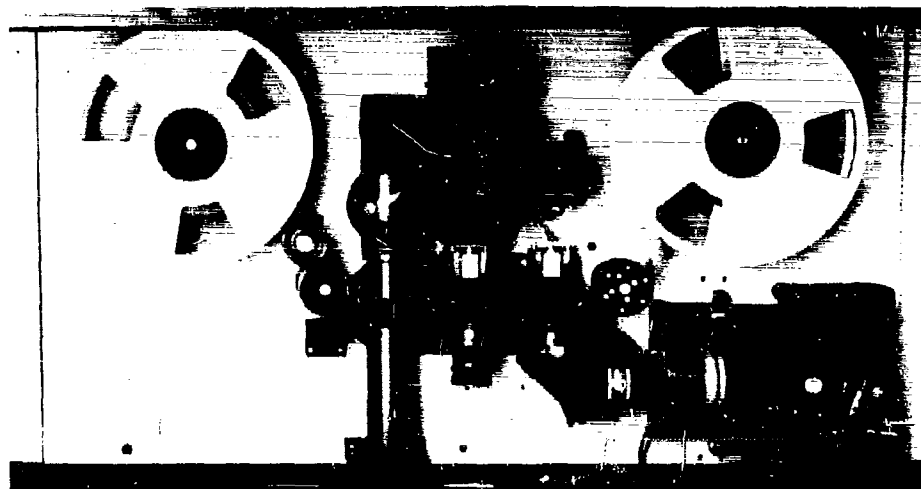


Filesearch Camera

camera in the Recording Unit. The coded data is placed on film at the same time that the first page of the document. The information input can proceed is required, it is recorded beside the second page of the document. The information input can proceed with a rate of 400 pages per hour.

A request for information also requires the creation of a punched card. However, in this case, the request is formulated using logical relationships of "and", "or", and "not" with up to six descriptors. After the punched card is inserted into the Retrieval Unit, the film transport is loaded with the appropriate reel of film and searched at the rate of 200 feet per minute. Each descriptor of a document or item read from film is compared with the contents of the request descriptors and the results are stored until the first-of-code character from the next stored item is sensed. The comparison results are associated according to the logical relationship contained on the punched card. If an item is to be selected for retrieval, the film transport is stopped and the first page positioned for viewing hard-copy output or microfilm recording.

File organization or updating in this system requires that recorded information be removed or placed on a roll of film by cutting and splicing. This system, like any roll-film storage system, is not amenable to situations where considerable file updating



Filesearch Film Drive

and reorganization are required. However, with a resolution capability of 200 lines per mm, it is applicable for storing a variety of data, both textual and graphic, provided the file manipulation requirements are compatible with roll-film storage characteristics.

FLIP

Status—Available off-the-shelf

Developer—Benson Lehner Corporation

Delivery Time—3 months

Description of Equipment

FLIP is an automatic microfilm searching machine which scans 16mm roll-film of 1200 feet in length at the rate of 300 to 600 frames per second. It is designed to select desired information stored on the film and display it for viewing. With a resolution capability of at least 25 lines/mm, the FLIP can store both textual and graphic data. Searching can be by frame number or by the descriptor information contained in the code area. The FLIP is a completely self-contained unit consisting of a display screen, control panel, and keyboard, and film transport assembly.

Operating Characteristics

Each frame of film in the FLIP system can contain up to 32 bits of coded information beside the image area. To initiate a search, the appropriate indexing information formulating a query is entered by keyboard. During scanning, the code areas of each frame are scanned by photosensitive elements until the desired frame is located and displayed. The frame number is also displayed, permitting verification of the selection.

The present FLIP model can search up to 8 descriptors and handle one 1200-foot roll of film having 72,000 frames. Modifications could expand this capability so that at least 15 descriptors per search and multiple reels of film could be used.

FOSDIC II

Status—Successful operating model

Developer—National Bureau of Standards

Cost—100K

Description of Equipment

Fosdic II is a particular type of Fosdic (Film Optical Scanning Device for Input to Computers) systems in which 16mm roll microfilm is used as the storage media. This device was specifically designed to meet the requirements of the National Weather Records Center which maintains a file of more than 450,000,000 punched cards containing climatological information. In using Fosdic II, the punched cards are stored in a microfilm file which is then searched to obtain characteristics on weather conditions. The output of Fosdic II is an exact duplicate of the original punched card on card stock punched to contain all the data originally recorded. A second Fosdic II system being tested will, in addition to this replica copy output, generate magnetic tape recordings for computer input.

Operating Characteristics

The document area in Fosdic II is approximately 0.075" x 0.307". Using reductions of 24:1 across the film and 43.5:1 along the film, punched cards are recorded such that they have a square image. The desired information can then be searched for directly from the card image, since the indexing and selection information will be any of that originally punched on the card. During a search, information can be selected from any 10 columns of the 80 columns on the card. The search, at 4000 cards per minute, is serial in terms of items.

Fosdic II combines electronic, mechanical and optical techniques with search questions set up by plugboard. The film is handled in 100-foot reels having a capacity of 13,200 cards. The reels must be hand-threaded and rearrangement of any items must be accomplished by cutting and subsequent splicing of the film.

MIRACODE SYSTEM

Status—Available off-the-shelf

Developer—Recordak Corporation

Delivery Time—6 months

Cost—25K to 30K

Description of Equipment

The Miracode System consists of the following basic units:



MIRACODE System

Miracode Microfilmer—This new planetary 16mm unit, which includes convenient operator controls, is especially designed for high-resolution recording and accurate illumination adjustment.

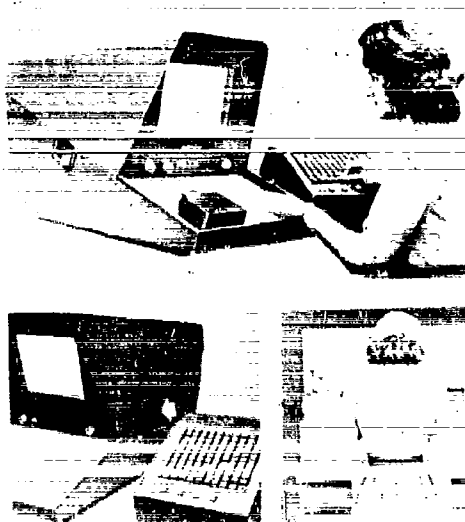
Miracode Retrieval Station—This equipment can store, within fingertip reach, approximately 400 film magazines. The station is modular in design and can be arranged in several configurations. It contains all the controls necessary to initiate and complete a search cycle and utilizes the Recordak Reader-Printer which can search the binary code on the microfilm at high speeds. Selective prints of documents in several print modes can also be provided by this unit.

Operating Characteristics

The Miracode System allows for indexing documents by accession number or by the subject content. Indexing is accomplished by using a dictionary containing terms for converting meaning to numerics

compatible with the Miracode System. For automatic input, an IBM 024 or 026 can be used to read punched cards whose information is encoded on the film by the Recordak Card Converter. This input operation takes 1½ seconds. Assuming six pages per document and four columns of code per document, 900,000 pages of information can be stored in 100-foot rolls contained in one Miracode Retrieval Station.

Retrieval of information requires that the appropriate search criteria be keyed into the Todestar Reader-Printer which can scan the entire 100 foot roll of film in 10 seconds. The first page of a specific coded document which answers the search request is located and is automatically displayed, ready for viewing or printout. Other documents, answering the same parameters, may be located by merely depressing the search button again. Using this mode of operation, a file of 10,000 pages randomly contained in five magazines can be searched in less than 2½ minutes.



Retrieval/Viewer/Reproducer for Hallcrafters RADIR
Microfilm File

RADIR

Status—R&D item

Developer—Hallcrafters Company

Delivery Time—6 to 18 months

Cost—35K

Description of Equipment

RADIR is a document storage and retrieval system using 35mm microfilm as the storage media.

The three basic components of the RADIR system are a planetary encoder unit, an index console, and a retrieval/viewer reproducer unit. Ancillary equipment includes a 35mm planetary camera, storage units for document and index film cartridges, and an electrostatic enlarger-printer for making hard copies.

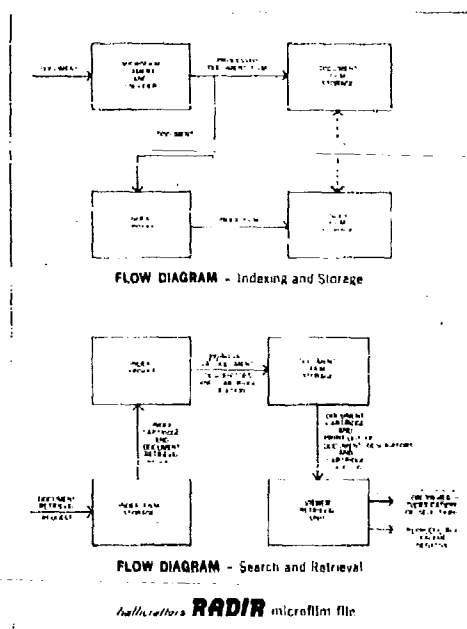
The planetary camera *encoder* is used for micro-filming documents and document identification codes. It incorporates an 11 digit decimal keyboard for document identification code input, a visual mixer tube display for verification of code input accuracy, circuitry for converting decimal keyboard input to four bit binary code, a 11 position binary coding device, and keyboard switch and coding device mal-



Index Console for Hallcrafters RADIR Microfilm File

function circuits. The unit adapts to most 35mm planetary cameras.

The *index console* records document identification and location information on microfilm during storage operations, scans this information and prints out location of document film during retrieval. The unit incorporates an alphanumeric typewriter for input and output with binary conversion circuitry, Kalvar processing equipment for processing the 35mm index film, and search logic circuitry which includes "and" functions. Up to 56 alpha and/or numeric characters are provided for document identification and location description. During retrieval, the index console scans the hexadecimal binary code with parity check at a rate of 700 item identifications per second. A minimum of 14,000 such document descriptions (almost 785,000 alphanumeric characters) can be indexed on



a single-film cartridge, and scanned in an average of eight seconds.

The *retrieval/viewer/reproducer* scans document film at the rate of 55 frames per second, and displays the desired document as a 6:1 blowback on a 7 x 9 inch viewer screen. It incorporates a decimal keyboard for input of the desired document identification code, digital to four-bit binary-code conversion circuitry (up to 11 digits capacity), film transport and viewer, and a Kalvar-film negative printer. The Kalvar negative is generated in less than five seconds upon push-button demand.

In RADIR, index information is stored on a separate 35mm roll of Kalvar film which can contain up to 10,000 coded descriptions of documents. Document identification and subsequent retrieval is accomplished by searching the index information, obtaining the document location, and then searching the appropriate microfilm roll of document information for the desired document.

An indication of retrieval speed is given by the fact that an index roll can be scanned in 15 seconds while a 100-foot roll of document film takes 8 seconds. Since the retrieval operation requires the



Keyboard Encoder for Hallicrafters RADIR Microfilm Files

manual insertion of both the index and document film in their respective searching units, maximum retrieval time for a document would be more than the 23 seconds of combined searching time of the two-film rolls. It is estimated that in a file of 850,000, any document can be retrieved in less than two minutes.

Operating Characteristics

Document input for RADIR begins at the microfilm camera where documents in random order are coded and aligned for photographing. Coding is accomplished by keyboard, verified visually on a nixie-tube display and converted to four-bit binary code on the coding attachment to the planetary camera. The document and binary code identification can then be photographed simultaneously. The film negatives are processed, printed on Kalvar film, and loaded into cartridges. The documents are viewed and assigned descriptors and index categories. This data

is keyed in the index console and the appropriate index films prepared. When completed, the index films are stored in cartridges until they are required for retrieval.

A document is retrieved by first searching the appropriate roll of microfilm that contains the index category of the requested document. The document query data is inserted into the index console which locates the desired entry and prints out the document identification and address. This information is entered into the retrieval/viewer/reproducer unit and the proper roll of document microfilm scanned. The desired document is located and displayed on the viewer. If a Kalvar negative is required, a negative ready for electrostatic reproduction can be processed within five minutes.

The system was developed for small-to-medium scale applications capable of using microfilm as the storage media. Its design and operating characteristics with manual operations are such that an automated storage and retrieval capability is provided at reasonable cost.

RAPID SELECTOR

Status—Successful feasibility model

Developer—National Bureau of Standards
Bureau of Census

Cost—\$5K

Description of Equipment

The Rapid Selector is a continuous roll-film storage and retrieval device using 35mm unperforated microfilm. Microfilm is handled on 100- to 6000-foot reels with storage capacity varying from 600 to 36,000 coded pages per reel. Other packing density characteristics are a resolution capability of up to 120 lines per mm and six coded frames per foot. Using a format with a document rewriting area of 1.15" x 1.75" that can be extended in length, documents in sizes from 3" x 5" to 22" x 34" can be recorded. Adjacent to the document area, a selection code area of 1.20" x 0.36" is provided for storing 280 bits of index information which are divided into 70 hexadecimal characters.

Using this recorded index information, selections can be made by simple address or by descriptive terms and indexing entries. Combination searches can also

be made in which both indexing terms and bibliographic data are used to select a desired item. A predictive search can also be made in which the number of items meeting search requirements is indicated so that the querist may modify accordingly the scope of his search.

A Rapid Selector system consists of a microfilm camera, card reader, card punch, film processor, microfilm copier and the selector.

Operating Characteristics

In the present Rapid Selector model, a modified IBM 407 card reader records the selection criteria. For recording hexadecimal characters, holes are punched in a specified four rows with their complements punched in four other rows of the same column. The cards are then read by the card reader which is connected to a coded light matrix in the camera. Each hole position on the card controls a light position in the matrix, thereby providing the required code pattern for photographing. As many cards as are required can be used for the document code. After filming is complete, the original film will be retained in a security file and master copies made from it as needed.

The search equipment for the Rapid Selector consists basically of a high-speed mechanical film transport, a photocell-activated interrogator and comparator and an on-the-fly output camera. A search question is initiated by punching the codes with the desired selection criteria and using "yes", "no" and "don't care" conditions, if required. For searching, the master film is run continuously at a uniform velocity as the selection code area is read. Whenever a pattern match is obtained, the copy film is brought up to proper speed and a one-to-one copy made for external use. Average access time for a full 2000-foot reel is six minutes. This has been accomplished using a search speed of 36 coded pages per second.

Since the storage medium is neither erasable nor reversible, items must be deleted by a manual cut-and-splice process. Similar manual operations are required for replacing damaged material and for rearranging the file order. During the input, the only provision for manual insertion or code correction is in replacing or removing the code card. However, with this concept, file integrity is maintained since the master film always remains in the file area.

PROPRIETARY INFORMATION

VIDEO FILM CONVERTER

Status—Available off-the-shelf

Military Sponsorship—

Government Agency—NASA

Contractor—Link Division, General Precision

Delivery Time—6 months

Cost—200K

Description of Equipment

The Video Film Converter is a device for converting from a film transparency to an analog voltage and, inversely, from an analog voltage to a film transparency. In either mode, reading or recording, the conversion is accomplished by an electron beam scanning system that uses both horizontal and vertical beam deflection. The scanning rate, resolution, and raster size are variable.

Operating Characteristics

The storage media in this system are 35mm and 70mm strip films, with the maximum frame size being 57 x 57mm. Film reading is done with the film stationary using a scanning motion from left to right with subsequent lines progressing from top to bottom. A single frame scan or repetitive frame scan mode of operation may be used for data reading. For recording, the same techniques are used, except that the photographic film is exposed while scanning with the flying spot scanner. Resolution for this system is 40 lines per minute.

In addition to reading and recording, the Video Film Converter has the capability to search for recorded data. This mode of operation is used for selecting a particular frame for scanning. In searching, the film can be scanned at a rate of 25 frames per second, each frame being scanned at standard TV rates and of the standard TV format for use with external monitors.

70mm ROLL FILM SELECTOR AND CAMERA

Status—Prototype Model

Military Sponsorship

Government Branch—U.S. Navy

Agency—U.S. Naval Photographic Interpretation Center

Contract Number—N600 (62845) 57003

Contractor—Photo Devices, Inc.

Delivery Time—6 months

Cost—70K

Description of Equipment

This system consists of a microfilm camera capable of up to 15x reduction, a code reader, and a searching unit. Designed primarily for recording graphic material, this system can photograph items up to 2 x 3 feet on an image area of $2\frac{1}{2} \times 2\frac{3}{8}$ ". Adjacent to the image area, a code area of 960 bits is used for storing identifying information. Item selection is accomplished by scanning the code area at 100 ft. second. Output is either a displayed image of the desired information or a duplicate of the recorded image.

Operating Characteristics

The input operation requires that the items to be photographed be manually placed on the recording area. A mylar overlay is then placed over the input material and held down by a vacuum system in order to level the item for photographing. Coding information is recorded by reading a punched card with Hollerith code, using a Richardson static card reader. This reader activates a light raster in the camera which produces the equivalent of the punched hole pattern on the input card. The coded information and input item are then simultaneously photographed on the 70mm unperforated roll film.

For selecting images, the required code patterns are again designated by punched card. Searching can proceed at speeds sufficient for scanning a 1000 foot reel of film in ten minutes.

D. Unitized Photographs

Unitized photographs are a form of small microfilm card. Because of their smaller dimensions, an external frame or holder and mechanical assistance are usually required to facilitate handling and to protect the image area. As a consequence, several equipments with sophisticated handling techniques are available for this application.

There are two major applications for unitized photographs: storage of aerial photography and storage of document information. Of these, the storage of aerial photography has been the more recent, because of the critical requirements for such storage in the past few years.

Current efforts in the Air Force for aerial photographic storage have concentrated on using a 70mm x 100mm film unit record. This format has designated areas for image, descriptor and index information and an identification number in both human and machine — readable forms.

Efforts in the document retrieval area have not been restricted by image quality considerations as exist when storing aerial photography. As a result, film unit records for document storage are smaller and can be manipulated with less care. However, both areas employ the file organization techniques that are identifiable with unit record storage. Most of the equipments are modular and can be adapted for use with various size files and file material.

This section will contain information on the following:

- Filmorex
- Magnavue
- Media
- Walnut System
- Minicard
- Automatic Unit Record Storage and Retrieval Device
- Unit Record Search and Dissemination Device.

FILMOREX

Developed by Jacques Samain, Paris, France

Status Available

Military Sponsorship None

Delivery Time 6-9 months

Cost —\$15,000

Description of Equipment

The Filmorex system consists of a document camera, selector, keypunch and contact printer. This equipment is of relatively simple design, and requires

considerable manual support for its operation. The storage medium is a 35mm x 60mm film chip of 8 mil thickness to provide sufficient rigidity for machine manipulation. Depending upon the camera lens system, up to two 8.5" x 11" documents pages can be recorded on a film chip, in addition to the code area of 400 bits capacity. In the present code system, up to twenty rows of 20 bits each can be used with four bits used to designate each alphanumeric character.

Operating Characteristics and Capability

The input operation requires the use of code cards to represent each item of descriptor information. These cards are arranged with just the top card displaying the alphanumeric designation of its code. All other cards have just their coded information showing. The microfilm camera then photographs simultaneously the code cards and related documents. A multi-entry file requires an additional exposure for each entry, with the appropriate code card displayed at the top of the code card deck. This allows the reading of the different key descriptors for appropriate sorting, filing and selection. The documents and associated coded data are recorded on roll-film approximately 100 feet in length. After processing, the film is manually cut and inserted in its proper storage location.

For selection, the film chips are passed through the selector unit at the rate of 600-700 per second. Query input is achieved by key punching holes, representing the complement of a coded descriptor, in an aluminum mask called a search key. This key can contain a maximum of three coded descriptor patterns and serves as a scanning grid as the film chips are passed between it and a light source in the Filmorex selector. Detection of complete opaqueness represents a match and a selection is determined by a match with a particular logical combination of "and," "or" and "not." Selected film chips are directed to a separate output bin from which they can be manually retrieved for viewing or preparation of hard copy prints.

The Filmorex equipment, because of its design, relies considerably on frequent manual adjustments for maintaining correct operating tolerances. However, with proper personnel support, this equipment can effectively be applied to the storage and retrieval of files of 10,000-150,000 items depending upon file activity. A complete system is considered relatively

inexpensive and does not require peripheral equipment.

MAGNAVUE SYSTEM

Status—Successful feasibility model has been tested

Military Sponsorship—

Government Branch or Agency—Rome Air Development Center

Contract Number—AF30(602)-2464

Contractor—Magnavox Research Laboratories

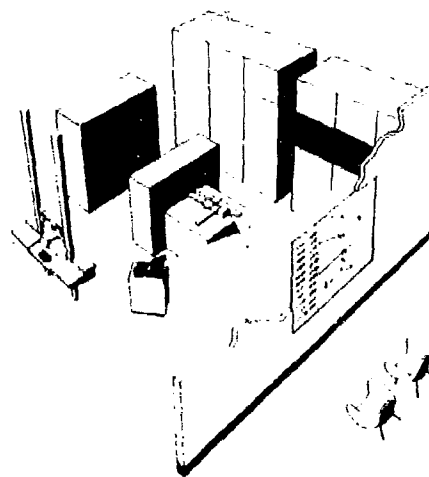
Delivery Time—18 months

Cost—500K to 1500K

(depending on system configuration)

Description of Equipment

The Magnavue system consists of the following elements: A general purpose digital computer (CDC 160) for control of the system; a rapid access file which stores 675,000 images in film chip form; a four-drum card transport which accomplishes sorting, merging and collating of the film chips; an output copy station which produces a Diazo aperture copy card with a developed image and which is simultaneously punched with identifying data (by means of a card punch); and a camera-coder which prepares Magnavue film chips from input aperture cards.



Display of Graphic Data Stored on Magnavue Card

Optional equipment includes a second rapid access file which brings the total capacity to 1.35 million drawings. Additional EAM equipment and magnetic tape may be added to the data processor.

The basis of the Magnavue system is a small mylar card or chip $1\frac{1}{2}$ inches wide by 3 inches long. One portion of this card is used to store a 35mm Diazo microfilm image from which a Diazo copy card is made. The remainder of the card is used to store 80 alphanumeric characters of photo optical data which identifies the image. These cards are handled on the card transport to which is attached the Diazo copy station. The card transport unit is a four-drum device capable of manipulating the cards at 90 cards per second with vacuum techniques under control of the data processor. The card transport has the capability for card merging, sorting, and collating on commands from the data processor.

An optional modification to the system provides the capability to process magnetic cards which store approximately 1000 alphanumeric characters in binary coded 6-bit characters. These magnetic cards are the same $1\frac{1}{8}$ x 3" size as the film cards and both types of cards can be processed on the system. The modified card handler then has magnetic read-write heads for the magnetic cards and photo optical reading for the drawing image cards. Data is transferred between the processor and the cards at 90,000 alphanumeric characters per second.

Operating Characteristics and Capability

The input operation for this system is the initiation of a Magnavue card. The image portion of the card may be exposed by reducing a negative image onto the image portion of the card or contact printing a given microfilm image. Binary coded photo optical data is displayed in code targets and exposed at the same time the image portion is exposed. The coded data can be transferred from punched cards or directly off opentime cards containing the related image. This complete input operation is accomplished by the camera-coder unit.

Magnavue cards are stored in a rapid-access file unit which consists of a 15 x 15 array of magazines. Each magazine has a storage capacity of 3000 cards, enabling a total of 675,000 images to be filed. During an operating period, magazines can be positioned for processing in 3.4 seconds. Maximum time for an

and developed aperture card. The card is produced at the Diazo copy station, which is associated with one of the drums on the card transport unit. Selected cards for reproduction are stopped at the Diazo copy station, automatically removed from the drum, and appropriately aligned with the film portion of an unexposed copy card. Under computer control, the film is then exposed to give the desired output Diazo copy card. The computer may cause single or multiple copy cards to be made from the image portion of a single Magnavue card.

The Magnavue system can store a variety of data, both textual and graphic. Depending upon the information, reduction ratios from 10:1 to 30:1 have to be used in recording images on Magnavue cards. This capability, combined with computer controlled file maintenance and automatic retrieval, allows for considerable system flexibility.

MEDIA

Status—Available off-the-shelf

Developer—The Magnavox Company

Delivery Time—3 months

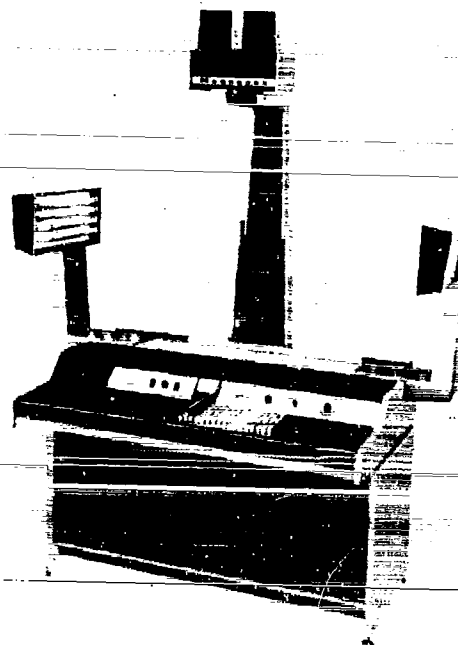
Cost—\$37K

Description of Equipment

The Media system is a photographic information storage and retrieval system utilizing the unit record concept. Information is stored on a 32mm x 16mm film card which can contain images of three 8 1/2" x 11" document pages, 17 digits of coded data and the film card identifying number in both numeric and machine readable form. A complete Media system consists of a camera-coder which simultaneously photographs and codes the documents to be stored, a film processing unit, a film duplicator unit, film cutter for cutting the Media film cards from roll film, Media file and capsules for storage of the film cards, and the selector reproducer for retrieving documents and producing hard copy prints of film cards.

Operating Characteristics and Capability

The Media system has been designed to retrieve documents by document number. In the input operation, the appropriate document number is keyed into the camera at the time the document is photographed.

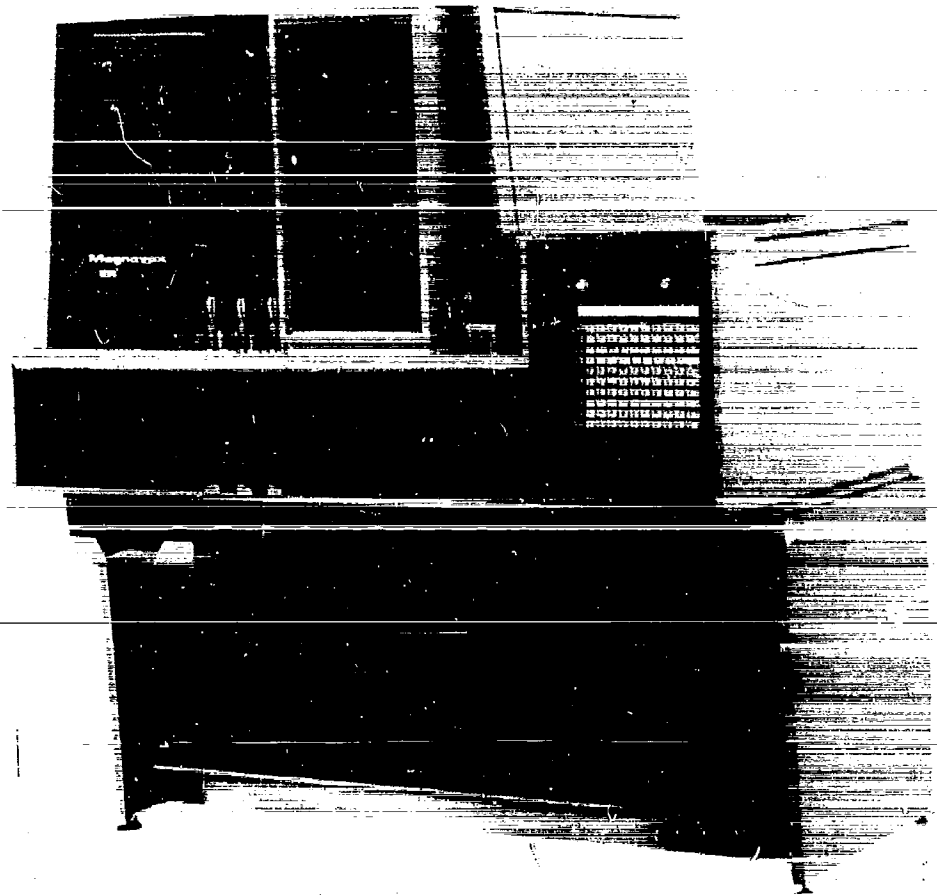


MEDIA Document Camera

The number is recorded numerically and encoded to permit both human and machine reading. Additional information, such as the date or subject information, up to 17 digits, can also be included as identifying information. The documents and associated data are photographed onto roll film of 100 foot lengths and cut after processing into the Media film cards. The cut film cards are then manually inserted in their appropriate storage location in the files.

The storage file has 10 numbered trays which contain 100 numbered pockets. These numbers are indicative of the cabinet and the tray contents. Each pocket in the tray can contain a capsule which has a capacity for holding 200 film cards. This storage configuration enables a cabinet to contain images of 100,000 documents averaging three pages each.

For retrieval, it is necessary to know the document number. The number designates the capsule in which the document is contained. When located, the capsule is manually removed from the file and placed in the Selector-Reproducer. Upon keying in the last two numbers of a 7-digit accession number, the Selector-Reproducer begins scanning cards at the rate of 10



MEDIA Selector

per second. When the desired film card is found, the card is momentarily stopped and a hard copy made of its stored information. The card is then released and allowed to return to the stacking station for eventual reinsertion into the capsule. With this form of output, information is retrieved without ever removing the film card from file. This retrieval operation can be accomplished in many cases in less than one minute.

The Media system relies on efficient combination of manual and machine operations. In this situation, the capability of operating personnel can considerably affect operating speed and overall effectiveness. How-

ever, inclusion of the manual operations has provided a system at relatively low cost.

MINICARD SYSTEM

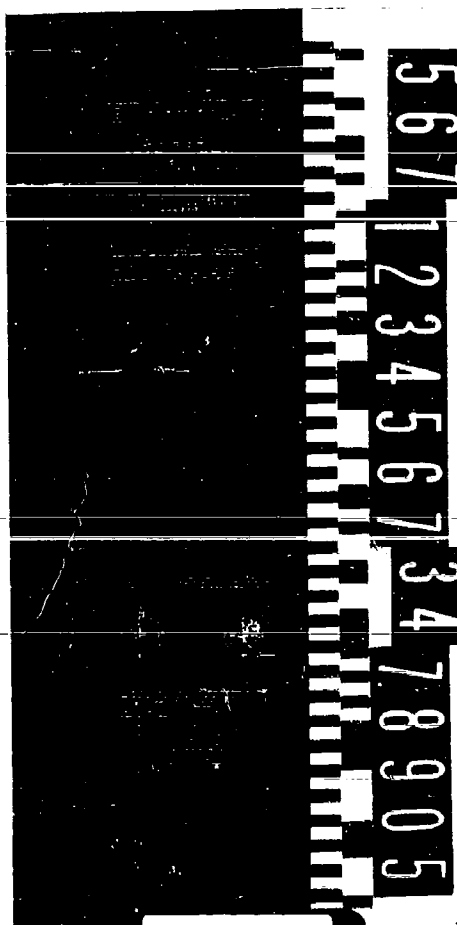
Document Data Processing Central AN GSQ-11A (v)

Developed by Eastman Kodak Company

Status—Available

Military Sponsorship—

Agency—Rome Air Development Center
Contract Number—AF30(602)-1603



MEDIA Card

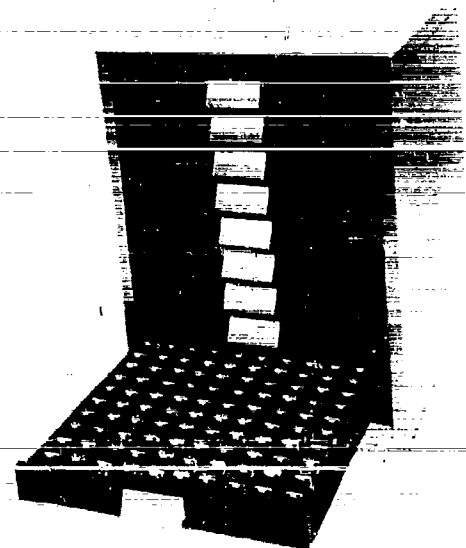
Contractors Involved: Prime Contractor
Eastman Kodak Co.
Magnavox Company
Computer Control Co.

Delivery Time: 18 months

Cost: 1000K to 1500K (depending on size of system)

Description of Equipment

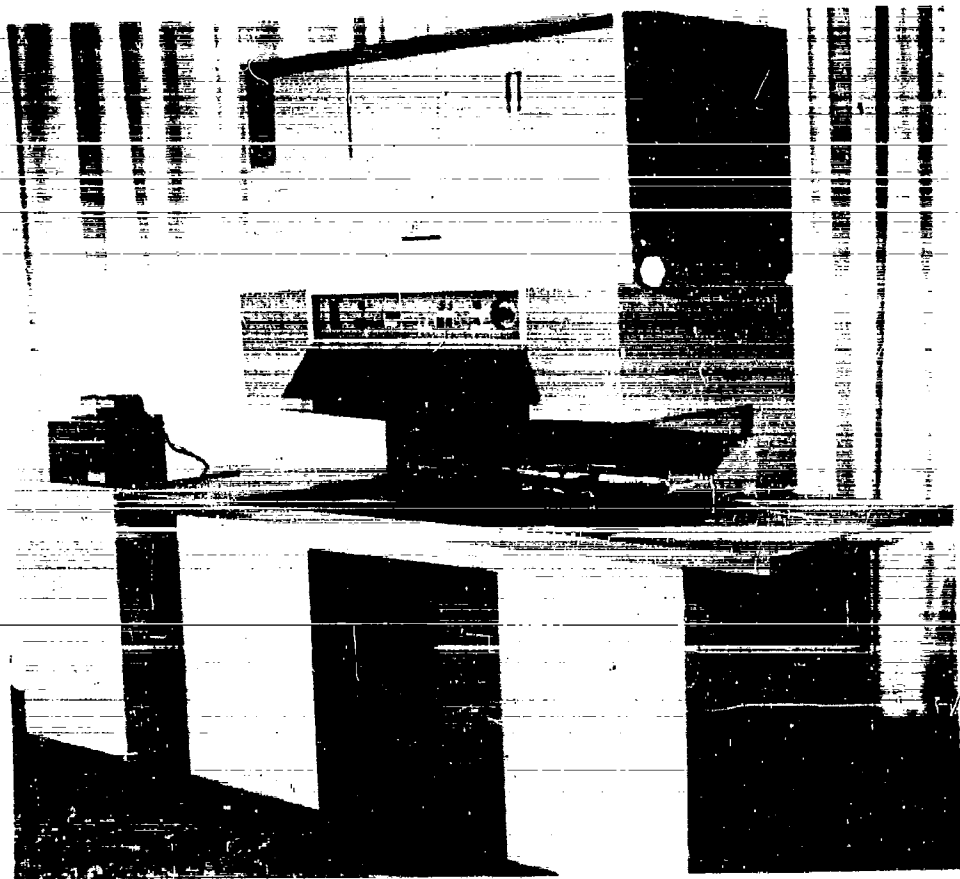
The equipments of a Minicard installation will vary with system size. An average installation would include the basic Minicard devices consisting of document camera, computer duplicator, film processor,



MEDIA Film File

selector sorter, analysis viewer, enlarger processor and peripheral equipment. The integration of such equipment has provided the capability for multiple copy filing and selection, rapid film processing and duplication, and high speed input, making Minicard extremely applicable for large data storage problems. A complete Minicard system would include:

- *Document Camera Model CD3A* Records documents up to 8.5 x 14 inches in size at a reduction ratio of 60:1.
- *Photonegative Camera Model CP2A* Records Photo Negatives 9.5 x 9.5 or 9.5 x 11 inches in size at a fixed reduction ratio of 20:1.
- *Opaque Copy Camera Model C12A* Handles opaque copy up to 18 x 22 inches in size and photographs these at a reduction ratio of 20:1 or 39:1.
- *Computer Duplicator Model DI 3A* This system combines a mechanical unit which is capable of reading digital code from film records, duplicating film records by contact printing and exposing code on film records, with a general purpose digital



MINICARD Camera Unit

computer that can process data and control the mechanical unit.

- *Selector-Sorter Model SS1A* Combines a film card unit which is capable of reading code from film cards and routing film cards to any one of several locations with a logic unit which is capable of analyzing the data read from film cards and can control the film card unit.
- *Document Enlarger Model ED3A* Produces 30X enlargements from images produced by the CD3A camera.
- *Aerial Photo Enlarger Model EP2A* Produces 20X enlargements from images produced by the CE2A and CP2A cameras.
- *Document Viewer Model VA2A* Displays film record images at 60X magnification for analysis.
- *Aerial Photo Viewer Model VP2A* Provides images of film records at 60X or 25X magnification for analysis.
- *Film Processor Model PF2A* Automatically develops, fixes, washes, and dries exposed roll film.
- *Finishing Equipment*
 - Film Lubricator Model AL2A



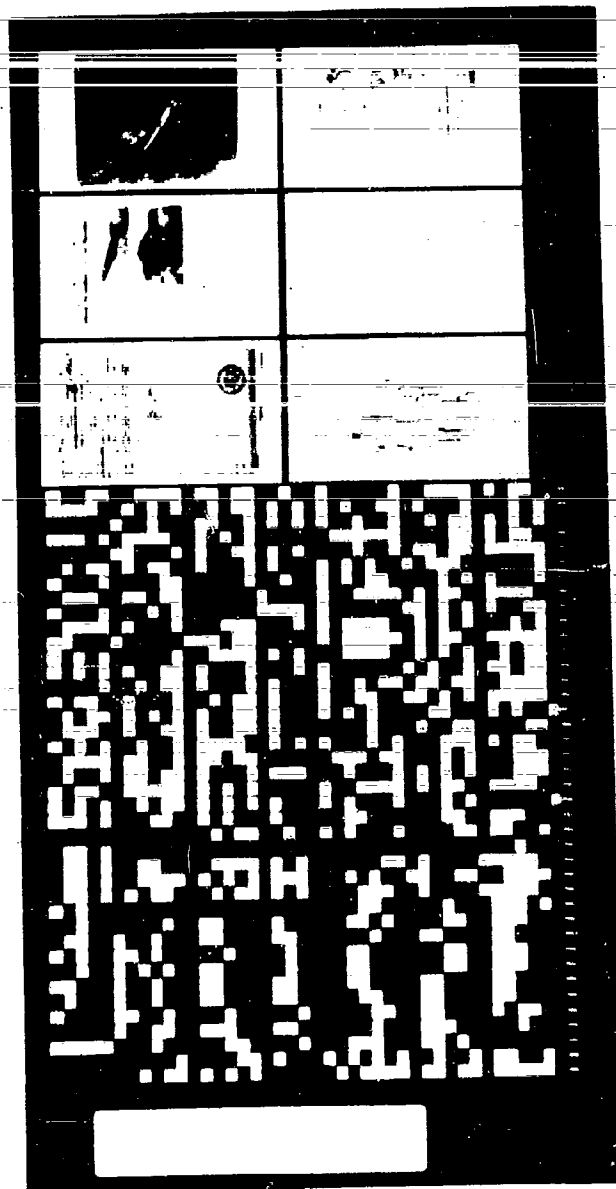
MINICARD Film Record Selector Sorter

- Inspection Viewer Model V13A
- Film Cutter Model AC2A
- Aperture Card Mounter Model AA1A
- *Peripheral Equipment*
 - File Cabinet Model FC3A
 - Film-Card Storage Stick Assembly Model FS1A
 - Transfer Tray Model FT2A
- *Paper Tape Handling Equipment*
 - Typewriter - Tape Punch Model TW3A
 - Typewriter - Tape Punch Model TW5A

- Typewriter - Tape Punch Model TW6A
- High Speed Tape Reader Model TR2A
- High Speed Tape Reader Model TR1A
- Motorized Tape Reader Model TR3A
- High Speed Tape Punch Model TP1A

Operating Characteristics and Capability

In the Minicard system, all documents, photographs, charts and maps to be stored are photographed on a fine-grain emulsion film with a triacetate base of 16 x 32mm in area. Using a reduction ratio of 60:1 and with resolutions of up to 500 lines per mm, it is



This shows code and actual size of *Graphic Information* recorded on a single *Minicard*

Minicards
Actual Size

THE KODAK MINICARD SYSTEM

A group of photographic and electromechanical machines all integrated into one system for recording, storing, arranging and correlating with great speed any conceivable type and volume of information for finding, compilation and evaluation

MINICARD Film Chip

possible to store 12 standard size document pages of material on each Minicard film chip. This storage arrangement can be varied from using the whole film chip area for code storage with a capacity of 2730 bits or 477 characters to a code capacity of 42 bits for 10 characters and the 12 document pages. A variable selective code format reserves two 42-bit columns for the sorting field and several other columns for control information, such as the document number. The remaining columns on the film chip are used for further descriptor information.

The Minicard film chip has a slot near one end which enables the chips to be handled in groups of up to 2000 on sticks. These sticks are used for transporting these film chips to and from the selector, sorter, and file block. For manipulation, the film chips are deposited in magazines from the handling stick and then replaced on the stick for manual handling.

Information for input into a Minicard system, as in other input operations, has to first be read, interpreted, and indexed according to pre-determined classifications. Cross indexing may be extended considerably because the unit record concept of the Minicard film chips lends itself to almost unlimited cross-filing. The indexing code is entered into the system by means of punched paper tape or by direct keyboard input. This coded information is then converted to the dot pattern for photographing onto the Minicard film chip. Immediately after this operation, the related textual or graphic material is microfilmed on the film chip at a reduction of 60:1. The 16mm Minicard film is exposed in rolls of 200 feet from which 2000 masters of negative Minicards will be prepared. From this, positive duplicates will be made and cut into film chips. The number of duplicates from each master depends upon the multiple entries required by the indexing and filing arrangements used.

Using an input camera with recording rates of 40 to 90 per hour, a duplication rate of 120 Minicards per minute and a processor which develops and dries a 200-foot roll of film in 40 minutes, this input operation can handle large volumes of information.

After the duplicates have been inspected, they are placed in their proper storage magazines by the sorter at the rate of 1000 a minute. These duplicates now become part of the Minicard Working File stored in file blocks of 50 magazines each. In this storage arrangement, 900,000 Minicards can be stored in a cabinet about the size of a four-drawer legal file.

Requests for information are stated such that a magazine or a particular group of magazines is identified. The Minicards in these are then manually removed by using the handling sticks and are inserted in an automatic selector which locates a desired Minicard film chip within 1.5 minutes. The selection is made according to the inquiry which has been input by paper tape in association with a particular logical relationship of "and," "or," "less than" or "greater than." The final output of the search can be a duplicate film chip, a film copy mounted on an aperture card, or an enlarged hard-copy print. Total time for an average search from input of request to delivery of the selected Minicard is 10 minutes.

Considering the number of units, their capabilities, and their integration, it is evident that the Minicard System has been designed for large data holdings of intensive activity. For this application, this system utilizes units with sophisticated operating characteristics and rapid operating speed. However, even with this capability, this system is considerably dependent upon effective man-machine integration for efficient operation.

PROPRIETARY INFORMATION

AUTOMATIC UNIT RECORD STORAGE AND RETRIEVAL DEVICE

Status—Experimental Model Delivered August 1964

Military Sponsorship—

Government Branch—U.S. Air Force, Rome Air Development Center

Contract Number AF30(602)-2553

Contractor Involved—Houston Fearless Corp.

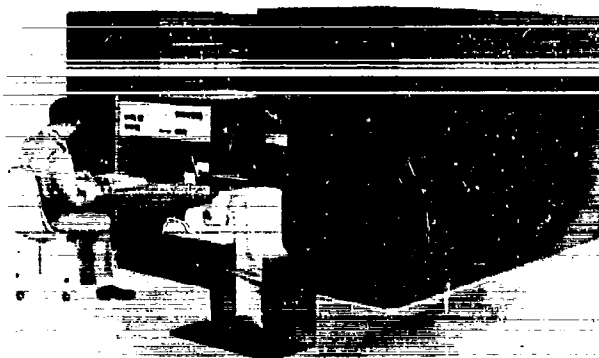
Delivery Time—12-18 months

Cost—150K to 500K (Estimated)

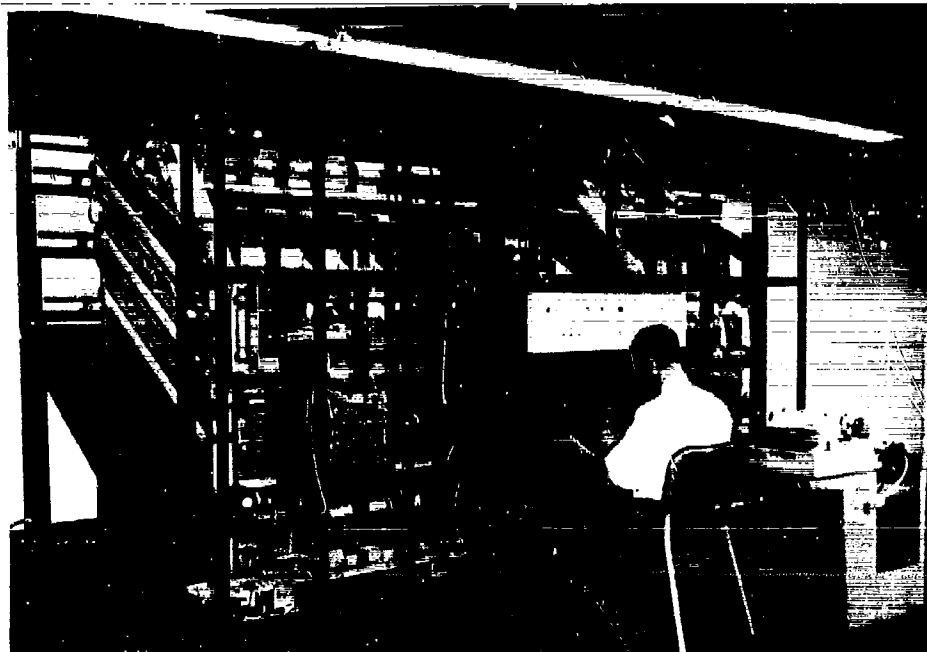
(depending on capacity of experimental model)

Description of Equipment

This device has been specifically designed for the storage and retrieval of 16mm x 70mm film chips. Any type of data can be placed on the film, however, particular emphasis has been placed on protecting the image to enable storage of aerial photography. To facilitate manipulation, the film chip is handled and stored in a plastic mount which provides protection



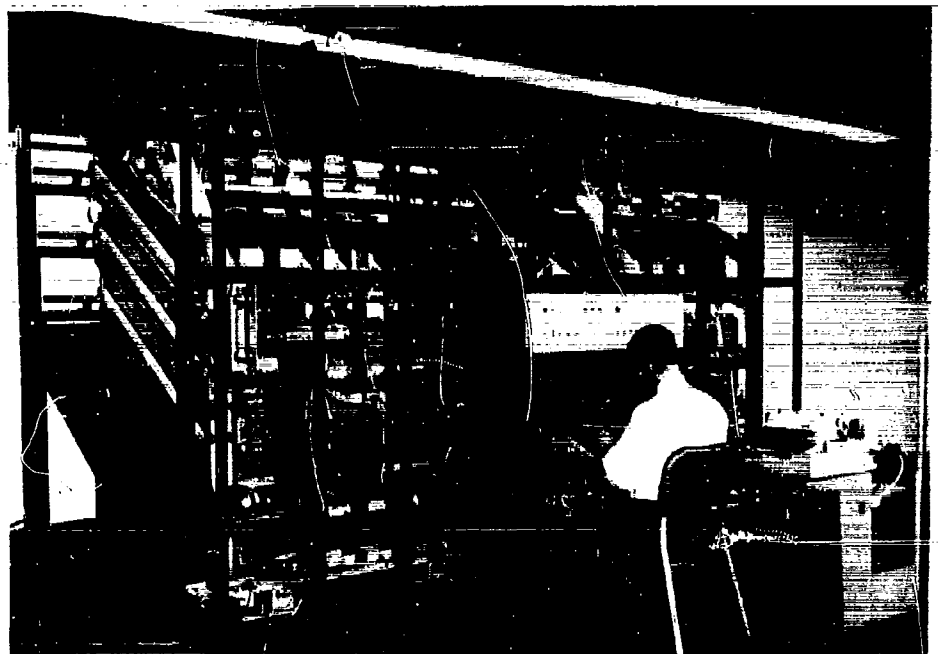
Unit Record Storage and Retrieval Device



H. F. Unit Record Storage and Retrieval Device with Exterior Shell Removed



Unit Record Storage and Retrieval Device



H. F. Unit Record Storage and Retrieval Device with Exterior Shell Removed

to the image area. These mounts are each stored in a separate compartment, 256 of which are contained in a module. With 40 modules, this provides a storage capacity of 10,240 film chips for this particular unit. Modular construction and consideration of expandable requirements have influenced design characteristics such that the current model's performance can be maintained up to a capacity of approximately one million film chips.

The Automatic Unit Record Storage and Retrieval Device consists of the storage files and film mount handling mechanisms, keyboard, display panel, paper tape punch and drum memory. Using random storage and parallel operation, this unit can retrieve one film chip in a maximum of 10 seconds and 60 film records in less than three minutes. Infilming can be accomplished at the rate of one film chip in three seconds. Input and output of film chips are achieved by using magazines by which up to 60 film chips can be removed from and placed in the storage unit during one operation.

Operating Characteristics and Capability

Input to this system requires the insertion of the film chip in the plastic mount and the subsequent placing of the mounts in the input magazine. For system integration, ease of manipulation and operating speed are attained by automatically performing most of these operations. Use of the film mount permits considerable mechanical handling while affording sufficient protection to the film chip.

Unit record retrieval requires the association of a unique 7-character alphanumeric accession number with a storage location in the file. This is accomplished by the integrated magnetic drum memory which maintains control over the physical storage unit and keeps track of the physical location of all film chips. The memory unit can respond to a request for an accession number, information in a particular area, or inventory control data. The output of a response is first indicated on a display panel so that further interrogation or modifications to the initial request can be considered before ejection of the requested film chips into the output magazine. Retrieved film chips are ejected into the output magazine in the order requested so that they can be immediately viewed in order, when ordered sequence is of importance.

This equipment has been developed for future integration in systems requiring the handling of information in the form of photographic images. In consideration of its potential applications, its design has allowed for compatibility with various peripheral equipments as well as for computer control in system operation.

UNIT RECORD SEARCH AND DISSEMINATION DEVICE

Status—Successful experimental model

Military Sponsorship—

Agency—U.S. Air Force, Rome Air Development Center

Contract Number—AF30(602)-2569

Contractor—Ittek Corporation

Delivery Time—18 to 24 months

Cost—300K to 1000K (depending on storage capacity of experimental model)

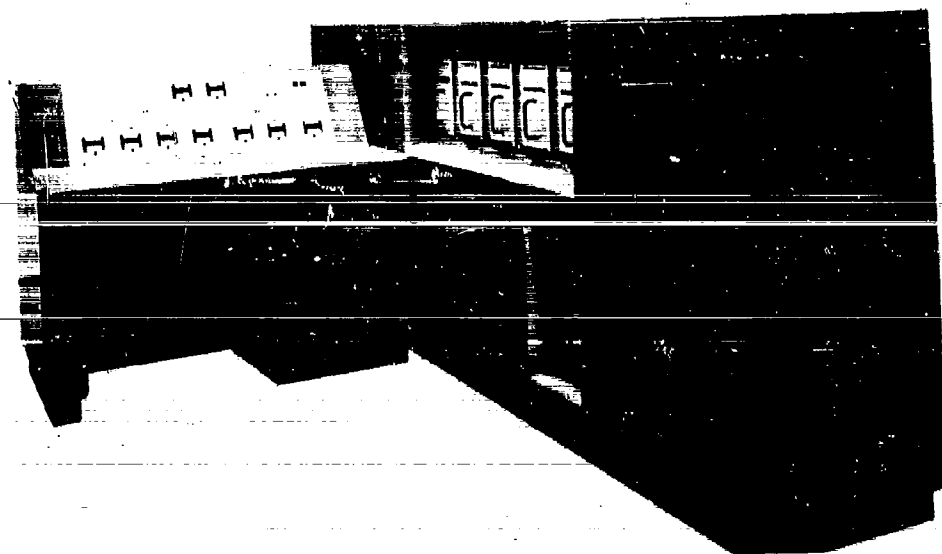
Description of Equipment

This device is an experimental model developed to determine the feasibility of handling and controlling 70mm x 100mm unit record film by the use of pneumatic propulsion, magnetic edge code reading and on-the-fly photographic code reading. The unit records are contained in frames which have magnetic, photographic and edge-notched code areas. In operation, the unit records are retrieved, selected and distributed back to storage on the basis of the coded information recorded on the frames. The frames are manipulated by a track system in which the carrier rides by means of four pins that protrude from the corners of the carrier frame.

The present experimental model consists of an operator's console and a main frame. The main frame contains a track system, 2 storage bins, 1000 experimental carriers, 6 removable carrier-magazines, 3 launching mechanisms, magnetic and photographic code readers, and required circuitry. The control console contains the logic system, power supplies and control panel required for operation of the experimental model.

Operating Characteristics

This device has a storage capacity for 1000 unit



Experimental Model

records which are stored in two bins of 500 records each. For searching, the unit records are ejected into an air stream, read magnetically and, if selected, passed through a photographic code reading station. Depending on the query imposed on the system, the selected unit records are directed to the appropriate output magazines; those magnetically selected in one, those selected both magnetically and photographically in another. The rejected unit records are returned to their proper storage bin by means of the edge-notched mechanical code in the unit record frame. This cycle from ejection to distribution and back into storage for 500 cameras is accomplished in approximately twenty seconds.

The primary purpose of this program was not to construct a piece of equipment which would fulfill a predefined functional requirement, but rather to develop automatic retrieval and dissemination techniques. However, initial consideration of applications has been concerned with using these techniques to store and handle graphic information.

E. Unitized Photographs— Film Strips

WALNUT SYSTEM

Status— Available

Government Sponsorship—
Central Intelligence Agency
*Contractor—*IBM
*Delivery Time—*Not available
*Cost—*Not available

Description of Equipment

Walnut is a large-scale document indexing, storage and retrieval system using an index computer subsystem, and a separate image file.

Document images are stored at a reduction ratio of 35:1 in the image file on Kalkar film strips 0.9" wide by 15.5" long. Each strip will accommodate reduced images of 99 (8 by 14 inch) pages arranged in three columns of 33 images each. The strips are grouped into "cells" of 50 strips each, with 200 of these cells forming a module capable of containing up to 990,000 document pages. For handling, the 200 cells of the image file are arranged in a circular bin which is simultaneously rotated and translated to position a specified cell beneath an access mechanism.

The index computer subsystem consists of a computer and a large random-access digital magnetic storage device. A typical configuration would employ an IBM 1410 processing unit working with a number of IBM 1301 Advanced Disc File memory units. Punched paper tape, punched cards, or magnetic tape can be used to read data in or out of the system. This data would be divided into three categories: Keyword table, subject index, and document address index.

For this system, search time averages about five seconds. This includes the output of the address data and abstract. Image search and delivery of the image information in the form of aperture cards can be made in 5-10 seconds.

Operating Characteristics

For input into the Walnut System, each incoming document is assigned a unique document number; the page is recorded; an index record and abstract are punched on paper tape; a microfilm image is made; and an input control card is punched with the document number and page count. The index information is then loaded into the magnetic index which is arranged according to pre-deferred subject or keyword headings for future search in response to user requests. Likewise, the microfilm and the punched

input control card are input into the image converter for transfer to the film strips. In completing the index, the file location of each document is recorded on the input control card and, in turn, this information is recorded in document number sequence in the document address section of the index.

A search in the retrieval process is initiated by feeding the desired search terms and their logical relationship into the computer. All abstracts matching the input criteria are printed out on response cards which also render the corresponding address of each document in machine-readable form. These cards are reviewed and those representing information desired are returned to the computer index which then duplicates addresses, page counts, document numbers and requestor numbers on blank photo aperture cards. When a punched photo aperture card is inserted into the image file and read, the appropriate film strip is drawn from its cell and up to four selected images are duplicated on the aperture card by use of a 200-watt mercury arc lamp. The image-bearing aperture card may be studied with the aid of a viewer or reproduced full size by a printer.

In the Walnut System, throughput of each image file is approximately 400 cards per hour. Image file modules may be added without limit, but, to minimize the number of modules required, all cells are removable and each image file has a special operational mode which allows use of single cells from static storage.

F. Photographic Plate Storage— Sheet or Scroll Storage

PROPRIETARY DATA

COMMAND INFORMATION RETRIEVAL SYSTEM (CRIS)

*Status—*Available off-the-shelf
*Developer—*Radcom, Division of Litton Industries
*Delivery Time—*6 months
Cost—\$33,500

Description of Equipment

In this system, micro-images of any printed or pictorial matter are stored on a scroll contained in a



CRIS

cartridge which is inserted in the unit. Upon entry of a location number corresponding to the desired image, the unit automatically positions the image for display or reproduction. The retrieval system is a combined 16mm and 35mm microfilm storage system. Because of the unique mapping of the scroll, it is possible to incorporate at random both 16mm and 35mm micro-images in the scroll. Each scroll may contain over 500,000 images of 8 1/2" x 11" pages, or over 28,000 large drawings, or any combination of the two formats. Average automatic retrieval time to any desired image, selected at random, is under 20 seconds. Sequential selection is proportionally much faster.

The basic unit is a desk-sized console containing the cartridge insertion and scroll positioning mechanism, the projection and display system, the key-

board entry unit, and the general control circuitry. The contact printer may or may not be incorporated in the unit, depending upon the output system selected.

Operating Characteristics and Capability

The information in this system is stored on a 200 or 400-foot by 1 1/2-inch Mylar based Kalvar scroll. A 400-foot scroll can store up to 500,000 pages of 8 1/2" x 11" material. The scroll is divided into eleven columns made up of 35mm (1 1/2" x 1 1/4") frames with these frames divided up into nine sub frames that can contain two standard 8 1/2" x 11" pages of information. Each column along the scroll is identified by a four-digit code group printed along the edge of the scroll. There are three stopping, or index, bits con-

tained in this code group area which are in line with the sub-frames and are used to stop the scroll on a particular sub-frame after the correct column is found. There are 33 sub-frames across the width of the scroll in one column, and the cross scroll logic and drive circuits will locate any particular sub-frame by means of a code plate and photocell system that is mounted on the carriage containing the scroll. The scroll search operation is conducted along the scroll and across the scroll at the same time.

The entry address is a seven digit number with the first four digits selecting the column; the fifth and sixth digits selecting a particular frame within the column; and the seventh digit selecting one of the nine sub-frames within a frame. The seventh digit also can be zero, which will position the scroll in the center of the frame selected and change the projection lenses to provide a display of the full frame on the screen. The projection of the scroll image onto the 18 x 24 inch display screen is accomplished by a lens-and-mirror system which uses an ultraviolet light source and a yellow filter to prevent exposure of the Kalvar material. Hard copy print-out of the scroll image can be made by inserting a film card into the unit which positions the card in front of the image, removes the yellow filter over the ultraviolet light source, and exposes the film card for a predetermined number of seconds. The film card is then developed by a desk top heater and the copy is ready for viewing.

A dual lens system, controlled by the image address, projects either the sub-frame or the full frame on the 18" x 24" display screen. A sequential scanning key permits rapid scanning of frames or sub-frames. Accordingly, it is possible to scan or reproduce up to 18 pages as a unit. In addition to the visual display, a micro-image contact print may be made from the selected frame or sub-frame. This film card, capable of containing as many as 36 page images of 8 1/2" x 11", may be used in conventional microfilm viewers and printers (2 apertures).

The CRIS equipment requires that the accession number delineating the document image location on the scroll be known before a search can be actuated. Operation of this device has to be combined with an external indexing system for applications where information is requested by document content. However, in making CRIS compatible with various indexing concepts, other system requirements have also

been considered. As a consequence, current efforts are considering the use of CRIS with various methods of input and output involving magnetic tape, paper tape, telephone and radio transmission, computers and cathode ray tubes.

ELECTRONIC FILE or VERAC 903

Status - Laboratory demonstration of critical elements

Developer - Asco Corporation

Delivery Time - 12 to 18 months for experimental model

Cost - Not available

Description of Equipment

This device stores microphotographic images at reduction ratios of 71X and 142X on sheets of film. Each film sheet can contain as many as 10,000 document pages in a matrix arrangement providing the capability for storing up to 1,000,000 pages in a complete file section of 100 film sheets. Selection of the desired document or document page is accomplished by coordinate designation indicating the column, row and plane of the item location.

The Electronic File consists of three basic units: The step and repeat camera for recording information on film, the direct access file for storing and retrieving microphotographic reproductions of documents and a document output unit. Output can be in the form of an electronic or optical display, microfilm reproduction onto 35mm film, electrostatic printing or facsimile printout.

Operating Characteristics

Documents can be recorded onto the film plane at the rate of one image a second. Two film planes are made simultaneously so that one can be placed in a master file. The index information for these images is then placed in an external index file with the item locations. For retrieval, it would be necessary to obtain identification of the item from the index file before retrieval of the desired item could be initiated.

The direct access file has a memory system that automatically manipulates the storage media in response to address command signals. Stored images are located by an accession number delineating the

row, column, and plane of each item. Input of this information activates a carriage which moves the required image plane to the reading station. The appropriate column is then aligned with a reading head and by means of index marks, the image is properly positioned. Average access time for any item in the file is one second.

The Electronic File with a total capacity of ten million legal size pages has been designed to be compatible with various system equipment configurations. Combined with an automatic index searching capability and high-speed printout, this equipment is capable of large file applications.

MICROCITE

Status—Successful feasibility model

Developer—National Bureau of Standards

Cost—15K-20K

Description of Equipment

The Microcite equipment is an extension of a peek-a-boo system. This concept utilizes index term cards to index literature by deducting unique positions for each index item on each appropriate card. By drilling holes at these positions, and superimposing a group of cards representing the key words or terms of interest expressed by a query, the exposed or lighted position will identify the desired item number. In this searching technique, the term cards correspond to the description of a search question.

Microcite provides a peek-a-boo system with a means for visual display and output copy of the selected document's abstract. These abstracts are stored as micro-images on a film matrix. When coincidence from a superimposition of term cards is achieved, the enlargement of the micro-image abstract is displayed onto a screen so that the indicated item may be readily inspected. Output may be limited to this display or a hard copy may be obtained on Polaroid Land film or oscillograph paper or the querist may himself record document numbers or other bibliographical citation data in order to retrieve the original documents.

The Microcite system consists of a peek-a-boo card punch and readout stand and the search-projection equipment.

Operating Characteristics

In initiating a search, the film matrix appropriate to the peek-a-boo set being searched is selected and mounted on a drum. Selected term cards are then placed on an illuminated area of the device and a set of cursors positioned on each unobscured hole. As the cursor is set on each hole, a full-size focused image of the item corresponding to that hole is projected onto a screen for viewing.

In this procedure, the location of each lighted hole is used as a reference point from which to position and project a microfilm image of the stored item for visual inspection. At this stage, a searcher may determine the probable relevance of the projected items to the initial query and decide from the results whether the search prescription requires modification. These operations are possible because the searcher becomes part of a closed feedback loop when he is conducting a search. In terms of browsing, a convenient tool is thus provided. A degree of "free browsability" is potentially available if consecutive document numbers are assigned for items of similar subject content.

The Microcite system uses two different storage media: Film in which the stored items of information are recorded and peek-a-boo cards for storage of the item codes. The process for storing the abstracts involves the filming onto 16mm microfilm strips and then contact printing to produce the proper array of polyester-based film sheets. Using a reduction ratio of 37.75 to 1, there are 18,000 3" x 5" items recorded in a 15" x 15" area on a 20" x 24" film sheet. In searching on a matrix of 18,000 items, approximately a minute would typically elapse between locating the term cards and projecting the stored item on the display screen.

G. Photographic Plate Storage—Disc

PROPRIETARY INFORMATION

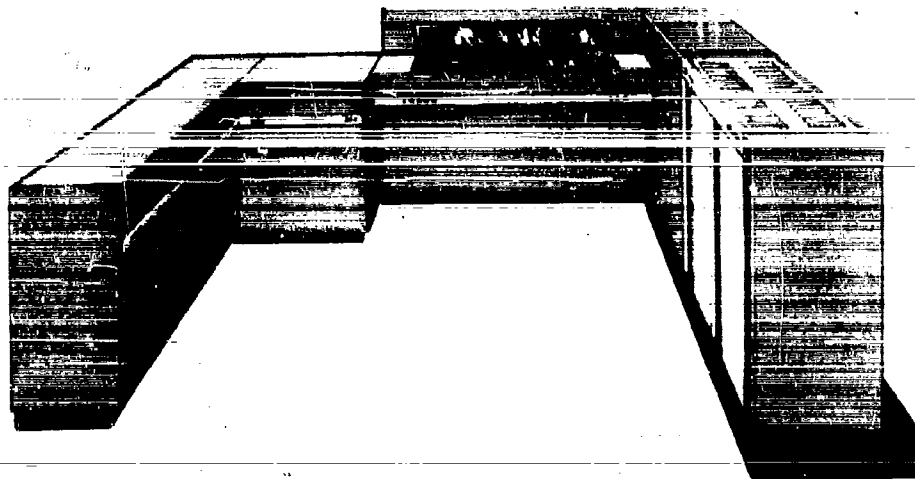
ITEK MEMORY CENTERED PROCESSOR

Status—Advanced development status

Military Sponsorship

Government Branch—U.S. Air Force

Agency—Rome Air Development Center



Itek Memory Centered Processor

Contract Numbers—AF30(602)-1566

AF30(602)-1823

AF30(602)-2072

AF30(602)-2080

Contractors—International Telemeter Corp.
International Business Machines
Itek Corporation

Efforts under these contracts were concerned with technique development and determination of the feasibility of memory storage and retrieval methods. The current program referred to as the Itek Memory Centered Processor is completely sponsored by Itek Corporation.

Estimated Date Available—September 1964

Cost—300K to 1000K (Estimated)

Description of Equipment

The design of the Itek Memory Centered Processor is centered upon a photographic digital storage unit invented by Dr. G. W. King and developed to high degree of practicality in the AN/GYA Computer Auxiliary Memory. A ten-inch diameter glass film disc with an annulus of photographically recorded information about an inch in width at its periphery is employed. Access to information on the disc is achieved by a rotational movement of the disc (cyclic

scan of circumferential dimension) and a radial movement of a light spot (combined CRT and lens arm movement in a closed servo loop) to access on a sampling basis, any one of several thousand concentric tracks of information. Search logic is such that for ordered entries in the store, specification of an input string of binary information (such as a list of words, sentence, etc.) will allow:

- Matching of any length string in the store to any equivalent entry in the input stream.
 - Determination of the longest match in the store to an input string.
 - Matching to small segments of the input string when no match to long segments can be found.
 - Conditional addressing by *athx* stuffing, i.e., the influence of one search by a prior or succeeding search.
 - Partial matching by storage of null characters.
 - Multiple matching and retrieval by insertion of a mask character in the input stream.
- This system consists of the following units:
- Memory Reader Unit
 - Search Logic Unit

- Auxiliary Buffer Memory Unit
- Disc Writer Unit
- Multiple Disc Storage Unit
- Input/Output Units

Operating Characteristics

The search proceeds as follows: The logic determines where the reading light spot is at the time the search is initiated by sampling the disc readout, and decides whether the spot should be deflected toward a higher or lower track. The spot is always reading. Absolute addresses are not involved—both the input stream and the stored data being considered part of an open set. When the spot is at a point just beyond where the desired data should be, if it is indeed in the store, a serial backward scan is initiated. Break points terminate an unsuccessful search and modify the search mode. When a match is made, a function of the matched segment is read out at a 5 megabit per second rate. This function can be arbitrary both as to struc-

ture and length. For example, it may be a control signal, a key to a table, a macroinstruction, an entire program, a sentence or paragraph of text, or a suggested list of possible index query words or "page numbers."

The *Index Memory-Centered Processor* is being developed for efficient processing of information that requires rapid access to dictionary or index type digitalized information on a probability-of-use basis. Each disc in the Processor is capable of storing 2.5×10^8 bits of information. Multiple disc units will be available for recording up to 10^{11} bits of information. Data can be stored at the rate of 250,000 bits/sec and retrieval rates will vary from .015 seconds for a single disc to .5 seconds for the maximum of 10^{11} bits. Processing capability will be a combination of table look-up and hardware logic tailored to the multiple branching characteristics of language processing rather than the batched and largely data independent instruction execution of existing business and scientific computers.

SECTION IV

SURFACE PERFORATION STORAGE

COMAC MARK II

Status—Available off-the-shelf

Developer—Benson Lehner Corporation

Delivery Time—3 months

Cost—Not available

Description of Equipment

COMAC is primarily a device for automatically searching a card index organized according to the Uniterm system. Using this concept, descriptors are selected to sufficiently describe the items of information to be stored. Cards are then initiated for each document or items of stored information and organized according to the descriptor or key words describing the information content. COMAC is used to compare the cards associated with descriptors that are of interest and to select the cards that satisfy the user's request.

Operating Characteristics

In use, the COMAC Mark II performs logical operations upon information contained in two decks of IBM cards. The decks of punched cards to be compared are placed in two adjacent card readers. Information from the cards is read in column sequence and successive fields are stored temporarily in the electronic circuitry. The items from the two decks are compared and, depending on the logical operation selected and the results of the comparison, are either ignored or transferred to the card punch. COMAC can also consolidate information from incompletely filled cards, transferring their items to the output as required to punch cards without blank fields.

In its various modes of operation, the COMAC Mark II can:

- Create cards
- Update existing cards
- Compare two card decks, selecting items that match

= Compare two card decks, selecting items that appear in one deck but not in the other

- Merge the items from two card decks
- Compare two card decks, selecting the items that appear in either deck but not in both.

TERMATREX

Status—Available off-the-shelf

Developer—Jonkers Business Machines, Inc.

Delivery Time—1 to 3 months

Cost—\$200 to \$5000

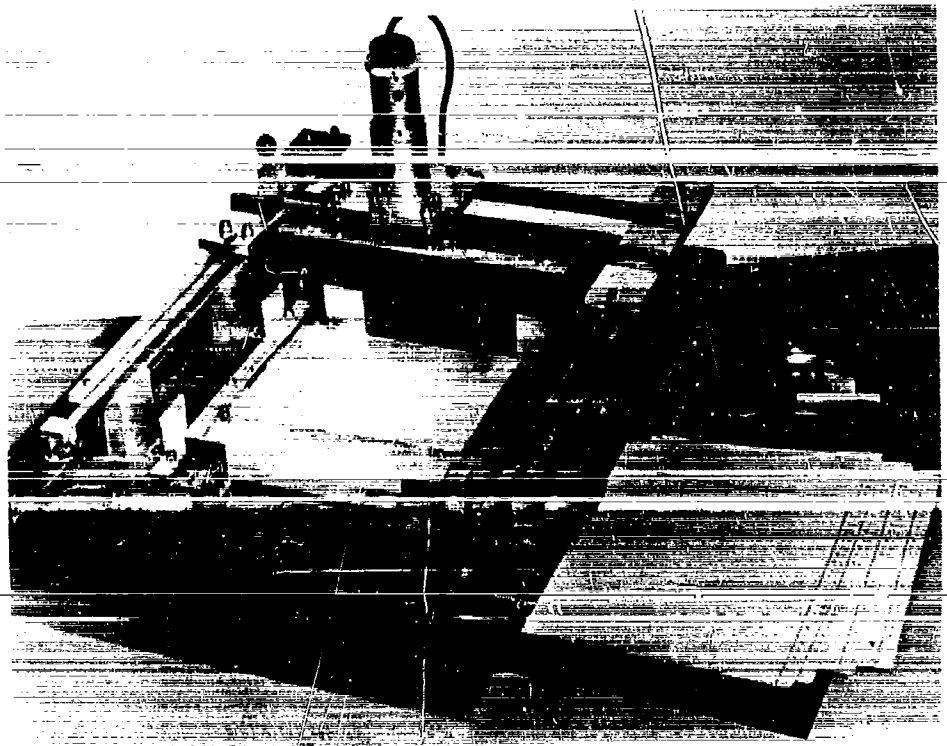
Description of Equipment

Termatrex is a manual system for handling index information. Output from this device is an identifying number which permits acquisition of the desired information from an external storage location.

A complete Termatrex system for handling up to 10,000 items consists of the card reader, card drilling unit and Termatrex cards. For larger capacity, models which search on tape instead of the Termatrex cards are available.

Operating Characteristics

The Termatrex equipment uses the uniterm indexing technique and superimposition for searching of stored information. A 9" x 11" Termatrex card is used for each key word or descriptor required for describing the file data. On each card, a unique location is devoted to a document or item of information that is being stored. To place an item in the file, all Termatrex cards with keywords describing an item of information are selected and holes punched in the position corresponding to the item number. Searching can then be accomplished by superimposing the key words dictated by a request on a card reader. The position of the punched hole will indicate the accession number or identifying number of the requested information. This information can then be retrieved from its storage location. Depending upon the system



TERMATREX

configuration, this retrieval operation could vary from manual to a completely automatic operation.

PUNCHED CARD

Status—Available off-the-shelf

Developer—E-Z Sort-Royal McBee Corporation

Delivery Time—3 months

Cost—\$200 to \$15,000

Description of Equipment

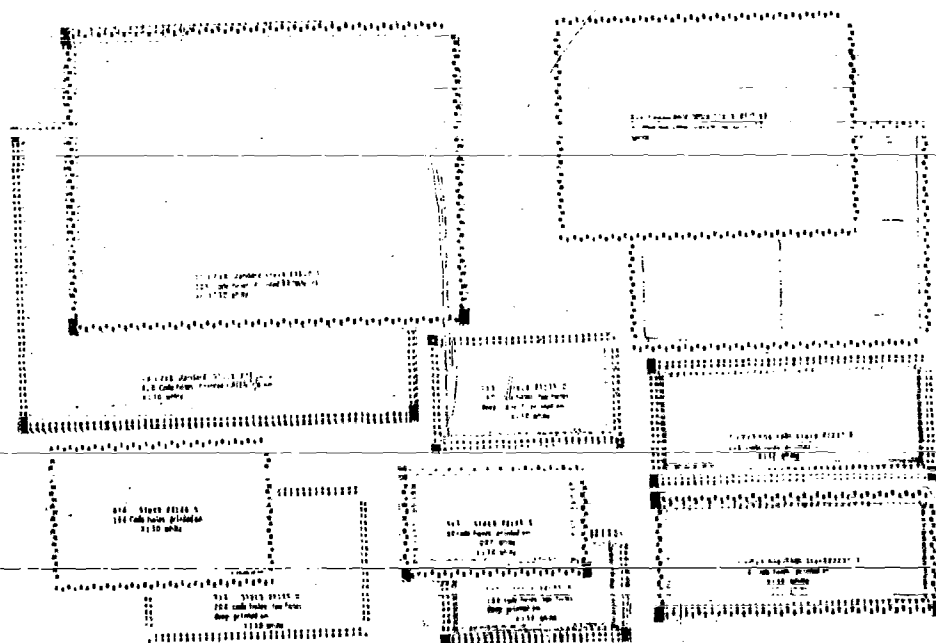
A high degree of orderliness can be accomplished in the processing, storing and recovery of technical information by the use of punched-card technique. Hand-sorted punched cards or machine-sorted punched cards employ the principle of a slot or hole, or combination of slots or holes inserted into a card.

Size and location of these slots or holes are assigned definite meanings. To find the information desired, only those cards bearing the coded arrangement of slots or holes are sorted.

Operating Characteristics

HAND-SORTED-PUNCHED-CARD DEVICES

The range of concepts available is limited to a set of terms that are used to characterize content of individual records. Because of this limitation, coding systems are selected for specific records to meet a given type of information request. One way to correct the inadequacy of this system is to divide the various holes into groups and to use a combination of punches without a group to designate, on a card, some one of several criteria. A superimposed coding of the edge-



Punched Cards

notched cards would greatly enhance the vocabulary of criteria.

The face area of the card may be used to record text material. To extend this capability, microfilm inserts may be added or pockets provided for strips of microfilm.

MACHINE SORTED PUNCHED DEVICES

Manual sorting or hand-sorted punched cards can become a tedious and time-consuming operation when dealing with large files. Much of the advance in card processing technology can be attributed to the development of machines used in processing punched cards. The range of equipment has widened; the controlling mechanisms have moved from manual to connection panel; the sensing mechanisms have become more reliable; card processing mechanisms have been made faster; and the ways of application multiplied.

FUTURE CARD PROCESSING MEDIA

The punched card, although a low cost and

practical data handling medium, is limited by the fixed amount of data that can be recorded on one card unit. To fill the gap between the limitations of conventional punched card equipment and the more expensive internally stored program computers, a font data processor with rapid card handling and hard copy producing characteristics is usually required.

A radically different card medium has been introduced. This new medium contains a sheet of Mylar film somewhat smaller than a punched card, and can record up to 12 times the capacity of a conventional card. Initially, this magnetic card has been introduced to be used with the internally stored program computer and may not offer to be a step forward in filling the data processing gap. This innovation does, however, introduce a new concept of recording data on cards and retains the essential principle of low cost card media.

Further progress in card processing technology may be expected to improve the production of hard copy output either by faster output mechanisms, or in

design of new systems for data reporting now produced as hard copy output. Development may also be expected in equipment design for original recording

of data directly onto a magnetic card from the source document without need to go through an intermediate computer conversion process.

SECTION V

SURFACE DEFORMATION

THERMOPLASTIC TAPE RECORDING

Status—Successful feasibility models of devices utilizing this technique

Developer—General Electric Company

Description of Equipment

Thermoplastic tape is a "sandwich" of material consisting of a base layer of Cronar, an extremely thin transparent layer of electrically conductive material, and a thin layer of a thermoplastic. This tape is manipulated as is magnetic tape but can be used at much greater storage densities. However, its recording and readout procedure is more involved and is still undergoing refinement.

Operating Characteristics

In recording, information is represented by a charge pattern which is applied to the tape by an electron gun. The tape with the charge image then moves over a heater which heats the thermoplastic sufficiently to allow it to deform under the electrostatic attractive forces between the charge on the surface and the conducting layer of the tape which is held at a uniform potential. The original charge pattern is, therefore, transformed into a groove pattern where the depth of the groove is at any point proportional to the local charge density and to the original signal strength.

When the grooves are formed, the information is available for readout or the tape can be wound on a take-up reel for future playback. The complete process from charge delivery to the creation of readable information can be achieved in milliseconds. At this point in the recording cycle, modification can be made such that the information can be made available in real time for use in displays.

The information now exists on the tape in the form of depth modulated grooves. For meaningful playback, Schlieren optics are used to generate an intensity-modulated image to which the eye or photo-sensors are responsive. In this technique, two sets of stops, called Schlieren bars, are added to the ordinary projector configuration of a condensing lens and a projection lens. When used with thermoplastic recording, the projection optics allow a gray scale to be achieved from the original microscopic grooves on the tape.

With these characteristics, it is evident that thermoplastic tape combines many advantages of both photographic and magnetic recording. It has the resolution capability for image formation and an immediate access to information and capability for erasure re-use as with magnetic tape.

Current efforts with this technique are concerned with investigating the implications encountered when considering its use in analog recording, digital data storage, display systems and electronic photography.

Best Available Copy

SECTION VI

STORAGE FILES

The majority of document storage and retrieval systems have some form of external storage file to maintain their information. In most cases, system effectiveness is extremely dependent on these files. The realization of a storage file's importance, combined with the desire for its compatibility with a variety of storage and retrieval requirements, has resulted in the development of an extensive array of filing concepts and equipments. Those that will be considered here are storage files that are not associated with any particular system, are manually operated, and have characteristics that classify them as specific filing concepts in contrast to the standard legal file cabinet type. The treatment of this category will be divided into two areas: manual visible files and electro-mechanically assisted files.

These files have two basic characteristics in common. All strive to place information within easy reach of an operator, either by stationary arrangement or by movable shelves or trays. Also, visible detection is emphasized as the primary means for facilitating the location of an item and is augmented by the use of such visual aids as index indicators, dividers, tabs, exposed margins, color coding and storage arrangement. The intent of these files then is to facilitate storage and retrieval by improving the physical access and visual location of the stored information.

Current commercial equipment of this type can be used for the storage of unit record items, including microfilm cards, aperture cards, and various size data cards. In order to obtain an extensive market, manufacturers of these equipments have expanded their product line to include consideration of as many applications as possible. As a consequence, filing units of each type are available in a variety of sizes and models, most of which can accommodate many types of file organization. Furthermore, most manufacturers will modify their current equipment or fabricate special units to satisfy specific requirements.

ELECTRO FILE

Status—Available off-the-shelf

Manufacturers—Acme Visible Records

Cost—\$1500 for basic unit

Delivery Time—2 to 90 days

Description of Equipment

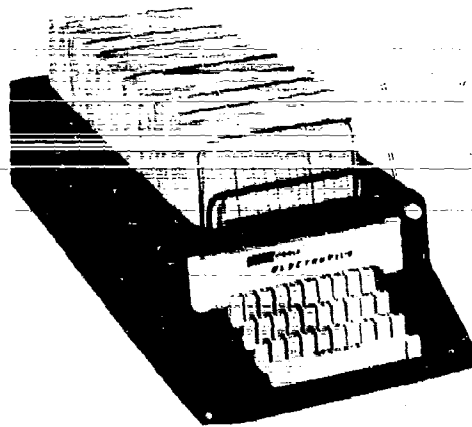
Electro File uses ordinary file cards with a strip of thin metal teeth attached to the bottom edge. These cards are held in position by a metal rack which can be lifted from the selecting unit after searching. With this arrangement, a number of card racks can be used with one selecting unit. These cards are selected by the use of edge-notched coding activated by keyboard input. This filing concept provides this device with a random access capability.

Operating Characteristics

A unique edge code is assigned to each card within a card rack. The edge-notched code is input by removing the appropriate teeth from the card, using the keyboard and cutting bar provided on the file unit. After edge coding, the cards are placed in the card rack in any location within a file group taking advantage of the random search capability.



Electrofile Console Unit



Electrofile Unit

For retrieval, the desired code is selected by use of the keyboard. Depression of the selection bar then activates metal strips which slip into the teeth of the cards. The card with the desired code has no teeth at the position of the metal strips and can therefore be pulled laterally by an electric magnet. As the card moves laterally, it is placed over a bar which elevates one corner, enabling the card to be picked from the file.

ELECTRO-KARDEX

Status—Available off-the-shelf
Manufacturer—Remington Rand
Delivery Time—2 to 90 days
Cost—\$2500 to \$3000

Description of Equipment

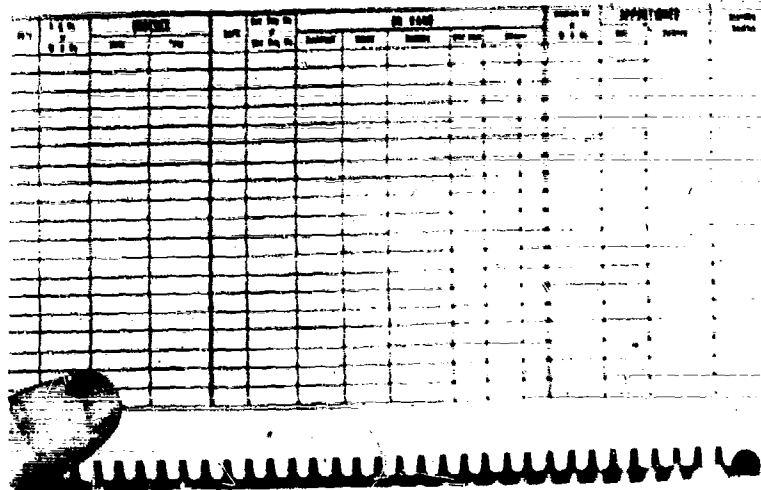
The Electro-Kardex has the same filing concept as the Tray card system, except that the slide trays are automatically pushed in or out of the cabinet frame at the depression of the correct index key. All slides are ejected at desk-high level in position for immediate posting or reference.

HORIZONTAL ROTARY FILES

Status—Available off-the-shelf
Manufacturer—Acme Visible Records, Inc.
Delivery Time—2 to 90 days
Cost—\$100 and up (depending on size and model)

Description of Equipment

These files consist of a drum or drums around whose periphery various size cards or paper records are stored. Access to a particular section of a file is achieved by manually rotating the drum in the hori-



Electrofile Card

zontal plane until the desired records are in front of the operator.

Rotary files are available in various sizes and in single or multi-tier arrangements. When tiers are used, each has independent movement and is raised an increment above the next larger. These tiers are arranged in concentric circles around the center of the drum in step-like fashion. Access to each step level can be acquired without interference from the adjacent tiers.

ROL-DEX

Status—Available off-the-shelf

Manufacturer—Watson Manufacturing Company

Delivery Time—2 to 90 days

Cost—\$400 to \$2500 depending on model and size

Description of Equipment

In the Rol-Dex equipment, cards from sizes 4" x 6" and up are stored in removable trays. These trays are set on rolling carriages enabling an operator to roll the desired tray of records in position for filing or retrieval. In this arrangement, access to any tray can be obtained by sliding trays over one another or to one side. Current Rol-Dex files are available with one or two levels of tray arrangements depending upon the file density desired.

TRAY FILES

Status—Available off-the-shelf

Manufacturer—Remington Rand

Acme Visible Records, Inc.

Delivery Time—2 to 90 days

Cost—\$80 to \$500 depending on model and size

Description of Equipment

The Tray Filing technique stores data cards on top of one another in a precessed fashion such that the margin of each card is exposed. These cards are attached to plastic pockets which in turn are fixed on a tray that slides into a cabinet for storage. Tray File units are available in various sizes and are amenable to modular arrangements for file expansion.

For use, index information is placed at the front of

each tray identifying its contents. The desired information is then obtained by sliding out the tray and flipping back the pockets covering the required card which was located by means of its exposed margin.

VARIADEx

Status—Available off-the-shelf

Manufacturer—Remington Rand

Delivery Time—2 to 90 days

Cost—\$5 to \$60 per 100 cards, depending on size and type

Description of Equipment

This filing concept uses filing cards with wide insert celluloid tabs as dividers. Color coding is also included in an index scheme which subdivides each letter of the alphabet into five "breaking points" which are a, e, i, o, and r. A different color is assigned to each of these five divisions. Thus, for the letter "B", Ba, Be, Bi, Bo, and Br would all have subdivider cards of a different color.

VERTICAL ROTARY FILES

Status—Available off-the-shelf

Manufacturers—Remington Rand

Diebold, Inc.

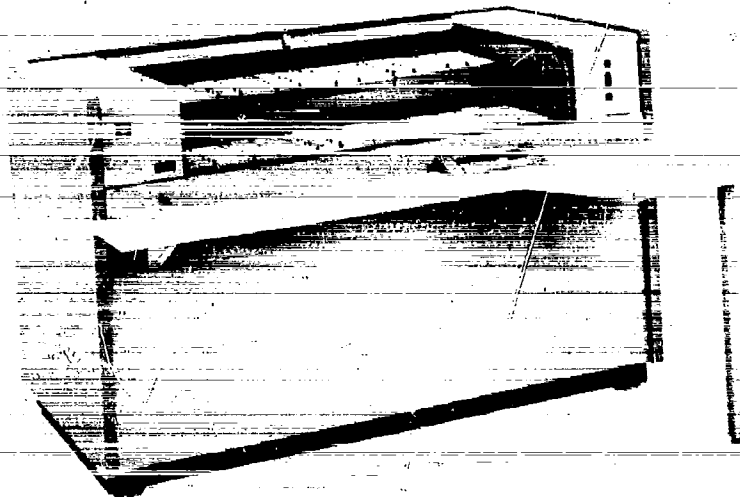
Perris Business Equipment

Cost—1.5K to 10K depending upon size

Description of Equipment

Vertical rotary files are used for storing various size cards, paper records and microfilm records. These files have shelves which can be rotated in a vertical plane such that the filing or retrieving of items can be accomplished at a constant level. This allows an operator to retrieve or replace items without excessive movement. With many models, operation can be conducted in the sitting position.

Depending upon the size of the file and items, storage capacity can vary from approximately 14,000 to over a million items. Current models are available with up to 32 shelves or tray levels. Each level can be subdivided in several ways to accommodate different sized items and various applications. This allows con-



Kard-Voyer Mechanized Card Filing Unit

siderable flexibility in file organization and in the use of filing techniques.

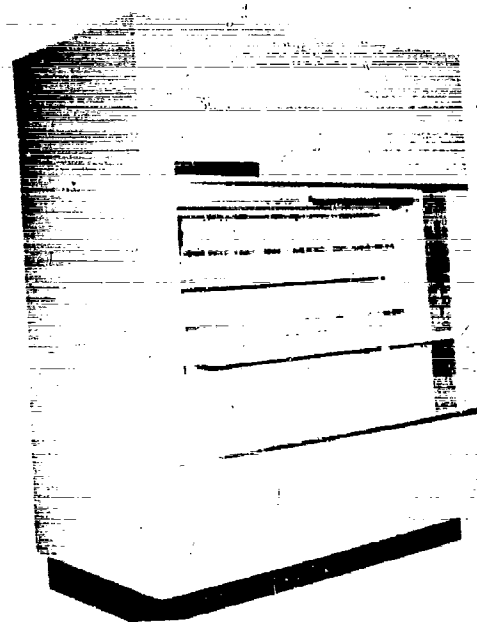
such that the direction of conveyor motion provides the shortest distance of shelf movement. In use, this permits parallel operation since an operator can be

Operating Characteristics

In using a rotary file, an item is retrieved by first selecting the proper shelf and then the position of the item on that particular shelf. Shelves are selected by pushing the appropriate buttons and are controlled



Lektrakard Automatic Card Filing System



Lektrafil

performing a portion of a filing function while the next shelf level is being positioned.

The shelves are driven by a motor-powered conveyor system. Maximum time for shelf selection would be that required for one half of a complete revolution of the conveyor system. For a unit with nine shelf levels, this time would be approximately seven seconds.

VISIBLE VERTICAL RECORD SYSTEMS

Status—Available off-the-shelf

Manufacturers—Acme Visible Records, Inc.

Visirecord, Inc.

Diebold, Inc.

Cost—\$200 to \$1000 depending upon model and size

Delivery Time—2 to 90 days

Description of Equipment

This filing concept uses an arrangement of cards in file such that a margin along one side of each card is exposed. The cards are stored vertically in rows separated by dividers which designate the contents of each row. Color coding facilitates filing and reduces errors by creating patterns whose interruption immediately indicates a misplaced or missing record.

This filing technique has been designed for very rapid insertion and removal of data card type records from file. Due to the file arrangement and frequent use of dividers, file density is considerably lower than in other visible file configurations. However, filing units are available in arrangements and sizes that allow one operator to effectively file 20,000 cards without difficulty.

SECTION VII SPECIAL DEVICES

MULTIPLE INSTANTANEOUS RESPONSE FILE

Status—Successful Experimental Model

Developer—Stanford Research Institute

Military Sponsorship—

Government Branch—U.S. Air Force

Agency—Rome Air Development Center

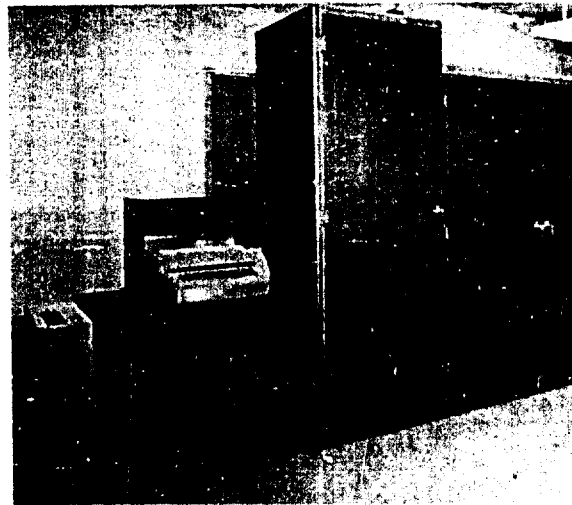
Contract Number—AF30(602)-2772

Cost—250K

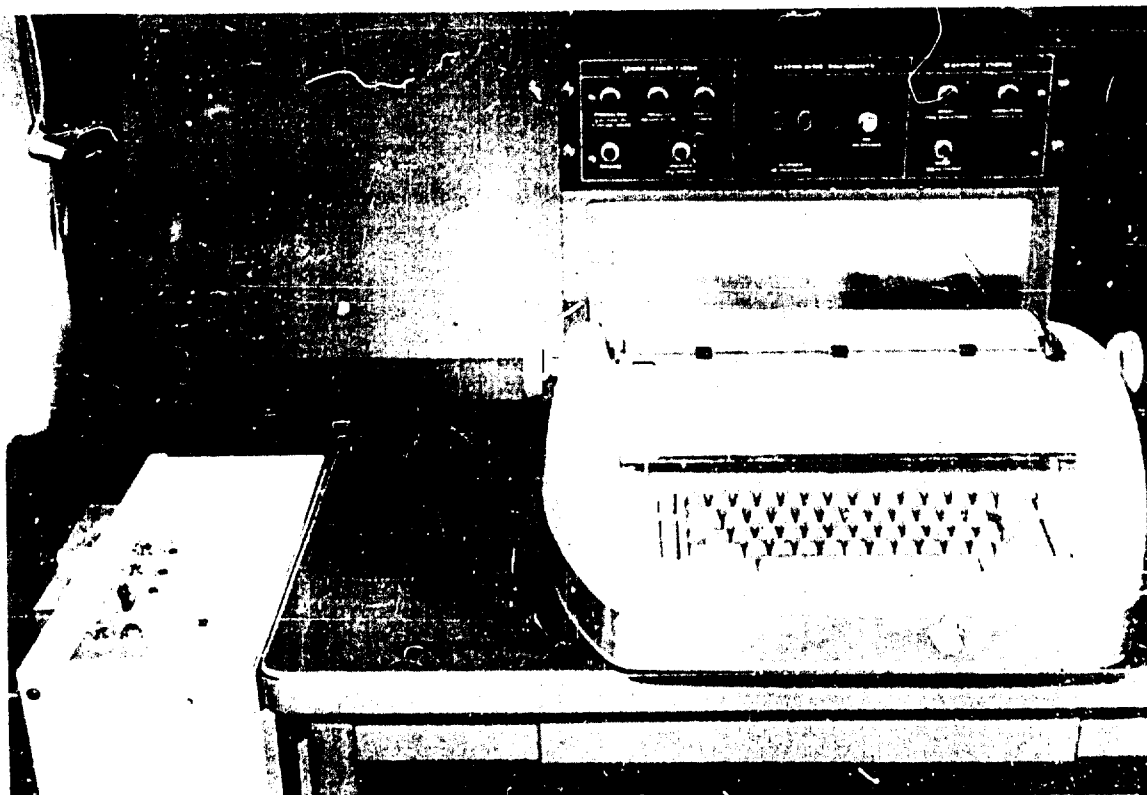
Delivery Time—September 1963

Description of Equipment

The Multiple Instantaneous Response File (MIRF) is an experimental model of an electronic reference retrieval file in which all file entries are interrogated simultaneously. The model is designed to store the indexes to 5000 documents. Each document is given an accession number and is described by up to eight descriptors selected from a 3000-word dictionary. A search question, consisting of one to eight descriptors in their natural form, is entered by means of an



Front View of Document Data Indexing Set



Closeup View of Input-Output Area

electric typewriter. The machine indicates immediately whether or not any file item satisfies the search question, and, if so, how many file items respond. The machine then resolves multiple responses and types out the accession number and full set of descriptors of each responding document.

The document indexes and the words of the dictionary are stored in wiring patterns associated with arrays of linear ferrite magnetic cores. During entry of the search question, the dictionary magnetic store is interrogated by the alphabetic code of each search word. If the word is not contained in the dictionary, it is automatically rejected. After all words of the search question have been entered, the document magnetic store is interrogated by the search question in superimposed code form.

The equipment can handle synonymous input descriptors and has the capability for automatically modifying the manually inserted search question

according to certain logical rules. New searches based on the modified search question (e.g., substitution of a see-also reference) for one of the original descriptors are initiated automatically.

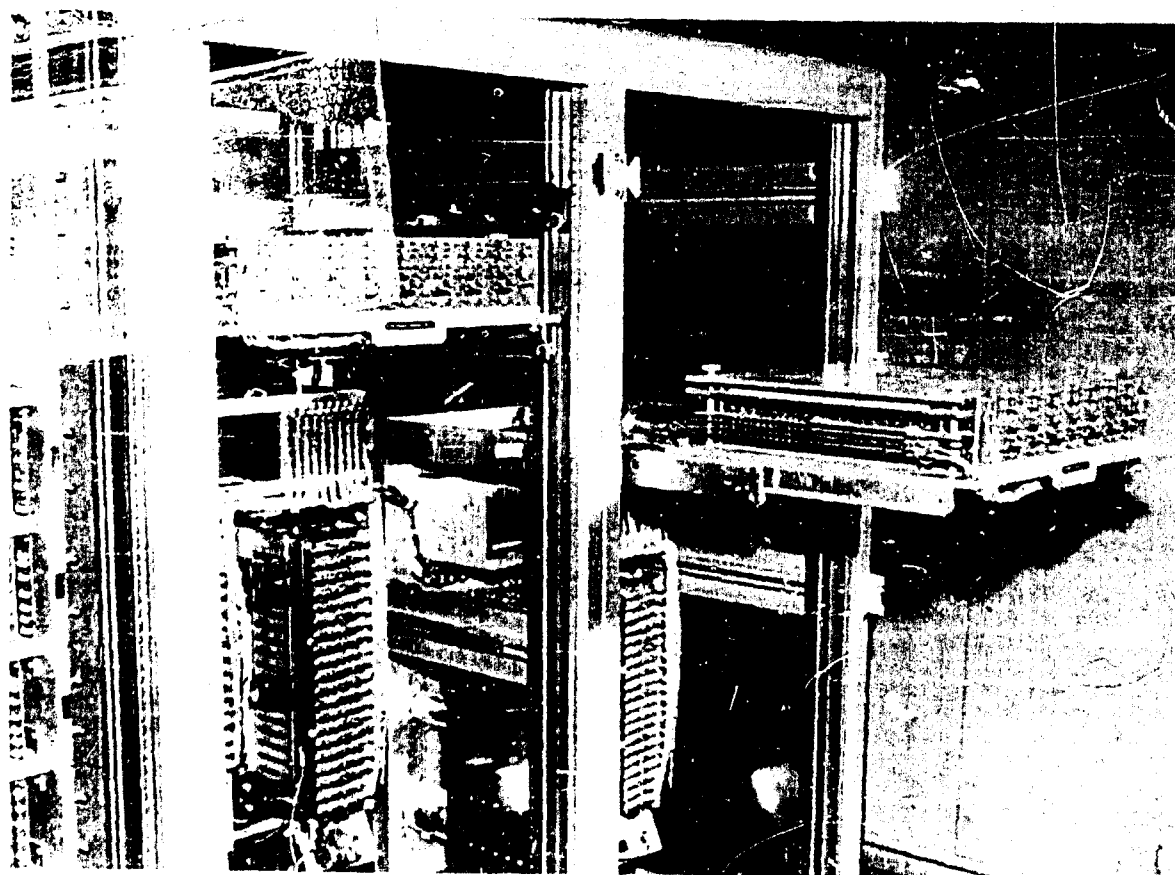
Operating Characteristics

- *Document MIRF*

The Document MIRF is the principal element of the system. It contains for each stored document index the document accession number and the key words (in coded form) that describe that document as well as a search code field that is used in the search process.

- *Dictionary MIRF*

The Dictionary MIRF translates during the input phase of operation from the alphabetic code of the word descriptor that is entered from the typewriter to the binary serial number assigned to that word for use



Front View of MIRF Section

inside the machine. During the output phase of operation, the Dictionary MIRF translates from the binary serial number of a word that is obtained during a search to the alphabetically coded form of that word.

THE PRINCIPAL MIRF UNITS

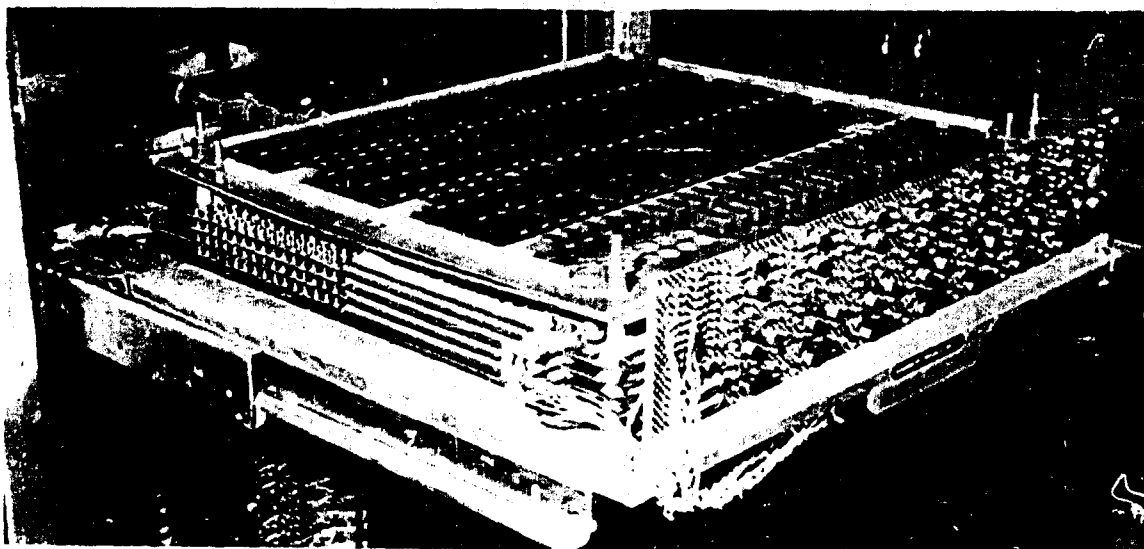
- *Magnetic Implementation*

The MIRF units of the document data indexing set are built according to a scheme, called the diode-diamond ring, which has properties of an associative memory. Information is stored in unique wiring patterns associated with an array of linear ferrite cores. Each item of stored information is represented by a conductor that passes through or around each associated core in a unique pattern determined by the information it contains. The cathodes of many diodes

are connected to form the input to a detector amplifier.

- *Relation of MIRFs and the Associative Registers*

Associated with each MIRF unit is a set of drive amplifiers and a match detector. Information to be gated into a MIRF unit by way of the drive amplifiers is held in flip-flop registers. Interrogation of an MIRF unit consists of applying a particular pattern of drive voltages to the primaries of the cores of the MIRF and observing the output of the match detector. One output voltage level indicates a match between the interrogation and the information contained in the MIRF, and the other voltage level indicates some degree of mismatch between the two. The output of the match detector is typically used to modify the contents of a flip-flop register.



Closeup of Document Module with Top Plate Removed

MANUFACTURER INDEX

Company, Equipment	Page	Company, Equipment	Page
Acme Visible Records, Inc. 8001 W. Alhambra Drive Croyet, Virginia		Eastman Kodak 100 Plymouth Avenue N. Rochester 4, New York	
1. Electro File	57	Minicard System	47
2. Horizontal Rotary Files	58		
3. Visible Vertical Record Systems	61	Ferris Business Equipment, Inc. 45 Seymour Street Stratford, Connecticut	
AVCO Corporation Electronics Research Laboratory 2630 Glendale-Milford Road Cincinnati 41, Ohio		Vertical Rotary Files	59
Verac 903	48	F.M.A., Inc. 1112 Nevada Street El Segundo, California	
Bell & Howell Co. Phillipsburg, New Jersey		Filesearch	24
Date System	19	General Electric Company Information Systems Section Defense Systems Department 4901 Fairmont Avenue Washington, D. C.	
Benson-Lehner Corp. 1860 Franklin Street Santa Monica, California		1. Search Comparator	13
1. FLIP	27	2. Thermoplastic Tape Recording	56
2. Comac Mark II	52		
Computer Control Co., Inc. 983 Concord Street Framingham, Massachusetts		General Precision Laboratories Pleasantville, New York	
Document Data Indexing Set AN/GSQ-26	11	Graphic Data Storage and Retrieval System	22
Dichold, Inc. Canton, Ohio		Hallcrafters Company 4101 W. Fifth Avenue Chicago 24, Illinois	
1. Vertical Rotary Files	59	RAVR	29
2. Visible Vertical Record Systems	61		
Documentation, Inc. 4827 Rugby Avenue Bethesda, Maryland		Houston Fearless Corporation 11801 W. Olympic Blvd. Los Angeles, California	
Docuform	19	Automatic Unit Record Storage and Retrieval Device	42

Company, Equipment	Page
International Business Machines 590 Madison Avenue New York 22, New York Walnut System	45
Itek Corporation 10 Maguire Road Lexington, Mass. 1. Acstrac	17
2. Unit Record Search and Dissemination Device	44
3. Itek Memory Centered Processor	49
Jonkers Business Machines, Inc. 404 N. Fedrick Avenue Gaithersburg, Maryland Termatrix	52
Link Division General Precision Hillcrest Binghamton, New York Video Film Converter	32
Magnavox 2131 Beuter Road Ft. Wayne 4, Indiana Magnacard Information Storage and Retrieval System	5
Magneto-Optics System	13
Magnavue System	34
Media	36
The Microcard Corporation 465 S. Oak Street West Salem, Wisconsin Microcard	19
Microfiche	20
Monroe Calculating Machine Co., Inc. 555 Mitchell Street Orange, New Jersey Monroe Card System	7

Company, Equipment	Page
Mosler Safe Company Hamilton, Ohio Mosler Document Retrieval Equipment	27
National Bureau of Standards Washington, D. C. 1. FOSDIC II	27
2. Rapid Selector	31
3. Microcite	49
National Cash Register Company Dayton 9, Ohio 1. Photochromic Micro-Images	2
2. CRAM	5
North American Aviation Space and Information Systems Division 12214 Lakewood Blvd. Downey, California Large File Document Retrieval System	21
Philco Corporation Aeronutronic Division Ford Road Newport Beach, California Computer Set Electronic Order of Battle AN/GSQ-38	12
Photo Devices Rochester, New York RASTAR	18
70mm Roll Film Selector and Camera	32
Radcom Div. of Litton Systems 1140 East West Highway Silver Springs, Maryland Command Retrieval Information System (CRIS)	46
Radio Corporation of America Electronic Data Processing Division Front and Cooper Streets Camden 2, New Jersey 1. Random Access Mass Memory System	8
2. Video File	11

Company, Equipment	Page
Recordak Corporation 415 Madison Avenue New York, New York Microdot System	27
Remington Rand Univac 3145 4th Avenue New York 10, New York Electro-Kardex	58
Tray Files	59
Variadex	59
Vertical Rotary Files	59
Royal McBee Corporation 350 Third Avenue New York 22, New York Punched Card	53

Company, Equipment	Page
Jacques Samain Paris, France Filmorex	33
Stanford Research Institute Palo Alto, California Multiple Instantaneous Response File	62
Visirecords, Inc. Copague, Long Island New York Visible Vertical Record Systems	61
Watson Manufacturing Company, Inc. Jamestown, New York Rol-Dex Files	59

SECTION INDEX

	Page		Page
Photochromic Micro-Images	2	VII. Film Computer	32
SECTION II. MAGNETIC STORAGE	4	70mm Roll Film Selector	32
A. Magnetic Card Storage	4	D. Unitized Photographs	34
CRAM	5	Edutorex	33
Magnacard Information Storage and Retrieval System	5	Magnavue System	34
Monroe Card System	7	Media	36
Random Access Mass Memory System	8	Minicard System	37
B. Magnetic Disc Storage	9	Automatic Unit Record Storage and Retrieval Device	42
C. Magnetic Drum Storage	10	Unit Record Search and Dissemination Device	44
D. Magnetic Tape Storage	10	E. Unitized Photographs—Film Strips	45
Document Data Indexing Set	11	Walnut System	45
AN/GSQ-26	11	F. Photographic Plate Storage	46
Computer Set Electronic Order of Battle AN/GSQ-38	12	Sheet or Scroll	46
Search Comparator	13	Command Information Retrieval System (CRIS)	46
Magneto-Optics System	13	Verac 903	48
Video File	14	Microcite	49
SECTION III. PHOTOGRAPHIC DIGITAL AND/OR IMAGE STORAGE	16	G. Photographic Plate Storage-Disc	49
A. Microfilm on Aperture Cards	17	Itek Memory Centered Processor	49
Aextrac	17	SECTION IV. SURFACE PERFORATION STORAGE	52
Rastar	18	Comac Mark II	52
B. Microfilm in Card Form	18	Termatrex	52
Dare System	19	Punched Card	53
Docuform	19	SECTION V. SURFACE DEFORMATION	56
Microcard	19	Thermoplastic Recording	56
Microfiche	20	SECTION VI. STORAGE FILES	57
Mosler Document Retrieval Equipment	20	Electro File	57
Large File Document Retrieval System	21	Electro-Kardex	58
Graphic Data Storage and Retrieval System	22	Horizontal Rotary Files	58
C. Roll Film	23	Rot-Dex	59
Filesearch	24	Tray Files	59
FLIP	27	Variadex	59
FOSDIC II	27	Vertical Rotary Files	59
Mitacode System	27	Visible Vertical Record Systems	61
RADIR	29	SECTION VII. SPECIAL DEVICES	62
Rapid Selector	31	Multiple Instantaneous Response File	62

APPENDIX I

COMMERCIAL ORGANIZATIONS SOLICITED FOR INFORMATION

A		
A. B. Dick Co. 5700 W. Touhy Avenue Chicago 38, Illinois	American Library Association 50 E. Huron Street Chicago, Illinois	Basic Systems, Inc. 52 E. 42nd Street New York, New York
*Armo Visible Records, Inc. 8803 W. Allview Drive Crozet, Virginia	American Telephone & Telegraph Co. 42 Avenue of the Americas New York 13, New York	Antelle Memorial Institute 505 King Avenue Columbus 1, Ohio
ACR Electronics Corp. 551 W. 22nd Street New York 11, New York	*Ampex Corporation 931 Charter Street Redwood City, California	*Rockman Systems Division 325 N. Muller Avenue Anaheim, California
*Addressograph-Multigraph Corp. 1200 Babbitt Road Cleveland 17, Ohio	Anso Division GAFC Vestal Pky, East Binghamton, New York	*Bell & Howell Phillipsburg Co. Phillipsburg, New Jersey
Aeroflex Corp. 34-06 Skillman Avenue Long Island City 1, New York	APECO 2100 W. Dempster Evanston, Illinois	Bendix Computer 5630 Arbor Vitae Street Los Angeles 44, California
AQFA, Inc. 516 E. 34th Street New York 1, New York	Armour Research Foundation 10 W. 35th Street Chicago 16, Illinois	*Benton-Lehner Corp. 1860 Franklin Street Santa Monica, California
*Allied Research Associates, Inc. 43 Leion Street Boston 15, Massachusetts	*Arthur D. Little, Inc. Operations Research Section Acorn Park Cambridge 40, Massachusetts	Berkeley Enterprises, Inc. 815 Washington Street Newtonville 60, Massachusetts
Alwac Computer Division Electronics, Inc. 13040 S. Cerise Avenue Haythorne, California	Auerbach Electronics Corp. Corporate Headquarters 1631 Arch Street Philadelphia 3, Pennsylvania	Boss, Allen & Hamilton 135 S. La Salle Street Chicago 3, Illinois
American Bosch Arma Corp. 320 Fulton Avenue Hempstead, New York	Autonetics Industrial Products Division of North American Aviation, Inc. 3400 E. 70 Street Long Beach 5, California	Borg-Warner Corp. 3300 New Port Blvd. Santa Ana, California
American Brake Shoe Company Raymond Archley Division 2231 S. Barrington Avenue Los Angeles 64, California	*AVCO Electronics Research Laboratory 2630 Glendale Millford Road Cincinnati 41, Ohio	Charles Bruning Co., Inc. 965 Commonwealth Avenue Boston 15, Massachusetts
American Data Machines, Inc. 7 Commercial Street Hicksville, Long Island New York		Bryand Computer Products Div. of Ex-Cell-O Corp. 850 Ladd Road Walled Lake, Michigan
American Electronics, Inc. 75 Front Street Brooklyn 1, New York		*Burroughs Corporation 6071 Second Avenue Detroit 32, Michigan

B

C. I. Barkley and Co. 1220 W. Van Buren Street Chicago 7, Illinois	Burton Mount Corp. New Hyde Park, New York
---	--

*Provided information to RADIC

C

Calculagraph Co.
Hanover, New Jersey

Canadian Applied Research Ltd.
750 Lawrence Avenue W.
Toronto 19, Ontario, Canada

CBS Labs
High Ridge Road
Stamford, Connecticut

CEIR, Inc.
1200 Jefferson Davis Highway
Arlington 2, Virginia

Clary Corp.
408 Junipero Street
San Gabriel, California

Collins Radio Co.
Western Division
19700 San Joaquin Road
Newport Beach, California

Computer Concepts
1012 14th Street, N.W.
Washington, D. C.

***Computer Control Co., Inc.**
983 Concord Street
Framingham, Massachusetts

Computer Operations, Inc.
600 Old Country Road
Garden City, Long Island
New York

Computer Sciences Corp.
Malaga Cover Plaza
Palo Verde, California

Computer Usage Co., Inc.
1825 Connecticut Avenue
Washington, D. C.

Computron Corp.
12740 San Fernando Road
Sylmar, California

Consolidated Avionics Corp.
800 Shames Drive
Westbury, New York

***Control Data Corp.**
501 Park Avenue
Minneapolis, Minnesota

Copense Corporation
P.O. Box 215
Westford, Massachusetts

Copy-Craft, Inc.
105 Chambers Street
New York 7, New York

D

Datagraphic Systems, Inc.
1627 K. Street, N.W.
Washington, D. C.

Datamasters, Inc.
2212 M. Street, N.W.
Washington, D. C.

***Datatrol Corporation**
8113-A Fenton Street
Silver Spring, Maryland

***Dinbold Corporation**
1634 Wisconsin Avenue, N.W.
Washington 7, D.C.

***Digitronics Corporation**
10 E. 40th Street
New York 16, New York

Documat, Inc.
75 E. 54th Street
New York 22, New York

***Documentation, Inc.**
4827 Rugby Avenue
Bethesda, Maryland

DuPont Corp.
Wilmington 98, Delaware

E

***Eastman Kodak Company**
400 Plymouth Avenue, N.
Rochester 1, New York

Ebasco Industries, Inc.
1240 N. First Avenue
Birmingham 3, Alabama

Thomas A. Edison Industries
Instrument Division
West Orange, New Jersey

The Electrodata Corp.
11244 Playa Street
Culver City, California

Electro Data
460 Sierra Madre Villa
Pasadena, California

Electronics Corporation of America
1 Memorial Drive
Cambridge 42, Massachusetts

E-Z Sort Systems, Ltd.
15 Second Street
San Francisco 5, California

F

Fairchild Camera & Instrument Corp.
Defense Products Division
400 Robbins Lane
Syosset, Long Island, New York

Farragut Electric, Inc.
40 Rockefeller Plaza
New York 20, New York

***Ferris Business Equipment, Inc.**
15 Seymour Street
Stratford, Connecticut

Film Sort Company
Pearl River, New York

***FMA, Inc.**
142 Nevada Street
17 Segunda, California

Ford Instrument Company
Long Island City 1, New York

***Friden, Inc.**
2750 Washington Avenue
San Leandro, California

G

***General Aniline & Film Corp.**
Drafing Division
Anexo Road
Johnson City, New York

***General Electric Company**
Information Systems Section
Defense Systems Department
1901 Fairmont Avenue
Washington, D. C.

General Electronic Laboratories, Inc.
18 Ames Street
Cambridge 42, Massachusetts

*Provided information to RAIDC

*General Precision Laboratories
Pleasantville, New York

*Graphic Microfilm Corp.
115 Liberty Street
New York, New York

*Graphic Systems
Yonkersville, North Carolina

H

*Halcrafters Company
4401 W. Fifth Avenue
Chicago 24, Illinois

Haloid Company
88 Broad Street
Boston 10, Mass.

Herner & Company
900 New Hampshire Avenue, N.W.
Washington, D. C.

*Hogan Facsimile Corporation
Subsidiary of Telecommunications
633 Greenwich Street
New York 14, New York

Honeywell Electronic Data
Processing Div.
6 Walnut Street
Wellesley Hills 81, Massachusetts

*Houston Fearless Corporation
11801 W. Olympic Blvd.
Los Angeles, California

Hughes Aircraft Company
Florence and Teale
Culver City, California

Information Handling Systems, Inc.
500 Glasgow Road
Alexandria, Virginia

Information for Industry, Inc.
1000 Connecticut Avenue
Washington, D. C.

Information Products Company
356 6th Street
Cambridge 12, Massachusetts

Information Research Associates
1126 G. Street, N.W.
Washington, D. C.

The Information Research Group
701 14th Street, N.W.
Washington, D. C.

*Information Retrieval Corporation
1000 Connecticut Avenue
Washington, D. C.

Information Storage Systems, Inc.
222 W. 100th Avenue
Pompton Lakes, New Jersey

Information Systems, Inc.
7450 North Ridgeway Avenue
Skokie, Illinois

Infotronics Corp.
1101 S. Post Oak Road
Houston 27, Texas

Institute for Scientific Information, Inc.
33 South Fifth Street

*International Business Machines
Corporation
500 Madison Avenue
New York 22, New York

*Itsk Corporation
10 Maguire Road
Lexington, Massachusetts

ITT Laboratories
500 Washington Avenue
Nutley 10, New Jersey

*Jacques Somain
Paris, France

*Jankers Business Machines, Inc.
101 N. Frederick Avenue
Guntersburg, Maryland

K

Kalvar Corporation
New Orleans, Louisiana

*Laboratory for Electronics, Inc.
Computer Products Division
1070 Commonwealth Avenue
Boston 15, Massachusetts

Lanugen Aperture Cards, Inc.
400 Fifth Avenue
New York, New York

Libroscope Division
General Precision, Inc.
808 Western Avenue
Glendale 1, California

*Link Division
GPI
Hillcrest
Binghamton, New York

Lifton Systems, Inc.
530 N. Foothill Road
Beverly Hills, California

MA

*The Magnaflex Company
P.O. Box 5121
St. Louis 30, Missouri

Magnovox
2829 Miricopa Street
Torrance, California

*Magnover Company
2141 Deater Road
Ellettsville, Indiana

*Marquardt Aircraft Co.
2709 N. Garey Avenue
Pomona, California

Massachusetts Institute of Technology
Engineering Projects Laboratory
Data Processing Systems Division
Cambridge, Massachusetts

*The Microcard Corp.
300 S. Oak Street
West Salem, Wisconsin

Micro-Data Division
7100 McCormick Road
Chicago 15, Illinois

*Provided information is for reference only

Microfilm Products
Division of Thermofax
 Newton Highlands, Mass.
Microseal Corporation
 6280 N. Cicero Avenue
 Chicago 18, Illinois

***Minneapolis-Honeywell Regulator Co.**
EDP Division
 60 Walnut Street
 Wellesley Hills 81, Mass.

***Minnesota Mining and Manufacturing Co.**
 9601 Rush Avenue
 St. Paul 6, Minnesota

***Monroe Calculating Machine Co., Inc.**
 555 Mitchell Street
 Orange, New Jersey

Moore Business Forms, Inc.
 Niagara Falls, New York

***Mosler Safe Company**
 Hamilton, Ohio

National Bureau of Standards
 1120 Connecticut Avenue, N.W.
 Suite 1120
 Washington, D. C.

N

***National Bureau of Standards**
Data Processing Systems Div.
 Washington 25, D. C.

***National Cash Register Company**
 Dayton 9, Ohio

Nor-Air Division
Northrop Corp.
 1001 E. Broadway
 Hawthorne, California

Norden Division
United Aircraft Corp.
 4501 Harbor Blvd.
 Costa Mesa, California

***Normandie Dataforms**
 350 W. 4th Street
 New York 11, New York

***North American Aviation, Inc.**
 1400 East 5th Avenue
 Columbus 16, Ohio

North American Aviation, Inc.
Space and Information Systems Div.
 12214 Lakewood Blvd.
 Downey, California

North American Aviation, Inc.
Autonetics Division
 9150 East Imperial Highway
 Downey, California

Nortronics
 500 E. Orangewood Ave.
 Anaheim, California

O

Olivetti Corp. of America
 375 Park Avenue
 New York 22, New York

***OPTO Mechanisms, Inc.**
 Logansville Hall
 Plainview, Long Island
 New York

Oxford Filing Supply Co.

Garden City, New York

Ozolid
 75 Anasco Road
 Johnson City, New York

P

***Pearless Photo Products, Inc.**
 Shoreham, Long Island
 New York

***Philco Corporation**
Aeronautic Division
 Ford Road
 Newport Beach, California

***Philco Corporation**
G & I Division
 1700 Wissasickon Avenue
 Philadelphia 11, Pennsylvania

Photo Devices
 Rochester, New York

***Photomechanisms, Inc.**
 15 Stegar Place
 Huntington Station
 Long Island, New York

***Potter Instrument Co., Inc.**
 Sunnyside Boulevard
 Plainview, Long Island
 New York

Pratt & Whitney Data Center
 P.O. Box 418
 Northridge, California

R

***Robinow Engineering Co., Inc.**
 1025 W. Montgomery Avenue
 Rockville, Maryland

***Rodcom**
Div. of Litton Systems
 1110 East West Highway
 Silver Spring, Maryland

Radiation Inc.
 P.O. Box 47
 Melbourne, Florida

***Radio Corporation of America**
Electronic Data Processing Div.
 Front and Cooper Streets

Ramo-Woolridge
 8434 Fall Brook Avenue
 Canoga Park, California

Raytheon Company
 101 River Street
 Waltham 54, Massachusetts

RCA Data Systems Division
 8500 Balboa Boulevard
 Van Nuys, California

***Recordak Corporation**
 415 Madison Avenue
 New York 17, New York

***Remington Rand Univac**
 415 4th Avenue
 New York 10, New York

Richardson Camera Co., Inc.
 2526 North Ontario Street
 P.O. Box 1066
 Burbank, California

Rockford Research Institute, Inc.
 1101 2 Mt. Auburn Street
 Cambridge 38, Massachusetts

*Provided information to RADIC

Royal McBee Corporation
850 Third Avenue
New York 22, New York

S

Space Technology Labs
P.O. Box 45738
Los Angeles 46, California

***Stanford Research Institute**
443 Ravenwood
Menlo Park, California

Stromberg-Carlson
Division of General Dynamics Corp.
100 Carlson Road
Rochester 3, New York

Sylvania Electronics
63 2nd Avenue
Waltham, Massachusetts

Systematics
Div. of General Instrument Corp.
300 11th Avenue
Flower Garden, New York

***Provided information to RADC**

System Development Corporation
2400 Colorado Avenue
Santa Monica, California

T

Thompson Radio Woodruffs, Inc.
Tapco Group
Cleveland 17, Ohio

Times Facsimile Corp.
540 W. 58th Street
New York 19, New York

U

University Microfilms, Inc.
313 N. First Street
Ann Arbor, Michigan

V

***Visirecords, Inc.**
Copague, Long Island
New York

W

Watson Mfg. Co., Inc.
Rt. Box 101, Dept. B-12

Wheelindex & Simpo Products
10 Bank Street
White Plains, New York

Western Electric Co.
222 Broadway
New York 38, New York

Westinghouse Electric Corp.
P.O. Box 2278
Pittsburgh 30, Pennsylvania

Westinghouse Electric Corp.
Electronics Division
Friendship International
Airport
Baltimore, Maryland

Barry Wright Corp.
Data Processing Div.
Worcester, Massachusetts

X

***Xerox Corp.**

APPENDIX II

APPLICATIONS CHART

The Application Chart provides a quick reference for determining the areas of applicability of the equipments and techniques included in the compendium. Applicability of a device for storing a particular form of data is indicated by an "X" mark in the appropriate rectangle associating the data form and device.

In compiling this chart the following definitions were used:

1. Input Data—The form in which the data to be stored is received or exists.

2. Processed Text—Any information which has been formatted, reorganized, condensed or classified. The objective of these operations is to provide a descriptor of the factual content of the information or the factual content itself in a specific form. Index

data, abstracts, extracts and business forms would be included in this category.

3. Digital Information—Digital representation of textual data such as the output of a character or print reader. This includes digital representation of processed text and raw text.

4. Raw Text—Document pages such as pages from technical reports, periodicals and books.

5. High Resolution Photography—Aerial Photography.

6. Graphic Reference Materials—All forms of graphic data excluding high-resolution photography. This includes maps, charts, graphs, engineering drawings and CRT display images.

EQUIPMENT OR TECHNIQUE	INPUT DATA				
	Processed Text	Digital Information	Raw Text	High Resolution Photography	Graphic Reference Materials
1. Photochromic Micro-Images	X		X		
2. CRAM	X	X	X		
3. Magnacard	X	X	X		
4. Montoe Card System	X	X			
5. Random Access Mass Memory System	X	X	X		
6. AN/GSQ-26	X	X			
7. AN/GSQ-38	X	X			
8. G.E. Search Comparator	X	X			
9. Magneto-Optics System	X	X	X		
10. Video File	X		X		X
11. Aperture Cards	X		X		X
12. Astrac	X				X
13. Rastar	X				X
14. Dare System	X		X		

EQUIPMENT OR TECHNIQUE	INPUT DATA				
	Processed Text	Digital Information	Raw Text	High Resolution Photography	Graphic Reference Materials
15. Docuform	X		X		X
16. Microcard	X		X		X
17. Microfiche	X		X		X
18. Mosler Document Retrieval Equipment	X				X
19. Large File Document Retrieval System	X		X		X
20. Graphic Data Storage and Retrieval System	X				X
21. Filesearch	X		X		X
22. FLIP	X		X		X
23. FOSDIC II	X				X
24. Miracode System	X		X		X
25. RADIR	X		X		X
26. Rapid Selector	X		X		X
27. Video Film Converter	X		X		X
28. 70mm Roll Film Selector	X		X		X
29. Filmorex	X		X		X
30. Magnavue System	X		X		X
31. Media	X		X		X
32. Minicard System	X		X		X
33. Automatic Unit Record Storage and Retrieval Device				X	X
34. Unit Record Search and Dissemination Device				X	X
35. Walnut System	X		X		X
36. CRIS	X		X		
37. Verac 903	X		X		
38. Microcite	X				
39. Memory Centered Processor	X	X	X		
40. Comac Mark II	X	X			
41. Termatrix	X				
42. Punched Cards	X	X			

EQUIPMENT OR TECHNIQUE	INPUT DATA				
	Processed Text	Digital Information	Raw Text	High Resolution Photography	Graphic Reference Materials
43. Thermoplastic Recording	X	X	X		X
44. Electro File	X				X
45. Electro-Kardex	X				
46. Horizontal Rotary Files	X				X
47. Rol-Dex	X				X
48. Variadex	X				
49. Tray Files	X				
50. Vertical Rotary Files	X				X
51. Visible Vertical Record Systems	X				
52. Multiple Instantaneous Response File	X				

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