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AUTOMATION OF THE DMA LIST OF LIGHTS AND RADIO
NAVIGATIONAL AIDS(U) DEFENSE MAPPING AGENCY
HYDROGRAPHIC/ TOPOGRAPHIC CENTER WASHINGTON DC

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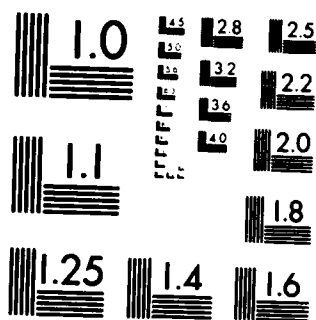
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20. The Defense Mapping Agency (DMA) has completed the software development required to automate the compilation, publication and maintenance of seven volumes of the DMA List of Lights and two volumes of the DMA Radio Navigational Aids. The List of Lights has been published by the United States Government since 1871 and the Radio Aids since 1925. Presently, both of these publications are completely produced by use of manual methods and files. Each of these publications has a long history of service to the fleet and are considered important navigational aids for all mariners.

This paper provides a detailed overview of the software subsystem necessary to load, process and publish the List of Lights and Radio Aid data on the Automated Notice to Mariners System (ANMS) computer. The List of Lights software will share all of the ANMS hardware and communications capabilities. It will provide remote query capabilities for mariners at sea, digital data transmission potential for computer applications and, most important, the potential to produce an up-to-date edition of any annual volume at any time.

**AUTOMATION OF THE DMA LIST OF LIGHTS
AND
RADIO NAVIGATIONAL AIDS PUBLICATIONS
(No. 2)**

By: Morris F. Glenn
Navigation Department
Hydrographic/Topographic Center
Defense Mapping Agency
Washington, D.C. 20315

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INTRODUCTION

The Defense Mapping Agency (DMA) has now (December 1982) almost completed the software development required to automate the compilation, publication and maintenance of seven volumes of the DMA List of Lights and two volumes of the DMA Radio Navigational Aids. The List of Lights has been published by the United States Government since 1871 and the Radio Aids since 1925. Presently, both of these publications are completely produced by use of manual methods and files. Each of these publications has a long history of service to the fleet and is considered an important navigational aid for all mariners. The statutory basis for these publications can be found in the U.S. Code, Title 10, Section ~~7391~~^{2791 (Public Law 97-255, October 12, 1982)} and Title 44, Section ~~213~~¹³³⁴.

Corrections to the List of Lights and Radio Aids, which are published in the weekly Notice to Mariners, were the initial data set scheduled for inclusion in the Automated Notice to Mariners System (ANMS). Once the weekly corrections were automated, the additional software required to automate the annual List of Lights and Radio Aids data and produce them on the ANMS was minimal. Therefore, the entire manual production operation was included in the initial software development project. Inclusion of the entire manual production process on the ANMS computer was a very cost effective project

allowing a new flexibility which has never been possible before. The ANMS computer will provide remote query capabilities for mariners at sea, digital data transmission potential for computer applications, and most important, the potential to produce an up-to-date edition of any annual volume at any time.

This brief paper is outlined and arranged in such a manner as to support an overview of the List of Lights automation project. Since computers have become ubiquitous in modern navigation, no attempt has been made to define usage of the most commonly used computer terms. This concept was succinctly presented by O.L. Martin in his paper entitled "Automation of DMA Nautical Information Products" presented at a symposium called Man and Navigation: An International Congress (Sussex, Brighton, England, Sept. 10-14, 1979). If there was ever a doubt that computers had become an integral part of DMA's support for mariners, Mr. Martin's illuminating presentation removed it and further defined DMA's future navigational automation goals. The combined materials in his paper have also helped to narrow the penumbra which had been allowed to grow in prior years between the separate fields of computers and navigation. Today, the merger of computers and navigation is obvious in practical application aboard ship and in all of its supportive adjuncts.

THE AUTOMATED NOTICE TO MARINERS SYSTEM

There are several published articles which will provide readers with details concerning the ANMS hardware specifications and the capabilities of the initial Chart Corrections Subsystem. In particular, refer to a paper by Morris F. Glenn presented at the 12th. International Hydrographic Symposium in Monaco, France in April 1982 entitled "Chart Corrections via Global Communications." This paper and several others are

reprinted in a DMA Navigation Department pamphlet entitled "Automated Notice to Mariners System" dated 5 March, 1982. (Available from DMA upon application).

The present ANMS hardware is a combination of three commercially available systems: Prime 400 computer and peripherals, Imlac PDS-4 intelligent terminals and peripherals, and a Photon Pacesetter Mark III typesetting machine. The intelligent terminals provide the man/machine interface to load data into the ANMS computer controlled and managed files. Intelligent terminals were selected for several reasons. The ANMS data entry procedure required the availability of several different screen character sets of varying font sizes and types with several data entry screen templates, a capability to plot hard copy of the information which is shown on the screen display, and a simplified data entry procedure which could be aided by pre-programmed computer function keys. The Prime computer is the heart of the ANMS and manages all data files, data processing and data communications (See Figure 1). It also creates the print tape in a special format to drive a Photon typesetter. *The resultant hard copy is formatted into sequential pages which are camera-ready for making press plates.* Once the data base is built, or corrected via an Imlac terminal, the computer can generate a whole volume of List of Lights information within minutes and the contents will be completely up-to-date. The three hardware units are combined to form a powerful publications management system collectively called the ANMS.

Although the hardware is of importance, one might say that the real heart of the ANMS is the specially developed applications software. The Chart Corrections Subsystem software took over four years to develop and it consists of about 45 individual programs. They operate under the Prime system software, PRIMOS, and are written in COBAL. A further complicating factor is that the applications software had to be developed to allow data entry on an intelligent terminal (written in assembly language). The data entry

software is also divided between the Prime Computer disk file and Imlac fixed disk storage (respectively identified as PSEE and ISEE). Each Imlac terminal has a 10 mb. disk storage capacity (5mb. fixed and 5mb. removable). This allows the specially designed Imlac software to be stored on-line and a number of character sets to be stored for output upon a printer/plotter (Versatec 1200A). The intelligent terminal is connected to the Prime computer via a 9600 baud line and is in continuous communication with the ANMS data files which are stored on the Prime Disk.

The Broadcast Warning Subsystem was the second software system to be installed on the ANMS. The first Daily Memorandum produced by the Navigation Department completely on the ANMS computer was No. 20 of February 1, 1982. The Broadcast Warning Subsystem shares the overall design concept of the Chart Corrections Subsystem (i.e., data is loaded to Prime disk files via the Imlac terminal and a print tape is created by the computer to drive the Photon typesetter). Additionally, the data base containing all active broadcast warnings is maintained by the Prime System and query software allows access over global communications links in the same manner as chart corrections.

When the List of Lights Subsystem is added to the Prime computer, the demand upon all peripherals as well upon the CPU will be extensive. The Prime now supports up to 64 interactive time shared users, but unfortunately, as the numbers of on-line users increases, the response time for all users will decrease. Another major system consideration, in view of the importance of meeting extremely strict Navigation Department daily and weekly production schedules, is to insure the existence of some reasonable back-up capability. Although there are many important reasons to maximize response time (i.e., remote users may be paying long distance communications rates for their connect time and data entry personnel need rapid response time to effectively utilize the Imlac terminals), the most important system planning consideration is to

provide a back-up production capability for vital DMA publications and ANMS master data files.

The solution to the overall system problem of improving response time, providing production back-up, and back-up for on-line files, is to network the present ANMS CPU with a second CPU (this item is in the DMA 1984 equipment procurement program). This final hardware acquisition, which is planned to complete the ANMS hardware configuration, will provide two CPU's operating in a computer network to share on-line data files, split processing workload, and provide essentially a complete back-up capability for all system hardware, files and software. In addition to copies of all master files (resident on a separate disk device), this configuration will make it immaterial which disk contains the master file (a benefit of a networked system). If one CPU becomes inoperative, the second CPU can be used to complete the query or data processing task. Even if the on-line disk is disabled, the task can be easily completed by use of back-up files.

Presently, the ANMS automation plan assumes a two processor environment which will allocate the data processing tasks as follows: the present CPU will handle routine production input/output, manage on-line Chart Corrections, support Broadcast Warnings and List of Lights weekly workfiles and automatically schedule ancillary tasks to support production; the second CPU will handle remote data base queries that can be generated from anywhere on the globe on a 24-hour basis. The second CPU will also handle all batch processing necessary to produce:

- A. Annual volumes of List of Lights
- B. Periodic Summary of Corrections volumes
- C. Daily back-up of work files

- D. Periodic back-up of master files
- E. New navigation publications which are planned for addition to ANMS.
- F. Future projects such as processing graphics.

The increased computer capability is not considered an optional feature when so many important and highly time oriented publications are involved. Banks, airlines and other business establishments have pioneered the redundancy concept of computer operations and this capability is now offered by most modern computer manufacturers. Also, by use of widespread international standards such as the CCITT X.25 which supports computer to computer or computer to terminal communications via packet switching software, computers marketed by many vendors may be connected into a single computer network. This is an important design concept when one considers the global nature and impact of the Chart Corrections, Broadcast Warnings and List of Lights data. In addition to a worldwide geographic distribution of users, DMA has numerous cooperative agreements with U.S. agencies and foreign governments for the exchange of hydrographic data. Without such exchanges, DMA would be unable to produce its navigational publications in a timely, accurate and comprehensive manner. Conceptually, the new hardware configuration of the ANMS advances the time when computers will perform a major role in the exchange and dissemination of international hydrographic information.

LIST OF LIGHTS AND RADIO AID DATA

DMA has been tasked with producing List of Lights and Radio Aids publications on a worldwide basis, except for the continental United States (CONUS). In CONUS, the U.S. Coast Guard produces the Light Lists, however DMA publishes the weekly corrections to the Coast Guard's Light Lists in the Notice to Mariners. Presently, there are about 59,000

lights and 3,000 radio aids listed and the weekly Notice to Mariners contains an average or about 80 information changes to these aids.

Each volume of DMA's List of Lights (Pub. numbers 110 thru 116) covers a particular geographic area of the world. Each volume contains a written description (in columnar form) of lighted navigational aids and fog signals (except secondary buoys) in use throughout the world (except CONUS). Storm signals, signal stations and radio aids operated in conjunction with light stations are also included in these volumes. These seven volumes are the only complete single source of identifying information for navigational aids during day and night or inclement weather published in the United States. Cartographic chart symbols and light legends located on nautical charts are not sufficient to describe the ranges, shapes, colors, light characteristics, structure, height of the light above water, sectors, stand-by or emergency apparatus, seasonal notes, fog signal characteristics/appliances or other text oriented details which are necessary for "all weather" identification. The radio navigational aids are presently published in DMA Pubs. 117A and 117B. After this automation effort is complete, the numbered radio aids will be removed from these volumes and merged geographically in the new automated volumes of the List of Lights. The remaining text in the two Radio Aid publications will be combined into a single volume published occasionally. Thus, the resultant volumes of List of Lights will provide mariners with a comprehensive sequential guide to navigational aids.

MANUAL COMPILATION METHODS

DMA's List of Lights data are now stored and produced by use of specially designed photo-list cards (which are not to be confused with the machine readable IBM type card

format). The cards are filed in the order of their respective geographic area. A Marine Information Specialists (MIS) evaluates all new light and radio aid information and determines the appropriate disposition of this new data by considering:

- A. Source of the information
- B. Consistency with existing information
- C. Impact upon shipping
- D. Degree of urgency
- E. International commitments
- F. Relevant operational requirements

Depending upon the reliability of the source and importance assigned to dissemination of a reported change in the status of a light, a correction will be written for publication in the Weekly Notice to Mariners. Upon receipt of the Notice to Mariners, the mariner will apply the correction of his copy of the List of Lights. The photo-list cards used to print these corrections will also be used to physically replace the former data card in the appropriate file drawer for subsequent inclusion in the next printing of the annual volume. Noncritical or editorial corrections are not published in the weekly Notice. These are processed and applied only to the file copy of photo-list cards. The new information will appear in the next annual volume.

The present manual production process utilizes several outdated, Vari-typer Model 900 machines. These machines allow the operator to select a choice of fonts and type sizes for use in each field of the photo-list card. The resultant line-of-type produces a clean, sharp image which is used as camera ready copy. For generating the annual publication, a manual paging process is required to count and arrange the large file of cards into a publication format. This is a long and tedious task because the color coded

cards, arranged in a vertical overlapping manner, must be positioned for photographing exactly as their content would appear in the final volume of the List of Lights. In other words, even a blank line must be manually input by use of a "spacer card" and every line accounted for by use of a counting device to ensure exact page lay out. The addition or deletion of a light thus substantially affects the card file, and each new printing of an annual volume requires a manual readjustment of the entire file system before paging. The advantages and savings involved in automating such a repetitive manual procedure were obvious from the beginning of the ANMS.

LIST OF LIGHTS AUTOMATION PLAN

In addition to automating the processing and publication system just described, the new digital List of Lights data base was planned so that it could provide many new capabilities for maintaining, extracting and disseminating data pertaining to lights and radio aids. Automation also includes the capability to utilize new digital techniques and to incorporate U.S. Navy communications systems as they become available. This supports future ANMS goals to interface the system with all new global communications systems and new international hydrographic reporting methods which may be developed (between national hydrographic offices and major shipping companies).

The List of Lights Subsystem was essentially modeled after the original Chart Corrections Subsystem of the ANMS. As noted earlier in relation to the development of the Broadcast Warning Subsystem, the initial software effort was in the nature of a research and development effort, because there were no other comparable systems available which DMA could use to develop specific designs. In addition to the existing Chart Corrections Subsystem software, all ANMS start-up hardware was already installed

and its operational capability was well established and clearly demonstrated. Thus, the design constraints around which the List of Lights was developed compared to most other software efforts, was exceedingly specific. Fortunately, the need for a phased development plan which allowed the addition of other publications to the system was anticipated during the original ANMS system design. Therefore, all hardware and software specifications were written accordingly. For example, the Screen Entry Editor (SEE) for the Imlac intelligent terminal was written in modules which could be easily changed to reconfigure the screen template (format). Since Chart Corrections data were only the first of several data sets to be automated on the ANMS, use of the software to allow input of data for other publications was an important stepping stone in ANMS development. Even though the fields, fonts and type of text to be input were subject to change, the operational parameters required to load the other publications were presumed to remain the same.

The List of Lights has been divided into three separate areas for discussion purposes in this paper: Weekly Production Cycle, Annual Production Cycle, and Communications Capabilities. The List of Lights Subsystem is referred to as LOLS in this text for purposes of brevity.

DESCRIPTION OF WEEKLY PRODUCTION CYCLE

The production sequence begins when a Marine Information Specialist (MIS) sends a printed form containing the text of light/radio aid change information to the ANMS to promulgate a change in the data on the Light Master file. The operator utilizes one of the Imlac data entry terminals and the LOLS data entry program. First, the LOLS data entry program requires the operator to load the light/radio aid number and then it searches the

Daily Work file and Light Master file for a record of any prior entries for this number. The program will display any available information on the screen within the proper fields of the LOLS screen entry template. If the number entered by the operator represents a new entry, all fields must be loaded with the required data in order to complete the data entry. If data is returned for an existing light, only the fields which are to be changed must be entered. Once the data is entered, the operator strikes the "Store Key" and the data is written to the daily work file (completing the data entry operation).

After the operator has entered a new light or correction into the file via the Data Entry Program, the "Clear Text" Mode is executed and a copy of the data set in its published form is displayed on the screen. The "Plot Key" is then hit to output hard copy on the Versatec to serve as the editor's proof copy (hard copy which can be attached to the data entry card). The MIS edits the input data and, if it has been properly loaded, the MIS will initial the proof plot. The edit initials are a vital record in this part of the entire processing procedure and are loaded into the data base. Input which does not have an entry in the field for editor's initials will be omitted from all subsequent processing and publication. Only edited data published because of the important uses to which the List of Lights data is subjected. If the editor's verification reveals that a change or correction to the original input transaction is needed, the entire data entry process will be repeated (from input of light/radio aid number onward to modify the items in error).

Once each week, depending upon the official "cut-off" date of the weekly Notice to Mariners, the Weekly Print Processor (hereafter referred to as a Proc) is executed. This is a control mechanism which is written to call and execute a series of software programs. It allows the operator to start a complicated ANMS computer operation, and except for mounting tapes, the operator is free to perform other tasks. The Proc consists of the following:

- A. Daily Work File Backup. A file copy is written as a safety precaution.
- B. Weekly Photocomposition. A Photon print tape is created which contains a series of typesetting commands necessary to drive a Photon Typesetter and data to be typeset. The computer also paginates the data, lines up the data, inserts the necessary column and page heading, inserts applicable footnotes, controls line length and page length, and if necessary, applies the logic for line splitting and other accounting steps necessary to maintain continuity within a multi-page, printed publication.
- C. Master/History Files Update. The master file is updated to reflect all changes in the Weekly Work File. If there is an existing light/radio aid record on the master file, one more processing step is performed. The "old" master file record must be moved to the history file to keep an accurate historical record. This allows the complete history of all automated light/radio aids to be automatically researched by the computer.
- D. Master File Backup. This provides a separate copy of the master file in case of loss by man made disasters or "electronic gnomes".

Each of the above programs may be invoked separately in order to handle unexpected occurrences and/or error conditions. The Weekly Proc will first ask the operator for publication information such as the Notice Number and Year pertaining to this weekly run (as NN/YY). The weekly program also checks for editor's initials, as noted earlier, before any data from the Daily Workfile will be processed further.

ANNUAL PRODUCTION CYCLE

The Annual Production Cycle runs under the control of the Annual Proc, or the operator may elect to run separately any individual program which is normally under control of the Annual Proc. Since the computer time for an annual volume of the List of Lights will be much longer than the computer time for the weekly notice, a check point procedure is utilized to allow the operator to restart the incomplete part of a long computer run in case a failure or problem is experienced in a program. This saves a great amount of CPU time when recovery procedures do not involve rerunning the entire program. The operation of the print program is the same as that previously described for the Weekly Print run, except that an Index Print file is created. The Index Print is a simultaneous operation and is written temporarily to disk during the Annual Print run. The disk file contains the name of the light/radio aid on the Master File (stored in front of the "Key Ended" symbol which the operator entered into the name and location field of the data line). For the Index, along with the name, a page number and a light number is also recorded. The Index entries for sub headings will not only print the name of the geographic area as it will appear, but also the number of the first aid to follow it. The index print program is then invoked by the Proc and this file is checked against a "See Proper Name" file to insure that proper reference is made to each light. The "See Proper Name" file is a sequential file stored on disk and is sorted with the Index Print file to show general names. The output is printed and recorded on a Photon tape.

Next, the U.S. International Cross Reference Program is run (independent of Annual Print Run). Two Photon tapes are output: one to print the U.S. - vs - International Light Number conversion table, and a second tape to print the International - vs - U.S. Light Number table. Processing sequence is not important, hence both of these tables may be run at any time.

COMMUNICATIONS CAPABILITIES

The initial query capabilities of the List of Lights software for public use have been limited to two queries. The Query by Heading is the most extensive data base search tool available providing access to all light/radio aid entries under a particular heading in the annual volumes (i.e. by heading, sub-heading, or, light name). The query by number of a light/radio aid is obviously the fastest method as the computer search will be much more specific. At present, the automation plan will allow remote users to query for the latest light/radio aid information for up to 10 numbered aids. Programs are:

- A. Query by Heading (Enter program LQMO2). The program then prompts the user to input the required data specifics.
- B. Light/Radio Aid Query (Enter program LQMO1). Entries will be the volume number of Annual List of Lights of requested light(s) and then numbers of Light/Radio Aids needed. Other queries may be added to the LOLS software if a need is demonstrated by a significant number of remote ANMS Users for more information. Changes may also be made to achieve a more efficient query procedure. Long distance communications are expensive and most users will want to maximize their use of the LOLS query system. The query system is not envisioned as a substitute for the annual volumes. It is meant to serve as an additional computer navigational tool for mariners to ascertain the latest changes to the lights/radio aids on DMA charts. In many cases, there are several particular light/radio aids upon which mariners place reliance for safe ship navigation. The specific procedure to facilitate a remote query will be published in the next edition of the Automated Notice to Mariners Communications Users Manual (present edition is May 1982). A system Users

Identification Number may be obtained from this office by submission of a written request at any time.

SUMMARY

The automation of the List of Lights has involved more than computer specialists and programmers. There has been an intensive effort to include Marine Information Specialists to insure the user orientation of the final software. Readers familiar with the present format in the Radio Navigational Aid publications can appreciate the magnitude of the task to reformat information into the eight columns which are utilized in the annual List of Lights. This requires the continuing participation of Maritime Safety Division personnel during the initial data base loading phase. During this same time period, operators will be loading the annual volumes of the List of Lights on a multiple shift basis. They will be using a specially tailored data entry program because of a lack of a weekly notice number, year or other ancillary files to interact with (i.e. history file, etc.) which will be associated with the "initial input" as taken directly from the annual volumes. Also, multiple light numbers will be loaded, exactly as they appear in the printed volumes; however, after the master file is loaded, the need for this software option will be infrequent and changes to the Light Master file will usually be processed one at a time.

The goals of the List of Lights Automation effort which we have developed in this paper can be summarized as follows:

- A. To automate the production and publication of the corrections to the annual List of Lights as well as production of the annual volumes of these publications.

- B. To merge the List of Lights and with radio aids into one publication, which will provide mariners with the most complete navigation Listing of sequential aids of its type available.
- C. To provide mariners with an on-line data base of the most up-to-date light/radio aid information via global communications links.
- D. To provide rapid digital data management tools to replace antiquated Vari-type equipment, extensive space consuming manual files and slow manual publication set-up methods.

The software developed by this effort is a major advance toward DMA's long-term goal of achieving a totally automated weekly Notice to Mariners. Although it builds upon earlier software, the new List of Lights software will make the remaining automation steps easier and less costly so we must give some credit to the synergistic effect of each of our completed ANMS Phases. Phase Three will complete the text oriented, data entry capabilities. Research and development efforts which are planned but are not now programmed, will address graphics. List of Lights automation adds two very important publications to the ANMS and its impact will extend beyond the actual DMA List of Lights publications themselves. The resultant automated subsystem will be a model for later automation efforts concerning other national List of Lights publications which are now produced by every major maritime nation in the world.

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Sabina L. Wu - Project Manager

Barbara D. Napjus - Associate Programmer

Other IITRI personnel have been associated with software development and their work has also been of importance in the delivery of a fully operational software system. Mr. V. Edward Leudtke of the General Services Administration was instrumental in the development of the initial system design. Mr. Steve Choy of the Harry Diamond Laboratory wrote the initial Screen Entry Editor (SEE) software.

ANMS FUNCTIONAL DIAGRAM

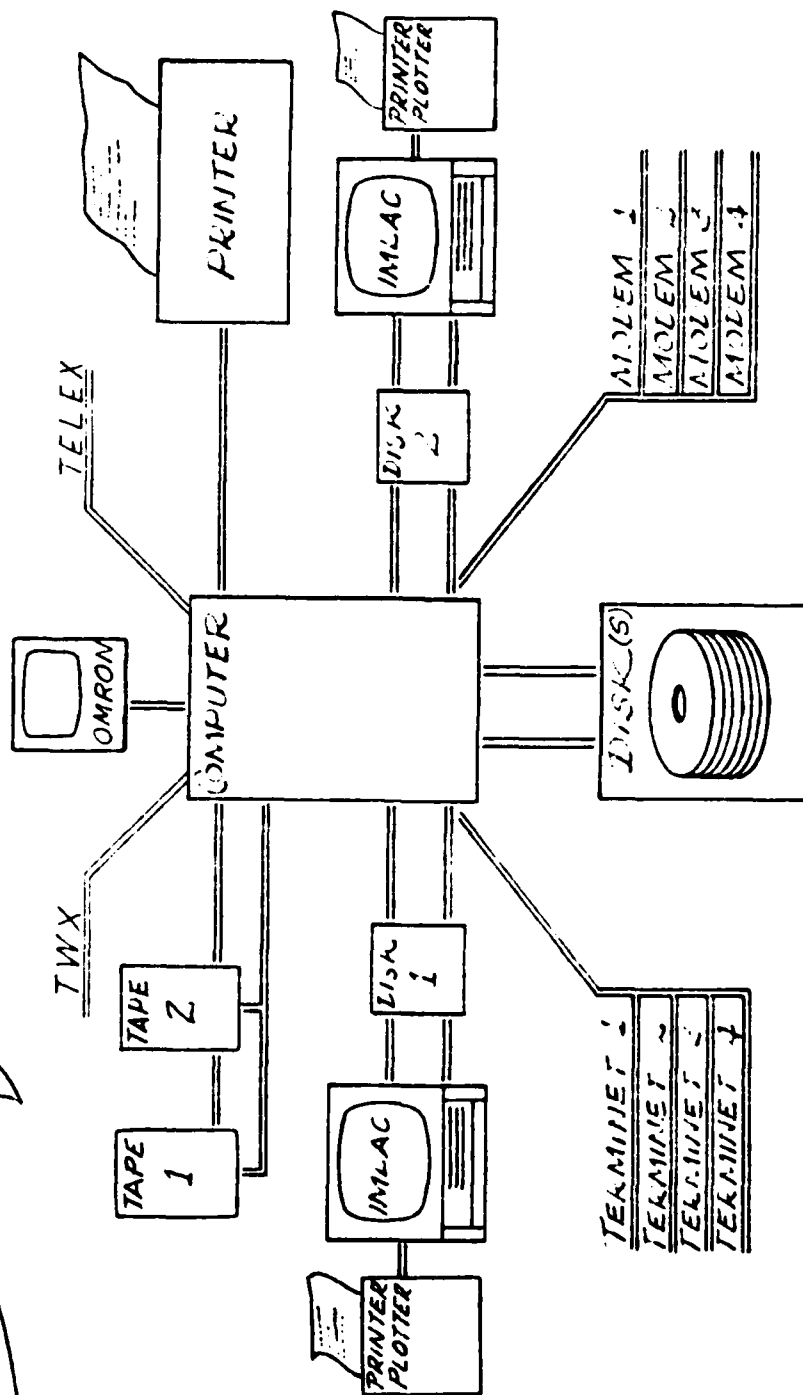


Figure 1

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