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CENTRAL BIBLIOGRAPHIC SYSTEM
TERMINAL REQUIREMENTS STUDY

TASK II REPORT
TERMINAL STATE-OF-THE-ART SURVEY

BY
HOBBS ASSOCIATES, INC.
CORONA DEL MAR, CALIF.

SUBMITTED TO

INFORMATION SYSTEMS OFFICE
LIBRARY OF CONGRESS
WASHINGTON, D. C. 20540

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APPENDICES

1. INTRODUCTION AND SUMMARY

This report presents the results of Task II of the study of terminal requirements for the Central Bibliographic System for the Library of Congress. Task I covered a study of the functional requirements and establishment of performance specifications. This report on Task II presents the results of a survey of the state-of-the-art related to the requirements for the Central Bibliographic System for the present, for mid-1970 and for mid-1972. Task III of this study will consist of analyses and evaluations including the identification of performance specifications that cannot be met with the anticipated state-of-the-art, developments that will be required to meet the Library's needs, and cost and trade-off studies of alternative configurations.

The requirements analyses in Task I identified categories of terminal stations that will be required, the terminal modules needed to configure these terminal stations, and the performance requirements for the terminal modules. The investigations in Task II surveyed the present state-of-the-art in the types of equipments required to implement the terminal modules and stations specified in Task I, identified problem areas, and projected the state-of-the-art into 1972. Manufacturers claims for performance, performance specifications that cannot be met, and new developments needed are to be identified in Task III. However, since it was convenient to do part of this work during Task II, this report identifies problem areas and some performance requirements that cannot be met with existing or anticipated state-of-the-art. These questions will be considered further during Task III.

Approximately fifteen different kinds of equipment have been covered in this survey. Since there are many versions and variations of each of these kinds of equipments, as well as many manufacturers for most of them, the correspondence, number of people interviewed, and material studied during this survey has been extensive. Letters requesting information have been sent to over 500 companies; replies have been received and analyzed from over 200; personal discussions and interviews have been held with representatives of 72 companies; and 44 technical articles, comparisons, and documents, in addition to many sales brochures, have been reviewed. A serious attempt has been made to contact or consider material from all of the manufacturers supplying the different types of equipment covered in this survey (see Appendix I). However, despite the intention of covering all applicable manufacturers, some have undoubtably been missed. Any such omissions are unintentional. The possibility of omissions has been increased by the fact that for some kinds of equipments, such as displays and small computers, new devices and new companies are announced almost weekly. This is an indication of rapid technological progress and proliferation of equipment in this field which makes an equipment survey transitory in nature. Hence, the comparison of specific equipments has been presented in Appendices. The body of the report presents trends and performance characteristics that are considered typical of the field, and hence more lasting.

Keyboards and other entry devices, badge readers, alphanumeric and symbol displays, hard copy devices, devices for generating and reading machine readable unit documents, devices for generating machine readable media, and small computers (calculating units) are highly developed at this time. For such equipment there is a considerable depth of technology and ready availability of off-the-shelf equipment. However, the Library's requirements for the 176 character extended Roman alphabet and for handling subsets of Roman alphabet along with alphabets of other languages imposes requirements for displays and hard copy devices that cannot be met with commercially available equipment. The requirements for keyboards for this large character set cannot be met with standard commercially available keyboard assemblies, but the configuration of larger character set keyboards is not difficult and does not require development funds because of the availability of modular key assemblies which permit configuring a keyboard to meet the Library's needs using commercially available key modules. Technology is available to meet the Library's requirements for displays and hard copy devices, but some development funds and customized equipment will likely be required since no commercially available devices handle such a large character set.

The devices required for the preparation and reading of PIN labels are also feasible from the technology standpoint, but there is no existing equipment that meets the Library's requirements -- particularly for the portable PIN reader.

Handling of special symbols and the oriental languages are the most serious problem from the terminal standpoint. Of these two, the oriental languages are considered to be the most serious problem because of the large amount of bibliographic material of this type that is handled by the Library.

The problems discussed above, as well as trade-offs and alternative configurations, will be considered further in Task III of this study.

2. THE RELATION OF HARDWARE DEVICES AND TECHNOLOGIES TO TASK I ANALYSES OF REQUIREMENTS FOR TERMINAL CATEGORIES AND MODULES

2.1 General

In Task I of this study, which covered the analysis of Library of Congress terminal requirements and the development of quantitative performance specifications, functional requirements were determined for eleven categories of terminals. The terms "terminal categories" and "terminal stations" are used somewhat interchangeably in this report. A category of terminals includes a number of terminal stations with similar characteristics and performance requirements. A terminal station is essentially a work station for one or more persons, such as catalogers, reference librarians, etc. A terminal station includes a number of terminal modules which together provide the capabilities and performance characteristics required for the user. For example, a preliminary cataloging station includes a PIN reader, a keyboard, a badge reader, a hard copy device, and an alphanumeric display module. All of the terminals in a given category have similar requirements and include similar modules, although some of the modules may operate in different languages for different terminal stations in that category. For example, one preliminary cataloging terminal station would be equipped with modules for handling the extended Roman alphabet while another would be equipped with modules for handling a set of non-Roman alphabets, as well as the Roman alphabet. The Task I report also derives the modules required to implement the terminal stations in each category.

2.2 Implementation of Terminal Stations from Terminal Modules

The Task I report includes a matrix which identifies the terminal modules necessary to implement each category of terminal stations. Although most of these modules represent separate hardware equipments (e.g., keyboards, printers, CRT displays, etc.), some of them may be implemented by logical arrays or programmed subroutines. Hence, the terminal modules derived in Task I for implementing the terminal stations in the eleven categories may be considered in a broad sense as functional modules rather than necessarily equipment modules. Section 3 and the Appendices to this report discuss the state-of-the-art and available equipments for those terminal modules which are physically distinct hardware or equipment modules. The remainder of Section 2 identifies those module requirements which can best be implemented with logic, and those which can best be implemented with software in the terminal station or controller. The last part of Section 2 identifies some of the considerations which must be analyzed as part of the trade-off analyses in Task III. For example, the Time and Date Clock could be implemented with logical hardware in the terminal station, with a programmed subroutine if the terminal station includes a small computer, or with a programmed subroutine in a controller which handles several terminals.

2.3 Module Requirements Implemented With Separate Hardware

The requirements that can best be implemented with separate hardware modules are those which require special purpose electronic, mechanical, and electromechanical parts and which cannot be easily implemented with logical arrays alone or with programmed subroutines. The following terminal modules should be implemented with separate hardware or equipment modules:

- PIN labelers and PIN readers
- Keyboards
- Entry devices for special symbols
- Badge readers
- Alphanumeric and symbol displays
- Hard copy devices
- Machine readable unit document generators and readers
- Machine readable media generators
- Calculating units
- Oriental language, input, display, and printing devices

Equipment applicable to these modules have been surveyed in Task II of this study. The current and projected state-of-the-art for these devices is discussed in Section 3 of this report, and presently available devices of these types are summarized in the Appendices at the end of this report. For the terminal stations in any terminal category, these modules represent almost the entire cost of the terminal and the major cost of any controller associated with the terminal. As used in this report the term "controller" refers to a local logic, storage, and control unit which works with several terminals. A controller is used in those cases where several terminals in reasonably close proximity to one another can share the capabilities of a common controller for some functions more economically than would be the case if these functions were included separately in each of the terminal stations. For example, a controller might provide the computing, stored program, buffer storage, and communication capabilities for several cataloger terminal stations which are physically located within a few hundred feet of one another.

2.4 Module Requirements Implemented With Logic or Software in a Terminal Station or in a Controller

Several of the functional modules identified in the Task I report can best be implemented with either logic or software in the terminal station, or perhaps in a controller associated with several terminal stations. The calculating unit function can be provided by logic or software in the terminal or controller. The ID Code Generator can be an array of logic gates wired to generate the code, a small read-only memory, or the contents of several storage locations in the memory of a small computer in the terminal station or in a controller. The generation of the ID Code could be accomplished in either the terminal itself or in a controller which is associated with that terminal. The generation of any record of data from the terminal would automatically cause the ID Code to be generated and inserted in the data record.

Similarly, the Time and Date Clock can be implemented logically with a controller or with a short programmed subroutine in a small computer in the terminal station or in a controller associated with the terminal. The Preprogrammed Data Entry Device will require selection keys on the keyboard to identify the particular preprogrammed message to be entered. This can be accomplished either by a set of keys each calling for the entry of a different preprogrammed message or by a single function key to indicate the entry of a preprogrammed message and the use of several of the regular keys on the keyboard to identify the particular preprogrammed message. For example, the depression of the function key indicating the use of a preprogrammed message followed by the depression of three particular numeric keys could select one of a thousand preprogrammed messages. The preprogrammed messages can be implemented internally in the terminal or in a controller with an array of logic gates, a read-only memory, or storage locations in the memory of a computer in the terminal or controller or can be stored in the central computer. The choice between these three alternatives depends upon the number of preprogrammed messages required and upon whether the small computer is available. If a very limited number of preprogrammed messages are required a logic array may be satisfactory. However, if many messages of this type are required, the read-only memory or the use of part of the main memory in a small computer would be a better approach.

2.5 Further Considerations for the Task III Trade-Off Analyses

The trade-off analyses to be made in Task III will include consideration of logic arrays, read-only memories, and stored data or subroutines in the small computer's main memory as alternative ways of accomplishing the module functions of ID Code Generation, Time and Date Clock, and Preprogrammed Data Entry. These trade-off analyses will also explore whether each terminal station should be a stand-alone system or whether in some cases several terminal stations should operate with and share the capabilities of a controller. In those cases where the controller is desirable, the trade-off analyses in Task III must then consider which functions should be performed in the individual terminal station and which should be performed in the shared controller.

In those cases where the terminal requirements and performance specifications developed in Task I for the Central Bibliographic system cannot be met with existing state-of-the-art equipment or with equipment or technologies expected to be available in 1972, the trade-off analyses in Task III will consider the compromises that can be made and the implications of making these compromises. In such cases, this will also involve the consideration of alternative modules or approaches.

These trade-off analyses may also indicate that some functions presently planned for the terminals can best be implemented in the central computer of the Central Bibliographic System, but there is no indication to date that will be the case.

2.6 Correlation of Technology Survey in Task II With Terminal Module List Derived in Task I

A list of the terminal modules derived during the Task I study was presented in Section 5.3 of the Task I report. This list included the following modules:

1. Full printer - standard Roman character set
2. Full printer - extended Roman character set
3. Full printer - combined sets (extended Roman and selected Non-Roman)
4. Full printer - combined sets (extended Roman and selected set for Oriental language or special symbols)
5. Full printer - combined sets (extended Roman, Non-Roman, Oriental language set, and special symbols)
6. Machine readable media generator - standard Roman character sets
7. Machine readable media generator - extended Roman character set
8. Machine readable media generator - combined sets (extended Roman and selected Non-Roman)
9. Machine readable media generator - combined sets (extended Roman and selected set for Oriental language or special symbols)
10. Machine readable media generator - combined sets (extended Roman, Non-Roman, Oriental language set, and special symbols)

11. Marking device - numeric character set
12. Machine readable unit document generator - standard Roman character set
13. PIN labeler - standard Roman character set
14. Full visual display - extended Roman character set
15. Full visual display - combined sets (extended Roman and set
16. Full visual display - combined sets (extended Roman and selected set for Oriental language or special symbols)
17. Full visual display - combined sets (extended Roman, Non-Roman, Oriental language set, and special symbols)
18. Keyboard - standard Roman character set
19. Keyboard - extended Roman character set
20. Keyboard - combined sets (extended Roman and selected Non-Roman)
21. Entry device - Oriental language character set
22. Entry device - special symbols
23. Preprogrammed data entry device - numeric character set
24. Machine readable unit document reader - standard Roman character set
25. PIN Reader - standard Roman character set
26. Badge reader - numeric character set
27. ID code generator - numeric character set
28. Time/date code generator - numeric character set
29. Calculating unit - numeric character set

The above list of modules from the Task I report are correlated in Table 2-1 with the devices and equipment modules discussed in this Task II report.

Table 2-1 serves as a cross reference between particular modules identified in Task I and the Sections and Appendices of this report which present information on devices and technologies applicable to those modules. A list of the names and addresses of the manufacturers of each type of equipment contacted during this study is presented in Appendix I.

Modules Identified in Task I (See list on pages 8 and 9 of this report)	Sections of This Task II Report Which Cover Devices and Technologies for Those Modules
1, 2, 3, 4, 5, and 11	3.3, 3.4, 3.7, Appendices A & D
4, 5, 16, 17, and 21	3.11, Appendix H
6, 7, 8, 9, and 10	3.9, Appendix F
12, and 24	3.8, Appendices B and E
13, and 25	3.2, Appendices B and E
14, 15, 16, and 17	3.6, Appendix C
18, 19, 20, 21, and 22	3.3, Appendix A
22	3.4
23, 27, 28	2.4
26	3.5, Appendix B
29	3.10, Appendix G

CORRELATION OF TECHNOLOGY SURVEY IN TASK II
WITH TERMINAL MODULE LIST DERIVED IN TASK I

TABLE 2-1

3. CURRENT AND PROJECTED (1970-1972) STATE-OF-THE-ART

3.1 General

This section presents the present state-of-the-art for each of the terminal modules that will be implemented by physically distinct hardware or equipment modules. The techniques or technologies used in implementing these modules, the state-of-the-art at present, problems encountered, and the improvements in performance and cost anticipated for the 1970 and 1972 time frames are discussed for these types of equipment.

In general, discussion is centered on equipment modules which perform the specific functions of individual modules derived in Task I from the functional requirements. Presently available systems which include several of these modules are usually not discussed as systems. For example, complete data entry systems, which include keyboards, printers, magnetic tape units, buffer memories, and controllers for controlling the operation of a number of such input stations, are available but they are not discussed as systems. The individual components, such as keyboards, printers, and magnetic tape units are discussed separately.

There are three partial exceptions and one major exception to this approach to the discussion of terminal modules. Keyboard/printers (e.g. an electric typewriter, teletype, etc.) which include both the keyboard and a serial character printer, are compared and discussed in the same subsection as keyboards. Since most CRT visual displays include a keyboard and a refresh memory, these are discussed as a unit under alphanumeric and symbol displays. All small computers include some complement of peripheral equipments (e.g. punched paper tape, magnetic tape, printers, etc.); hence, the peripheral equipment offered with each small computer is summarized in the Appendix on small computers. The major exception is found in the case of oriental language devices. Because of the scarcity of suitable devices for handling the oriental languages and the close interrelationship between the way data is entered, the way it is displayed, and the way hard copy is generated, all oriental language devices are discussed together in Section 3.11. That section also considers the encoding of the oriental language characters in machine readable code. The discussion of presently available devices for oriental languages in Appendix H also treats data entry, display, and printing together.

3.2 PIN Labelers and PIN Readers

3.2.1 General

The PIN, or Piece Identification Number, is on a small unobtrusive label attached to the outside cover of a book or other document to uniquely identify a physical item. The PIN label must be prepared by a terminal station and later read automatically by either a reader in a fixed terminal station or a portable PIN reader. The portable PIN reader may be connected to a terminal station or it may record on a machine readable media which is later read by a terminal station. The decoded Piece Identification Number is used automatically to retrieve the corresponding bibliographic record for processing by a terminal. The PIN must also be human readable.

When a new piece of bibliographic material is received, an identification number must be assigned to it. The process of adding a call number to a PIN label can be accomplished either by employment of a "temporary" label which is replaced after shelf-listing by a "permanent" one or a label to which call number data can be added in some relatively simple manner after it is attached to an item. When the label is read at any terminal station, the PIN information is recorded, decoded and used to carry out identification, processing and retrieval functions.

The operational requirements necessary to effect a PIN Assignment category are: generating next available PIN to be assigned, linking PIN to machine readable record, creating label with coded PIN, attaching label to item, and verifying that proper record is linked to item.

In some cases, such as individual titles ordered via the Library's Order Division's system, a computer record will already exist and entering the assigned identification number into that record will link the material to its computer record. In other cases, where no computer record exists when the identification number is assigned, the number on the label affixed to the material can later be entered into the computer at the time the first computer record is generated for that document (e.g. at the accessioning station). After the assignment and linkage of the PIN has been completed a PIN label is generated. The PIN may be either the call number and copy number of the item or some numeric code which can be uniquely derived from the call number and copy number. If the handling of alphabetic characters by the PIN reader is not overly difficult, the call number could be used directly, otherwise some transliteration would be required.

There is a significant difference between PIN labelers and readers and the other equipments discussed in this section. There are no off-the-shelf PIN labelers and readers to survey. Existing keyboards, badge readers, displays, printers, unit document devices, machine readable media devices, and small computers can be surveyed by requesting information on existing devices and analyzing this information and comparing the devices. A request to manufacturers for information on PIN labelers and PIN readers would, of course, bring no response. Hence, PIN labelers and PIN readers must be analyzed in terms of devices designed for other purposes which may be adapted to meet the PIN requirements and in terms of techniques and technologies which may be used as a basis for developing PIN labelers and PIN readers. There are no PIN labelers and PIN readers at present. If devices developed for other purposes can be adapted to meet PIN requirements, the solution will be quicker and less expensive than if it becomes necessary to develop new devices for this purpose. Hence, the Task III trade-off analyses may indicate that the ideal or optimum PIN modules must be compromised to permit a solution that is timely, economic, and technically feasible.

The consideration of PIN labelers in this report is limited to the techniques and technologies that may be used to generate the PIN label and to read the PIN label. Consideration of the actual labeling device itself (i.e., the device that prints and dispenses the label, and the physical method of affixing the label) will be considered in Task III when the more appropriate technique or technology for PIN identification has been determined. Consideration of the physical characteristics of the label and the physical labeling device are heavily dependent upon the PIN identification and reading technique to be used.

3.2.2 Techniques or Technologies

The techniques and technologies that are suitable for adaptation to the PIN modules are also possible candidates for the badge reader and machine readable unit document modules. Hence, approaches to the PIN problem are discussed here but the presently available equipments that embody these techniques and technologies are covered in Appendix B on Badge Readers and Appendix E on Machine Readable Unit Document Devices.

The technique chosen to implement the PIN must have the following characteristics:

1. human readable
2. machine readable
3. both alphabetic and numeric
4. readable when affixed to a book or soft covered item (e.g. magazine, single page, etc.)
5. readable by both a fixed and a portable device
6. printed from computer selected and generated data
7. either readable with poor alignment and registration or includes an automatic or easy manual alignment method
8. readable with high signal to noise ratio (e.g. when dirty)
9. long life

Reading speed and capacity are not significant requirements since only 10 to 12 characters are involved in the PIN.

The techniques and technologies that can be considered for meeting the requirements listed above include:

Optical Character Recognition
Magnetic Ink Character Recognition
Optical Bar Codes
Optical Circular Codes
Magnetic Bar Codes
Magnetic Circular Codes
Other Optical Materials, e.g. reflective, fluorescent, etc.

A number of conventional techniques, such as those involving punched holes or embossed characters or bars, cannot be considered because of the requirement for affixing the label to the front of the book. Several other possible techniques, such as the magnetic recording strip now being placed on the back of credit cards, must be discarded because of the alignment and registration problem.

Of the techniques listed above, presently available equipment for optical character recognition and magnetic ink character recognition are discussed in Appendix E on Machine Readable Unit Document Devices. Presently available equipment for optical and magnetic bar codes and magnetic circular codes are discussed in Appendix B on badge readers. As far as can be determined, there are no equipments commercially available at this time for optical circular codes nor for other optical material such as fluorescent markings.

If character recognition techniques are used to permit direct maching reading of the Call Number, alphabetic as well as numeric capability will be required because of the use of alphabetic characters in a few positions of a conventional book call number. However, both optical character recognition and magnetic ink character recognition techniques are considered unsuitable for the PIN label, primarily because of alignment problems and secondarily because of the relative cost of the equipment required compared to other techniques described below--particularly if alphabetic characters are to be read. Another objection to magnetic ink character recognition is the highly stylized font required which makes human readability more difficult.

The techniques that are most suitable for the PIN problem are those which involve the simultaneous printing of human readable characters and a corresponding bar or circular code. A circular code consists of concentric circles each representing a coded character. The bar code approach has the advantage that each code can be printed above or below the human readable character and thus directly correlated with it. Hence, a bar code can be printed character by character by the same print mechanism that prints the human readable character. This character by character correlation is not possible if a circular code is used. The circular code on the other hand offers some advantage with respect to alignment and registration since registration must be made on only a single point--the center of the circle. Thus the book or label could be skewed in the reader in any way as long as this one point is registered. The bar code on the other hand would require a linear registration, but if a bar code is used which is reasonably large physically, the alignment and registration need not be extremely accurate.

Alignment and registration for a bar code could be accomplished on 2 points compared to the single point for a circular code.

The use of magnetic or optical retro-reflective material (see Appendix B) for the bar or circular code would improve the signal to noise ratio when the label is old or dirty. However, insufficient information is available about the life and wear of these materials under the type of use that will be incurred in the Library over a period of years. For example, the magnetic ink characters on bank checks are required to have only a short life span. The check is written and processing is usually completed within a period of a few days. It is uncertain how this magnetic ink technique would stand up after several years of the wear and tear involved in handling of books and putting them in and out of stacks. The use of printed bar or circular codes that can be scanned optically is believed to represent the best approach for the PIN labeler. If the label is damaged or becomes excessively dirty, it can be easily replaced by affixing a new label with the same number, either on top of the old label or after removing the old label.

3.2.3 Present State-of-the-Art

As pointed out in the preceding discussion, there is no present state-of-the-art for PIN labelers and PIN readers per se at this time. The present state-of-the-art for optical and magnetic ink character recognition is discussed in Section 3.8.3 under "Machine Readable Unit Document Generator and Reader". The present state-of-the-art for bar codes and circular codes is also covered to some extent in Section 3.8.3 and in Section 3.5.3 under "badge readers". There is of course a considerable state-of-the-art at present in labels and labeling machines--i.e., the equipment for actually fabricating the labeling. However, the consideration of the label and the device that actually fabricates and dispenses the label is being postponed to Task III because of the possible effect that the selection of a particular PIN technology will have on the physical characteristics of the label and labeling device.

3.2.4 Problem Areas

The major problem areas for PIN labelers and readers are:

the alignment and registration problem;

the signal-to-noise problem that may be caused by dirt and wear;

the requirement for reading the label when it is affixed to a book or soft covered item rather than as a separate slip of paper;

the requirement for a hand-held portable PIN reader.

The requirement that the label be both human readable and machine readable is not considered a problem since it is permissible to have two types of printed information on the same label--the human readable PIN number and a coded machine readable version of that number. The alignment and registration problem is relatively easy to handle if manual positioning of the document or the read head is permitted. This problem is further mitigated if a bar code or circular code is used and the coded characters are made relatively large--e.g. 3/8" to 1/2" in heighth for a bar code or 3/4" to 1" in diameter for a circular code. The signal-to-noise problem is not considered a serious one because in the worst case the PIN label can be replaced if it becomes damaged or excessively dirty. The requirement for reading the label when it is affixed to a thick book is not technically difficult but is a serious problem at present because the available equipment is almost universally designed to handle a slip of paper, card stock, or a plastic card (e.g., credit card). The requirement for a hand-held portable reader is a serious one at present because there is no known equipment of this type available--probably because of the lack of demand or application for such a device. However, several companies are known to be working on portable hand-held readers for bar codes and circular codes. Future commercial needs for devices of this type are seen in applications such as inventory control, warehousing, shipping, grocery and retail store check-out, etc.

3.2.5 Projected State-of-the-Art for 1970 and 1972

Although it is technologically feasible, there are no known developments underway that will provide a portable PIN reader nor a fixed station reader capable of reading a PIN affixed to a thick book during 1970. However, at least two companies are known to be working on hand-held portable devices for reading bar or circular codes (one is optical and one is magnetic) that may lead to available equipment by the end of 1972. Unfortunately, one of the companies insisted that nothing be written about their device in this report, although we have permission to discuss it verbally with Library of Congress personnel. Hence, both of the devices that offer promise for a possible solution to the PIN problem by the end of 1972 will be discussed verbally with Library of Congress personnel. The solution to the PIN problem is considered technically feasible within the next two years. Whether equipment actually becomes available within that time span is a function of industry's view of commercial demand and marketability and of funding, either within a company or from external sources such as the Library of Congress.

3.3 Keyboards and Keyboard/Printers

3.3.1 General

The functional requirements and performance specifications call for keyboards in most of the terminal stations for the manual entry of catalog and other data. Delete, shift, space, backspace, carriage return, shift-lock, shift-release, tab, and interlock features are required. The ability to enter 176 characters from a keyboard is required for the extended Roman alphabet. This section discusses keyboards and keyboard/printers for the extended Roman alphabet and non-Roman alphabets. The input equipment requirements for oriental languages are discussed separately in Section 3.11.2 and entry devices for special symbols are discussed separately in Section 3.4

The keyboards are used to permit input of data by operators in most categories of terminal stations as itemized in the Task I report. Since there are over 100 companies in this country that make different types of keyboards, the discussion here and in Appendix A is limited to the technologies involved in the major types of keyboards rather than attempting to discuss 100 individual keyboard devices. The highest volume production of keyboards in this country today are those which are directly associated with a serial character printer. Examples of this are electric typewriters and Teletype machines. Hence, Appendix A discusses different types of keyboards and compares the characteristics of presently available keyboard/printers.

Some of the companies that make complete keyboard/printers offer the keyboard as an item that can be purchased separately. Many of the smaller companies making keyboard/printers buy the keyboard as a unit from one company and the printing mechanism from another company and then assemble them to make the complete keyboard/printer. Keyboards are also purchased as separate items by many of the companies that make cathode-ray tube terminals where the keyboard is used for the manual entry of data and the CRT for visual display of data for the operator.

One important consideration for the Library of Congress application is whether the keyboard is fabricated as a complete assembly by the manufacturer or whether the keyboard can be purchased as individual key devices which are then assembled into the keyboard. Some of the techniques, particularly electromechanical ones, that are used to make complete keyboard assemblies are very difficult to modularize or vary in terms of the number or placement of the keys. On the other hand, those types of keyboard devices which are sold by the manufacturer as individual key devices for assembly into complete keyboards permit great flexibility in the physical arrangement of the keyboard and in the number of keys involved.

3.3.2 Techniques or Technologies

Keyboard technologies are discussed here in terms of the way in which the characters are generated by the keyboard and linked to the printing mechanism or encoded for transmission to other part of the system. The major keyboard technologies are:

- Mechanical
- Electro-mechanical (switch or relay closures)
- Photo-electric (optical)
- Magnetic/electronic
- Fluidic (pneumatic)

Since the terminals for the central bibliographic system interface with either a controller or directly with a central computer, it is desirable that the keyboards be physically decoupled from the printer mechanism to permit full-duplex operation. Full-duplex operation means that when the key is depressed by the operator it does not directly activate the printer or CRT, but rather the character is transmitted to the controller or computer and then back to the printer or CRT. Full-duplex operation assures that the printed or displayed character is the same one received by the computer. In half-duplex operation the key depression activates the printer or CRT directly with a consequent possibility of the operator visually verifying the character which he thinks has been entered into the computer, whereas the computer has actually received a different character. For this reason, strictly mechanical keyboards are not considered suitable for implementing terminal modules.

Electro-mechanical keyboards are the most widely used at present. This is the type of keyboard used in most electric typewriters and Teletype equipment. In an electro-mechanical keyboard the key depression causes contact closures in a switch or relay. This may be either a single contact closure which activates the line to a particular logic network that generates the coded character, or it may be several contact closures which generate the coded character directly. The former requires logical circuitry for encoding while the latter requires more contact closures. Electro-mechanical keyboards of this type permit full-duplex operation, but they are usually noisy and less reliable than some of the other techniques such as optical and magnetic ones. If the noise is within reasonable limits it may be an advantage rather than a disadvantage, because operators who are accustomed to typewriters or similar devices expect to hear some sound that indicates that the key has been activated. Completely quiet keyboards have been found to be very distracting to operators.

In photo-electric or optical keyboards the depression of the key interrupts a particular combination of several light paths. There may be a single light source but a separate photo cell for each light path. The key depression blocks a set of light paths corresponding to the particular character represented by the key. Hence, the photo cells pick up the coded character. For example, when using a seven-level code the output of 7 photo-detectors would be the coded representation of a character corresponding to the key depressed. This type of keyboard involves a minimum of moving parts and a minimum of encoding electronics. The only sources of failure are the light source and the 7 photo-detectors.

Magnetic/electronic keyboards are a relatively recent development in which a depression of the key changes the magnetic field around another element. In one such device a magnetic shunt containing two barium-ferite filled PVC magnets is attached to the switch plunger. Depressing the key causes this magnetic element to move over a solid-state Hall effect circuit. The depress ion of the key causes the magnetic field through the Hall element to increase thus raising the voltage to a level that operates the circuit. A trigger circuit then provides a signal which is amplified and sent to the encoding circuitry for the code generation. Another device uses capacitive effects.

Of the keyboard types discussed above, the magnetic/electronic keyboard and one form of electro-mechanical keyboards are most suitable for the Library of Congress terminal application because of their flexibility. The particular type of electro-mechanical keyboard that is attractive is one in which each key is completely self-contained, including the top cap, the housing, the plunger or stem, and the electrical contact or relay. This type of modular key assembly may either encode the character directly within the key assembly or may provide a single output signal which is sent to an encoding matrix.

The advantage of these two types of keyboards is that they can be assembled as individual key modules in any desired configuration or number of keys. This flexibility and expandability is essential to provide the capability for the 176 character extended Roman alphabet and to facilitate handling a subset of extended Roman alphabet plus character sets for other languages. A modular keyboard arrangement of this type with an adequate number of shift keys can meet all of the keyboard requirements using commercially available key elements but arranged in a different configuration than commercially available keyboard assemblies. For example a 4 x 17 keyboard key array with 3 shift levels would provide a 204 character capability or a 4 x 13 key array with 4 shift levels would provide a 208 character set. This would permit handling the extended Roman character set. For combined character sets using a subset of the extended Roman character set in conjunction with the character set for another language, additional shift levels may be required. The 44 key plus 4 shift level MARC keyboard could be implemented easily.

Character Serial Printers

Character serial printers are used in combination with different types of keyboards to make conventional keyboard/printer terminals. The type of printer mechanism used for this purpose is one in which characters are printed serially across a line in contrast to the line printer operation in which all of the characters in one line are printed during one rotation of the print drum. The character serial printer used with keyboards is an incremental printer in which a single character is printed for each depression of the key. The character serial printer can also print characters individually upon receipt of character codes from the computer or controller as well as from the keyboard. Hence, the character serial printer can operate in a full-duplex mode with the keyboard or can operate directly from a computer or controller without a keyboard.

Four major techniques are currently in use for character serial printers:

- Impact printers
- Electrostatic printers
- Thermal printers
- Ink spray printers

The print mechanisms in keyboard/printers are discussed in greater detail along with other types of printers in Section 3.7 on Hard Copy Devices and in Appendices A and D.

3.3.3 Present State-of-the-Art

Keyboards are highly developed but new and improved technologies are still being developed as evidenced by the magnetic and electrostatic keyboards discussed previously. Typical characteristics for the major types of keyboards available today are compared below:

Characteristics	Mechanical (i.e. typewriter)	Elect-Mech. (i.e. Reed)	Solid-State (i.e. Hall Effect)	Optical (PhotoElectric)
Noise Immunity	Not applicable	Fair	Good	Good
Expandability	Poor	Good	Good	Fair
Reliability	Fair	Good	Good	Good
Maintainability	Poor	Good	Good	Good
Cost	Low	Medium	High	High

Conventional keyboards range from 50 to 96 character keys but special keyboard configurations with a larger number of keys can now be made relatively easily with some of the new modular keys in which each key is a self-contained assembly including the top caps, the plunger, the contact or magnetic/electronic elements, and the encoder. With modular keys of this type the full extended Roman alphabet, or a subset of the extended Roman alphabet plus the character set of another language, can be implemented in several ways. For example four rows of 17 keys plus three shift levels or four rows of 13 keys with four shift levels could be used to generate over 200 character types, or the 44 key 4 level MARC keyboard could be implemented.

3.3.4 Problem Areas

There are no significant technical problems in implementing the keyboard requirements for the Library of Congress Central Bibliographic System. The only significant problem is that there are no standard commercially available keyboards that exactly meet the Library's requirements. However, the modular keyboards of the type discussed above permit configuring keyboard assemblies to meet the Library's needs with relative ease.

3.3.5 Projected State-of-the-Art for 1970 and 1972

Improvements in the state-of-the-art for keyboards are anticipated by 1972, but none of these are expected to be of major significance. One advance expected in state-of-the-art for keyboard capabilities is the use of MOS circuitry to provide complete encoding flexibility. This technique makes a four mode (4 way shift) operation easier, which would facilitate the 176 character set required by the Library. Expanded use of modular key assemblies is anticipated which should lead to cost reductions in special keyboards of this type.

3.4 Entry Devices for Special Symbols

3.4.1 General

In the Task I report, Appendix A on "Languages and Character Sets" defines "special symbols" as all those alphabets and character sets for which encoding by keyboard devices is considered for one reason or another to be impractical. This includes the following:

a. Non-Roman keyable alphabets which are of relatively infrequent occurrence amonst Library of Congress acquisitions.

b. Archaic writing systems in which, presumably, nobody is currently publishing but for which materials may conceivably turn up and require cataloging.

c. Idiosyncratic productions of authors who sometimes produce books with titles such as an ampersand or a pointing finger (a very small percentage of the materials acquired by the Library of Congress).

The keyboard devices discussed in Section 3.3 of this report are applicable to the non-Roman keyable alphabets of infrequent occurrence, but if their occurrence is sufficiently infrequent it may not be practical to provide separate keyboards for all such languages. The types of character sets listed above present the same problem -- the need for inputting any arbitrary symbol configuration that can be drawn. These arbitrary symbols have one important point in common with the oriental languages with respect to the Library catalog card -- they are not used for machine searching or automatic identification of the bibliographic material. The material is identified and searches are made on a transliterated Romanized title. Hence, in the record stored in the computer the symbols that make up the title for such material may be represented by a stored digital image, or by an index identification number that would provide a reference to some other media (e.g., micro-film) where the symbols and possibly complete catalog cards are stored in image form.

3.4.2 Techniques or Technologies

If any arbitrary symbol configuration is to be permitted, the only methods of input that can be considered are ones which permit hand drawing of the symbol by the terminal user. The technique or technology used must provide some form of digital encoding of the hand drawing. Several approaches can accomplish this including:

A light pen with a CRT display

A RAND tablet

A ball or joy stick cursor with a CRT

Optical or photo-electric scanning and encoding

Curve followers - manual or automatic

With any of these techniques, the symbol can be considered as being overlayed on a dot matrix where the coordinates of the points on the matrix intersected by the symbol are used to encode it. Hence, the encoding is a description of the symbol which would permit it to be redrawn, but it is not a dense code nor one which would permit easy machine identification of the symbol.

A light pen is a device used with cathode-ray-tube display terminals which permit the user to identify positions on the face of the tube or draw lines by moving the pen across the face of the tube. As the electron beam passes the point on the face of the cathode-ray-tube on which the light pen is placed the beam is capacitively coupled into the light pen and a signal is sent to the computer or controller driving the display to identify the particular point. A line or symbol drawn by a light pen consists of a stored sequence of such identified points.

A RAND tablet consists of a matrix of X and Y lines embedded in a large print circuit card or plastic sheet where each line corresponds to a particular code. As the stylus is moved across the tablet the codes for the X and Y lines over which it passes are picked up capacitively and transmitted to the computer where they are stored to form a description of the path followed by the stylus and, hence, of the shape of the character.

Ball and joy stick cursors are standard techniques for permitting an operator to identify points or draw lines on a CRT display. As the operator moves the ball or joy stick, its position is converted to a digital code which causes the electron beam to be positioned at the corresponding location on the face of the tube. A sequence of these digital codes can be stored in the computer or controller to provide a description of the symbol.

With an optical or photo-electric scan technique a hand drawn symbol can be scanned and a digital code generated each time the scan intersects a line of the symbol A stored sequence of such point identifications provides a stored description of the symbol. In a somewhat different photo-electric approach a digitizer or curve follower can be made to follow the lines of the symbol generating a coded description. This can run into ambiguities for symbols which consist of several non-contiguous lines.

It is important to note that all these techniques permit entering and storing a digital image of the symbol, but they require a relatively large amount of storage and do not produce high quality images. These disadvantages are discussed also in connection with the oriental languages in Section 3.11. The microfilm approach for oriental languages discussed in Section 3.11.6 represents a possibly attractive approach for handling special symbols. The special symbols could be identified in the computer record by means of an index number which references the microfilm file. Either the complete catalog card or the special symbols making up the title could be stored in the microfilm file and reproduced from there. This permits a significant advantage in terms of the reproduction quality. If a digital image is stored in the computer using any of the techniques discussed above, the quality of the catalog card generated on request would be significantly poorer than that which could be achieved from a microfilm record.

Another possibility for handling these special symbols, if the occurrences are sufficiently infrequent and they represent a sufficiently small percentage of the total bibliographic material handled by the Library, is to continue using the present manual techniques.

3.4.3 Present State-of-the Art

Present state-of-the-art cannot be considered in a meaningful way until further trade-off analyses in Task III indicate the preferred approach for handling special symbols. Light pens, RAND tablets, cursors, curve followers and photo-electric scanners are all available today. The feasibility of using any of these devices is also heavily dependent upon the other characteristics of the terminal in which they are used. For example, a light pen could not be used without a cathode-ray-tube display.

3.4.4 Problem Areas

The problems encountered for special symbols are significant. They include:

- An almost unlimited number of possible symbol configurations
- Slow speed and poor quality for hand drawn symbols
- Appreciable computer storage required to store a digital image of the symbol
- Requirement for a plotter, CRT, or other special device to recreate the stored image from computer output
- Poor print quality of output generated from computer stored digital image.

Problems cited above appear to favor a microfilm system or manual handling of special symbols, but this will be considered in greater detail in the trade-off analysis in Task III.

3.4.5 Projected State-of-the Art for 1970 and 1972

The state-of-the-art for entry of special symbols cannot be projected into the future until the trade-off analyses in Task III indicate the method which should be used for handling special symbols.

3.5 Badge Readers

3.5.1 General

A badge reader, an identification card reader, or some similar device is required to control access to and use of certain types of terminals, such as some processing and cataloging terminal and circulation control terminals. The use of the badge reader permits the use of terminals by authorized persons and/or provides an automatic identification of attendants, users, and borrowers. Each expected user of a certain type of terminal will be provided with a badge, a card, or a key-like device which can be inserted into the reader in the terminal. The reader will then permit access, when such access is requested, if the identification code of the user is authorized for that terminal. The reader can automatically insert the user's identification in any messages sent to the central processor. The badge reader uses numeric characters only.

Some of the techniques used in badge preparation and badge reading devices may also be applicable to the PIN Labeler and PIN Reader requirement discussed in Section 3.2. However, none of the presently available badge preparation and badge reader devices are directly applicable to the PIN problem.

3.5.2 Techniques or Technology

Techniques in use and under development for badge readers and other identification devices include large or small round or rectangular punched holes, several magnetic techniques, optical coding, machine readable embossing,

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Techniques in use and under development for badge readers and other identification devices include large or small round or rectangular punched holes, several magnetic techniques, optical coding, machine readable embossing, printed optical codes, and key-like devices. A wide range of materials are used. Cards are made of paper, polyvinyl chloride mylar, and other types of durable plastics.

The oldest encoding technique used is punched holes with the conventional Hollerith code using rectangular holes being the most common. Large round holes are also used widely in industrial and outdoor applications because of the wider tolerances they permit. Another device uses small round holes. Recently, several types of magnetic encoding techniques have been developed which offer advantages of higher character packing density and greater difficulty in copying. Printed optical code patterns are also used with a significant advantage in the ease of preparation. Machine readable embossing is widely used, largely because of the low preparation cost and the ability to use the embossed card as a printing device in applications such as gasoline station credit cards. Other techniques include a notched key which offers low preparation and reading cost and the use of a key type device which includes an integrated circuit to provide a binary encoding scheme. Circular tracks are used in some optical devices and in some magnetic devices because of the greater ease of registering on a single spot in the center of the card.

3.5.3 Present State-of-the-Art

Badge preparation devices, badge readers, and other identification devices that are commercially available at present are discussed and summarized in Appendix B. The maximum number of characters that can be encoded on one badge or card varies from 6 for key like units to 75 for magnetic stripe units. The size of the character set ranges from straight numeric to full ASCII. Typically, card sizes are similar to the standard 2-1/8 x 3-3/8 inch credit card.

The Air Transport Association has adopted the IATA magnetic stripe technique as an interim standard with ability to record 75 8-bit characters at a density of 210 bits per inch in 2.7 inches. One manufacturer uses a different recording technique based on the use of a four track magnetic stripe and lower character packing density to improve reading reliability, while another uses magnetic materials in groves where only the presence or absence of the magnetic material is sensed.

One company uses an optical code pattern made up of four types of bars which permits recording 61 characters in a 3 inch space. In punched Hollerith code and similar techniques, 22 characters can be punched on a standard 2-1/2 by 3-3/8 inch credit card type plastic card. Other punched card approaches permit from 12 to 24 characters.

A system using circular magnetic tracks permit 40 characters to be recorded. This particular system uses a single hole in the center for registering the reader and records circular tracks on a magnetic media where the tracks are accurately registered to that hole. One hand-held optical reader under development also uses circular tracks recorded optically and registered on a center hole.

3.5.4. Problem Areas

No significant problem areas are foreseen in the use of any one of several currently available badge techniques for identifying terminal users in the Central Bibliographic System.

3.5.5 Projected State-of-the-Art for 1970 and 1972

The state-of-the-art in badge readers in 1970 is expected to be the same as that discussed in Section 3.2.3 and as indicated in the comparison of presently available devices in Appendix B. By 1972, magnetic encoding techniques are expected to dominate for most applications because of the wide impetus given this technology by credit card applications. Both magnetic stripe and circular magnetic track techniques appear to be gaining in favor. The ability of the magnetic stripe and circular magnetic track techniques to provide a relatively large number of characters may be of importance in Library applications because of the ability to enter more than a simple identification number from the card.

If only a simple identification number is required, consideration could be given to entering this from the keyboard, thus eliminating the need for a badge reader but increasing the chance of errors.

3.6 Alphanumeric and Symbol Displays

3.6.1 General

The requirements analysis in Task I indicated the need for visual display devices in a number of types of terminal stations (e.g., cataloging, accessing, reference, etc.) to permit the user to view data being entered and data stored in the computer, to edit and rearrange messages, and to verify messages which have been modified before their transmission to the central computer. The visual displays must handle extended Roman, selected non-Roman, and selected oriental language and special symbol character sets. Display devices for oriental languages are discussed in Section 3.11.3 Those techniques are also applicable to special symbols. This section discusses visual displays for Roman and non-Roman alphabet languages.

A few simple devices, such as TV monitors, are available as display only devices, but most of the CRT displays offered on the market for viewing data to be entered into a computer, or data retrieved from the computer or a central storage system, are offered as complete terminals including a keyboard, buffer storage, control logic, character generation circuitry, communications interfaces, and in some cases a hard copy device. Hence, the CRT display terminals for displaying alphanumeric and symbol data discussed in Appendix C are complete terminals -- not a display module alone.

For purposes of this study, the buffer storage, control logic, character generation circuitry, and communications interface can be considered part of the visual display module, although some of these functions may reside in a controller which is shared by a number of display modules in different terminal stations. Keyboard and hard copy devices are considered as different modules and discussed in Subsection 3.3 and 3.7, respectively. However, in comparing presently available equipment, the keyboard is included with the available CRT display terminals compared in Appendix C.

Logic and control functions frequently offered with commercially available alphanumeric CRT display terminals include formatting, editing, selective erasure and insertion of characters and words, entry of preprogrammed data or messages, and cursor or point-of-type indicators which indicate the position at which the next character will be entered.

3.6.2 Techniques or Technologies

Cathode-ray-tube technology completely dominates the alphanumeric display field at this time and will continue to do so for the foreseeable future. A number of new display technologies are in various stages of research and development including the following:

Crossed-grid electroluminescent matrix displays
Magneto-optic displays
Plasma panel displays
Laser displays
Injection electroluminescence or light emitting diode displays

None of these are expected to have an impact on the market for small screen (single operator size) alphanumeric display terminals within the time frame covered by this study. Of the new display technologies listed above, magneto-optic, plasma panel, and injection electroluminescence diode technologies are most likely to provide commercially feasible alphanumeric displays in the future. However, it is extremely unlikely that any of these will be used in commercially available alphanumeric display terminals until after 1972 -- probably closer to 1975. Some of the new display technologies offer promise for characteristics which are superior to those of conventional CRT displays, but even when their feasibility and reliability are proven, it will be a number of years before their cost is competitive with that of CRT displays. These new display technologies will probably find their earliest application in military systems where cost is a secondary consideration to factors such as size, power, reliability, ruggedness, and so forth. Hence, within the time frame and scope covered by this study, CRT display terminals are the only ones that can realistically be considered for terminals requiring the display of more than 50 to 100 characters on the screen.

The most common and widely used type of CRT terminal uses a conventional cathode-ray-tube in which the image must be scanned forty to sixty times per second to refresh the phosphor to avoid noticeable flicker to the user. This refresh requirement necessitates the use of some type of storage device to store the alphanumeric and symbol information displayed on the screen so that it can be repeatedly scanned to refresh the image on the screen. In some cases the image is refreshed from the computer's main internal storage, but this is an excessive load on the computer's input/output capabilities and is completely impractical for remote terminals because of the transmission speeds that can be achieved over conventional telephone lines.

Hence, in most CRT display terminals and particularly those used in a remote mode, some type of buffer storage must be provided in the terminal itself to permit refreshing the image on the screen. Magnetic core and magneto strictive delay line memories have been widely used for this buffer storage function in the past. Several new display terminals are now using MOS (metal-oxide-semiconductor) storage for refreshing the screen. This is particularly advantageous in display terminals with smaller screen capacities (e.g., a few hundred characters) since magnetic core storage becomes increasingly uneconomic for smaller numbers of characters. MOS buffer storage is expected to play an increasingly significant role in CRT display terminals in the future.

In addition to the essential but rather mundane function of refreshing the image on the screen forty to sixty times per second, the buffer storage in the terminal plays several other important roles in most alphanumeric CRT display terminals. One of these is the storage of a complete message as it is being entered by the user to permit transmitting it to the computer as a complete message rather than on a character by character basis as it is entered. This facilitates communication with the computer and provides the entire message to the computer at one time. More importantly, it permits the user to visually verify the message and make any corrections prior to the transmission of the message to the computer. Another important function provided by the buffer storage in remote terminals is in making possible the selective editing and changing of characters and words in a message that has been entered by the user or that has been transmitted from the computer and displayed to the user. When a message is retrieved from the computer's central storage system which the user wishes to edit or rearrange, the use of the buffer storage permits the message to be edited on a purely local basis, and then sent back to the computer or central storage system. Only a single transmission of the message from the computer is required.

The use of some type of storage tube is an alternative to the use of the conventional CRT which eliminates the need for the buffer storage from the standpoint of refreshing the image on the screen. Several types of storage cathode-ray-tubes are available which permit the storage of the image within the tube itself thus eliminating the need for externally refreshing the image in the phosphor on the face plate of the tube. The use of a storage tube in remote display terminals permits the displayed information to be transmitted from the computer at rates that can be handled by a conventional telephone line without the requirement for buffer storage in the terminal itself. However, as buffer storage costs continue to drop as a result of improvements in memory technology, the potential economic advantage of the storage tube becomes less. Storage tube displays available today do not offer the ability to selectively erase individual characters or words. Most of these require the erasure of the complete screen. Hence, if the user wishes to change something in a message, it is necessary to send the change to the computer, erase the entire screen, and then have the computer rewrite the message on the screen including the change. This problem makes the use of a storage tube unattractive for applications, such as cataloging stations in the Library of Congress Central Bibliographic System, which involve extensive editing. Storage tube terminals may be more advantageous in graphic applications which are more complex and which involve different requirements for changing displayed information than is the case for straight alphanumeric and symbol terminals. Storage tube terminals may also be attractive for alphanumeric terminals which involve only the displaying of data retrieved from the computer without the need for changing or editing that data.

Another difference found among CRT terminals offered by different manufacturers is the technique used for generating the image or displayed characters from the coded characters received from the computer. The character generation techniques currently in use include:

- Dot matrix
- Stroke
- Monoscope
- Charactron tube

Each of these character generation techniques has its own advantages and disadvantages and it is difficult to generalize in the sense of saying that one is better than another. The dot matrix approach is the most widely used, but some manufacturers have valid reasons for offering different types of character generation techniques related to their specified equipments. Since the dot matrix approach is the most common, it is used as a basis for discussions in subsequent parts of this section dealing with the problem of the large character set requirement in the Library of Congress applications. However, if other manufacturers prefer to meet these requirements by using other character generation techniques, there should be no objection to this. In the dot matrix character generation approach a 5 x 7 dot matrix is the most commonly used for the 64 characters in the most commonly used character sets offered today. Many manufacturers are moving toward the use of a 96 character set as an optional capability which will require at least a 6 x 8 and probably a 7 x 9 matrix for satisfactory character legibility with the larger character set. The 176 character set required for the Library of Congress application will necessitate the use of a 9 x 11 matrix or the equivalent using one or the other character generation techniques.

3.6.3 Present State-of-the-Art

Many alphanumeric CRT display terminals are available today offering 64 character sets. A few are available which offer 96 character sets. The presently available CRT display terminals of the type required for the Library of Congress application (except for the size of the character set) are discussed and compared in Appendix C. Typical characteristics for alphanumeric CRT terminals available are shown below:

Number of Displayable Characters	500 - 2000
Character Set Size	64 - 96
Lines per Screen	15 - 30

Characters per Line	40 - 80
Cursor Controls	3 - 8
Number of Character Positions	1000 - 4000
Stand-Alone Terminal	
Price	$4K - $15K
Monthly Lease	$88 - $380
Multi-Station/Terminal	
Price (average per terminal)	$3.5K - $6K
Monthly Lease	$83 - $200

Typical Range of Characteristics for Alphanumeric CRT Terminals

The wide price range of $4,000 to $15,000 results from the wide variation in characteristics that are available. The price is heavily influenced by the number of characters displayed on the screen, the editing and formatting features offered, and the quality and legibility of the image. The price for each individual display terminal is also affected significantly by whether the terminal operates in a completely stand-alone mode or whether it is one terminal in a multi-terminal system in which much of the storage and logic required for such terminal is centralized in a central station which operates with and controls several terminals. A number of CRT terminal manufacturers offer both stand-alone and multi-station versions of their terminals. If a controller is used for several terminal stations in the Library of Congress application, the CRT display portion of these terminals will be operated in a manner similar to that for multi-station CRT terminal systems.

3.6.4 Problem Areas

The only significant technical problem in implementing the requirements for alphanumeric and symbol displays in the Library of Congress Central Bibliographic System is that of generating a large character set or a large number of special symbols. The number of characters to be displayed on a screen at one time, the formatting capabilities, and the editing capabilities required are all readily available in commercial CRT terminals. However, no commercially available CRT terminal offers a character set greater than 96 characters and most are limited to 64 characters. The 176 character set required for the extended Roman alphabet, or for characters of other languages plus a subset of the extended Roman alphabet will require significantly larger size matrices for dot matrix character generation or corresponding changes in other character generation techniques. In this regard, it is important to note that the differences required in the terminal to handle a larger dot matrix are much greater than a mere change in the character generator itself. If the number of characters to be displayed on the screen at one time is held constant, a 9 x 11 dot matrix would require almost three times as many dot positions on the screen as a 5 x 7 dot matrix. This is reflected in requirements for greater resolution, faster sweep times with correspondingly more expensive deflection amplifiers, and faster blanking and unblanking rates and consequently more expensive blanking circuits. These factors will be reflected in higher costs for the terminal even on a production basis. This plus the fact that such a terminal would be a non-standard, hence requiring development engineering, and the fact that these would be produced in smaller quantities than a manufacturer's standard product line will result in significantly higher costs for CRT alphanumeric display terminals for use in the Central Bibliographic System.

3.6.5 Projected State-of-the-Art for 1970 and 1972

The state-of-the-art in alphanumeric CRT display terminals in 1970 is expected to be essentially the same as that for the more advanced terminals today shown in the comparisons in Appendix C. Cost improvements in the order of one-fourth to one-third are anticipated by 1972. Most of the CRT terminal characteristics that will be available in 1972 are available in some terminals today, but the major change by 1972 will be availability of given characteristics and a given performance at a lower cost. None of the new display technologies are expected to have a significant impact nor to replace CRT terminals for small screen alphanumeric applications by 1972. However, the use of MOS techniques for buffer storage in terminals will be wide spread by that time. Character sets of 96 characters will be readily available by 1972, but it is unlikely that a 176 character set will be commercially available.

3.7 Hard Copy Devices (Printers)

3.7.1 General

Printers are required for preparing hard copy of catalog and other data in almost all of the terminal categories. The format and positioning of the hard copy must be controlled by the operator, the terminal station or controller, and the central computer. Speed requirements for printers in terminal stations are limited by the rate at which the operator can use the data and by telephone line transmission speeds. Typical printer speeds required are in the 10 to 40 characters per second range; hence, character serial printers, which can be obtained at lower cost, will suffice in most cases.

The printers must handle Roman, extended Roman, selected non-Roman, and selected oriental language and special symbol character sets. Printers for oriental languages are discussed in section 3.11.4. Those techniques are also applicable to special symbols. This section discusses printers for Roman and non-Roman alphabet languages.

One of the terminal modules identified in the Task I analysis was called a marking device which prints numeric only information in a single column. In the survey of the state-of-the-art printer technology this marking device is considered a printer since the requirement can be met by most of the equipments surveyed in the printer category. However, a simpler device may be used - e.g., a one character print wheel.

3.7.2 Techniques and Technologies

Remote printers can be considered in two categories -- character serial printers and line printers. Character serial printers, which are also discussed in Section 3.3 under "Keyboard/Printers," print characters serially across a line one at a time. In the operation of a drum printer all of the characters in one line are printed during one rotation of the print drum. Printer techniques such as bar printers, chain printers, electrostatic, and others not classified as character serial printers are included in the general category of line printers. Character serial printers are well suited to most terminal applications where data is entered at a relatively slow rate by keyboard and data is received from the computer over a telephone line. Four major techniques presently in use for character serial printers are impact, electrostatic, thermal, and ink spray. Impact printers are those in which a print hammer or ball forces the ribbon into the paper to generate the character imprint. Because of the mechanical impact involved, this type of print can easily produce carbon copies. However, the speed and reliability are limited by the electromechanical movement and the noise level is usually quite high. This is the lowest cost type of serial character printer available. Electrostatic printers and thermal printers generate characters by using a dot matrix format. In an electrostatic printer a dot matrix (5 x 7 matrix) is energized in the proper combination for the particular character and the electrical signals on the energized wires in the matrix transfer the character image to the sensitized paper. Thermal printers work in a similar manner except that the dot matrix in the print head is thermal rather than electrical. The combination of heating elements in the matrix transfers the character image to a heat sensitive paper.

Ink spray printers direct a fine spray of fast drying ink toward the paper and deflect the ink spray electrostatically to generate the characters. In one ink jet printer the ink jet is deflected electrostatically to actually draw the characters as the ink nozzle is moved horizontally across the paper in a manner similar to drawing characters of an electron beam on the face of a cathode-ray-tube. Another type of ink spray printer uses a dot matrix.

Impact printers have the advantage of providing multiple copies through the use of carbons but are usually slower and less reliable than the other types because of the mechanical motions and parts involved. Electrostatic printers and thermal printers provide higher speeds and higher reliability because of fewer moving parts, but they usually cannot print multiple copies and they require special sensitized paper. Ink jet printers have the same advantages and disadvantages as electrostatic and thermal printers except that they do not require a special treated paper. However, at present, ink jet printers are more expensive than electrostatic or thermal printers.

Line printers, which are both faster and more expensive than character serial printers, are of two major types -- drum printers and chain printers. In a drum printer the print font for each column to be printed is placed around the circumference of the continuously rotating drum. The ink ribbon and paper, which are interposed between the hammers and the print drum, are impacted by the hammers for each column at the proper time to imprint the particular character called for. The selection of the character to be printed is by the timing of the firing of the hammer at the proper point in the rotation of the drum.

In chain printers, the entire character set is placed longitudily on a chain which rotates past the hammers parallel to the print line. This is in contrast to the drum printer which rotates perpendicular to the print line. Hence, in the chain printers a separate character set is not required for each column to be printed but multiple character sets are usually used to increase the printing speed. Again the selection of the character to be printed is by means of the timing of the firing of the hammers in each print position to coincide with the desired character passing under that hammer. In general, chain printers have larger character sets but are slower than drum printers.

It is easier to expand or change the character set on a chain printer by increasing or modifying the characters affixed to the chain. Since the character set is usually repeated several times around the chain for higher speed, a larger character set can be achieved at a slower speed. It is more difficult to change the character set on a drum printer since this would require fabricating a new drum and a larger character set would require a larger diameter drum and possibly a major redesign of the printer.

3.7.3 Present State-of-the-Art

Electromechanical character serial and line printers have been in use for many years and are highly developed. Non-impact printers are a relatively recent development, but have been perfected to a commercially feasible state. Impact techniques are more widely used at present in character serial printers. Because of the ready availability of copying machines, the requirement for multiple copies is less important now than in the past. Presently available remote printers are discussed and compared in Appendix D. The characteristics of presently available keyboard printer terminals which utilize character serial printers are presented in Table A-1 in Appendix A.

Typical characteristics available for the four different types of character serial printers are shown below:

	Impact	Electrostatic	Thermal	Ink Jet
Print Quality	Excellent	Fair	Fair	Good
Special Paper Required	No	Yes	Yes	No
Speed-Char/Sec	10-30	20-40	20-40	120-250
Type Font - No/Char (at present)	64/96	64/96	64/96	96
Changeable Type Font	Yes	Yes	Yes	No
Reliability	Poor	Good	Good	Fair
Mechanical Complexity	High	Low	Low	Medium
Cost (complete Keyboard/Printer Term.)	$1,000 to $3,000	$2,500 to $4,000	$2,500 to $4,000	$5,000 to $7,000

Typical characteristics available today for serial printers as a class are compared with those for remote line printers of both the drum and chain variety in the table below:

	Character Serial Printers	Drum Line Printers	Chain Line Printers
Character Set Size	62-94	64-128	192-288
Number of Columns	80-132	80-160	132
Printer Speed	10-250cps	60-600lpm	140-245 lpm
Price Range of Printers with Buffer but not Interface to the Communications link	$1,600 to $6,000	$8,000 to $21,000	$12,000 to $50,000
Price Range of Printers Complete with Interface to the Communications link	$2,000 to $5,000	$14,000 to $56,000	$20,000 to $120,000

Most character serial and drum printers are limited to character sets in the 64 - 96 character range while chain printers may have larger character sets. The character set and speed shown in the preceding table for Chain Printers were chosen for the maximum character sets. Using a smaller character set would permit a higher printing speed.

3.7.4 Problem Areas

The only significant problem in implementing the hard copy and printing requirements for terminals for the Central Bibliographic System is the large character set required. The requirement for 176 characters is a major problem for most types of character serial printers and for line printers of the drum type. The large character set for a drum printer is not strictly speaking a technical problem in the sense that the solution is relatively straightforward. It is an economic problem in that it would require a significant redesign of a drum printer to provide a larger character set around the drum and sacrifice printing speed to accomplish this.

Two or three companies are believed to be considering the problem of a larger character set for impact character serial printers, either by using a larger print ball on a selectric type mechanism or by using two print mechanisms. However, no assurance could be obtained that appreciable development work is underway on this and there is no indication at this time that such a device would be marketed without government support of a development effort. The most attractive approach to obtaining a larger character set in a character serial printer probably lies in one of the non-impact technologies. For an electrostatic, a thermal, or an ink jet printer which uses a dot matrix (e.g., 5 x 7 at present) the printable character set could be be expanded by expanding the size of the matrix to 9 x 11. This would require an increase of almost three times in the number of elements in the matrix, but it should not require a significant change in the mechanical portion of the printer. If a 7 x 9 print matrix could be used as a compromise, the increase in the number of elements would be slightly less than a factor of two.

3.7.5 Projected State-of-the-Art for 1970 and 1972

No significant improvements are expected in electromechanical impact printers by 1972 although some cost improvements can be anticipated. Chain printers, and possibly drum printers, with 176 character sets, are feasible within this time span but it is not certain whether any company will consider the market potential sufficient to justify the development and production of printers with larger character sets. This is an area in which encouragement from the Library of Congress could affect the availability of the necessary equipment.

Continued improvement in non-impact character serial printers is anticipated in both printing speed, equipment cost, and paper cost. The larger character set required by the Library of Congress is technically feasible within this time span with the three major non-impact technologoes - electrostatic, thermal, and ink jet. However, since there is no commercial demand for that large a character set, it is unlikely that equipment with a 176 character set capability will be available during this time frame unless development efforts are funded by some government agency or the Library community can convince some company of a sufficiently large demand in the Library market to justify the development and production cost.

Non-impact line printers with a full 132 character line width may be available by 1972 because of the higher speed permitted by these techniques and the availability of alternative methods of obtaining multiple copies. However, the development of such a printer would not be important for terminal applications. Such a printer would be pointed toward the high speed generation of large volumes of computer output.

3.8 Machine Readable Unit Document Generator and Reader

3.8.1 General

The Task I requirements analysis indicated requirements in the PIN Assignment and Charging terminals to generate unit documents which are both human readable and machine readable. Requirements for reading these unit documents are found in a number of other terminal categories, such as Reference, Reading room control, Material Request, Discharging, and Invoice Clearing. The function of the generator is to prepare documents that can be read into a terminal or other parts of the CBS later, while the function of the reader is to permit reading these documents.

The requirement for a document that is both machine readable and human readable can be met by using stylized characters that can be read by optical character recognition or magnetic ink character recognition equipment. This requirement can also be met by using any style or font of printed characters in conjunction with encoded information (e.g., dots, bars, punched holes) which is machine readable. In other words, the machine readable and human readable characters may be the same or they may be two different types of characters which are printed at the same time. The requirements call for a fixed number of fields which are relatively limited in length totalling between 40 and 160 standard Roman alphabet characters per unit record.

3.8.3 Techniques or Technologies

There are basically five approaches that can be considered for generating and reading unit documents which are both human readable and machine readable. These are:

1. Optical character recognition
2. Magnetic ink character recognition
3. Printed characters with optically readable codes
4. Printed characters with magnetic readable codes
5. Printed punched cards

The first two approaches, which involve the machine reading of the same character font as that read by the human, usually require that the character font be stylized. The next two approaches above involve reading a code which is printed at the same time as the human readable character. With the last three approaches any type font can be used for the human readable characters. The machine reader only looks at the coded information.

Optical character recognition equipment permits either numeric or alphanumeric characters to be read by one of several scanning techniques, such as circular scan curving tracing and matching against stored patterns, dot matrix scanning and matching against stored patterns, and stroke recognition. Optical character recognition techniques permit type fonts which are more easily human readable than the standards that have been accepted for magnetic ink character readers.

Magnetic ink characters readers, which are widely used in the banking industry, use a special font style defined by the American Banking Association. These characters are read by a serial scan technique and appear to the reader as a magnetic code. The standard character set is limited at ten numerals and four special symbols with no alphabetic characters.

Either optical or magnetic techniques can be used to read coded marks if they are printed above or below the human readable character. A modified typewriter or printer may be used to print the characters in which the coded information is on the same type bar as the human readable character. For example, in a keyboard input device such as a modified electric typewriter, depressing the key for the character "C" would cause the corresponding type bar to hit the ribbon thus printing on the paper both the character "C" and the code for the character "C". If an ordinary ribbon is used the code can be read optically by a photoelectric technique. If a magnetic ink ribbon is used the code can be read by a magnetic reading head. In the latter case the magnetic reading head senses only the presence or absence of magnetic material and does not require that the material be recorded in the sense of magnetic tape recording. Hence, the readability of the code is not affected by magnetic fields or environmental factors. Excessive wear is the only thing that could seriously affect accurate reading of the magnetic ink code. Magnetic techniques have an advantage over optical techniques in that dirt, pencil, and ink marks do not affect the machine readability of the characters. Magnetic approaches which only sense the presence or absence of the magnetic material should provide long life and good shelf wear. For terminal applications in the Library of Congress there is no apparent reason that the techniques which involve printed codes as well as human readable characters should not be acceptable. These techniques will permit less expensive reading equipment. They will also provide characters which are more legible to the human than the conventional magnetic ink character set in use in the banking industry. Present optical character recognition equipment and punched card equipment that both punches and prints on the card are more expensive than those discussed above and offer no significant advantage. However, lower cost remote terminal optical readers are being developed for optical character recognition applications.

Optical character recognition equipment is usually classed by whether it reads full pages, documents less than one page in size (usually with only one to three lines being read on the document) or journal tapes (i.e., roll type tapes from cash registers or adding machines). For the Library of Congress terminal applications only a few lines are to be read so that a document reader would be adequate if the optical character recognition approach is chosen.

3.8.3 Present State-of-the-Art

The present state-of-the-art in optical character recognition equipments, magnetic ink character readers, and optical mark sense readers is discussed and compared in Appendix E. Some other bar code approaches that may be applicable are considered under Badge Readers in Appendix B. Equipment for generating and reading unit documents that are both machine readable and human readable are readily available today, but many of them are not well suited to terminal applications. Several companies are now developing remote terminal optical character recognition equipment. One device of this type scans the document in a facsimile manner at the remote terminal and transmits and recreates the image at a central station where the character recognition is accomplished by a computer program. Typical characteristics for presently available optical character recognition equipment is summarized in the following table:

	Page Reader	Document Reader	Remote Terminal Reader
Document Size (width and length)	12 x 14 to 8.5 x 11	4 x 8	8-1/2 x 11
Documents/Minute	30 - 180	1200	400
Reading Speed (characters/second)	370-2400	2400	740
Price	$100K to $750K	$100K to $750K	$3K

Typical Machine Readable Unit Document Reader Characteristics

The magnetic ink character readers which are available are designed primarily for the requirements of the banking industry. The devices for printing and reading both human readable and machine readable characters in the same document are so diverse that no "typical" characteristics can be cited. Available devices of this type are included in Appendices D and E.

3.8.4 Problem Areas

There are no significant problem areas from a technology standpoint, but the specific devices required for the Library of Congress applications do not exist at this time. It will be necessary to adapt techniques used in other devices. If optical character recognition equipment is used, the unit document generation can be handled by a straightforward character serial or line printer with the proper type font. If the approach of using both machine readable and human readable characters on the same document is used, conventional printers are again applicable with modifications in the type font to include the coded as well as the human readable characters. If magnetic ink character reading approach is chosen, the device used for recording magnetic ink numbers on bank checks might be applicable, but magnetic ink character reading equipment designed for banks which is primarily designed for high speed handling of large volumes of checks, would not be suitable to remote terminal applications. Conventional optical character recognition page readers and document readers are also designed for high volume applications. However, the remote terminal readers which have been introduced recently and are under development by several companies may provide an adequate solution to the requirement for a low cost reader in terminals. One of the devices which prints the coded character and human readable character at the same time is designed to print and read a strip or paper tape rather than a document or page.

3.8.5 Projected State-of-the-Art for 1970 and 1972

The state-of-the-art in 1970 for this type of equipment is expected to be essentially the same as that today presented in Appendices B and E. However, by 1972 remote terminal readers are expected to be readily available and in widespread use for optical character recognition applications. The development of devices in which both human readable and coded machine readable characters are used is also expected to provide more commercially available equipment of this type by 1972, including readers that can read documents or pages in which several of the lines are machine readable as well as human readable.

3.9 Machine Readable Media Generator

3.9.1 General

The functional requirements and performance specifications call for generating some type of machine readable media for off-line data capture, PIN assignment, material status recording, and cataloging terminals. This media will be used to store data temporarily after it is captured before it is entered into the computer system and to serve as a buffer and permanent storage media. The media may be physically carried to a central location to be read into the computer, or the media may be read remotely and the data transmitted to the central computer over telephone lines. Although the functional requirements call for a generator only at the terminal, a reader will also be required at the central computer, and possibly at the terminal. In some cases, it may be advantageous to use the machine readable media for temporary storage only at the terminal - i.e., data recorded on the media and later read back into the terminal for further editing. Machine readable media generators are needed for recording coded characters for Roman, non-Roman, oriental, and special symbol languages.

3.9.2 Techniques or Technologies

Potential technology candidates for this function include punched paper tape, magnetic tape, punched cards, and disc pack devices. Of these possibilities some form of magnetic tape device offers the best approach. The reasons for rejecting the other candidates are shown below:

Media	Reasons for Rejection
Punched Paper Tape	Noisy, lower reliability, higher maintenance, low density, media not erasable
Punched Cards	Slows the input operation, physically bulky, noisy, lower reliability, higher maintenance, low density, media not erasable
Disc Packs	Expensive, physically bulky, much higher speed than required

For the reasons cited above, the detailed analysis and survey of devices for Machine Readable Media Generation has been limited to magnetic tape devices. Conventional computer tape units are not included because they are expensive and provide higher speed than required. For direct compatibility with a keyboard terminal, either a buffer must be included in the terminal or a tape unit which can be stopped and started on individual characters must be used. Three types of magnetic tape devices are presently available that meet the requirements for generating machine readable data--cassette tape units, cartridge tape units, and compatible incremental tape units. The first two would require a small buffer (e.g., 80 characters) in the terminal while the latter would record character-by-character incrementally.

Magnetic tape cassette units use a small bi-directional magnetic tape cassette physically similar to those used in small audio record and play back units. However, the tape is specially selected computer quality tape and closer quality controls are placed on the manufacturer of the cassette itself. These units have the advantage of being low-cost, very compact, and using parts which are made in high volume production for commercial applications (but not at the same quality level). Most, but not all, of these devices record two tracks redundantly for greater reliability. They have the disadvantage of being slow speed (e.g., 1-7/8 ips), but the speed is more than adequate for the input operation since input is limited by the operator's keyboard speed. In reading the data from the cassette into the computer, either a special slow speed channel would be required or a special device would be required to transcribe data from cassette tape units onto conventional computer tape, which could then be read into the computer at high speed.

Magnetic tape cartridge units are similar in most respects to the magnetic tape cassette units except that they do not use a cassette that is physically compatible with those used in commercial audio cassette recorders. The cartridge unit, which is somewhat larger than the cassette and may use a wider tape, is usually designed specially for the handling device for which it is intended. There is no "standard" cartridge. One form of cartridge tape unit uses an endless loop of tape from a single reel while other cartridge units are more similar to the cassette units in that they use two reels and move the tape from one to another. The use of two reels either requires rewinding the tape or running it backwards and recording in the opposite direction. In other respects the advantages and disadvantages of the magnetic tape cartridge are very similar to those of the magnetic tape cassette. Magnetic tape cassette and magnetic tape cartridge handling units include both read and write capability so that the same device can either read or record the tape. Hence, the machine readable media generator at the terminal could also be used as a reader for a very minor increase in cost--essentially the cost of the read amplifier.

In incremental magnetic tape units, the bits of a character are normally stored in parallel tracks across the width of the tape and the tape starts and stops between successive characters - hence, the term incremental. For example, when used with a keyboard device the incremental tape unit records a character in seven to nine parallel tracks as the operator depresses a key and then steps into position to record the next character and stops until the operator depresses the next key. In general, incremental magnetic tape units are physically larger and more expensive than magnetic tape cassette or magnetic tape cartridge units. However, they have the advantage of producing a tape which is compatible with the high speed tape handlers used by the computer. Hence, a tape recorded on an incremental tape recorder in compatible format can be read by a conventional high speed tape handler on the computer. In contrast to the tape cassette and tape cartridge units, which normally read and write by switching different electronics to the same heads, incremental magnetic tape units usually use different heads for reading and writing. In fact, incremental magnetic tape recorders and incremental magnetic tape readers are frequently fabricated and sold as separate units.

The relative economics of converting magnetic tape cassettes or magnetic tape cartridges to a compatible tape by using a special purpose device, of reading magnetic tape cassettes or magnetic tape cartridges directly into the computer, and of using a compatible incremental magnetic tape will be considered further in the cost and trade-off analysis during Task III.

However, at this time it appears that the cost and physical size of incremental magnetic tape units does not favor their use in this application.

3.9.3 Present State-of-the-Art

Magnetic tape cassette units, tape cartridge units, and compatible incremental magnetic tape units that are presently available are summarized and compared in Appendix F. The characteristics representative of the present state-of-the-art for these three types of magnetic tape devices are shown below:

Characteristics	Magnetic Tape Cassette typical	Magnetic Tape Cartridge typical	Incremental Magnetic Tape typical
Number of tapes per unit	1	4	1
Transfer rate in (char/second)	300 to 625	636	200 to 1500
Tape transport speed in inches/second	1-7/8 to 10	10 to 20	Incremental
Recording density in bits/inch	550 to 1200	600	200/556/800
Price (incl. Electronics)	$2,000	$5,000	$13,700

3.9.4 Problem Areas

The major problems that have been encountered to date in using magnetic tape cassettes have resulted from the attempt to use commercially available audio tape cassettes. By this time most manufacturers have found that the quality control on commercial cassettes is inadequate for computer usage. Hence, most manufacturers now load the cassettes with tested computer quality tape and place higher quality-control standards on the physical cassette fabrication and assembly. The same problem has been encountered to some extent in magnetic tape cartridge units although most of the cartridge units offered now are physically different from audio cartridge units and, hence, must be specially made.

In selecting a tape cassette or tape cartridge unit for use in the terminal, careful attention must be given to the design characteristics of the specific tape handling mechanism, and care must be taken to assure that only computer quality cassettes or cartridges are used. The major problems with incremental tape units for terminal applications are the cost and physical size.

3.9.5 Projected State-of-the-Art for 1970 and 1972

Most of the magnetic tape cartridge and cassette devices available today have been developed within the last two years; hence no significant improvements in the tape drive units are anticipated during 1970. Significant improvements in the mechanical tape handling within the cassette or cartridge will be necessary and fully tested digital quality tape will be used. This should occur during 1970. The major improvements that can be expected by 1972 are in quality and reliability. Evolutionary improvements will be made in speed and density by mid-1972--in the order of 1,000 to 1,500 bytes per second and 800 to 1600 bits per inch. Price per tape drive is expected to drop below $1,000 by mid-1972.

Incremental magnetic tape recorders have been available for several years and appear to have passed the knee of the development curve and are improving at a relatively slow and gradual rate at this time. Hence, no noticeable improvement is anticipated during 1970, and improvements in performance and cost will most likely be no more than 10% to 20% by mid-1972.

3.10 Calculating Unit and Controllers (Small Computers)

3.10.1 General

Functional requirements developed in Task I indicate the need for a calculating unit in terminal stations used for invoice clearing. This functional requirement can be met by including a small computer as a module in that terminal station. However, the most significant application for small computers in the terminals for the Central Bibliographic System is as controllers providing functions which are common to and shared between several terminals in relatively close physical proximity to one another. It is also very likely that some of the individual terminal stations which are not connected to a controller can best be implemented by including a very small low cost computer in the terminal station. The function of the small computer in this case would be to provide the necessary buffer storage, control logic, and timing functions required in the terminal. Also, Section 2.4 of this report discussed some of the functions and module requirements (e.g., the time and date clock and the storage of preprogrammed messages to permit entry of preprogrammed data) that might best be implemented with logic or software in a small computer in the terminal station or in the controller.

3.10.2 Techniques or Technologies

The main memory in most small computers today are implemented with magnetic core technology. In the future magnetic core memories will be threatened by competition from plated wire memories and semi-conductor memories as discussed in the preceding paragraph. Magnetic core memories enjoy a significant advantage in terms of existing technology and large production facilities. For larger capacity memories, plated wire technology is the most likely to supplant magnetic core technology within the next two to three years. However, for very small computers the memory requirements tend to be more limited; hence, semi-conductor technologies may have an advantage over plated wire technology. An important characteristic of semi-conductor memories is that for capacities larger than a few hundred bits the cost per bit is not significantly dependent upon the capacity of the memory. For plated wire and magnetic core memories the cost per bit decreases significantly as the capacity of the memory increases. Hence, plated wire and magnetic core memories tend to be less economic for very small capacities, in the order of a few hundred words. For this reason, as well as the speed advantage, semi-conductor memories are being used more and more for small capacity memories of a few hundred words, which provide storage for control functions (e.g., micro-programs or firmware) and frequently used data and subroutines. Larger capacity magnetic core memory or plated wire memories are used for the bulk of the data and program storage.

A few very small computers have been announced recently in which the entire program may be stored in a read-only memory. In the future, semi-conductor memories may be used for this function, which would permit electrical alterability of the memory, and hence greater ease in adapting the machine to a specific application. MOS read-only memories are available now with 256 words being a typical capacity for this type of memory. If micro-programs are stored in this type of memory they must be preprogrammed at the manufacturer's facility and cannot be easily changed in the field without replacing the memory. In the future, as an extension of this technique, an alterable semi-conductor memory could be used for storing micro-programs and other control functions in the same way that read-only memories are used in a few machines at present. This would permit the easy extension of memory capacity using the same kind of memory technology, with the possibility of storing micro-program operations as well as data and the main program in the same memory. Although there is a definite trend toward the use of micro program operations in a number of small computers at present, it is not clear at this time whether this trend will continue in the future toward the use of read-only memories or whether programmed operations will be stored in an electrically alterable memory thus permitting greater flexibility for field changes.

Most of the small computers available today are implemented with magnetic core matrix memories and bipolar integrated circuit logic. A number of companies are actively working on small computers using MOS semi-conductor memory arrays and MOS logic arrays. MOS is an acronym for "metal oxide semi-conductor" which is a type of semi-conductor element that utilizes the surface effects in semi-conductors and is fabricated by growing oxide layers and depositing metal layers on a semi-conductor surface rather than by the diffusion processes used in fabricating conventional bipolar LSI arrays. However, many people in the semi-conductor and computer industry believe that MOS devices, which provide a higher component density in a given area of silicone chip and which require fewer processing steps, will offer a lower cost approach to implementing computer memory and logic functions in LSI (large scale integrated) arrays.

In general, MOS devices are significantly slower than bi-polar devices by a factor of between two-to-one and five-to-one. On the other hand, many people in the field expect MOS devices to enjoy a significant cost advantage over bi-polar devices. For large scale high speed computers, bi-polar LSI arrays are more attractive because of their speed; but for small computers, such as those required in terminal applications, speed is not as important a factor and cost is the more important factor. Hence, if present development on MOS arrays proves the technical and economic feasibility of this type of device, they may be more attractive for use in small computers.

At this time, it appears that the present state of development permits larger MOS memory arrays than bi-polar LSI memory arrays. The trade-off made for this higher density and lower cost is one of speed. MOS memory arrays offer potential for memories in the 500 nanosecond cycle time range within the next year or two and perhaps as low as 150 to 250 nanoseconds by 1975. This is in contrast to bi-polar LSI memory arrays where the cycle time is expected to be in the 150 to 250 nanosecond range within the next year and in the 100 nanosecond or faster range by 1975. A cost differential of approximately two to one is anticipated between these two types of memories. Since speed is not the primary consideration for small computers, many people expect MOS technology to dominate the small computer field, if satisfactory yields, reliabilities, and stability over long life periods can be proven. However, bi-polar LSI technology has a significant potential advantage because of the extensive development of bi-polar LSI devices for other applications. It is likely that bi-polar LSI technology will benefit from more extensive research and development efforts; hence, the two technologies may not compete on a completely equal basis.

In general, the memory speed is a limiting factor on the basic operation speed of a computer. It is expected that logic circuits will be readily available that are more than capable of matching any available memory speed in small computers. Hence, the future capability of small computers will be heavily dependent upon the memory technology used. It is important to note, however, that for a given circuit and memory speed the performance and capability of a small computer is significantly affected by the organization or architecture of the computer and the instructions and functions implemented in the machine. There are many cases where a small computer with a memory speed significantly slower than that of another outperforms the second because of the greater capability in the architecture and logic implementation of functions such as arithmetic operations, interrupt operations, and input/output control functions. Hence, a small computer cannot be selected on the basis of memory speed or basic operation speeds alone. The machine must be selected in terms of the requirements of the particular application on an overall basis giving adequate consideration to the types of interrupt and input/output control functions required. This is particularly important for terminal and control applications. Interrupts may occur from the human operator, the display, the printer, the communication line or other terminal modules. The communication capabilities of the small computer are particularly important if it is to be used in a controller application since the controller must communicate over a telephone line or other type of long distance communication line with the central computer on one side and with a number of local (and probably hard wired) stations on the other side.

Other important considerations in the selection of a small computer are the software and peripheral equipments available with the computer. For some types of applications the availability of extensive system software, such as Fortran compilers, is a major consideration; but this is not as important in a real time application such as a terminal controller because of the strong likelihood that the controller will be programmed in assembly language in order to achieve maximum efficiency and real-time speed. The major software requirements for a computer to be used in a terminal or controller are the assembly language, the real-time operating system, and diagnostic routines.

The availability of a wide range of peripheral equipments is generally an important consideration in selecting a small computer, but again this may not be as important for the terminal and controller application. More important for this application is the ease with which different types of peripheral equipment can be interfaced with the computer. It is very likely that the terminal modules with which the small computer will be required to interface will not be standard peripheral equipments offered by any computer manufacturer. Hence, the complement of peripheral equipment already interfaced to the computer by the manufacturer is less important than the ease with which new kinds of equipments can be interfaced to the computer by those designing the terminal station.

3.10.3 Present State-of-the-Art

The technology for small low cost computers is highly developed at this time and there are a large number of equipments offered in this category with new companies and new equipments entering the field at a rapid rate. The characteristics of the small computers available at the time this report was written are summarized and discussed in Appendix G. The tables in Appendix G indicate the availability of a large number of small computers offering wide range of characteristics and prices. Typical characteristics for small computers available today are summarized below:

Memory Cycle Time (us)	1.0 - 2.0
Memory Capacity	4K - 32K
Instruction Word Length	8 - 16
No. of Hardware Registers	4 - 8
Indirect Addressing	Multi-level
I/O Data Path Width	8 - 16
DMA Word Transfer Rate	200 KHZ - 1.2 MHZ
No. of External Interrupt Levels	2 - 32
Relocatable Assembler Core Reg.	4K
Price of 4K Memory and TTY-33	$5K - $16K
Price of 8K Memory and TTY-33	$10K - $22K

Typical Range of Small Computer Characteristics

Almost all types of peripheral equipments are offered with small computers, although some manufacturers offer a wide variety of peripheral equipments than others. The ASR-33 Teletype is typically used as a computer console and punched paper tape equipment, magnetic tape equipment, magnetic discs and drums, punched card equipments, and external interrupt lines are usually offered. Many of these machines also offer some type of communication interface and modem.

Words sizes of 8 and 16 bits are most common with the 8 bit machines being in the lower end of the price range and the 16 bit machines in the upper end. Some of these machines offer memory expansion capability only to 8,000 or 16,000 words, while others offer expansion capability up to 32,000 words.

3.10.4 Problem Areas

There are no significant problems in implementing small computer requirements for terminals for the Library of Congress Central Bibliographic System. Very small computers in the below $5,000 price range are available which could be used in the terminal itself and somewhat larger small computers in the $10,000 to $15,000 price range are available which could be used as controllers for a number of terminals. The availability of low cost peripheral equipments is a problem in some small computer applications, but this is not a factor in the Library of Congress application.

3.10.5 Projected State-of-the-Art for 1970 and 1972

The state-of-the-art in small computers is advancing very rapidly and will continue to do so for a number of years. However, the major improvements will be in cost rather than in performance. That is, any performance level required is available today, but the price for a given level of performance is continually declining. This also implies that for a given price greater capability will be available in the future. A number of the small computers shown in the tables in Appendix G have only recently been announced, and in some cases none have been delivered. Hence, the state-of-the-art for small computers in 1970 is represented by several of the machines shown in Appendix G. By 1972 price decreases in the small computer field should provide cost improvements in the order of one-fourth to one-third over those available today for a given level of performance. Small computers for use in an individual terminal sould be available in the \$2,500 to \$3,000 price range, while small computers capable of serving as controllers for a number of terminals should be available for under \$10,000 by 1972. These prices, which are for the central processor and minimum memory capacity, will be increased to the extent that additional memory capacity, additional features, or peripheral equipments are added to the central processor.

3.11 Oriental Language Devices

3.11.1 General

This section is concerned with the written form of the three ideographic oriental languages. These are in order of increasing complexity of "mechanization" Japanese, Korean, and Chinese.

Japanese

Japanese is considered the simplest of the three because of its more limited repertoire of Chinese derived characters. The number of these characters, referred to as Kanji, in current use is limited (by edict) to 1850, plus a few special characters used only for proper names. The Kanji are supplemented by two syllabic alphabets, the Katakana and Hiragana. Words of foreign origin are transliterated (as closely as possible considering the fact that certain sounds, most notably "L", are not present) into Katakana. Words of native origin for which Kanji are not available are phonetically spelled out in Hiragana syllables. Hiragana syllables are also used for special word endings.

The Katakana and Hiragana syllabaries consist of approximately 49 basic symbols each. The basic syllabaries are extended by the use of two diacritical marks, ゜ and ゛ to indicate consonantal changes, e.g.

ハ is HA
バ is BA
パ is PA

The Japanese also use arabic numerals and the roman ("Romanji") characters as well. The maximum number of symbols, Kanji, Katakana, Hiragana, and Romanji is, however, well under 2000.

Korean

Korean has only a limited alphabet (not as versatile as the Japanese Katakana) and hence must depend more heavily on the Chinese derived characters, referred to as Hancha. Some attempts have been made to reduce the number of Hancha characters to less than 600, but somewhere between 1300-2000 are considered "indispensable". If the number of sanctioned characters can be reduced to the lower limit, mechanization of Korean will be simpler than Japanese, as of now Korean is somewhat more complex to mechanize than Japanese.

Chinese

Chinese has no phonetic alphabet and depends exclusively on the traditional characters. Whereas the Japanese form complex words by placing two or more Kanji characters side by side, the Chinese have tended to construct new words by combining the essential parts (radicals) of simpler characters to form new characters. The number of "essential" characters is estimated as between 6000 and 10,000 (depending on the estimates) but older works contain upwards of 20,000 characters. The standard Chinese Telegraph Code (CTC), originally devised during the last century, provided for some 799 characters, but it has been continuously augmented and modified ever since.

Because the more complex characters can be considered as made up of one or more radicals plus additional strokes, dictionary look up is feasible on the basis of first looking up the basic radical and then counting the number of additional strokes to find the desired character.

3.11.2 Entry Devices for Oriental Languages

While simple keyboard devices are practical for entry of the Japanese syllabaries and the Korean alphabet, the use of a one-to-one correspondence between key and character is impractical for the ideographic symbols.

Two distinct approaches have been found at least partly successful. These are discussed below. Analog drawing has been suggested also and is discussed later. A new method which has not been found in the literature will also be presented.

The oriental characters are made up of combinations of vertical, horizontal and diagonal linear strokes. Curvilinear strokes are used also, but the curvature is slight and not truly essential to recognition. The "hooks" at the ends of some of the strokes are analogous to seriphs and are also not essential to recognition. The characters are stroked in a rigidly prescribed sequence, generally left to right, top to bottom.

The RCA photocomposition machine (see Appendix H) uses a keyboard with 21 basic strokes, plus punctuation and "entity" keys (entities are the most frequently used radicals). The keys are struck in the traditional stroke sequence. When enough keys have been struck to define a unique character beginning with the selected sequence of strokes, that character is displayed for acceptance or rejection by the operator. Certain combinations of strokes lead to ambiguous patterns. In these cases the ambiguous characters are displayed simultaneously for operator selection. The number of such ambiguities is surprisingly low. Shashoua[1] states that in a vocabulary of some 2500 characters only 20 pairs and 4 triads of ambiguous characters were found. The RCA photo-composition machine has a repertoire of up to 10,000 characters.

A second approach is based not on strokes but on "features". Lin Yutang is credited with pointing out that the top and bottom halves of the characters can be categorized separately into a limited number of "features" or patterns. All characters can be reasonably well categorized to within small families in terms of only 36 top and 32 bottom features. The ITEK Chicoder is based on the Yutang principle and requires three keystrokes per character. A pair of top and bottom feature keys is struck and all ideographs containing these features are displayed. The third key stroke identifies the individual character by its position in the display. The Chicoder has a repertoire of over 10,518 characters.

It has been suggested that characters be entered by essentially tracing the strokes on a RAND tablet or some other analog-to-digital conversion device. The problems connected with this approach will be discussed below in connection with the inverse problem (digital-to-analog) of display. Such a means of input is not recommended for the oriental languages although it may have some merit for special symbols.

A fourth approach which appears to have some merit but does not seem to have been discussed in the literature is the use of a digital input matrix.

[1] Shashoua, F. E.: Photocomposition Machine for the Chinese Language, RCA Applied Research Paper, 1964.

The matrix could contain 32 x 32 = 1024 squares each 1/2" on a side with the most frequently used characters arranged in a systematic (e.g. dictionary order) fashion.

A stylus is used to enter a 10 bit code by "pointing" the stylus to the desired character. A 64 x 64 matrix would be 32 inches square and provide a 12 bit code. A single matrix of this size would be complete in itself for Japanese. Either the larger or smaller matrix could be extended to cover Korean, Chinese, or all three languages by providing keyed overlays with additional groups of characters. For example sixteen 32 x 32 overlays or four 64 x 64 overlays could provide a 2^{14} (16,384) character font. The selection of a particular overlay would, by self-keying, introduce the additional 4 or 2 bits into the encoding and a three position switch could be used to select the desired language. Because of the lack of ambiguities, a feedback display would not be required and "checking" could be provided by double entering such as is now done to verify punched cards.

Further study of matrix devices of this type from a human usage standpoint would be required to evaluate the input speeds which may be achieved, particularly as compared with the RCA and ITEK devices which require multiple keystrokes and near instaneous display to resolve ambiguities. The digital input matrix could be quite inexpensive, especially since feedback display is not required. Such a matrix could be implemented in many ways, e.g. mechanically, electrically, optically, etc.

Since the Chinese characters have been assigned 4 decimal digit numbers for purposes of telegraphy (see Section 3.11.5 on Machine Readable Codes for Oriental Languages), a 10 key keyboard may be of limited use particularly in entering corrections. Such a device may prove slow since it would require four keystrokes per character and prolonged experience to memorize the digital codes. The codes are not as easy to memorize as the meanings of the characters because of the meaning mnenomies inherent in the characters.

An additional set of four digit codes, which is well accepted, is the Mathews number assigned to each character in the Mathews Chinese-English dictionary.

3.11.3 Display Devices for Oriental Languages

An electronic display operating on line with the input keyboard or other entry device will permit "instant" verification of the input data, will permit more rapid proof reading and correction (more of the errors may be caught by the input operator) and will permit editing.

While displays need not be of typographic quality, the characters should be legible and unambiguous. Variable line widths and graceful curves are not required. Some stylization is permissible from a cost/effectiveness standpoint.

The cathode-ray-tube (CRT), which is the most widely used individual display device, is the only such device to be considered here. A number of methods for generating characters on the face of a CRT are described in the literature.[2] Many of these methods are immediately seen to be impractical for the oriental languages. The electron beam stencil used in the Charactron[R] for example is practically limited to around 128 symbols. The Monoscope[R] and similar techniques are also limited in repertoire for the same reasons.

The limitations of these devices are due to the necessity for generation of the symbols within a CRT itself. If the symbol generation is performed externally to the tube envelope much larger repertoires are possible. Optical means, as used in typographical systems can be used, but the film must be replaced by a storage tube. This method will be discussed below. The immediately following paragraphs will describe the advantages and dis-advantages of two all electronic methods for symbol generation. These are the well known dot matrix and stroke methods. Of the two, the stroke method presents better appearing characters and requires less memory. However, an optical/electronic method using a video pickup of an optically projected character and a storage tube on which sequentially generated string of characters may be displayed offers certain advantages over all electronic systems. A single optical generator could be time shared for both hard copy generation and a number of simultaneous displays because both

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[2] Luxemberg, H. R. and Kuehn, R. L.: Display Systems Engineering, McGraw Hill, 1967, Chapter 8.

the recording material and the individual storage tubes provide the required self storage.

Dot Generators

While a 5 x 7 matrix can provide just marginal legibility for Roman characters, at least a 16 x 24 matrix is required for the more complicated oriental characters. See, for example, Figure 1 which is a reproduction of an electrostatic printer output using a 16 x 24 dot matrix. Even this is definitely marginal in appearance. A larger matrix would be desirable from the appearance standpoint, but that could be prohibitive from a cost standpoint. The 16 x 24 matrix contains 384 bits and the storage of the dot structure for 10,000 characters on this format would require 3.84×10^6 bits. Larger matrices would of course require proportionately more memory.

Stroke Generators

Stroke Generators provide better appearing characters than dot matrix characters. The most complicated Kanji characters, Shū and Kan shown in Figure 2 consist of 23 strokes each. If these strokes are created by joining points of a matrix as large as 32 x 32 only 20 bits are required to designate the starting and ending points of each stroke. A 23 stroke character would thus require 460 bits of storage. This is more than required for a 16 x 24 bit dot matrix character, but simpler characters would require less storage as will be shown.

A Guide to Reading and Writing Japanese, Charles E. Tuttle Company, Rutland, Vermont, and Tokyo, Japan, 1959 (reprinted 1966), provides the following stroke data for Kanji characters (selected from the essential 1850).

Storage Required for the Most Complex Kanji Characters

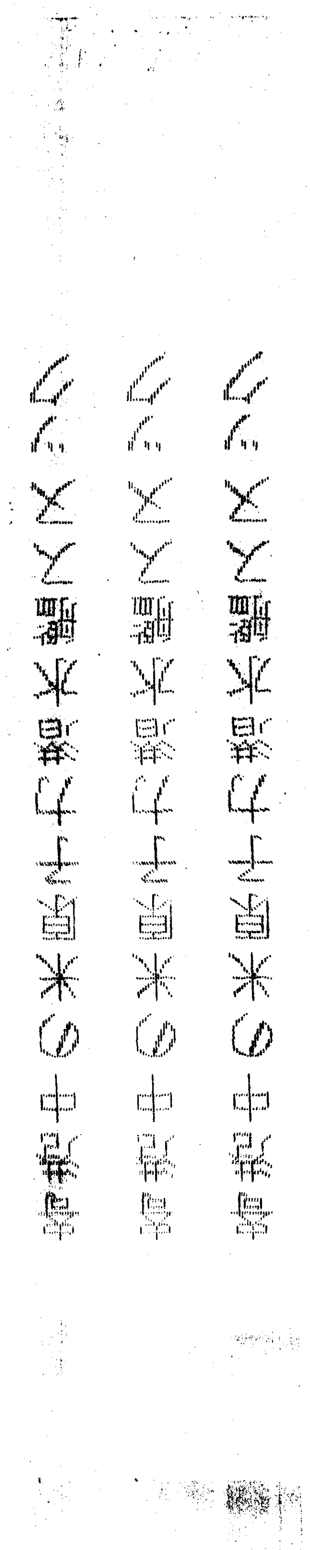
No. of Strokes	No. of Characters	Bits/Character
23	2	460
22	1	440
21	5	420
20	11	400
19	17	380
18	32	360
17	31	340
16	67	320
15	98	300

The table has not been extended to include all of the 1850 Kanji characters, but it shows that only 19 of the Kanji characters built up of strokes on a 32 x 32 matrix require more data storage than do all of the characters built up of dots on a 16 x 24 matrix. The simpler stroke characters require, of course, far less storage, even if additional storage requirements are introduced to permit curvatures to be generated either by segments or curved stroke generation techniques. This implies that a stroke generation method is more economical of storage and provides better appearing characters than does a dot generation technique, if all electronic methods are required.

Mechanization of the Display

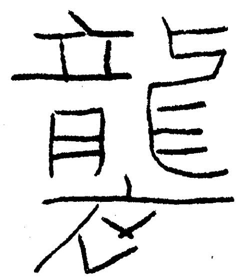
Character generation which involves a translation from the storage code to the display code that drives the digital-to-analog converters may be done either through hardware or software. For limited fonts, hardware has proven more cost effective; for large fonts, such as Kanji, software conversion will be more cost effective.

The number of characters which may be simultaneously displayed at a flicker-free rate, depends on numerous parameters, e.g., number of



FUJITSU, LIMITED, ELECTROSTATIC PRINTER OUTPUT (16 x 24 DOT FORMAT)
(16 x 24 DOT FORMAT)

FIGURE 1

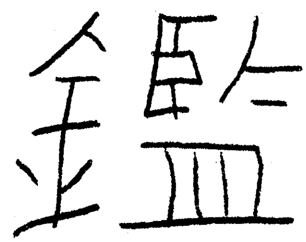


SHŪ

attack

succeed

suprisevisit



KAN

model

pattern

example

Note that these characters consist of groups of strokes.

THE 23 STROKE KANJI CHARACTERS SHŪ AND KAN

FIGURE 2

stations in simultaneous use, time per character, etc.[3]

The number of oriental characters which may be simultaneously displayed will be less than the number of Roman characters because in general more writing time will be required per character because of the greater complexity. These problems of number of characters versus refresh rates may be resolved by using a storage tube. For an all electronic system the combination of a software stroke generator and a storage type CRT appears to be an optimum solution.

Optical/Electronic Method

The use of a storage tube, with the absence of a refresh requirement opens the way for slower (i.e., non-electronic) character generation techniques. A film stencil, which is the optical analog of the electron beam stencil in the Charactron[R] and the pattern plate in the Monoscope[R] can store far more information than its electronic analogs. The film stencil is properly positioned in a projection path and the image of the projected character is scanned with a video pick-up system. A synchronized recording beam in the storage tube will then generate the image of the character in its specified position where it will remain until erased.

Optically shaped characters will be far more attractive than either stroke or dot matrix characters. Because the optical stencils are easily interchangeable, all three of the languages under consideration may be handled with the same hardware.

Because of the existence (although not in quantities) of devices for generating hard copy (ITEK and RCA), and the state-of-the-art in video and storage tube technology, no extensive development is required for this photo-optical/storage tube display approach. However, the equipments themselves are relatively expensive.

[3] Luxenberg, H., and Kuehn, R.: Display Systems Engineering, McGraw-Hill, New York, 1968, p. 275.

3.11.4 Hard Copy Devices for Oriental Languages

Hard copy devices are required to produce characters of graphic arts quality. While all electronic photo composition devices have been developed for Roman (and italic, bold face, and gothic) characters, the large repertoire of Chinese characters is most easily generated by optical means. At least two United States manufacturers, RCA and ITEK, have produced photo-composition machines for the oriental languages. The specifications for these existing machines are given in Appendix H.

The means of entry into these two devices is by keyboards which have already been described. They may be operated either "on-line" or from a keyboard prepared tape.

Output is to a film which is then used to prepare the reproducible master, by the usual graphic arts methods.

The optical technique used in the RCA photo-compositor is unique in that selection of the desired individual character is done by illuminating only a single block (of 16 characters) on the matrix plate, which remains stationary. A system of mirrors and beam splitter superimposes the images of all the blocks into a single aperture, but only the illuminated block is visible. This approach permits rapid selection of the characters since no mechanical motion is required.

The original RCA photo-compositor used conventional photo imagery in the matrix plate. It is understood that a newer version of the RCA photo-compositor will use a holographic image in the photo-matrix plate to reduce size and weight.

3.11.5 Machine Readable Media Code for Oriental Languages

Each of the input devices discussed above (except the RAND tablet used as a drawing tablet) is capable of directly generating a simple unique digital code for each character. For the ITEK and RCA machines these are only indirectly related to the combination of keys struck. In those machines the desired characters are recovered from the photographic image memory for immediate verification on a Kinescope, and the binary location of the stored image is available for direct encoding. Since the same machine is used for both input and output machine readable media (e.g., a magnetic tape or a punched paper tape) can be prepared simultaneously with the hard copy. As an alternative, the machine readable media can be generated instead of the hard copy for future hard copy preparation. The digital tape thus prepared is in proper form for computer entry

The Japanese Kanji Teletypewriter, described in Appendix H, operates on a 12 bit code and is designed to prepare a punched paper tape.

The Chinese Teleprinter described in Appendix H also prepares a punched paper tape.

For some purposes, the use of a "code book" which assigns an arbitrary identification number to each character may be feasible, particularly if several systems using different bit patterns are combined. In this case a "dictionary" converting each systems bit patterns into the common code could provide the commonality. Examples of such codes are:

1. The serial arrangement of the Kanji characters in a standard Japanese dictionary
2. The four digit serial numbers of the Standard Chinese Telegraph Code (STC)

Either of these codes may be generated on a standard keyboard at rates dependent on the operator's memory and proficiency in converting characters into their equivalent digital codes.

3.11.6 Projected State-of-the-Art for 1970 and 1972

The keyboard devices and the character serial printers (e.g., Chinese Teleprinter and the Kanji Teletypewriter) discussed in this section and in Appendix H are available now but they are limited to under 2,000 characters and symbols. The Fujitsu electrostatic printer, which uses a 16 x 24 dot matrix, is also available. The other devices discussed in this section and Appendix H are in a developmental stage. None of these capable of handling oriental language character sets will be available by 1970 except in developmental models with a consequent high price. It is very doubtful that any of them can be considered off-the-shelf or commercially available equipment by 1972 for oriental language character sets. It is difficult to predict the availability of devices of this type, which are presently in the experimental stage, because their development and availability depends very heavily on the funding available for the completion of research and development efforts and the conversion to production status. There is no strong indication at this time that demand is sufficient or that funding is available to assure production status for these equipments by the end of 1972.

4. POTENTIAL PROBLEM AREAS

Four major problem areas exist with respect to the availability of devices for implementing terminal requirements for the Central Bibliographic System.

The first of these is the PIN Labeler and PIN Reader. Several techniques and technologies used in Badge Readers and Optical Character Recognition Equipment are applicable to the PIN problem but specific devices do not exist that can handle the PIN reading requirements. The two major bars to the use of existing equipment are the size (thickness) of the book in fixed stations and the need for a hand-held reader in the portable stations. Two hand-held devices currently under development may offer a solution to both of these problems by 1972.

The second problem area results from the requirement to handle character sets of 176 characters for the Extended Roman alphabet and combined character sets for other alphabets plus a subset of the Extended Roman alphabet. This does not present a serious problem for keyboards, but it is quite serious for printers and displays.

The larger character set can be handled in line printers of the "chain" type by expanding the character set on the chain at the expense of printing fewer lines per minute and the cost involved in customized equipment. It can also be handled in character serial printers of the matrix type (e.g., thermal, electrostatic, ink jet) by using a 9 by 11 matrix instead of a 5 by 7 matrix, at a consequently higher cost. The cost could be substantially higher because of the higher number of dots in the matrix, the development costs required, and the fact that the equipment is not a standard production item.

The same considerations are true for CRT displays. A display using a dot matrix character generator would require a 9 by 11 matrix instead of a 5 by 7 matrix, one using a stroke character generator would require more strokes, and one using a monoscope or a charactron tube would require a larger character mask.

The third and most serious problem area is in the handling of Oriental languages. This problem, which is discussed in detail in Section 3.11, is so difficult and equipment so expensive that an alternate approach that does not require terminal entry and computer storage and print-out of the oriental languages may be required.

The fourth problem area is in the handling of special symbols. A limited number that are frequently used can be handled in the same way that non-Roman character sets are handled with special keyboards, printers, and displays. However, the use of unlimited special symbols presents the same problem as the Oriental languages.

5. CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations from this study depend heavily on the other two tasks of the study and will be presented in the Final Report. However, some of the hardware and equipment problems discussed in the preceding sections require consideration by Library of Congress personnel while the work on Task III is underway.

It is recommended that the Library give consideration to partially supporting development work in the following areas:

1. A portable PIN Reader
2. A character serial printer and a line printer capable of handling a character set of 176 characters
3. A CRT display with a 9 by 11 matrix for handling a character set of 176 characters.

It is further recommended that the Library seriously consider the use of a microfilm storage and retrieval system for the Oriental languages and many special symbols. In such a system the microfilm file could be accessed by an index number stored in the computer record. The cataloging could be done at a semi-automated terminal station, but with the Oriental language characters or special symbols originally added by hand and then printed on the card by a photocompositer as it is done now. The complete card could then be stored in microfilm form for accessing and reproduction under computer control.

APPENDIX A

SUMMARY AND COMPARISON OF PRESENTLY AVAILABLE KEYBOARDS AND KEYBOARD/PRINTERS

The characteristics of the more prominent keyboard/printer terminals available today and the major technologies for implementing keyboards are presented in this Appendix. Keyboard/printer terminal requirements are primarily for on-line use where individuals are interacting with a computer system and for off-line data preparation where data is recorded on some machine readable media. Quite often these devices are used in conjunction with other types of terminal equipment modules and, hence, these equipments might also be included as modules in other types of equipments. Most of the products of this type include a keyboard and a serial character printer that produces hardcopy but which at the same time generates electrical signals to the computer over communication lines or to a machine readable media generator (e.g., a paper tape punch). There are also some applications of keyboard-only units where the printed copy is not required or where visual copy is generated by some other device. Such units have applications as transaction input units, as portable input units, and as input for CRT terminals.

Keyboards

Since there are upwards of 100 manufacturers making keyboard equipments of one kind or another, this study did not compare all of the specific keyboard products from various manufacturers. Instead, different technologies or techniques for implementing keyboards were analyzed. A few selected keyboard units that are representative of the different technologies are shown in Table A-1.

Keyboards are designed to enter alphanumeric and symbolic information. These numbers and letters are usually supplemented with other non-spoken symbology -- special characters such as %, and punctuation marks. Keyboards may be numeric, alphabetic, symbolic or any combination thereof. They can be designed to meet many special needs. Most typewriters have 44 keys which provide 26 alphabetic numbers and some punctuation marks with upper case and more punctuation marks available in a shift position. The MARC Pilot Project Keyboard designed by the Library of Congress uses

Manufacturer	No. of Keys	Keyboard Technique	Encoding in Key Module	Special Comments
Clare-Pendar	88	Solid State (reed switch & MOS)	No	Encoding flexibility up to four levels, Modular
Controls Research Corp.	58	Electronic (reed switch & diodes)	Yes	Modular
Digitronics PK-275	75	Photo-electric	No	Maximum of 75 keys
George Risk Industries -573	73	Electronic (reed switch & diodes)	No	--
IKOR	66	Capacitive	Yes	No mechanical switching Modular
Licon-550	73	Electronic (magnetic cores)	Yes	Modular
Mechanical Enterprises Inc.	55	Electromechanical (mercury switch & diodes)	Yes	--
Microswitch	63	Solid State (Hall effect & MOS)	No	Encoding flexibility up to four levels, Modular
NAVCOR-1050	50	Electronic (reed switches & diodes)	No	Buffered outputs
Synergistics	65	Electromechanical	Yes	Maximum of 160 keys

Clarification of Terms Used in Table A-1

Keyboard Technique - whether the technique used to implement the keyboard is sold state, electronic, photo electric, capacitive, or electromechanical.

Encoding in Key Module - whether the encoding is accomplished in the key assembly itself or in some external encoding equipment.

SELECTED KEYBOARD UNITS

TABLE A-1

44 keys and 2 shift keys (4 shift levels) to input 176 characters for the extended Roman alphabet.

Although many non-standard keyboards are available for special purposes, there are three standard keyboards that are accepted in this country: they are the alphanumeric or typewriter keyboard, the numeric ten-key keyboard, and the numeric bank or columnar keyboard. Many variations occur within each of these standards. However, there is enough standardization to allow the training of personnel in their operation.

Alphanumeric keyboards are designed to operate at a peak repetition rate for a single character of ten or fifteen times per second. As most alphanumeric keyboards are not interlocked to prevent the simultaneous depression of characters, it is possible to operate such keyboards at speeds up to 20 characters per second providing that the same character is not repeated in sequence. Typical operator rates are about five characters per second when copying from legible data.

Ten-key numeric keyboards are designed to be operated by one hand. A trained operator can produce output at the rate of ten to twenty characters per second for reasonably long periods of time.

The bank or columnar keyboard provides a column for each digit position. Each column contains all of the digits which may be entered in that position, usually one through nine. This keyboard can be used as a fixed format forced entry device as all zeros or all blanks are automatically entered in each column when no key is depressed.

Currently available technology is adequate to provide for the construction of any desired configuration or speed of keyboard. Although most of the keyboards now in use are electromechanical in nature and involve the use of several moving parts, it is possible today to get a keyboard which senses key depression electronically or magnetically and uses solid state logic to generate coded output. These keyboards have the advantage of eliminating the wear problems associated with moving parts and have high reliability. Another common keyboard technique used today is a reed switch module which is also actuated by a magnet when the key is depressed. These types of keyboard and some other types of contact keyboards also offer an advantage in providing modular key assemblies that can be assembled into keyboards with larger numbers of keys and greater flexibility.

Microswitch offers a solid-state keyboard using the concept of triggering integrated circuits with plunger mounted magnets. The magnetic field created by the plunger being depressed causes a Hall effect voltage to be generated and this is amplified to a usable level which is fed into the encoding matrix of the keyboard. This technique eliminates the need for discrete diodes, thus reducing the cost of encoding.

Ikor uses a different solid-state approach employing capacitive coupling in which each key generates its own code. There are no switch contact closures and the key can be placed anywhere on the keyboard layout. In other words, each key contains its own function code. The depression of the key establishes an AC signal between the transmit and selected receive bars thus generating the specific code for that key. Any code up to 12 bits can be handled with the restriction that one and only one binary code be assigned to each character.

Keyboard/Printers

Impact keyboard/printer terminals provide hard copy, which is essential in most applications, but these types of terminals are slow, have high maintenance costs, and are usually quite noisy. The most common and widespread example of keyboard/printer terminals using impact printing are the hundreds of thousands of Model 33 Teletypes presently in use which operate at 10 characters per second. Other keyboard/printer terminals are designed around electric typewriters, with the IBM Selectric being the most commonly used. Such terminals typically operate at 15 characters per second but some go up to 20 characters per second. The characteristics of these and other keyboard printer terminals are presented in Table A-2. Manufacturers of other types of keyboard/printer terminals are attempting to either serve specialized applications or to overcome some of the present

Manufacturer Model Number	No. of Keys	Printer Char. Set Size	Keyboard Technique	Printing Technique	Keyboard/ Printer Mfgr. (if bought out)	Trans-mission Rate (char/sec)	Trans-mission Code	Special Comments (options available, etc.)	Price
Anderson Jacobson ADT 233	54	63	E-M	Impact	TTY	10	ASCII	Coupler incl.	$2,085
Computer Transceiver Systems Execuport 300	80	96	E	Thermal	NCR	30	ASCII	PTR/P, GRT Cassette	$3,800
Connecticut Technical Corporation	55	90	E	Impact	Olivetti Underwood	14.5	ASCII	Coupler incl.	$4,500
Data Products (Stelma) 8110	82	64	E	Impact	MITE (kybd/prtr.)	10	ASCII	Coupler incl. 26 pounds	$2,400
Datel Thirty	57	88	E-M	Impact	Selectric (IBM)	15	BCD	Coupler incl.	$5,430
Dura-Model 1021	68	88	E-M	Impact	Selectric (IBM)	15	BCD	PTR/P & Card I/O	$4,000
Friden-7100	56	91	E	Impact	--	12.7	ASCII	Coupler incl.	$3,200
GE Terminet 300	74	94	E	Impact	--	10, 15, 30	ASCII	PTR/P	$3,400
IBM 1050	54	88	E-M	Impact	Selectric (IBM)	15	BCD	--	$3,100
IBM 2740/2741	54	88	E-M	Impact	Selectric (IBM)	15	BCD	--	$6,000
Kleinschmidt-311	51	64	E-M	Impact	--	40	ASCII	PTR/P	$4,800
Microdyne	56	88	E-M	Impact	Selectric (IBM)	15	BCD	Incr. MT	$5,000
Teletype Model 33	54	63	E-M	Impact	--	10	ASCII	PTR/P	$ 750
Teletype Model 35	56	63	E-M	Impact	--	10	ASCII	PTR/P	$2,000
Teletype Model 37	54	126	E-M	Impact	--	15	ASCII	PTR/P	$3,000
Terminal Equipment Corp. Tycom 20/20	55	63	E	Impact	Selectric (IBM)	15	ASCII	PTR/P	$4,000
Texas Instruments 720	102	95	E	Thermal	--	40	ASCII	Coupler incl.	$4,950
MITE Model 123	50	64	E-M	Impact	--	10	ASCII	Coupler Req	$ 600

KEYBOARD PRINTER TERMINALS
Table A-2

Manufacturer/ Model Number	No. of Keys	Printer Char. Set Size	Keyboard Technique	Printing Technique	Keyboard/ Printer Mfgr. (if bought out)	Trans-mission Rate (char/sec)	Trans-mission Code	Special Comments (options available, etc.)	Price
MITE Model 123	50	64	E-M	Impact	--	10	ASCII	Coupler req.	$ 600
INVAC (Digitronics) TR-200	54	88	E-M	Impact	Selectric (IBM)	15	BCD	Coupler req.	$1,800
ECCO 1656	54	88	E-M	Impact	Selectric (IBM)	15	ASCII	Coupler req.	$2,500
NOVAR 5-50	54	88	E-M	Impact	Selectric (IBM)	15	ASCII	Modem incl. MT opt.	$6,000
OMNITEC 800	50	63	E	Impact	--	10	ASCII	Coupler incl.	$1,490

Clarification of Terms Used in Table A-2

Keyboard Technique - whether the technique used to implement the keyboard is electronic (E) or electromechanical (E-M)

Printing Technique - the technique used to implement the printer.

Keyboard Printer Mfgr. - identification of the company that manufactures the keyboard printer if it is not manufactured by the terminal manufacturer. (A dash indicates that the terminal manufacturer also manufactures the keyboard printer used in the terminal).

Transmission Rate - the number of characters transmitted per second.

Transmission Code - the code in which data is transmitted to and from the terminal.

KEYBOARD PRINTER TERMINALS (continued)

Table A-2

disadvantages of teletype or electric typewriter terminals. These kinds of keyboard/printers usually offer higher speeds at higher costs.

Most users consider trade-offs on keyboard/printers in order of importance as:

1. Cost
2. Reliability
3. Speed

It is likely that 20 to 50 characters per second will be avilable with impact printers in the near future, but non-impact techniques will be required to achieve significant improvements in speed and reliability.

Non-impact thermal and electrostatic printers are higher in cost, form characters from a dot matrix, require special paper, and do not provide multiple copies; but they provide higher speed, are more reliable, and are quieter. They are presently suited to applications where quietness and higher speed are important, but use of these techniques in terminals is expected to become widespread as their cost drops with further development.

Computer Transceiver uses the NCR thermal printer (see Appendix D on Printers) in its terminal. This non-impact technique permits faster printing rates with fewer mechanical difficulties than in impact printers. The price of the special paper needed with thermal non-impact printers is quoted between 1¢ and 5¢ per 8-1/2 x 11 inch page.

Texas Instruments offers a Model 720 remote keyboard printer using a 5 x 7 dot matrix thermal printer. This terminal can handle data rates up to 40 characters per second. Incorporated in this terminal is an internal buffer memory (using LSI and MOS circuitry) which stores the keyboard data input by the operator until the CPU polls that terminal. This buffer also allows the user to erase the last character or line entered if desired. The thermal printer in this unit uses a 3M paper that now costs $3 for a 100 foot roll.

APPENDIX B

SUMMARY AND COMPARISON OF PRESENTLY AVAILABLE BADGE READERS

The characteristics of presently available badge readers and badge preparation units are presented in this Appendix.

During the past year many new companies have entered this field because of the urgent need for low cost, pocketable, machine readable cards, badges and tickets. The companies listed in Table B-1 manufacture either reading units or card preparation equipment. Major applications include personal identification for credit, ticketing and retailing. Some of the badge reader techniques (but not equipments) discussed in this Appendix are also possible candidates for use in PIN labeling and reading.

The primary characteristics of the products offered by these companies are listed and compared in Table B-1.

Encoding techniques in use and under development include large or small, round or rectangular punched holes, several types of magnetic techniques, optical coding, and machine readable embossing. In addition, two companies, Addo-X and Digital Identification Systems, make key-like devices. The maximum number of characters that can be encoded on one unit varies from 6 for the key-like units to 75 for magnetic stripe units. The size of the character set ranges from full ASCII to straight numeric.

A wide range of materials are used. Cards are made of paper, polyvinyl chloride, mylar and other types of durable plastics. Typically, the card size will be similar to the 2-1/8 x 3-3/8 inch credit card. The Addo-X plastic key is made from DuPont Delvin. Digital Identification Systems uses a small integrated circuit. Card prices vary with quantity and the technique used but are in the order of 10¢ to 20¢ per card.

Some companies such as Dasher Business Machines specialize in making

Company	Model	Encoding Method	Number of Char or Bits on One Card	Badge or Card Material
Addo-X Inc.	CPI-3100 Key	Notched Key	Max. 7 numeric	Delrin
American Computer and Communications	7090-A-210-1	IATA Magnetic Stripe	Max. 75 alphanumeric 8-bit ASCII	Plastic, 2 1/8 x 3 3/8" with Magnetic Stripe
	Docutel Reader	4-Track Magnetic	Max. 50 bits/inch	Plastic, 2 1/8 x 3 3/8" with Magnetic Stripe
	Accounting Terminal	2-Track Magnetic	Max. 40 bits/inch	2 1/8 x 3 3/8" with Magnetic Stripe
Amp Inc.	360 Series	Rectangular Holes	Max. 12 rows 22 columns, Hollerith	Plastic, 2 1/8 x 3 3/8"
Audac Corp.	Telephone Terminal	Optical Bar Code	Max. 61 4-bit Characters	Plastic, Laminated 2 1/8 x 3 3/8"
Control Data	0107	Rectangular Holes	Max. 12 rows 22 columns, Hollerith	Plastic, 2 1/8 x 3 3/8"
	1020 Series	Rectangular Holes	Max. 12 rows - 15, 22, or 80 columns Hollerith	Plastic, 2 1/8 x 3 3/8" and Full Tab Card Size
Credit Systems	440	Rectangular Holes Hollerith	Max. 12 rows 22 columns	Plastic, 2 1/8 x 3 3/8"
Data Pathing	1101	Rectangular Holes	Max. 12 Rows 22 columns, Hollerith	Plastic, 2 1/8 x 3 3/8"
Digital Identification Systems	Digi-Lock	Integrated Circuit	Max. 60 bits	"Key-type" Device Integrated Circuit mounted on 1-1/4" x 1-1/2" Etched Circuit Board

BADGE AND CARD READERS

Table B-1

Company	Type of Preparation Equipment	Reader Physical Characteristics	Interface	Price of Reader
Addo-X Inc.	Encoding (key cutter) Rental - $85/month Blank keys - $.05 Pre-cut-$.25	2-1/2" x 3/4" x 4"	Parallel Binary Output	$ 750
American Computer and Communications	IATA Credit Card Encoder (Service Bureau	Approx. 4.75" x 5" x4"	Char. Serial Bit Parallel	$2,650
	Encoder available ($8,500 est.)	Approx. 12" x 4" x 5"	Char. Serial Bit Parallel	$2,650
	Encoder available ($8,500 est.)	Approx. 4.75" x 5" x 12"	Char. Serial Bit Parallel	$300 - $400 (in quantities 200-300)
Amp Inc.	Service Bureau	Approx. 5.3" x 4.2" x 4.5"	Bit Parallel	
Audac Corporation	Standard Embossing Machine & Audac Optical Code Generator	Slightly Larger than an Ordinary Telephone	Direct Telephone Line Connection	
Control Data	Service Bureau	18" x 12-3/4" x 6-5/8"	Designed for Specific System	$1,590
	Service Bureau	18" x 12-3/4" x 6-5/8"	Designed for Specific System	$3,340
Credit Systems	Service Bureau	-----	Designed for Specific System	-----
Data Pathing	Service Bureau	Approx. 11.5" x 18" x 12.75"	2-Wire Serial Pulse Train	$2,300
Digital Identification	$300 for Unit that Encodes Key Blanks (Approx. $2 for blanks)	Approx. 3" x 1-1/2" x 5"	Serial Pulse Train or Bit Parallel	$100

BADGE AND CARD READERS

Table B-1 (continued)

Company	Model	Encoding Method	Number of Char or Bits on One Card	Badge or Card Material
Friden[1]	30 - Data Collection System	Rectangular Holes Hollerith	Max. 10 columns	Plastic, 2 1/8 x 3 3/8"
General Electric Oklahoma City	MRA 001	2 Circular Magnetic Tracks	22 7-bit ASCII Char per Track	3/4" Diameter Magnetic Patch
Hickok Electrical Instrument Co.	50	Round Holes	5 x 10, 8 x 10 matrix	Plastic, 1-1/2" x 3-3/4"
	264	Rectangular Holes Hollerith	12 rows, 22 columns	Plastic, 2 1/8 x 3 3/8"
IBM[1]	1035	Rectangular Holes Hollerith	Max. 12 rows 22 columns (Max. of 10 columns can be read, numeric only)	Plastic, 2 1/8 x 3 3/8"
Key Data Machines	Badge Reader	Rectangular Holes Hollerith	Max. 12 rows 96 columns (using new IBM card standard)	Plastic, 2 1/8 x 3 3/8"
Kimball Systems Div.	KR-20	Small Round Hole	Special 1-2-4-7 Code Max. 24 bits	Plastic, 1 1/2 x 3 3/4"
Sealectro Corporation	SCR-1012	Rectangular Holes Hollerith	Max. 12 rows 22 columns	Plastic, 2 1/8 x 3 3/8"
Synergistics		Magnetic (presence or absence, not conventional recording)	35 7-Bit Characters per inch, Max. 50	Plastic 2 1/8 x 3 3/8"

(1) Normally furnished as part of a complete system

BADGE AND CARD READERS

Table B-1 (continued)

Company	Type of Preparation Equipment	Reader Physical Characteristics	Interface	Price of Reader
Friden	Service Bureau	18" x 18" x 18"	Char. Serial Bit Parallel	$1,800
General Electric Oklahoma City	Reader available (Dashew Business Machines will provide units on order)	4-1/2" x 3-3/4" x 6"	Printed Circuit Connector Serial Pulse Train	Approx. $525 in small quantities
Hickok Electrical Instrument Co.	Service Bureau	4" x 4" x 5"	Bit Parallel	Approx. $195 (50 contact) Approx. $295 (80 contact)
	Service	3" x 5" x 4"	Char. Serial Bit Parallel	$250 est. ($100 for quantity)
IBM	Service Bureau	8" x 14" x 9-3/4"	Char. Serial Bit Parallel	$1,090
Key Data Machines	Service Bureau	Approx. 5" x 8" x 3"	Char. Serial Bit Parallel	$100 (1 - 10)
Kimball Systems	Service Bureau	Approx. 8" x 6" x 9"	Bit Serial	$350 (Small Quantities) $150 (1,000)
Sealectro Corporation	Service Bureau	Approx. 5-7/16" x 6-1/16" x 9"	Char. Serial Bit Parallel	$424
Synergistics	Service Bureau or Buy Equipment		Serial pulse Train	Approx. $350 (small quantities) Under $100 for 1000 units in 1971

BADGE AND CARD READERS

Table B-1 (continued)

Clarification of Terms Used in Table B-1

Encoding Method - the method used to encode the identification number or other data on the badge or card.

Type of Preparation Equipment - the type of equipment or other method used for preparing the badge or card--i.e., recording or encoding the data on the badge or card.

Physical Characteristics - the physical size of the reader.

Interface - the type of interface provided by the badge or card reader as seen from external equipment.

BADGE AND CARD READERS

TABLE B-1 (continued)

the equipment used to prepare the cards or badges. This equipment is sold or leased to large users. In addition, Dasher Business Machines will prepare cards to order for customers who do not own preparation equipment, offering nearly every encoding technique.

A wide variety of interfacing techniques are available. Many manufacturers are willing to build "specials" because their readers are frequently built into other equipment.

The oldest encoding technique is punched holes. The Hollerith code using rectangular holes is the most common. Large round holes are commonly used for industrial and outdoor applications. They have the advantages of wider environmental tolerance, more wear resistance and wider dimensional tolerance but the disadvantage of fewer characters per square inch. Kimball, who makes the familiar merchandise tickets uses small round holes.

Recently, several types of magnetic encoding techniques have been developed. Manufacturers claim the advantages of higher character packing density and greater difficulty in illegal copying.

The Air Transport Association has adopted the IATA magnetic stripe technique as their standard. In 2.7 inches, 75 eight-bit characters can be recorded at a density of 210 bits per inch. Companies manufacturing equipment to use this technique are actively encouraging other industries and users to adopt it. However, no information is available about wear, life, or reliability in an application like that for the Library of Congress. The possibility of intentionally or unintentionally damaging or destroying the recorded information with a strong magnetic field would pose problems also for the Library's application.

American Computer and Communications Company uses a four track magnetic stripe recording system differing from the IATA standard by having four tracks instead of one and a lower character packing density.

These changes substantially improve the reading reliability.

An optical code pattern made up of four types of bars is used by Audac Corporation. With this technique they can record 61 characters in a 3-inch space. The main advantages claimed are inexpensive preparation and reading equipment, great tolerance for wear, dirt, and mutilation.

Machine readable embossing is a widely used technique. Low encoding cost is one of the main advantages. The embossed card is frequently used to print the code on a sales slip which is then read optically.

An interesting encoding technique is used by Addo-X. A key made of DuPont Delvin is encoded with notices which can handle seven numeric digits. Extremely low encoding and terminal costs are claimed. Another "key-type" device is manufactured by Digital Identification Systems. The unit uses an integrated circuit. A binary encoding scheme is used presumably in the form of the layout of electrical conductors on the integrated circuit.

Optical character recognition techniques are also used now in some credit card readers, replacing bar codes in many applications. OCR techniques and equipments are discussed in Appendix E.

With the Hollerith and similar rectangular hole encoding schemes, the maximum number of characters on a 2-1/8" x 3-3/8" (standard sized credit card) is 22. Up to 24 characters can be handled by the Kimball Systems small round hole cards. The present Bell System Touch-Tone dialing cards can handle fourteen characters.

The IATA magnetic stripe technique allows up to 75 eight-bit ASCII characters. Forty characters can be handled by General Electric's Tradar System cards. Approximately 60 characters can be handled on a standard sized credit card using the optical bar technique.

The standard eight bit ASCII character set can be handled with the IATA magnetic stripe technique. Using the Hollerith encoding technique, a full alphanumeric set of 64 characters can be defined. Kimball Systems, with their small round hold encoding technique uses a modified binary code to handle a numeric character set. Both alphabetic and numeric characters can be provided by the optical encoding technique. The key device recently introduced by Addo-X handles only numeric information. Digital Identification Systems "integrated circuit key" uses a binary code which could encode alphabetic or numeric characters in a binary number.

Dasher Business Machines provides card preparation service to handle most types of encoding techniques. They are widely used by companies requiring small quantities of cards, a few thousand or less. Large users (e.g., credit card companies), will buy or lease the card preparation equipment from Dasher and other manufacturers.

If some less commonly used technique, such as optical or magnetic bar coding is selected, purchasing or leasing card preparation equipment would be required. Potter Instruments offers a system in which the magnetic bar code card or sheet can be prepared on a modified typewriter (see Appendix E). In this system each alphanumeric character typed has a code of dots typed above and below it by the same typewriter key and hammer using a magnetic ink ribbon. The reader then senses the presence or absence of the dots. The magnetic material is not "recorded"; it is merely present or absent.

Synergistics Inc. offers a magnetic system which depends only on the presence or absence of magnetic material. Groves are cut in a plastic card and then filled with magnetic material corresponding to the desired code. This approach is said to be less expensive and more durable than other approaches which rely on recording patterns on the magnetic material.

Another approach under development by Monarch Marking Systems uses either a pressure sensitive lable or a pin-on ticket which is round and has a hole in the middle. The hole is used to register a hand-held optical scanner that can read 18 characters of data encoded in radial bars. This approach using pressure sensitive labels may be applicable in the future to PIN labeling and reading, but the requirement for achieving registration by inserting a "centering" pin in the hole in the center of the label may preclude its use on the cover of the book. Also, nothing is known at this time about the wear or long-life qualities of a label of this type. For these reasons, and because it is not available at this time, this device is not included in Table B-1.

Minnesota Mining and Manufacturing Company makes a retroreflective material that will be used by Identicon Corporation to place a bar code on labels to be read by a device presently under development. This device is not included in Table B-1 since it is not available at this time.

APPENDIX C

SUMMARY AND COMPARISON OF PRESENTLY AVAILABLE ALPHANUMERIC AND SYMBOL DISPLAYS

The display terminals included in this Appendix are alphanumeric low-cost remote CRT terminals selling for less than $20,000. The costs used for these terminals and equipments are restricted to an operational unit on the remote end of a communications voice grade telephone line not including the modem. Since these devices all have to meet a standard interface requirement, namely the 232B, for operation over telephone lines there are a large number of independent companies offering these products in addition to the computer companies one would expect to offer display peripheral devices.

This Appendix includes all the alphanumeric displays offered at the time this report was written where the display characters are alphabetic, numeric, and special. These characters can be presented in any fashion on the CRT in a text format or, in some cases, in a random format. These types of CRT display terminals can be one way or two way in that information can be displayed only or the operator can employ some means of modifying, editing or changing the information displayed. This changing of information occurs via a keyboard associated with the CRT display terminal. Characteristics of available displays are shown on the next 15 pages (Table C-1).

Remote alphanumeric display terminals can be categorized in basically two ways: stand-alone and multi-station configurations. "Stand-alone" refers to one terminal at a remote location tied to a computer via a communication link whereas "multi-station" refers to more than one terminal at a particular location sharing storage and control logic. In the multi-station configuration a large controller is usually shared between the terminals at a site, but the stand-alone terminal includes its dedicated

Manufacturer/ Model No.	Displayable Char. Set Size	Max. No. of Display. Char.	Lines/ Screen	Char/ Line	Screen Size	Char Size	Char. Gen Technique	Cursor
A. B. Dick Videograph 990	64	768	16	48	Any TV	Ghar.	5 x 7 dot	Std.
Atlantic Tech. ATC 2000	64/96	1920	24	80	8 1/2 x 11	.12 x .18	Stroke	Blinking
Bolt Beranek & Newman Teleputer	64	500	25	20	3.1 x 3.1	.13 x .10	Stroke	no
Bunker Ramo 2206	62/92	960	12/24	80/80	8.75 x 6.25	.125 x .125	5 x 7 dot	Std.
Bunker Ramo 2223	62/92	960	12/24	80/80	8.75 x 6.25	.125 x .125	5 x 7 dot	Std.
Burroughs 9351/9352	64	960	25	80	12 x 9	.15 x .115	Stroke	Std.
Computer Comm. Inc. CC30	64/96	960	24	40	Any TV	Adj.	5 x 7 dot	Std.
Computer Terminal Corp. 3300	64	1800	25	72	9 x 6.25	.16 x .11	Mod TV Scan	Std.
Conrac Corp. 201	64	888	24	37	7.5 x 8.5	Adj.	5 x 7 dot	Std.
Control Data Corp 216	63	1000	20	50	8 x 6	.25 x .125	5 x 7 dot	Std.
Control Data Corp 217	63	1000	20	50	8 x 6	.25 x .125	5 x 7 dot	Std.
Courier Executerm I	64	512	15	40	6.4 x 4.8	.11 x .14	7 x 8 dot	Std.
Data Disc Inc. 6200	64/96	4080	48	85	Any TV	Adj.	5 x 7 dot	Std.
Delta Data Systems Corp. 1	64	960	24	40	Any TV	Adj.	5 x 7 dot	Std.
General Electric 760	64	1196	26	46	8 x 6.3	.16 x .12	5 x 7 dot	Std.
IBM Corp. 2260	64	960	6	40	10.5 x 9.5	.14 x .094	5 x 7 dot	Std.
IBM Corp. 2265	64	960	15	64	9 x 7.5	.178 x .126	Stroke	Std.
Spiras Systems Inc. IRASCOPE	63/96	1000	32	64	7 x 9.5	.13 x .10	Monoscope	Std.
National Cash Register 795	64	768	12	64	7.5 x 9.5	.12 x .09	Stroke	Std.

DISPLAY TERMINAL CHARACTERISTICS TABLE C-1

Manufacturer/Model No.	Cursor Controls (back, up, down, etc.)	Bright-ness	Contrast	Type of Memory	Memory Buffer Size (No. Char.)
A. B. Dick Videograph 990	3	Adj.	Adj.	core	1024
Atlantic Tech. ATC 2000	7	75	Adj.	delay line	1920
Bolt Beranek & Newman Teleputer	--	7	4:1	storage tube	--
Bunker Ramo 2206	5	Adj.	Adj.	delay line	1024
Bunker Ramo 2223	5	Adj.	Adj.	delay line	1024
Burroughs 9352	5	50	10:1	delay line	960
Computer Comm. Inc. CC30	6	Adj	Adj	core	1024
Computer Terminal Corp. 3300	6	75	12:1	MOS	1800
Conrac Corp. 201	6	50	Adj	delay line	1000
Control Data Corp 216	5	75	8:1	delay line	1000
Control Data Corp. 217	5	75	8:1	delay line	1000
Courier Executerm I	3	Adj	Adj	MOS	600
Data Disc Inc. 6200	5	Adj	Adj	disc	250K
Delta Data Systems Corp. 1	6	Adj	Adj	core	960
General Electric 760	6	Adj	Adj	delay line	2012
IBM Corp. 2260	5	Adj	Adj	delay line	960
IBM Corp. 2265	5	Adj	7:1	delay line	960
SpirasSystems Inc. IRASCOPE	5	Adj	Adj	delay line	1200
National Cash Register 795	8	30	Adj	delay line	1024

DISPLAY TERMINAL CHARACTERISTICS TABLE C-1 (continued)

Manufacturer/Model No.	Refresh Rate (frames/sec)	Character And/or Line Editing	Tab Feature	Split Screen Capability	Partial Transmit Capability
A. B. Dick Videograph 990	60	No.	No	No	No
Atlantic Tech. ATC 2000	60	Full	Yes	No	No
Bolt, Beranek & Newman Teleputer	--	No	No	No	No
Bunker Ramo 2206	54	Full	Yes	No	Yes
Bunker Ramo 2223	54	Full	Yes	No	Yes
Burroughs 9352	60	Partially	Yes	No	Yes
Computer Comm. Inc. CC30	60	Partially	Opt	Yes	Yes
Computer Terminal Corp. 3300	60	Partially	No	No	No
Conrac Corp. 201	60	Partially	Opt	No	No
Control Data Corp. 216	50	Partially	No	No	Yes
Control Data Corp. 217	50	Partially	No	No	Yes
Courier Executerm I	66	Partially	Yes	Yes	No
Data Disc Inc. 6200	30	Full	No	Yes	No
Delta Data Systems Corp. 1	60	Partially	Yes	No	Yes
General Electric 760	30	Partially	No	Yes	Yes
IBM Corp. 2260	30	Partially	No	No	No
IBM Corp. 2265	54	Partially	No	No	No
Spiras Systems Inc. IRASCOPE	60	Full	Yes	Yes	Yes
National Cash Register 795	46.5	Full	Yes	Yes	Yes

DISPLAY TERMINAL CHARACTERISTICS TABLE C-1 (continued)

Manufacturer/Model No.	Transmission Code	Modem Interface	Hard Copy Capability	Stand-Alone Terminals	
				Price	Monthly Rental Lease
A. B. Dick Videograph 990	ASCII	201A	Opt.	$8,300	N. A.
Atlantic Tech. ATC 2000	ASCII	201/202	No	$10,000	$365
Bolt, Beranek & Newman Teleputer	ASCII	201B	Opt	--	--
Bunker Ramo 2206	ASCII	200 Series	Opt	--	--
Bunker Ramo 2223	ASCII	200 Series	Opt	$8,600	$235
Burroughs 9352	ASCII	201/202	Opt	$ 8,775	$200
Computer Comm. Inc. CC30	ASCII	200 Series	Opt	$ 6,845	$215
Computer Terminal Corp. 3300	ASCII	200 Series	Opt	$ 4,500	$147
Conrac Corp. 201	ASCII	201A	No	$ 7,500	
Control Data Corp 216	BCD	200 Series	Opt	--	--
Control Data Corp. 217	BCD	200 Series	Opt	$12,000	$330
Courier Executerm I	ASCII	200 Series	Opt	$ 3,800	$150
Data Disc Inc. 6200	ASCII	201/202	Opt	--	--
Delta Data Systems Corp. 1	ASCII	200 Series	Opt	$ 6,600	$ 85
General Electric 760	ASCII	200 Series	Opt	$24,820	$620
IBM Corp. 2260	ASCII	201/202	Opt	--	--
IBM Corp. 2265	ASCII	201/202	Opt	$15,050	$380
Spiras Systems Inc. IRASCOPE	ASCII	200 Series	Opt	$ 5,995	$150
National Cash Register 795	ASCII	200 Series	Opt	--	--

DISPLAY TERMINAL CHARACTERISTICS TABLE C-1 (continued)

Manufacturer/Model No.	Multi-Station Terminals (Max. No. Terminals Per Controller) Maximum Number Terminals	Price of Full Complement	Mo. Rental/Lease Full Complement	Price/Terminal in Max. Config.	Rent/Lease Ter. in Max. Config.
A.B. Dick Videograph 990	--	--	--	--	--
Atlantic Tech. ATC 2000	4	$38,500	$ 1,050	$ 9625	$260
Bolt, Beranek & Newman Teleputer	32	$182,250	$ 6,080	$ 5,700	$190
Bunker Ramo 2206	9	$ 50,000	$ 1,500	$ 5,555	$166
Bunker Ramo 2223	--	--	--	--	--
Burroughs 9351/9352	16	$83,820	$ 1,905	$ 5,990	$122
Computer Comm. Inc. CC30	--	--	--	--	--
Computer Terminal Corp. 3300	--	--	--	--	--
Conrac Corp. 201	--	--	--	--	--
Control Data Corp. 216	12	$ 75,050	$ 2,345	$ 6,250	$195
Control Data Corp. 217	--	--	--	--	--
Courier Executerm I	--	--	--	--	--
Data Disc Inc. 6200	32	$121,000	$ 6,500	$ 3,781	$203
Delta Data Systems Corp. 1	--	--	--	--	--
General Electric 760	32	$101,240	$ 2,655	$ 3,160	$ 83
IBM Corp. 2260	24	$102,500	$ 2,189	$ 4,270	$ 91
IBM Corp. 2265	--	--	--	--	--
Spiras Systems Inc. IRASCOPE	--	--	--	--	--
National Cash Register 795	12	$ 66,850	$ 1,910	$ 5,560	$159

DISPLAY TERMINAL CHARACTERISTICS TABLE C-1 (continued)

Manufacturer/ Model No.	Displayable Char. Set Size	Max. No. of Display. Char.	Lines/ Screen	Char/ Line	Screen Size	Char Size	Char. Gen Technique	Cursor
Philco D22	64	512	16	32	18.4 x 13.8	.517 x .359	5 x 7 dot	Std.
Radiation 6603	63	1520	32	134	19" TV	.125 x .25	Stroke	Std.
Raytheon 402	64/96	1040	13	80	8.5 x 6.5	.17 x .14	Monoscope	Std.
R C A 70/750	64	1080	20	54	8 x 6	.14 x .10	Monoscope	Std.
R C A 70/752	64	1080	20	54	8 x 6	.14 x .10	Monoscope	Std.
Sanders 620	64	768	12	64	7.5 x 9.5	.13 x .08	Stroke	Std.
Sanders 720	64	1024	12	64	7.5 x 8.5	.13 x .08	Stroke	Std.
Stromberg Carlson 1110	64	1066	13	80	10 x 10	.13 x .07	Charactron	Std.
Trans Elect. Corp 560/565	64	1000	20	50	9 x 6.25	.15 x .115	Stroke	Std.
Ultronic 7000	64	960	12	80	7.4 x 10	.12 x .08	5 x 7 dot	Std.
Univac 100	64/96	960	16	64	5 x 10	.15 x .113	Stroke	Std.
Univac 300	56/61	1024	16	64	5 x 10	.15 x .113	Stroke	Std.
Wyle Laboratories Model 600	64	256	8	32	6 x 4.5	.28 x .14	Stroke	Std
Xerox Data Systems 7550/7555	96	2048	32	86	10 x 7	.125 x .125	Monoscope	Std.

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (Continued)

Manufacturer/Model No.	Cursor Controls (back, up, down, etc.)	Bright-ness	Contrast	Type of Memory	Memory Buffer Size (No. Char.)
Philco D22	4	75	15:1	core	2048
Radiation 6603	3	50	10:1	core	4096
Raytheon 402	7	50	Adj	delay line	1040
R C A 70/750	5	50	6:1	delay line	1080
R C A 70/752	5	50	6:1	delay line	1080
Sanders 620	5	30	Adj	delay line	768
Sanders 720	8	30	Adj	delay line	1024
Stromberg Carlson 1110	5	50	200:1	delay line	1111
Trans Elect. Corp. 560/565	5	Adj	Adj	core	1000
Ultronic 7000	5	Adj	Adj	delay line	960
Univac 100	7	50	10:1	core	1024
Univac 300	8	50	10:1	core	1024
Wyle Laboratories Model 600	1	Adj	Adj	core	1024
Xerox Data Systems 7550/7555	6	20	5:1	delay line	2048

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (Continued)

Manufacturer/Model No.	Refresh Rate (frames/sec)	Character And/or Line Editing	Tab Feature	Split Screen Capability	Partial Transmit Capability
Philco D22	60	Partially	Opt	No	Yes
Radiation 6603	60	Partially	No	No	No
Raytheon 402	67	Partially	Yes	Yes	Yes
R C A 70/750	60	Full	Yes	Yes	Yes
R C A 70/752	60	Full	Yes	Yes	Yes
Sanders 620	60	Full	Yes	No	Yes
Sanders 720	46.5	Full	Yes	Yes	Yes
Stromberg Carlson 1110	50	Full	No	Yes	Yes
Trans. Elect. Corp. 560/565	60	Full	No	No	Yes
Ultronic 7000	60	Full	Yes	No	No
Univac 100	60	Full	Yes	Yes	Yes
Univac 300	60	Full	Yes	Yes	Yes
Wyle Laboratories Model 600	40	Partially	No	Yes	No
Xerox Data Systems 7550/7555	50	Full	No	Yes	Yes

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (Continued)

Manufacturer/Model No.	Transmission Code	Modem Interface	Hard Copy Capability	Stand-Alone Terminals	
				Price	Monthly Rental Lease
Philco D22	ASCII	201/202	No	--	--
Radiation 6603	ASCII	200 Series	Opt	--	--
Raytheon 402	ASCII	201/202	Std	$ 6,000	$167
R C A 70/750	ASCII	200 Series	Opt	--	--
R C A 70/752	ASCII	200 Series	Opt	$ 8,325	$190
Sanders 620	ASCII	200 Series	Opt	$ 5,400	$180
Sanders 720	ASCII	200 Series	Opt	--	--
Stromberg Carlson 1110	ASCII	200 Series	Opt	$ 8,500	$250
Trans. Elect. Corp. 560/565	ASCII	200 Series	Opt	$ 5,868	N.A.
Ultronic 7000	ASCII	201/202	Opt	$ 4,980	$156
Univac 100	ASCII	200 Series	No	$ 4,000	$ 88
Univac 300	ASCII	201A	No	--	--
Wyle Laboratories Model 600	ASCII	202D	Opt	$ 5,000	N.A.
Xerox Data Systems 7550/7555	ASCII	202	Opt	$10,000/$12,500	$225/$285

N.A. - Not Announced/Not Available

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (Continued)

	Multi-Station Terminals (Max. No. Terminals Per Controller)				
Manufacturer/Model No.	Maximum Number Terminals	Price of Full Complement	Mo. Rental/Lease Full Complement	Price/Terminal in Max. Config.	Rent Lease Ter. in Max. Config.
Philco D22	7	N. A.	N. A.	--	--
Radiation 6603	16	$250,000	N.A.	$15,625	--
Raytheon 402	64	$307,840	N. A.	$ 4,800	--
R C A 70/750	48	$274,950	$ 5,850	$ 5,749	$122
R C A 70/752	--	--	--	--	--
Sanders 620	--	--	--	--	--
Sanders 720	12	$ 45,050	$ 1,330	$ 3,800	$120
Stromberg Carlson 1110	--	--	--	--	--
Trans. Elect. Corp. 560/565	16	$ 62,000	N. A.	$ 3,875	--
Ultronic 7000	--	--	--	--	--
Univac 100	--	--	--	--	--
Univac 300	48	$267,865	$ 8,330	$ 5,600	$173
Wyle Laboratories Model 600	--	--	--	--	--
Xerox Data Systems 7550/7555	--	--	--	--	--

N. A. - Not Announced/Not Available

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1(Continued)

Manufacturer/ Model No.	Displayable Char. Set Size	Max. No. of Display. Char.	Lines/ Screen	Char/ Line	Screen Size	Char Size	Char. Gen Technique	Cursor
Infoton KDT-1D	64	1,280	20	64	12"	.45 x .40	5 x 7 dot	Std.
Infoton KDT-2D	64	1,280	20	64	12"	.45 x .4	5 x 7 dot	Std.
Computer Terminals Inc. TK-360	64	448	7	64	11"	.5 x .5	5 x 7 dot	Std.
Courier Executerm 60	64	240/480	12	40	6.4 x 4.8	.11 x .14	7 x 9 dot	Std.
Video Systems Corp. VST-1000	64	1,296	18	72	12"	.25 x .17	5 x 7 dot	Std.
Alphameric Data Corp. DW-33	64	1,800	25	72	11"	.14 x .09	5 x 7 dot	Std.
Sugarman Laboratories Video T6	96	1,600	20	80	14"	Adj.	5 x 7 dot	Std.
Beehive Electrotech Alpha 101	64	800	20	40	11"	Adj.	5 x 7 dot	Std.
Lear Siegler, Inc. Model 810	64	640	20	32	12 x 9	.25 x .18	Stroke	No
Honeywell 2323	64	960	24	80	9 x 6.25	.25 x .125	5 x 7 dot	Std.
Honeywell 2322	64	960	24	80	9 x 6.25	.25 x .125	5 x 7 dot	Std.
RCA Digital Video	117	512	16	32	5.1 x 6.8	.16 x .14	TV Mod. Scan	Std.
Computer Displays, Inc. ARDS-100A	96	4,000	50	80	8.25 x 6.5	Adj.	7 x 9 dot	No
Computek Model 100	64	1,000	20	50	7 x 9.3	.14 x .19	7 x 9 dot	Std.
Computer Optics CO-70	88	3,000	30	100	9.5 x 7.5	.09 x .18	TV Mod. Scan	Std.
Computer Optics CO-75	88	3,000	30	100	9.5 x 7.5	.09 x .18	TV Mod. Scan	Std.
Computek Model 400/12	96	3,400	40	85	6.5 x 8.5	.06 x .11	Stroke	Std.

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (Continued)

Manufacturer/ Model No.	Cursor Control (back, up, down, via CPU, etc.)	Bright-ness	Contrast	Type of Memory	Memory Buffer Size (No. Char.)
Infoton KDT-lD	5	Adj	Adj	MOS	1,280
Infoton KDT-2D	5	Adj	Adj	MOS	1,280
Computer Terminals Inc. TK-360	6	Adj	Adj	Core	896
Courier Executerm 60	7	Adj	Adj	MOS	600
Video Systems Corp. VST-1000	5	Adj	Adj	delay line	1,296
Alphameric Data Corp. DW-33	3	Adj	Adj	delay line	2,000
Sugarman Laboratories Video T6	7	Adj	Adj	MOS	1,750
Beehive Electrotech Alpha 101	5	Adj	Adj	MOS	800
Lear Siegler, Inc. Model 810	--	Adj	Adj	core	1,024
Honeywell 2323	5	Adj	Adj	delay line	960
Honeywell 2322	5	Adj	Adj	delay line	960
RCA Digital Video	5	Adj	7:1/ 4:1	delay line	1,024
Computer Displays, Inc. ARDS - 100A	--	3	3:1	Storage tube	--
Computek Model 100	5	30	Adj	delay line	1,080
Computer Optics CO-70	4	Adj	Adj	delay line	3,000
Computer Optics CO-75	4	Adj	Adj	delay line	3,000
Computek Model 400/12	5	Adj.	Adj.	Storage tube	--

DISPLAY TERMINAL CHARACTERISTICS

TABLE C -1 (Continued)

Manufacturer/ Model No.	Refresh Rate (frames/sec)	Character and/or Line Editing	Tab Feature	Split Screen Capability	Partial Transmit Capability
Infoton KDT-1D	60	Partially	No	No	No
Infoton KDT-2D	60	Partially	No	No	No
Computer Terminals Inc. TK-360	60	Partially	No	No	No
Courier Executerm 60	66	Full	Yes	No	No
Video Systems Corp. VST-1000	60	Partially	No	No	No
Alphameric Data Corp. DW-33	60	Partially	No	No	No
Sugarman Laboratories Video T6	60	Full	Yes	No	No
Beehive Electrotech Alpha 101	60	Full	Yes	No	No
Lear Siegler, Inc. Model 810	60	No	No	No	No
Honeywell 2323	54	Full	Std.	No	No
Honeywell 2322	54	Full	Std.	No	No
RCA Digital Video	60	Full	Yes	No	No
Computer Displays, Inc. ARDS-100A	--	No	No	No	No
Computek Model 100	60	Full	Yes	Yes	No
Computer Optics CO-70	60	Full	Yes	Yes	Yes
Computer Optics CO-75	60	Full	Yes	Yes	Yes
Computek Model 400/12	--	No	No	No	No

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (Continued)

Manufacturer/ Model No.	Transmission Code	Modem Interface	Hard Copy Capability	Stand-Alone Terminals Price	Monthly Rental Lease
Infoton KDT-1D	ASCII	200 Series	Opt	$2,495	N.A.
Infoton KDT-2D	ASCII	200 Series	Opt	$2,995	N.A.
Computer Terminals Inc. TK - 360	ASCII	200 Series	Opt.	--	--
Courier Executerm 60	ASCII	200 Series	Opt	$5,500	N.A.
Video Systems Corp. VST - 1000	ASCII	201A	Opt	$3,990	N.A.
Alphameric Data Corp. DW - 33	ASCII	201/202	Opt	$3,500	N.A.
Sugarman Laboratories Video T6	ASCII	200 Series	Opt	$5,500	N.A.
Beehive Electrotech Alpha 101	ASCII	200 Series	Opt.	$3,495	N.A.
Lear Siegler, Inc. Model 810	ASCII	200 Series	No	--	--
Honeywell 2323	ASCII	201/202	Opt	$10,500	$230
Honeywell 2322	ASCII	201/202	Opt	--	--
RCA Digital Video	ASCII	200 Series	Opt	--	--
Computer Displays, Inc. ARDS -100A	ASCII	200 Series	Opt	$8,485	N.A.
Computek Model 100	ASCII	Yes	Opt	$5,700	N.A.
Computer Optics CO-70	ASCII	200 Series	Opt	$8,000	$200
Computer Optics CO-75	ASCII	200 Series	Opt	--	--
Computek Model 400/12	ASCII	200 Series	Opt	$7,400	N.A.

N.A. = Not announced or Not available

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (Continued)

Manufacturer/ Model No.	Maximum Number Terminals	Price of Full Complement	Mo. Rental/Lease Full Complement	Price/Terminal in Max. Config.	Rent/Lease Ter. in Max. Config.
	Multi-Station Terminals (Max. No. Terminals Per Controller)				
Infoton KDT-1D	--	--	--	--	--
Infoton KDT-2D	--	--	--	--	--
Computer Terminals, Inc. TK - 360	6	$20,000	$828	$3,340	$138
Courier Executerm 60	--	--	--	--	--
Video Systems Corp. VST - 1000	--	--	--	--	--
Alphameric Data Corp. DW - 33	--	--	--	--	--
Sugarman Laboratories Video T6	--	--	--	--	--
Beehive Electrotech Alpha 101	--	--	--	--	--
Lear Siegler, Inc. Model 810	12	N.A.	N.A.	--	--
Honeywell 2323	--	--	--	--	--
Honeywell 2322	18	N.A.	$1,692	--	$94
RCA Digital Video	14	$58,000	N.A.	$4,143	--
Computer Displays, Inc. ARDS -100A	--	--	--	--	--
Computek Model 100	--	--	--	--	--
Computer Optics CO-70	--	--	--	--	--
Computer Optics CO-75	32	$194,500	$4,870	$6,078	$152
Computek Model 400/12	8	$36,400	N.A.	$4,550	--

N.A. = Not announced or Not available

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (Continued)

Clarification of Terms Used in Table C-1

Displayable Char. Set Size - the size of the character set or number of different characters that can be displayed.

Max. No. of Display. Char. - the maximum number of characters that can be displayed on the screen at one time

Lines/Screen - the number of lines of characters displayed on the screen.

Char/Line - the number of characters displayed in each line.

Screen Size - the physical size of the viewing screen.

Char Size - the physical size of each individual character.

Char. Gen Technique - the technique used to generate the characters displayed on the screen.

Cursor - whether a cursor is available as a standard or optional item in the display terminal.

Cursor Control - the number of different controls provided for moving the cursor.

Brightness - whether the brightness is adjustable or fixed and if it is fixed, the number of ft'lumens.

Contrast - whether the contrast is adjustable or fixed and if it is fixed, the contrast ratio.

Type of Memory - the type of memory used for storing the displayed characters and refreshing the CRT screen.

Memory Buffer Size - the number of characters stored in the buffer or refresh memory.

Refresh Rate - the rate in frames per second at which the information displayed on the CRT screen is refreshed from the buffer memory.

Character and/or Line Editing - whether means are provided for editing individual characters and lines.

Tab Feature - whether the ability is provided to move the character position to certain tab locations.

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (continued)

Clarification of Terms Used in Table C-1 (continued)

Split Screen Capability - whether the ability is provided to display two different sets of information in different parts of the screen with the ability to control each set independently of the other.

Partial Transmit Capability - whether the ability to transmit only a portion of the displayed information is provided.

Transmission Code - the code in which data is transmitted to and from the terminal.

Modem Interface - the type of Bell system modem to which the terminal interfaces.

Hard Copy Capability - whether hard copy capability is available as an option.

Stand-Alone Terminals - a terminal that is capable of operating independently as a self-contained unit.

Multi-Station Terminals - terminals which cannot function independently as self-contained units but which require a controller that provides certain functions common to all of the terminals connected to it.

Maximum Number Terminals - the maximum number of terminals that can be connected to a single controller.

Price of Full Complement - the price of a full system including the controller and the maximum number of terminals that can be connected to the controller.

Mo. Rental/Lease Full Complement - the monthly rental or lease price including the controller and the maximum number of terminals that can be connected to the controller.

Price/Terminal in Max. Config. - the average price of a terminal in the maximum configuration including a prorated share of the controller costs.

Rent/Lease Ter. in Max. Config. - the average monthly rental or lease price per terminal including a prorated share of the controller costs.

DISPLAY TERMINAL CHARACTERISTICS

TABLE C-1 (continued)

buffer storage and controller. One should note however that some of these units can be configured either way with some equipment modifications. Both types of alphanumeric terminal configurations are included in the survey. Graphic CRT display terminals are not included in the survey.

The equipment characteristics presented in Table C-1 fall into the following five basic categories:

1. General Characteristics
2. Memory Specifications
3. Editing Features
4. Optional Features
5. Equipment Pricing

The table shows the purchase price and lease price both for stand-alone terminals and for multi-station configurations where one terminal price includes its prorated share of a controller in the maximum multi-station configuration prices. These prices supplied by the manufacturers are intended to include all the necessary equipment on the remote end of the communications link except the modem itself to make the display terminal operational. A reasonable effort was made to verify these figures but in all cases this cannot be guaranteed and they are subject to change without notice.

The general characteristics include the character set size, display size, characters per line, lines per display, maximum number of displayable characters, character size, brightness and contrast ratio. These are self-explanatory and well established specifications. The typical character set available today is 64 characters with 4 or 5 manufacturers offering the full 96 character ASCII set. These manufacturers are offering the 96 character set to provide upper and lower case capability since some users seem to want this additional feature, but usually at little or no additional expense. Hence, in order to be more competitive, a few manufacturers have offered that capability. By the latter part of 1970 most CRT display manufacturers will probably offer this 96 character set as a standard optional capability. Typically, 1000 is the maximum number of displayable characters on the viewing screen, but some CRT terminals are available with up to 4000 character screens. By mid-1971 most manufacturers foresee screen capacities up to and including 2000 displayable characters as the trend in alphanumeric CRT displays.

Ease in formatting the display is dependent upon the maximum number of characters that can be stored and displayed in relation to the maximum number of character positions on the screen. One of the basic limitations of larger screen sizes is an electronic circuitry problem arising because of the larger currents or voltages required to deflect the electronic beam across the screen at high speed. This results in higher costs and thus puts limits on screen size. Display size is given in inches for heighth and width respectively and character size is given in inches for the heighth and width respectively.

The character generator techniques used with these types of terminals is one of the following: a 5 x 7 dot matrix, a stroke method, or monoscope. Many trade-offs are involved in the selection of the appropriate technique to meet the overall specifications. The important considerations include character generation rate, number of character types, the complexity and quality of characters, and the number of displays being driven by the character generator. In the 5 x 7 dot matrix method characters are written by brightening the proper combination of spots within the 5 x 7 dot matrix. Character generation rates can be increased in this method by limiting the number of dots used to make up these characters but the character quality will not be as clear as with other techniques. A unique approach which overcomes this limitation typical of dot matrix implementations was developed at MIT on the Intrex Project. Instead of incrementing the beam to each position before intensification, the new Intrex generator selectively intensifies a 750 KHZ sinusoidal signal. This method uses a phased-locked signal to provide a nine (column) by thirteen (row) element array which gives excellent character definition. In this technique a 5 x 7 dot matrix of information is stored and is expanded to the 9 x 13 matrix according to a set of rules.

By going to a larger dot matrix, for example 7 x 10 or 9 x 13, one can generate a satisfactory character representation for the extended Roman alphabet 176 character set. This might be better done by using the stroke method which allows even more freedom in implementing each character. In the stroke method, each stroke is generated from a voltage matrix network which provides a time variable voltage to drive the appropriate deflection circuitry. This method is usually better than the matrix method for generating complex symbols, although the character generation rate is slower.

The monoscope generates each character via an image drawn in ink on a target anode. This technique also produces quality characters but at a slower character generation rate. The CHARACTRON tube made by Stromberg Carlson uses a special technique whereby the characters are generated through a metal electrode in which the 64 character set is etched by a shaped electron beam. This method produces a very legible and distinct print like image on the CRT.

The refresh rate used to maintain a flicker-free viewing screen for all of the CRT displays is included in the characteristics. The type of refresh memory, either magnetic core, MOS or delay lines, is also shown. The size of the memory relates directly to the maximum number of displayable characters and how the memory is organized internally. One efficient method called non-spacial organization requires memory capacity only for the displayed characters plus some control characters.

This eliminates the need for memory to store all blank character positions which can be more efficiently stored by just using the proper control characters. One alternative method for storage in a CRT terminal not using core or delay line memory is the use of a storage tube CRT. A storage tube retains the image on the face plate for several minutes and this saves the cost of an internal memory, but editing of alphanumeric data is cumbersome. It requires special software programs for identifying, deleting, and inserting characters displayed on the screen. Whenever the user wishes to make a correction, he does so through a special function key. The non-storing cursor is used to identify the characters to be edited by a directional control on the keyboard.

Editing capability is a very important feature on any interactive user oriented display terminal. For some requirements the display terminal will be used by the Library of Congress as an information inquiry device but in other situations a large amount of text or data manipulation will be required. Most units in this survey were rated as having either partial or full edit capability for doing operations related to correction, modification, and deletion of certain portions of material presented on the CRT. Each device incorporates a cursor of one type or another which indicates the character position which an operator is editing. Control keys are usually included on the keyboard layout to allow the operator to position the cursor for data manipulation at various positions or locations on the screen. In addition to providing full editing capabilities several of these terminals provide horizontal and vertical tabulation which allows the operator to set specified stops. Some units also provide a line erase feature and a line insertion feature which allows the operator to selectively insert characters in a line of data.

Other features sometimes useful in various applications are partial transmit which allows transmission of a selected portion of the total display screen in contrast to having the whole display screen transmitted. Split screen capability allows retention of previously displayed information while new information is being entered or received. With this means one can be prevented from modifying formatted data as such.

Probably the most important option available on a CRT display terminal in terms of the Library of Congress needs is that of some type of hard copy capability for information and data displayed on the CRT. In many instances an auxiliary printer can be added to provide this permanent method of recording data. Such units typically are low speed teleprinters or typewriters. Hard copy capability is not necessary for all the information displayed on the CRT, but usually only for that generated after several editing steps--i.e., the final copy. This hard copy capability extends the flexibility of the display system and permits other conventional data communications tasks to be performed concurrently.

Since remote terminals imply transmission of information, the units included in this survey are all available with standard telephone line communications interface either to a telephone company or other manufacturer's modem. Practically all the terminals surveyed in this Appendix use the ASCII character code format for data communication. The ASCII code is considered to be the accepted standard throughout the industry now, particularly in government installations.

Human factors considerations are important in display design, including factors such as eye fatigue, legibility, screen background color, size of characters and size of screen. The latter two characteristics are determined largely by the number of characters that must be displayed and the viewing distance from the operator to the screen.

Eye fatigue can be considered a function of parameters such as flicker, brightness, contrast and visual acuity. There is little definitive experience with alphanumeric CRTs in this regard and no published information could be found on eye fatigue while viewing alphanumeric displays. Since brightness and contrast are usually controllable by the operator, there is little difference in eye fatigue between different commercial displays which are flicker free. A light green-yellow screen background is somewhat easier on the eye, but this can be adjusted by filters in front of the screen.

Legibility of displayed characters is difficult to evaluate because the term "legibility" has a wide latitude of meaning to different people. The character font that gives the best reading performance by the operator is usually said to be the most legible. Studies have been made to investigate how operator performance depends on brightness, contrast ratio, character size and style, character spacing and other qualities. The results relate "legibility" to reading ease, reading time and reading error, but no definition or specification of legibility is given--only the claim that certain character fonts are better than others. Even this varies with different operators. In general, more "legible" characters can be generated with TV raster scan, charactron, and monoscope techniques than with dot matrix or stroke techniques.

APPENDIX D

SUMMARY AND COMPARISON OF PRESENTLY AVAILABLE REMOTE PRINTERS

In this Appendix a survey of remote printer terminals including both line and character printers is presented. Table D-1 summarizes the more important characteristics of available remote printers for generating hard copy. The line printers, which are much faster than character serial printers, print one line of data at a time. The printing speed is independent of the number of characters printed on each line but is dependent on the number of columns (or printable character postions per line) and the total number of character types that can be printed. Character printers are designed to print one character at a time horizontally across the paper. Printing speed for character serial printers is in direct proportion to the number of characters printed and control actions that must be taken by the printing device. Typical of the control actions used are the space, back space, upper and lower case, etc. Character serial printers are also discussed to some extent in Appendix A under "Keyboard/Printers".

In general, printing techniques consist of impact printing and non-impact printing. Impact techniques are used in the majority of digital printers today. The impact printer mechanism must selectively present a character type face from a character set to the desired position on the paper. This is done character at a time in the character printer and line at a time in the line printer. The way in which the character set is made selective usually determines the speed and printing technique limitations. In general, impact printers easily make multiple copies while non-impact printers do not.

Impact printers are usually electromechanical while non-impact printers use a variety of technologies, such as electrostatic, thermal, ink jet, etc. Within these categories there are several subdivisions according to the printing and operating principles and technologies involved.

Manufacturer/ Model Number	Type of Printer (Char/ line)	Printable Character Set Size	Printer Speed (lines/min char/sec)	Printing Technique	Number of Columns	Physical Size (width, depth heighth)	Communi-cations Interface (std., opt.)	Price
SERIAL PRINTERS:								
Codamite 771	char	63	10 cps	special	80	20.375x19.875 x 6	opt.	$ 1,800
Gulton Industries LG 10/30	char	64	30 cps	wheel	132	28x29.2x35	opt.	$ 5,500
IBM 2770 Model 2213	char	63	66 cps	7x9 wire matrix	132	23.75x26.5x17	opt.	$ 4,600
AB Dick Videojet 960	char	64	250 cps	ink jet 9x11 matrix	136	24.5x16.375 x 36.75	std.	$ 7,000
NCR EM-TI	char	96	30 cps	thermal 5x7 matrix	80	12.5x7.25x4.88	opt.	$ 1,650
Tally	char	64	60 cps	special	120	34x24x46	opt.	$ 6,000
Teletype Inktronic	char	62	120 cps	ink jet 8x10 matrix	80	18x27x47.75	std.	$ 5,500
Univac 0769	char	63	30 cps	wheel	132	27.25x18x9	opt.	$ 2,800
Computer Terminals Inc. LP-210	char	64	250 cps	ink jet	136	24.5x29.75x36.75	std.	$ 7,500
Motorola MTP-6000	char	63	320 cps	electrostatic 5x7 matrix	80	17x18x10.125	opt.	$ 3,850
DRUM PRINTERS:								
CDC 9340	line	64	300 lpm	drum	132	46x25x44	opt.	$15,000
Data Printer Corp. F-80	line	64	600 lpm	drum	80	18.125x16.25 x 12	opt.	$ 8,250
Data Printer Corp. F-132	line	64	600 lpm	drum	132	23.75x16.25x12	opt.	$ 9,860
Data Products DT-8280	line	64	356 lpm	drum	80	24x22x24	std.	$17,100
Data Products 2410	line	64	245 lpm	drum	132	48.5x24x46	opt.	$11,900

HARD COPY DEVICES (REMOTE PRINTERS)

TABLE D-1

Manufacturer/ Model Number	Type of Printer (Char/ line)	Printable Character Set Size	Printer Speed (lines/min char/sec)	Printing Technique	Number of Columns	Physical Size (width, depth heighth)	Communi-cations Interface (std., opt.)	Price
NCR 740-501	line	64	250 lpm	drum	132	39x24.5x48	opt.	$20,000
Digitronics 4021	line	64	292 lpm	drum	120	44x30x48	std.	$42,420
G.E. I-541	line	64	100 lpm	drum	136	26.5x14x28.25	opt.	$ 8,000
G.E. 105 RTS	line	64	250 lpm	drum	120	46.5x26.5x51.5	std.	$56,670
Honeywell MBP-12	line	64	300 lpm	drum	132	45x30x45.5	opt.	$12,000
Mohawk Data Sciences 4013	line	64	300 lpm	drum	120	39x24.5x48	opt.	$11,500
Vogue Shepard 400A	line	128	600 lpm	drum	80	41x29x47.5	opt.	$14,250
Vogue Shepard 400B	line	128	600 lpm	drum	132	46x29x47.5	opt.	$17,850
Vogue Shepard 880C	line	64	600 lpm	drum	80	20.5x16x36.5	opt.	$10,500
OTHER TYPE PRINTERS:								
Datamark, Inc. Series 700	line	64	300 lpm	oscillating bar	132	45.5x22.5x43	std.	$14,500
IBM 2780 Model 3	line	63	200 lpm	type bar	80	42x26.75x47.5	std.	$32,010
Clevite 4800	line	64	4800 lpm	electrostatic	75	21x14x39	opt.	$19,000
Nortec	line	128	100 lpm	belt	132	22.5x20x9.5	opt.	$ 9,800
CHAIN PRINTERS:								
Mohawk Data Sciences 4330	line	128	162 lpm	chain	136	40.5x29.25x48	opt.	$ 9,500
CDC 9360	line	288	245 lpm	chain (train)	132	62x28x50	std.	$75,000
IBM 1403	line	240	140 lpm	chain	132	46x28x50	std.	$126,000
Potter HSP-3502	line	192	170 lpm	chain	132	45.125x30.875x 49.875	opt.	$11,220

HARD COPY DEVICES (REMOTE PRINTERS)
TABLE D-1 (continued)

Clarification of Terms Used in Table D-1

Type of Printer - whether the printer is character serial or line printer.

Printable Character Set Size - the size of the character set or the number of different types of characters that can be printed.

Printer Speed - the speed of the printer in characters per second or lines per minute.

Printing Technique - the technique used for printing.

Number of Columns - the maximum number of columns that can be printed across the width of the page.

Physical Size - the physical dimensions of the printer.

Communications Interface - whether a communications interface is provided as standard equipment or is optional.

HARD COPY DEVICES (REMOTE PRINTERS)

TABLE D-1 (Continued)

Typical non-impact types include dot matrix printers (both electrograph and thermograph) and ink jet printers. The NCR EM-T1 printer is typical of this approach. A single print head is used to print one character at a time over an 80 column print line. The print head contains a 5 x 7 dot matrix and the characters are formed by heating selected elements of the matrix and bringing the head into contact with the heat sensitive paper.

Motorola uses an electrographic technique in which an electric pulse applied to a stylus in contact with the paper causes a change to take place on the paper's surface in the form of a dark dot. Electrical pulses from the printing heads instantly mark the dry current sensitive paper. As the print head is moved across the paper, it receives five sequential sets of seven parallel pulses to form a 5 x 7 dot matrix.

Line printers available today are capable of printing line lengths (i.e., columns) of 80 to 160 characters with type fonts of 64 characters or more. These units and their important characteristics are included in Table D-1. Strip and half page (i.e., 32 columns or less) printers are not included in this survey because these types of printers are primarily used in data logging or monitoring functions.

The printer characteristics used in this survey related to the use of printers in a data entry or communication terminal. Any trade-off analyses with respect to printer characteristics must include the printer line speed which is a function of the number of columns (or character positions) per line and the number of characters in the character set. The size of the character set determines the speed because it takes a finite amount of time to present each character in the set to the print position when moving font techniques are involved, thus the larger the character set the slower the speed. Typically the speed of line printers range from 100 to 1200 lines per minute although even higher speed line printers are available. Within the next few years speeds will probably be pushed up to 2000 lines per minute.

The interface between the printer and the data source is another very important consideration. Input data formatting, timing, and device control must be examined along with the electrical and mechanical interface problems. For example, a serial printer receiving parallel data requires a buffer interface. The timing considerations must include the formatting and conversion of data to synchronize with the print cycle.

Line printers that are commercially available today are of the electro-mechanical impact type. There are two major types of impact line printers--drum printers and chain printers.

In drum printers the print font is on a continuously revolving drum with one or more hammers impacting it "on the fly" while the drum moves. An inked ribbon and the paper are interposed between the hammers and the print drum. In this type all the characters in the set are available to each print position so that a properly timed firing of a hammer will print the selected character. Recent research in electromechanical drum printers has been directed toward time-sharing hammers to reduce hammer and hammer driver cost. This is done by separating the type used for odd and even columns in a manner such that a hammer with a head two columns wide is first fired to print the odd columns and then to print the even columns. This technique allows 60 hammers and hammer drives to print 120 columns.

Chain printers are much like drum printers in that an inked ribbon is interposed between the type font and the face of the paper, and the character to be printed is selected by firing a hammer against the back of the paper or the ribbon when the selected character reaches that hammer position. Chain printers require characters to be carried on a flexible band, which must be routed around pulleys of fairly large diameter to avoid excessive stresses in the band.

Research on chain printers has been directed toward reducing the cost of type font and allowing field changes in the type font. Mohawk Data Sciences (Anelex) recently announced a new low cost chain printer (Model 4330) which has both a 136 column line and a 128 character set.

It sells for $9,500 with buffer.

Table D-1 also includes other printers that do not fit in the drum and chain categories--e.g., oscillating bars or belts for font and hammer selection, dot matrix designs where the character is made dot at a time by either multiple impacts of a single hammer or by impacts of multiple hammers, and electrostatic techniques.

A recent announcement in this field is the Model 2213 matrix printer which is part of the IBM 2770 modular remote terminal. This character serial matrix printer, which is capable of 66 characters per second, utilizes a mechanism for impressing a 9 x 7 dot matrix to form characters. The dots are formed by the ends of wires which are moved forward by energy supplied from an actuator. The printing occurs when the wires forming the character are fired against the paper through an inked ribbon.

A Philips subsidiary in West Germany announced it has developed a 90 character per second character serial print-out device. This high speed typeless print technique uses a vertical line of magnet-actuated printing pins to form alphanumeric characters as patterns of dots on a raster field. One significant advantage of this printing technique is that it can produce all kinds of characters, including Roman hieroglyphs or Chinese ideograms provided the character generating circuitry is programmed accordingly. Sufficient information is not available to include this in Table D-1.

Codamite offers a low cost remote receive only impact printer terminal which uses digital step motors for type font and hammer indexing. The font is behind the paper and the hammer impacts a ribbon in front of the font. The font translates and rotates simultaneously but is stationary at the instant of printing. This unit is said to require very little maintenance and no lubrication.

The Teletype Inktronic utilizes a fine spray of fast-drying ink directed against a roll or sheet or ordinary paper to achieve a 120 characters per second speed. In present technology, the ink source is moved horizontally across the paper to determine character position and the ink is electrostatically deflected in order to "draw" characters. The principle used is much the same as that achieved in a cathode-ray-tube by the electron beam being deflected to draw characters on the face of the tube. The number of moving parts required for a spray printer is reduced to a minimum and includes only the paper transport, which is required for all printing devices, and the spray positioner.

A.B. Dick offers an ink-stream communication terminal printer which has a speed of 250 cps. In contrast to Teletype's Inktronic keyboard/printer terminal (which employs 40 stationary nozzles each printing two characters) the Videojet 960 uses one nozzle driven in a horizontal plane. The movement of the nozzle provides horizontal deflection of the ink droplets and high voltage plates provide vertical deflection.

Conventional electromechanical character serial printers are also discussed further in Appendix A under "Keyboard/Printers".

APPENDIX E

SUMMARY AND COMPARISON OF PRESENTLY AVAILABLE MACHINE READABLE UNIT DOCUMENT DEVICES

This Appendix on Machine Readable Unit Document Devices covers the characteristics of the three major types of devices available today for this function -- Optical and Magnetic Character Recognition Equipment and Optical Mark Sense Readers. The characteristics of presently available devices of these types are presented in Table E-1. Some of the techniques discussed here may be applicable to PIN Labels as well as Machine Readable Unit Documents. Since Section 3.8 points out that punched card equipment that both punches and prints on the card are more expensive than devices using other techniques discussed here and offer no significant advantage, conventional card punches and readers are not included in this Appendix.

The first technique to be widely used commercially was Magnetic Ink Character Readers (MICR). They are extensively used in the banking industry. A special font style, defined by the American Bankers Association, is used. The character set consists of ten numerals and four special symbols. No alpha characters are allowed. Disadvantages of MICR are lack of alpha characters and difficulty of human readability.

Optical character Recognition Equipment (OCR) is in use and is being actively developed for many commercial applications. It has the advantages that a full alphanumeric character set can be handled (although numeric only sets are frequently used for lower cost) and the font style is more easily human readable. The main disadvantage is high cost; although recent development of remote terminal readers will greatly reduce the cost by sharing central control and recognition logic and circuitry among a number of remote readers. The major present commercial application of OCR is in handling documents such as credit card receipts. However, applications also extend to full size pages. In fact, OCR is being used in some applications for reading full pages of typed information as a way of generating computer input data in lieu of conventional keypunching.

Name of Company	Equipment Model	Document Feed Type	Document Transport Type	Document Size (Inches)	Documents Per Minute	Reader Scanner Type	Recognition Type
Burroughs	B102 & B103 Sorter-Reader	Friction	Conveyor Belt	Length:5.94-9.06 Width:2.69-4.06	1,000 to 1,565	Magnetic	Analog Wave-form Matching
	B9134-1 Reader-Sorter	Friction	Conveyor Belt and Roller	Length:5.94-9.06 Width:2.69-4.06	1,625 Max.	Magnetic or Optical	Matrix Matching
Control Data Corporation, Rabinow Div.	915 Page Reader	Vacuum	Conveyor Belt	Length:2.5 to 14 Width: 4 to 12	Max. 180 for 8.5 x 11"	Optical Parallel Photocells	Matrix Matching
	935-1/935-2 Document	Vacuum	Belt and Roller	Length:2.25-8.5 Width:3.00-5.50	200 Max.	Optical Parallel Photocells	Matrix Matching
	Remote Terminal Reader			Paper: Length:4.87-11.12 Width:3.25-12.62 Cards: Length:4.87-8.5 Width:3.25-5.5 (Optional) (Journal) Single Line Document	Approx. 400		
Farrington Electronics, Inc.	3010 Document Reader	Vacuum	Drive Rollers	Card Stock: From:2.2 x 2.75 to: 8.5 x 6.0 Documents: From:2.625 x 2.75 to: 8.5 x 6.0	Max. 440	Optical Mechanical Disc	Stroke Analysis
	3020 Self-Punch	Vacuum	Drive Rollers	Standard Tab Cards: 51 or 80 Columns	Max. 500	Optical Mechanical Disc	Stroke Analysis
	3030 Page Reader	Vacuum	Drive Rollers	From:4.5 x 5.5 to: 8.5 x 14	(1)	Optical Mechanical Disc	Stroke Analysis

(1) Dependent upon number of lines and fields within lines to be read

OPTICAL AND MAGNETIC CHARACTER RECOGNITION
EQUIPMENT AND MARK SENSE READERS

TABLE E-1

Name of Company	Equipment Model	Type Font	Character Set	Reading Speed (ch./sec.)	First Installation	Approximate Base Price
Burroughs	B102 & B103 Sorter-Reader	E-13B CMC-7	Numerals, Four Special Characters	Max. 3,200	1960	$ 91,000
	B9134-1	E-13B CMC-7 USASC OCR-B	Numerals, Four Symbols (Five Symbols OCR-B)	2,400 (MICR) 3,000 (OCR)	Late 1969 (MICR) 1970 (OCR)	$ 96,000 $ 80,400
Control Data Corporation, Rabinow Div.	915 Page Reader	USASC	Alphanumerics Punctuation	Max. 370	1965	$110,000
	935-1/935-2 Document	USASC (935-1) USASC, 1428, 407-1, 1428E, Selfchek 12F, 7B, Mark Sense (935-2)	Numerals, Three Symbols (935-2 reads USASC Alphanumerics)	Max. 750	1969	
	Remote Terminal Reader	USASCOCR - 48 ch. (Optional) (USASCOCR-58 ch.) (USASCOCR-Lower Case) (Hand Print) (NOF)	Alphanumeric Special Symbols	Approx. 740		
		USASI OCR	Alphanumeric	15		$ 3,000 for 300 Units
Farrington Electronics, Inc.	3010 Document Reader	Selfchek 7B, 12F and/or Selfchek 12L IBM 407, IBM1428 USASC	Alphanumerics, Punctuation Marks, Special Symbols	Max. 400	1967	$ 2,920 R (rental
	3020 Self-Punch	Selfchek 7B, 7BR, 12F and 12L IBM 1428 USASC	Numerals Special Symbols Punctuation	Max. 600	1969	$ 2,635 R (rental
	3030 Page Reader	Selfchek 12F and/or Selfchek 12L, USASC	Alphanumerics, Punctuation Marks Special Symbols	Max. 400	1967	$ 3,625 R (rental

OPTICAL AND MAGNETIC CHARACTER RECOGNITION EQUIPMENT AND MARK SENSE READERS TABLE E-1 (continued)

Name of Company	Equipment Model	Document Feed Type	Document Transport Type	Document Size (Inches)	Documents Per Minute	Reader Scanner Type	Recognition Type
Farrington Electronics, Inc. (Cont'd.)	3050 Page Reader	Vacuum	Drive Rollers	From: 4.5 x 5.5 to: 8.5 x 13.5	(1)	Optical Mechanical Disc	Stroke Analysis
	4040 Journal Tape Reader	Tape Spool	Vacuum Conveyor	Length: to 350 ft. Width: 1.31-4.5	6,000 lpm	Flying Spot Scanner	Stroke Analysis
General Electric	MRS-200/205	Friction + Vacuum	Conveyor Belt	Length: 5.25-9.0 Width: 2.5-4.15	Max. 1,200	Magnetic or Optical	Analog Wave-form Analysis (MICR) Inbuilt Code (OCR)
	DRD-200	Friction + Vacuum	Conveyor Belt	Length: 3.5-8.5 Width: 2.5-4.19	1,200	Optical	Inbuilt Code
GE/Bull	MDR-100	Friction	Belt	Length: 2.35-8.75 Width: 2.75-4.5	300-650	Magnetic	Inbuilt Code
Honeywell	H-243	Vacuum	Conveyor Belt	Length: 3 x 3.5 Width: 4 x 8	1,100	Optical Photo Cells	Matrix Matching
IBM	IBM 1412	Friction	Conveyor Belt	Length: 6-8.75 Width: 2.75-3.66	Max. 950	Magnetic	Matrix Matching
	IBM 1418 I and II	Friction	Vacuum Drum and Conveyor Belt	Length: 5.875-8.75 Width: 2.75-3.67	Max. 420	Optical Mechanical Disc	Matrix Matching
	IBM 1419 Model I	Friction	Conveyor Belt	Length: 6 - 8.75 Width: 2.75-3.67	Max. 1,600	Magnetic	Matrix Matching
	IBM 1428 I, II, & III	Friction	Vacuum Drum and Conveyor Belt	From: 3.5-2.25 to: 8.75 x 4.25	Max. 400	Optical Mechanical Disc	Matrix Matching
	IBM 1282	Friction	Card	51 or 80 Column Cards	Max. 200	Optical	Matrix Matching
	IBM 1285	Tape Spool	Tape	Journal Rolls Width: 1.31-3.5 Length: 36" to 200'	Max. 2,000 lpm	CRT Scanner	Matrix Matching

(1) Dependent upon number of lines and fields within lines to be read

OPTICAL AND MAGNETIC CHARACTER RECOGNITION EQUIPMENT
AND MARK SENSE READERS

TABLE E-1 (Continued)

Name of Company	Equipment Model	Type Font	Character Set	Reading Speed (ch. /sec.)	First Installation	Approximate Base Price
Farrington Electronics, Inc. (Cont'd.)	3050 Page Reader	Selfchek 12L or OCR-A Only (either, not both)	Alphanumerics Special Symbols Punctuation Marks	Max. 400	1969	$ 2,345 R (renta
	4040 Journal Tape Reader	Selfchek 7B or 12F IBM 1428, NOF, USASC	Numerals Special Symbols Limited Punctuation	Max. 2,000	1969	$ 3,150 R (renta
General Electric	MRS-200/205	E13B, CMC-7, COC-5	Numerals, Limited Symbols	Max. 2,400		$ 2,080 R (renta
	DRD-200	COC-5	Numerals, One Symbol	2,400		$ 1,200 R (renta
GE/Bull	MDR-100	CMC-7	Alphanumerics Limited Symbols	Max. 700		
Honeywell	H-243	USASI-OCR Type A	Numeric, Special Symbols	1,100		$ 67,300
IBM	IBM 1412	E-13B	Numerals, Four Special Symbols	Max. 1,600	1960	$ 91,400
	IBM 1418 I and II	IBM 407-1 Font or 407-E-1	Numerals, Special Symbols	Max. 500	1962	$120,300
	IBM 1419 Model I	E-13B	Numerals, Four Special Symbols	Max. 2,112	1962	$110,500
	IBM 1428 I, II, and III	IBM 1428	Alphanumerics, Symbols	Max. 480	1963	$138,600
	IBM 1282	1428E, Farrington Selfchek	Numerals Three Symbols	N/O	1964	$ 72,000
	IBM 1285	1428-NOF	Numerals Seven Symbols	Max. 365	1966	$ 84,000

OPTICAL AND MAGNETIC CHARACTER RECOGNITION EQUIPMENT AND MARK SENSE READERS TABLE E-1 (continued)

Name of Company	Equipment Model	Document Feed Type	Document Transport Type	Document Size (Inches)	Documents Per Minute	Reader Scanner Type	Recognition Type
IBM (Cont'd)	IBM 1287	Friction + Tape Spool	Belt and Roller	Max. 5.91 x 9.00 Min. 2.25 x 3.00 Journal Rolls 1.31 to 4.5 x 36" to 200'	(1) Max. 750 (Doc.) Max. 3,400 lpm (J.T.)	Optical CRT Scanner	Curve Tracing Matrix Matching
	IBM 1288	Friction	Belt and Roller	3" x 6.5" to 9" x 14"	(1) Max. 444	Optical CRT	Curve Tracing Matrix Matching
National Cash Register Co.	420-2	Automatic Tape Spooling Device	Tape	Journal Rolls Width: 1.31 x 3.25 Length: 10 to 1560"	52 lines per sec.	Optical Mechanical Disc	Inbuilt Code
	670-101 Sorter-Reader	Friction	Conveyor Belt	Length: 5.8 to 8.75 Width: 2.5 to 3.85	Max. 600	Magnetic	Analog Wave-form Matching
	671-101 Sorter-Reader	Friction	Conveyor Belt	Length: 4 to 8.75 Width: 2.75 to 4.5	1,200	Magnetic	Matrix Matching
Optical Scanning Corporation	Opscan 288	Vacuum	Conveyor Belt	Length: 3.5 to 8.5 Width: 2.5 to 4.5	1,200	Optical, Parallel Photocells	Matrix and Feature Matching
Philco	General Purpose Print Reader	Vacuum	Conveyor Belt	From 5 x 7 to 8.5 x 11	180	Optical, Flying Spot Scanner	Matrix Matching
	P6600	Customer Supplied	Customer Supplied	------	600	Multiple Remote Vidicon (Max. 30)	Matrix Matching
	P6700	Microfilm	Film Reel	35 mm. x 100'	N.A.	Flying Spot Scanner	Matrix Matching

(1) Dependent upon number of lines and fields within lines to be read

OPTICAL AND MAGNETIC CHARACTER RECOGNITION
EQUIPMENT AND MARK SENSE READERS

TABLE E-1 (continued)

Name of Company	Equipment Model	Type Font	Character Set	Reading Speed (ch./sec.)	First Installation	Approximate Base Price
IBM (Cont'd)	IBM 1287	Handprinted Numerals + 5 Alpha, 1428, Selfchek 7B, USASC NOF, 3/16" Selected Gothics	Numerals, Special Symbols, Mark Sense, Upper Case Alphabetics	Max. 2,000	1968	$126,000
	IBM 1288	Handprinted Numerals + 5 Alpha, USASC, NOF 1428, Selfchek 7B, 3/16" Selected Gothics	Upper Case Alphabetics Special Symbols Mark Sense Numerals	Max. 1,800	1970	$230,000
National Cash Register Company	420-2	NOF	Numerals, Special Symbols	Max. 1,664		$ 80,000
	670-101 Sorter-Reader	E13B	Numerals, Four Special Symbols	Max. 1,200		$ 45,000
	671-101 Sorter-Reader	E13B, CMC-7	Numerals, Special Symbols	Max, 3,200		$117,500
Optical Scanning Corporation	Opscan	Handprinted Characters USASC, Mark Sense, 1428, Selfchek 7B	Numerals + 6 Alpha, Two Symbols	Max. 800	1969	$100,000
Philco	General Purpose Print Reader	Multiple Type Fonts	Alphanumerics, Punctuation Special Symbols	Max. 1,000	1965	$300,000
	P6600	Futura, 1403	Numerals, Dash and Slash	Max. 1,000	1969	$ 80,000 Base
	P6700	Customer Selected	Alphanumeric	Max. 300	1969	

OPTICAL AND MAGNETIC CHARACTER RECOGNITION
EQUIPMENT AND MARK SENSE READERS

TABLE E-1 (Continued)

Name of Company	Equipment Model	Document Feed Type	Document Transport Type	Document Size (Inches)	Documents Per Minute	Reader Scanner Type	Recognition Type
Recognition Equipment, Incorporated	Electronic Retina Document Reader	Vacuum	Conveyor Belt	Length: 3.25 to 8.75 Width: 3.25 to 4.75	1,200	Optical Photocell Matrix	Matrix Matching
	Electronic Retina Rapid Index Page Reader	Vacuum	Belt and Roller	Length: 3.25 to 14 Width: 4.88 to 14	Max. 30	Optical Photocell Matrix	Matrix Matching
Scan Data	100/300 Page Reader	Vacuum	Conveyor Belt	8.5 x 11	(1)	Optical Flying Spot Scanner	Feature Analysis
	200 Page Reader	Vacuum	Conveyor Belt	8.5 x 11	(1)	Optical Flying Spot Scanner	Feature Analysis
Hewlett-Packard	2760A/2761A	Friction	Drive Rollers	3.25"x 7.375"	Max. 250	Optical Parallel Photocells	Hollerith Code
Motorola	MDR Series	Friction	Drive Rollers	Min. 4.875" in Reading Area - No limit on length Will transport full 8.5" wide pages	Max. 16	Optical Parallel Photocells	Hollerith Code
Potter Instruments Company	MCR 8000	Mechanical Picker	Roller	3.25 x 7.375" 3.3 x 2.65	300 1,500	Magnetic	Bar Code

(1) Dependent upon number of lines and fields within lines to be read

OPTICAL AND MAGNETIC CHARACTER RECOGNITION EQUIPMENT
AND MARK SENSE READERS

TABLE E-1 (continued)

Name of Company	Equipment Model	Type Font	Character Set	Reading Speed (ch./sec.)	First Installation	Approximate Base Price
Recognition Equipment, Incorporated	Electronic Retina Document Reader	Handprint, Multiple Type Fonts, Mark Sense	Alphanumerics, Punctuation, Special Symbols	Max. 2,400	1964	$730,000
	Electronic Retina Rapid Index Page Reader	Handprint, Multiple Type Fonts, Mark Sense	Alphanumerics, Punctuation, Special Symbols	Max. 2,400	1964	$740,000
Scan Data	100/300 Page Reader	Handprint, Multiple Type Fonts	Alphanumerics, Punctuation, Special Symbols	Max. 600	1968	$400,000
	200 Page Reader	USASC, OCR-B, 1403, Selected Typewriter Handprint	Alphanumerics Punctuation, Special Symbols	Max. 600	1969	$175,000
Hewlett-Packard	2760A/ 2761A	Mark Sense Pencil or Punched Holes	64 Char. Hollerith 64 Char. Dial Codes Available	Max. 105	1967	$ 3,000
Motorola	MDR Series	Mark Sense Pencil or Punched Holes	EBC DIC USASCII PIIC/BCD	Max. 105	1968	$ 4,890
~~Potter~~ Instruments Company	MGR 8000	Any	Up to 256	3,500 6,000	-----	-----

OPTICAL AND MAGNETIC CHARACTER RECOGNITION EQUIPMENT AND MARK SENSE READERS

TABLE E-1 (continued)

Note: Much of the material in the above tables was taken from: "Optical Character Recognition - A Survey," by P. L. Andersson, Datamation, July 1969, pp. 43-48.

Clarification of Terms Used in Table E-1

Document Feed Type - the method used for feeding documents into the reader.

Document Transport Type - the method used for transporting documents through the reader.

Document Size - the size in inches of documents that can be handled by the reader.

Documents Per Minute - the rate at which documents are handled by the reader.

Scanner Type - the method and technique used for scanning the characters or marks to be read.

Recognition Type - the method or technique used for identifying and recognizing the characters.

Type Font - the type font which can be read or recognized.

Character Set - the character set which can be read or recognized.

Reading Speed - the speed at which characters are read.

First Installation - the year in which the equipment was first installed in field use.

OPTICAL AND MAGNETIC CHARACTER RECOGNITION
EQUIPMENT MARK SENSE READERS

TABLE E-1 (continued)

The third technique covered here involves readers that can detect ordinary pencil marks (or in some cases printed marks or bar codes) made in specific locations on pre-printed forms. The most common application is where fixed data is to be stored on the same form as manually entered data. Some readers of this type mark sense data as well as punched data. The best applications are those which involve a relatively small amount of data. One of the main advantages of the Optical Mark Sense Reader is that it can be used as a Computer Terminal at a cost that is low compared to conventional OCR and MICR equipment.

MICR

Most MICR equipment in use today reads the highly stylized font specified for the banking industry by the American Bankers Association. The characters are printed with magnetic ink. The pick-up or reading device is a magnetic head. This technique is not sensitive to overprinting by pen or pencil. The size of the American Bankers Association character set is limited to ten numerals and four special symbols. A 41 character set defined by the CMC-7 Magnetic Font is used in Europe but very little in the United States. CMC-7 characters are made up of bars.

Another approach is used by Potter Instruments for MICR. It consists of a special bar code that is printed simultaneously with conventional human readable characters. Since each character has eight bars or bits up to 256 characters can be defined. However, when error detecting techniques are added the more practical limit appears to be 81 characters. Preparation equipment for the Potter approach may be either a printer or a typewriter in which the print slugs contain the bar code above and below each human readable character. Potter feels this technique will allow production of readers in the $10,000 price range. Another advantage is that document preparation equipment costs will be much lower than for American Bankers Association MICR font since more conventional equipment can be used.

OCR

OCR equipment is usually classed by the type of paper handling, document or page, and by the font or fonts that can be read. Three types of documents can be handled:

1. Document Readers

   Size is typically less than normal 8-1/2" by 11". The number of lines that can be read are usually small - i. e., 1, 2, or 3. The transport is designed to handle high document rates (up to 30/second).

2. Page Readers

   Size is typically 8-1/2" by 11" or legal size, 8-1/2" by 14". All lines on the page can be read. Although the character reading rate may be as high as for document readers, the average paper handling rate is usually much lower.

3. Journal Tape Readers

   These handle the normal roll-type tapes from cash register or adding machines.

Some machines incorporate more than one type of document transport.

The most common type font for OCR is the USASI font proposed by the Bureau of Standards and adopted by the American Standards Association. It includes the upper case English alphabet, ten numerals and twenty special symbols. Most machines in use today can read the USASI-OCR font. Another commonly used font is the Farrington self-check font.

Machines that can handle only one of the stylized fonts are called single font machines. Those that can handle more than one are called multifont machines. One well known pioneer in the OCR field, Jacob C. Rabinow, classifies OCR equipment by font and by application as follows:

1. Fixed-Font -- "Turn-around" documents printed by or for the OCR user himself, such as bank checks, subscription blanks, bills, credit card slips, notices, documents generated by card imprinters, typewriters, high speed printers and other printing equipment. In addition to turn-around documents, fixed-font applications include the reading of journal tapes, message forms, and "internally" generated records of business and government.

2. Multifont -- Documents generated in a large enterprise that has more than one type of printing equipment, documents with several fonts selected from a large multitude of fonts, situations where the reading machine can have its fonts changed to fit the documents.

3. Handprint Readers -- Unconstrained printing such as found on mail envelopes (for example, the Toshiba machine in Japan, which reads a form of zip code) and semi-constrained readers such as built by IBM, CDC, Recognition Equipment, and others. In semi-constrained hand printing, the characters have to be printed in "boxes" and can be well formed. Such machines generally read only numerals and perhaps three or four alphabetic characters. At the present time there are no machines that can read unconstrained script.

Many companies are developing or have announced machines that will read handprinted characters. The most commercially successful unit is the

IBM 1287 document reader. It employs the technique of small circular scan curve tracing. If the stored pattern fits, within the prescribed tolerance, the machine will identify the character correctly. Cost of these machines appears to be directly related to the constraints that are placed on the "quality" of the handprinting.

Due to the high cost of OCR equipment, there is a strong movement to develop remote time-shared readers. Recognition Equipment Incorporated has announced the Remote Time-Sharing Retina. Control Data is discussing their model X with potential large users. It will sell for approximately $3,000 in large quantities. One company, Cognitronics Corporation, which is very active in remote optical character recognition, is not included in Table E-1 because they do not sell their equipment except under special conditions. They are in the "service bureau" business. Cognitronics quotes the rental of their remote scanner at $250/month plus $175/month for a bandwidth saving device plus a service charge proportional to the amount and type of data converted to computer language. A facsimile type remote scanner is used to transmit the document to the central "service bureau" where it is reproduced and read optically.

Optical Mark Sense Readers

The earliest optical readers were mark sense readers that detected the presence or absence of a pencil or "special pencil" mark in a prescribed box. Early applications concentrated on test scoring. IBM was a pioneer in this field.

Recently two companies, Hewlett Packard and Motorola, have concentrated on marketing terminal devices that handle pencil marked pre-printed forms. The equipment offered reads the cards or documents, encodes the information and transmits it over voice grade telephone lines to a central computer.

The real benefits offered by the Hewlett Packard and Motorola units depend on the ingenuity of form design. Both units will handle "IBM card size" documents. The Motorola unit will also handle normal page-sized paper with a 4.875 inch edge reserved for optical marking.

The best application for Optical Mark Sense documents are where pre-printed or pre-punched fixed information must be handled in addition to some quantity of variable information. For example, the fixed information could be printed for human use or in Hollerith punched code for machine reading or a combination of both. The variable information is entered as pencil marks on the prescribed area of the particular form. Purchase prices of this type of equipment range from approximately $3,000 to $5,000. Lease plans are also available. The interface can be through ordinary telephone lines to the central computer.

Printed bar codes can also be read with optical mark sense techniques. This approach is discussed in Appendix B also.

A relatively new line of equipment offer by INTERMEC is not included in the Table E-1 because it cannot be directly compared with the other devices in that Table. This line of equipment called "Dual Image Recording" appears to have been designed originally as a replacement for punched paper tape but has wider applications. In this equipment as each human readable character is printed a coded character consisting of dots and bars is printed vertically below it. These characters are printed on a strip of paper somewhat similar in appearance to conventional punched paper tape before it is punched. This equipment can record up to 128 character types at a rate of up to 75 characters per second. The equipment for reading these strips of paper tape can read at rates of up to 100 characters per second or 120 characters per second asynchronously. The equipment can run the tape in either direction and can record 50,000 characters on a 5" reel of paper tape. A simple keyboard and printer combination costs between $1,750 and $2,700 while a reader cost between $1,000 and $1,500. Because of the paper strip approach this equipment may not be directly applicable to terminal requirements for the Library of Congress but the same technique applied to pages could be appropriate.

APPENDIX F

SUMMARY AND COMPARISON OF PRESENTLY AVAILABLE TAPE DEVICES FOR MACHINE READABLE MEDIA

Because of the very wide application areas in which remote terminals are now being used, the demand for inexpensive data storage and entry over telephone lines is increasing. The need for lower cost storage to be used with minicomputers has also become very apparent in the last year or two. Costs of presently used paper tape punch/reader units are well below $1,000, but these are limited in performance. When the cost of intermediate magnetic tape storage drops to become competitive with punched paper tape, applications which were previously not practical suddenly become very promising.

Tables F-1 and F-2 compare the characteristics of available magnetic tape devices of types suitable for the Library's applications. The equipments included in this survey of magnetic tape storage devices are divided into three classifications:

1. Magnetic tape cassette
2. Magnetic tape cartridge
3. Incremental magnetic tape

The IBM MTST unit which provides magnetic tape storage in conjunction with a selectric typewriter was reviewed but not included because it does not meet the performance capabilities or cost objectives needed in these terminal applications. This device has had wide business acceptance and it is typically an off-line text editing and reproducing device for a typist.

The other type of equipment not included in this survey is the keyboard to computer compatible magnetic tape units which are primarily used as key-punch replacements. One keyboard to magnetic tape unit, however, deserves serious consideration because it offers a 256 character set. In addition to the standard selectric keyboard, they offer a function panel and auxiliary keyboard which allows the user to select characters from this large character set. The standard typewriter keyboard provides 102 input codes with the auxiliary keyboard capable of 94 more input codes for a total of 196 codes.

Manufacturer/ Model Number	Type of Unit	Number of Tape Units	Number of Read/Write Heads	Buffer Size (No. of Char.)	Transfer Rate (bytes Per Second)	Tape Transport Speed (ips)	Recording Density (bpi)	Price
Tri-Data 4096	cartridge (endless loop)	4	4	Variable	636	10	600	$5,000*
International Computer Products	Phillips cassette	2	2	Variable	300	5	550	$2,500
Sykes - Compu/Corder	cassette (reel to reel)	1	Single	2	500	5	1,000	$2,950*
DICOM-100 Series	Phillips cassette	1	Single	Variable	500	10	550	$1,125
Computer Terminal Corporation 3300T	Phillips cassette	1	Single	100	300	1-7/8	1,200	$2,250
Cipher Data Products	cassette (reel to reel)	1	Dual	Variable	600	6	1,600	$1,050**
Universal Data Acquisition Co., Inc. Twindek 5800	cassette (reel to reel)	2	2	--	110	Incremental	400	$2,450

MAGNETIC TAPE CASSETTES AND CARTRIDGES

(MACHINE READABLE MEDIA)

TABLE F-1

* Includes interface to mini-computer and software driver

** Price does not include power supplies

Manufacturer/ Model No.	Track Format	Recording Speed (Asynchronous Chars/Second)	Rec. Density (bits per inch)	Reel Size (in.)	Price
Cipher Data Products					
Model 70H	7/9	0-300	200/556	7	$2-3K
Model 85H	7/9	0-600	200/556/800	8 1/2	$2.5-3.5K
Model 100	7/9	0-1000	200/556/800	10 1/2	$3-4K
Digi-Data					
Series 1400	7/9	0-200	200/556/800	10 1/2	$3.2-6K
Series 1300	7/9	0-500	200/556/800	8 1/2	$2.1-4.3K
Series 1500	7/9	0-500	200/556/800	10 1/2	$2.5-4.7K
Kennedy Co.					
Model 1600	7	0-500	200/556	8 1/2	$2.7-4.5K
Model 1610	7	0-500	200/556/800	10	$3.5-4.8K
Model 1600/360	9	0-750-1500	200/556	8 1/2	$3.9-5.2K
Model 1610/360	9	0-750-1500	200/556/800	10	$4.7-6.0K
Peripheral Equipment Corp.					
Series 1000	7/9	0-700	200/556/800	8 1/2	$4-6.5K
Series 2000	7/9	0-1000	200/556/800	10 1/2	$4.5-7K
Precision Instruments					
Model PI-1387	7	0-200	200	7	$2.4K
Model PI-1207	7	0-600	200/556/800	10 1/2	$6K
Model PI-1209	9	0-600	200/556/800	10 1/2	$7.5K

INCREMENTAL MAGNETIC TAPE RECORDERS

(MACHINE READABLE MEDIA)

TABLE F-2

Clarification of Terms Used in Table F-1

Type of Unit - whether the unit uses a cartridge or a cassette.

Number of Tape Units - the number of individual tape units included in one device.

Number of Read/Write Heads - the number of read/write heads included in a device.

Buffer Size - the number of characters contained in the buffer included in the device.

Transfer Rate - the number of bytes per second transferred to or from the device.

Tape Transport Speed - the rate at which tape is moved through the device in inches per second.

Recording Density - the density in bits per inch in which information is recorded in a single track on the tape.

Clarification of Terms Used in Table F-2

Track Format - whether the device reads and writes 7 or 9 tracks in parallel.

Recording Speed - the rate in characters per second at which information is recorded. Since incremental magnetic tape records are asynchronous a range from 0 to the maximum value is shown.

Rec. Density - the density in bits per inch in which information is recorded in a single track on the tape.

Reel Size - the diameter of a reel of magnetic tape that the device can handle.

TABLES F-1 AND F-2 (Continued)

Cassettes and Cartridges

The tape cassettes included in this survey are reel-to-reel cassette devices. Some of the manufacturers design their own tape transport while others use the Norelco tape transport. The Norelco type cassette was not originally intended to be used as a digital storage device and it does not have bi-directional fast stop/start capability. The tolerance variations in the cassette are substantial. There are manual tolerances and skew angles which can cause edge wear and rubbing problems. These all contribute to a reliability problem for digital recording along with the fact that the thin tape used in audio tape cassettes to get larger data storage capacities can cause several tape handling problems in the tape transport.

Reliable bi-directional and high performance operation must be achieved in order for the tape cassette recorder to be acceptable in computer applications. Either the cassette itself must be improved or the transport mechanism must be designed to overcome these deficiencies. Certified 1-1/2 mil computer tape has been added to conventional tape cassette devices. Since several manufacturers are working in this area, there is a good chance that the standard Norelco type tape cassette may be upgraded for digital applications requiring higher performance in reliability. However, its suitability at present is questionable.

In application such as inputting of keyboard data, which is done in an incremental or asynchronous fashion, there has been a great deal of interest in incremental tape cassette drives. To date, two manufacturers say that they plan to have incremental tape transport capability with their cassettes, but they do not presently offer it. The trend towards incremental operation may not materialize because of the low cost of buffer storage which is continually coming down in price. This will make continuous tape drives much more practical and lower cost. The appropriate buffer size can be tailored to the application at hand to permit writing records on the tape in a continuous manner.

The magnetic cartridge device, which has a different type of enclosure than the device, has gained considerable consumer attention with an endless loop tape recorder technique applied to this tape drive. The cost is reduced by virtue of the fact that the endless loop device allows all the driving to be done by one motor and the tape is pulled off the center of the reel and onto the outside. It is not bi-directional.

The recording techniques on cassettes and cartridges are basically one of two types: phase encoding which places both clock and data on a single track, thereby producing simplicity, and the non-return to zero (NRZ) recording technique which requires two tracks since NRZ data is not self-clocking. When the single track head is used with phase encoding, recording costs are less than for the dual track head. Since skew problems can occur with more than one track, the packing density is substantially reduced for multi-track heads and tapes. Final consideration must be given to means of error detection and correction. The dual gap (read-after-write head) provides the user with absolute certainty of the data being properly recorded on the tape. Read-after-write allows the user to do a check on the data immediately after it is written to assure himself that the data is correct. The other method employed is to not detect errors but to provide redundancy on the tape through dual tracks. With dual tracks one must use more complicated error correction schemes including vertical and longitudinal parity checks.

Incremental

The strongest advantage in using incremental magnetic tape recorders as opposed to cassette/cartridge units is the fact that the tape is written in a computer compatible fashion on standardized reels of 1/2" wide computer tape. This recorder tape is indistinguishable from the tape produced by conventional computer transport in both physical appearance and the format. It is recorded at densities of 200, 556, and 800 bits per inch, including normal beginning of block and end of block marks and end of record gaps. The major advantage in using incremental tape is not having to make a conversion from the tape cassette to a computer grade tape format as would be necessary with tape cassette cartridge units; thus, time savings and efficiency in terms of getting information into the computer.

When fairly large amounts of data are to be recorded for entry into the system, a one thousand foot reel of paper tape has approximately one hundred thousand character capacity whereas a one hundred foot reel of incremental magnetic tape is able to record 9.6 million characters at 556 bits per inch. Note that both reels are about the same diameter because of the greater thickness of paper tape.

APPENDIX G

SUMMARY AND COMPARISON OF PRESENTLY AVAILABLE SMALL COMPUTERS

The emphasis in the survey of small computers in this study is primarily for their potential use as controllers in tying together different terminal modules that the Library of Congress will require in several areas within the CBS. Small computers will be used primarily to provide functions (e.g., storage) common to several terminals and to interface to the communications link and format the data for remote entry into the computer system with the central computer system.

This survey and Table G-1 covers all of the available low cost computers offered in the marketplace at the time this report was written but new entries are appearing all the time. The small computers included in this Appendix are restricted to low cost units selling for less than $25,000. The price information included in this table is meant to include all of the equipment necessary to make an operational system suitable for interfacing to the communications link but not including the modem.

The prime reasons for using small computers in the terminal controller application are:

1. Low cost
2. Programmable flexibility. Read-only memories and other protective techniques are available once the controller design is frozen.
3. Versatility of these units to interface with various modules both electrically and from a functional standpoint.
4. Previous use of small computers in other terminal configurations indicates their usefulness and minimizes the engineering development cost as opposed to designing from scratch special-purpose controllers to do the same job.

		CPU FEATURES				
Manufacturer/ Model Number	R/O Memory (std, opt, no)	Instruction Word Length(s)	No. Acc. (or Gen. Purp. Registers that can be used as Accumulators	No. Hdwr. Reg. not including Index Registers	No. Index Reg. (hdwr., memory or other)	Indirect Addressing (multi-level, single-level, no)
Computer Automation 216/816	no	16	1	6	1 hardware	multi-level
Data General Nova	yes	16	4	10	2 hardware 16 memory	multi-level
Data Mate Computer Systems 16	no	16	2	6	1 hardware	multi-level
Redcor RC-70	no	16/32	1	5	1 memory	single-level
GRI Computer Co 909	opt.	16	1	4	1 auto index	single-level
Hewlett Packard 2114A/2114B	no	16	2	7	none	multi-level
Hewlett Packard 2115A	no	16	2	7	none	multi-level
Honeywell H-316	no	16	2	4	1 hardware	multi-level
Honeywell DDP-416	no	16/32	1	4	none	multi-level
Information Tech, Inc. ITI-4900 (Model 20)	no	16/32	8	16	6 hardware	multi-level
Interdata Model 2	yes	16	16 memory	--	15 memory	no
Interdata Model 3	yes	16/32	16	18	15	no
Interdata Model 4	yes	16/32	16	33	15	no
Lockheed Electronics MAC-16	no	16	1	6	4 memory	multi-level
Raytheon 703	no	16	1	6	1 hardware	no
Raytheon 704	no	16	1	6	1 hardware	no
Raytheon 706	no	16	1	6	1 hardware	no

SMALL COMPUTER CHARACTERISTICS TABLE G-1

Manufacturer/ Model Number	MEMORY CHARACTERISTICS Cycle Time (us)	Word Length (bits)	Minimum Size (words)	Increment Size (words)	Maximum Size (words)	Parity Check (std, opt, no)	Protect (std, opt, no)
Computer Automation 216/816	2.6/8	16	4K	4K	16K	no	no
Data General Nova	2.6	16	1K	1K, 2K, 4K	32K	no	no
Data Mate Computer Systems 16	1.0	16	4K	4K	32K	opt.	std.
Redcor RC-70	.860	18	4K	4K	16K	std.	std.
GRI Computer Co. 909	1.76	16	1K	1K, 4K	32K	no	no
Hewlett-Packard 2114A /2114B	2.0	16	4K	4K	8K	opt.	no
Hewlett Packard 2115A	2.0	16	4K	4K	8K	opt.	opt.
Honeywell H-316	1.6	16	4K	4K	16K	no	no
Honeywell DDP-416	0.96	16	4K	4K	16K	opt.	opt.
Information Tech, Inc ITI-4900 (Model 20)	0.975/ 1.75	16	4K	4K	32K	opt.	opt.
Interdata Model 2	3.0	16	1K	1K	2K	opt.	opt.
Interdata Model 3	.980/ 1.5	16	2K	2K, 4K	32K	opt.	opt.
Interdata Model 4	.980/ 1.5	16	2K	2K, 4K	32K	opt.	opt.
Lockheed Electronics MAC-16	1	16	4K	4K	65K	opt.	opt.
Raytheon 703	1.75	16	4K	4K	32K	no	no
Raytheon 704	1.5	16	4K	4K	16K	no	no
Raytheon 706	0.9	16	4K	4K	32K	opt.	opt.

SMALL COMPUTER CHARACTERISTICS TABLE G-1 (Continued)

Manufacturer/ Model No.	I / O CAPABILITY Data Path Width (bits)	Direct Memory Access (DMA) Channel (std, opt, no)	Max. DMA Word Transfer Rate	No. External Priority Interrupt Levels in Basic System	Max. No. External Interrupts	OTHER FEATURES Power Failure & Automatic Restart (std, opt, no)	Real-time Clock or Internal timer (std, opt, no)
Computer Automation 216/816	8/ 16	std	125 KHZ	3	256	opt	opt
Data General Nova	16	std	312 KHZ	16	62	std	opt
Data Mate Computer Systems 16	16	opt	1 MHZ	8	64	std	opt
Redcor RC-70	16	opt	1. 1 MHZ	1	32	opt	opt
GRI Computer Co 909	16	std	570 KHZ	16	64	std	opt
Hewlett Packard 2114A/2114B	16	no/yes	--/500 KHZ	8	56	opt	opt
Hewlett Packard 2115A	16	opt	500 KHZ	8	40	opt	opt
Honeywell H-316	16	opt	1 MHZ	2	50	std	opt
Honeywell DDP-416	16	opt	1 MHZ	2	48	std	opt
Information Tech. Inc. ITI-4900 (Model 20)	16	opt	1 MHZ	8	256	opt	opt
Interdata Model 2	8	no	--	2	256	opt	opt
Interdata Model 3	8	opt	450 KHZ	2	255	opt	opt
Interdata Model 4	8	opt	450 KHZ	2	255	opt	opt
Lockheed Electronics MAC-16	16	opt	800 KHZ	4	64	opt	opt
Raytheon 703	16	opt	571 KHZ	1	16	opt	opt
Raytheon 704	16	opt	1. 1 MHZ	1	16	opt	opt
Raytheon 706	16	opt	1. 1 MHZ	1	16	opt	opt

SMALL COMPUTER CHARACTERISTICS TABLE G-1 (Continued)

Manufacturer/ Model No.	MICRO-Programming (i. e. firmware)	SOFTWARE					
		Assembler (1 pass, 2 pass, both)	Relocatable Assembler (yes, no)	Min. Core Size necessary to use Relocatable Assembler	Macro Assembler Capability	Real-time Exec. Monitor Available (yes, no)	Disc Operating System Avail. (yes, no)
Computer Automation 216/816	no	2 pass	yes	4K	no	no	no
Data General Nova	no	2 pass	no	--	no	no	no
Data Mate Computer Systems 16	no	2 pass	yes	4K	yes	no	no
Redcor RC-70	no	1 pass	yes	4K	no	no	no
GRI Computer Co 909	yes	no	no	--	no	no	yes
Hewlett Packard 2114A/2114B	yes	2 pass	yes	4K	no	no	no
Hewlett Packard 2115A	yes	2 pass	yes	4K	no	no	yes
Honeywell H-316	no	both	yes	4K	no	yes	yes
Honeywell DDP-416	no	both	no	--	no	no	yes
Information Tech. Inc. ITI-4900 (Model 20)	no	1 pass	yes	4K	yes	yes	no
Interdata Model 2	yes	both	no	--	no	no	no
Interdata Model 3	yes	both	yes	4K	no	no	no
Interdata Model 4	yes	both	yes	4K	no	no	no
Lockheed Electronics MAC-16	no	2 pass	yes	4K	yes	no	no
Raytheon 703	no	both	yes	4K	yes	yes	yes
Raytheon 704	no	both	yes	4K	yes	yes	yes
Raytheon 706	no	both	yes	4K	yes	yes	yes

SMALL COMPUTER CHARACTERISTICS TABLE G-1 (Continued)

Manufacturer/ Model Number	PERIPHERALS AVAILABLE Magnetic Tape Available (yes, no)	Approx. Price For Oper. Unit (Incl. Controller, Comp. Options Nec., etc.)	Mass Storage Device Available (yes, no)	Approx. Price For Oper. Unit (Incl. Controller, Comp. Options Nec., etc.)
Computer Automation 216/816	yes	$5,700 to $10,000	yes	$6,500 to $9,950
Data General Nova	yes	$12,000	yes	$6,500 to $9,250
Data Mate Computer Systems-16	yes	$19,500	yes	$18,000 to $45,000
Redcor RC-70	yes	$12,000	yes	$15,000
GRI Computer Co. 909	no	---	no	---
Hewlett-Packard 2114A/2114B	yes	$12,500 to $15,000	no/yes	/$26,500 to ---/$31,500
Hewlett-Packard 2115A	yes	$15,500 to $21,500	yes	$26,500 to $31,500
Honeywell H-316	yes	$23,355 to $35,430	yes	$22,300 to $36,000
Honeywell DDP-416	yes	$23,355 to $35,430	yes	$22,300 to $36,000
Information Tech. Inc. ITI-4900 (Model 20)	yes	$18,000	N/A	---
Interdata Model 2	yes	$9,900	yes	$17,400
Interdata Model 3	yes	$9,900	yes	$17,400
Interdata Model 4	yes	$9,900	yes	$17,400
Lockheed Electronics Co. MAC-16	yes	$6,000 to $10,000	yes	$17,000
Raytheon 703	yes	$10,500 $28,000	yes	$21,500
Raytheon 704	yes	$10,500 to $28,000	yes	$21,500

N/A = Not Announced or Not Available

SMALL COMPUTER CHARACTERISTICS TABLE G-1 (Continued)

Manufacturer/ Model Number	High Speed Paper Tape Reader (yes, no)	Speed (char/sec)	Approximate Cost of Operational Paper Tape Rdr.	High Speed Paper Tape Punch (yes, no)	Speed (char/sec)	Approximate Cost of Operational Paper Tape Pun
	PERIPHERALS AVAILABLE (Continued)					
Computer Automation 216/816	yes	300	$2,200	yes	60	$3,300
Data General Nova	yes	300/150	$2,650/ $2,150	yes	63.3	$2,200
Data Mate Computer Systems - 16	yes	300	$2,000	yes	120	$4,000
Redcor RC-70	yes	300	$2,500	yes	120	$4,000
GRI Computer Co. 909	yes	300	$2,090	yes	50	$1,750
Hewlett-Packard 2114A/2114B	yes	300	$2,100	yes	120	$4,100
Hewlett-Packard 2115A	yes	300	$2,100	yes	120	$4,100
Honeywell H-316	yes	300	$3,800	yes	110	$4,500
Honeywell DDP-416	yes	300	$3,800	yes	110	$4,500
Information Tech. Inc. ITI-4900 (Model 20)	yes	300	$2,500	yes	50	$3,000
Interdata Model 2	yes	300	$2,500	yes	60	$3,800
Interdata Model 3	yes	300	$2,500	yes	60	$3,800
Interdata Model 4	yes	300	$2,500	yes	60	$3,800
Lockheed Electronics MAC-16	yes	300	$2,200	yes	60	$2,700
Raytheon 703	yes	300	$3,300	yes	110	$4,200
Raytheon 704	yes	300	$3,000	yes	110	$4,000

N/A = Not Announced or Not Available

Manufacturer/ Model No.	BASIC MAINFRAME COSTS Basic System Price with 4K words incl. Power Supplies	Total System Price incl. ASR-33 Teletype & CPU	Basic System Price with 8K words incl. adequate power supplies, enclosure, control panel	Total System Price incl. ASR-33 Teletype & CPU
Computer Automation 216/816	$7,990/$9,980	$10,000/$11,990	$12,840/$15,430	$14,850/$17,440
Data General Nova	$7,600	$9,000	$10,885	$12,285
Data Mate Computer Systems - 16	$13,900	$15,900	$20,400	$22,400
Redcor RC-70	$12,800	$14,000	$18,600	$19,800
GRI Computer Co 909	$8,290	$9,900	$11,530	$13,140
Hewlett Packard 2114A/2114B	$8,500	$10,500	$12,500	$14,500
Hewlett Packard 2115A	$14,500	$16,500	$19,500	$21,500
Honeywell H-316	$9,700	$11,400	$15,200	$16,900
Honeywell DDP-416	$15,700	$16,900	$23,700	$24,900
Information Tech. Inc. ITI-4900 (Model 20)	$9,950	$12,450	$15,950	$18,450
Interdata Model 2	$5,750 (1K)	$7,650 (1K)	$6,650 (2K)	$8,550 (2K)
Interdata Model 3	$10,800	$12,700	$17,700	$19,600
Interdata Model 4	$13,800	$15,700	$20,700	$22,600
Lockheed Electronics MAC-16	$11,950	$11,950	$15,900	$15,900
Raytheon 703	$15,000	$15,000	$23,000	$23,000
Raytheon 704	$10,000	$11,900	$15,600	$17,500
Raytheon 706	$19,000	$19,000	$24,600	$24,600

SMALL COMPUTER CHARACTERISTICS TABLE G-1 (Continued)

		CPU FEATURES				
Manufacturer/ Model Number	R/O Memory (std, opt, no)	Instruction Word Length(s)	No. Acc. (or Gen. Purp. Registers that can be used as Accumulators	No. Hdwr. Reg. not including Index Registers	No. Index Reg. (hdwr., memory or other)	Indirect Addressing (multi-level, single-level, no)
Motorola MDP-1000	no	12	4	9	3 hardware	single-level
Systems Engineering Lab. 810A	no	16	2	2	1 hardware	multi-level
Tempo Computers Inc Tempo 1	no	16/32	2	7	1 hardware	multi-level
Varian 620 i	no	16/32	2	6	2 hardware	multi-level
Digital Equip. Corp. PDP 8/I	no	12/24	1	4	8 memory	single-level
Digital Equip. Corp. PDP 8/L	no	12/24	1	4	8 memory	single-level
General Automation SPC-12	opt	8, 12, 16	4	8	3 hardware	single-level
General Automation 18/30	opt.	16	16	20	3 hardware	single-level
Business Information Technology 480/482	no	8/16	1	8	none	single-level
Computer Automation 208-808	no	8/16	1	8	none	multi-level
Micro Systems 800	std.	16	15(8)	15(8)	--	no
Micro Systems 810	opt.	8/16/24	2	4	1 hardware	single-level
Varian 520 i	no	8/16	7	7	1 hardware	multi-level

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (Continued)

Manufacturer/ Model Number	MEMORY CHARACTERISTICS Cycle Time (us)	Word Length (bits)	Minimum Size (words)	Increment Size (words)	Maximum Size (words)	Parity Check (std, opt, no)	Protect (std, opt, no)
Motorola MDP-1000	2.16	8	4K	4K	16K	no	no
Systems Engineering Lab. 810A	1.75	16	4K	4K	32K	opt.	opt.
Tempo Computers Inc Tempo 1	0.9	16	4K	4K	65K	opt.	opt.
Varian 620 i	1.8	16/18	4K	4K	32K	opt.	opt.
Digital Equip. Corp. PDP 8/I	1.5	12	4K	4K	32K	opt.	std.
Digital Equip. Corp. PDP 8/L	1.6	12	4K	4K	8K	opt.	std.
General Automation SPC-12	2.0	8	4K	4K	16K	opt.	no
General Automation 18/30	1.2	16	4K	4K	32K	std.	std.
Business Information Technology 480/482	3.0	8	1K	1K, 2K, 4K	65K	opt.	no
Computer Automation 208-808	2.6/8.0	8	4K	4K	16K	no	no
Micro Systems 800	1.1	8	1K	1K, 4K	32K	opt.	opt.
Micro Systems 810	1.1	8	1K	1K, 4K	32K	opt.	opt.
Varian 520 i	1.5	8	4K	4K	32K	opt.	std.

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (Continued)

Manufacturer/ Model No.	I / O CAPABILITY: Data Path Width (bits)	Direct Memory Access (DMA) Channel (std, opt, no)	Max. DMA Word Transfer Rate	No. External Priority Interrupt Levels in Basic System	Max. No. External Interrupts	OTHER FEATURES: Power Failure & Automatic Restart (std, opt, no)	Real-time Clock or Internal timer (std, opt, no)
Motorola MDP-1000	8	opt	400 KHZ	2	64	opt	std
Systems Engineering Lab. 810A	16	opt	572 KHZ	3	96	std	opt
Tempo Computers Inc. Tempo 1	8/16	opt	800 KHZ	4	256	std	opt
Varian 620 i	16/18	opt	200 KHZ	none	64	opt	opt
Digital Equip. Corp. PDP 8/I	12	opt	666 KHZ	1	64	opt	opt
Digital Equip. Corp. PDP 8/L	12	opt	625 KHZ	1	64	opt	opt
General Automation SPC-12	8/12	opt	430 KHZ	2	256	opt	std
General Automation 18/30	16	opt	833 KHZ	6	59	std	std (3)
Business Information Technology 480/482	8	std	250 KHZ	1	1	opt	opt
Computer Automation 208-808	8	no	--	3	64	opt	opt
Micro Systems 800	8	opt	910 KHZ	no	--	opt	opt
Micro Systems 810	8	opt	910 KHZ	8	64	opt	opt
Varian 520 i	8/16	opt	660 KHZ	3	11	opt	opt

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (Continued)

		SOFTWARE					
MANUFACTURER/ MODEL No.	MICRO-Programming (i. e. firmware)	Assembler (1 pass, 2 pass, both)	Relocatable Assembler (yes, no)	Min. Core Size necessary to use Relocatable Assembler	Macro Assembler Capability	Real-time Exec. Monitor Available (yes, no)	Disc Operating System Avail. (yes, no)
Motorola MDP-1000	no	2 pass	yes	4K	no	yes	no
Systems Engineering Lab. 810A	no	2 pass	yes	8K	yes	no	yes
Tempo Computers Inc. Tempo 1	no	both	yes	4K	yes	no	no
Varian 620 i	yes	2 pass	no	--	no	no	no
Digital Equip. Corp. PDP 8/I	no	both	yes	8K	yes	no	yes
Digital Equip. Corp. PDP 8/L	no	both	yes	8K	yes	no	yes
General Automation SPC-12	no	1 pass	yes	4K	no	yes	no
General Automation 18/30	no	2 pass	yes	4K	yes	no	yes
Business Information Technology 480/482	no	3 pass	no	--	no	yes	no
Computer Automation 208/808	no	2 pass	no	--	no	no	no
Micro Systems 800	yes	--	--	--	--	no	no
Micro Systems 810	yes	both	no	--	no	no	no
Varian 520 i	no	2 pass	yes	4K	no	no	no

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (Continued)

Manufacturer/ Model Number	PERIPHERALS AVAILABLE Magnetic Tape Available (yes, no)	Approx. Price For Oper. Unit (Incl. Controller, Comp. Options Nec., etc.)	Mass Storage Device Available (yes, no)	Approx. Price For Oper. Unit (Incl. Controller, Comp. Options Nec., etc.)
Raytheon 706	yes	$10,500 to $28,000	yes	$21,500
Motorola MDP-1000	yes	$18,000	yes	$12,000 to $19,500
Systems Engineering Lab. 810A	yes	$24,000	yes	$30,000
Tempo Computers, Inc. Tempo 1	yes	$12,000	yes	$16,600
Varian 620 i	yes	N/A	yes	N/A
Digital Equipment Corporation PDP 8/I	yes	$24,700	yes	$8,700 to $15,700
Digital Equipment Corporation PDP 8/L	yes	$24,700	yes	$8,700 to $15,700
General Automation SPC-12	yes	$11,000	yes	$6,000 to $15,000
General Automation 18/30	yes	$14,000 to $25,000	yes	$14,000 to $30,000
Business Information Technology 480/482	yes	$18,700 to $22,500	yes	$7,390
Computer Automation 208/808	yes	$5,700 to $10,000	yes	$6,500 to $9,950
Micro Systems 800	no	--	yes	N/A
Micro Systems 810	no	--	yes	N/A
Varian 520 i	yes	$9,000	yes	N/A

N/A = Not Announced or Not Available

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (Continued)

PERIPHERALS AVAILABLE (Continued)

Manufacturer/ Model Number	High Speed Paper Tape Reader (yes, no)	Speed (char/sec)	Approximate Cost of Operational Paper Tape Rdr.	High Speed Paper Tape Punch (yes, no)	Speed (char/sec)	Approximate Cost of Operational Paper Tape Pun.
Raytheon 706	yes	300	$3,000	yes	110	$4,000
Motorola MDP-1000	yes	300	$3,000	yes	120	$4,000
Systems Engineering Lab. 810A	yes	300	$4,000	yes	100	$4,000
Tempo Computers Inc. Tempo 1	yes	400	$2,700	yes	120	$4,100
Varian 620 i	yes	300	$2,900	yes	60	$3,300
Digital Equipment Corporation PDP 8/I	yes	300	$2,000	yes	50	$2,000
Digital Equipment Corporation PDP 8/L	yes	300	$2,000	yes	50	$2,000
General Automation SPC-12	yes	300	$3,000	yes	120	$4,000
General Automation 18/30	yes	300	$2,500	yes	60	$3,000
Business Information Technology 480/482	yes	300	$2,300	yes	60	$3,000
Computer Automation 208/808	yes	300	$2,200	yes	60	$3,300
Micro Systems 800	yes	300	$2,750	yes	110	$3,000
Micro Systems 810	yes	300	$2,750	yes	110	$3,000
Varian 520 i	yes	300	$2,900	yes	60	$3,300

N/A = Not Announced or Not Available

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (Continued)

Manufacturer/ Model No.	BASIC MAINFRAME COSTS			
	Basic System Price with 4K words incl. Power Supplies	Total System Price incl. ASR-33 Teletype & CPU	Basic System Price with 8K words incl. adequate power supplies, enclosure, control panel	Total System Price incl. ASR-33 Teletype & CPU
Motorola MDP-1000	$8,500	$9,700	$11,500	$12,700
Systems Engineering Lab. 810A	$18,000	$18,000	$23,000	$23,000
Tempo Computers Inc. Tempo 1	$15,000	$15,000	$19,000	$19,000
Varian 620 i	$9,950	$11,750	$15,850	$17,650
Digital Equip. Corp. PDP 8/I	$12,800	$12,800	$16,300	$16,300
Digital Equip. Corp. PDP 8/L	$8,500	$8,500	$13,200	$13,200
General Automation SPC-12	$4,000	$5,100	$7,400	$8,500
General Automation 18/30	$18,000	$19,500	$25,000	$26,500
Business Information Technology 480/482	$9,310	$9,310	$11,250	$11,250
Computer Automation 208/808	$5,990/$4,990	$8,000/$7,000	$8,940/$7,690	$10,950/$9,700
Micro Systems 800	$5,700	$6,900	$8,200	$9,400
Micro Systems 810	$6,900	$8,100	$9,400	$10,600
Varian 520 i	$7,500	$8,900	$10,000	$11,400

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (Continued)

Clarification of Terms Used in Table G-1

CPU Features - features and characteristics of the central processing unit.

R/O Memory - whether a read only memory is available as standard equipment or an option.

Instruction Word Length - the length of the instruction word in bits.

No. Acc. or Gen. Purp. Registers that can be used as Accumulators - the number of accumulators in the computer or the number of general purpose registers that can be used as accumulators.

No. Hdwr. Reg. not including Index Registers - the number of registers in the machine implemented with separate hardware (i.e. not main memory locations) not including the index registers.

No. Index Reg. - the number of effective index registers in the computer and whether they are implemented by separate hardware or as locations in the main memory.

Indirect Addressing - whether indirect addressing is provided and whether it is single level or multi-level.

Memory Characteristics - the characteristics of the computer's main memory.

Cycle Time - the time to complete a memory cycle in microseconds.

Word Length - the length in bits of words stored in the memory.

Minimum Size - the minimum size of memory available in thousands of words.

Increment Size - the size of the increments in which memory can be increased in thousands of words.

Maximum Size - the maximum size of memory that can be utilized in thousands of words.

Parity Check - whether a parity check is provided and whether it is standard or optional.

Protect - whether memory protection is available and whether it is standard or optional.

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (continued)

Clarification of Terms Used in Table G-1 (continued)

Input/Output Capability - the capability of the computer for handling input/output data.

Data Path Width - the number of bits transferred into and out of the computer in parallel.

Direct Memory Access Channel - whether a direct memory access channel is available and whether it is standard or optional.

Max. DMA Word Transfer Rate - the maximum rate at which words are transferred into and out of the memory through the direct memory access channel.

No. External Priority Interrupt Levels in Basic System - the number of external priority levels that are provided in the basic computer without adding options.

Max. No. External Interrupts - the maximum number of external priority interrupt levels which the computer can handle if optional equipment is added.

Power Failure & Automatic Restart - whether the ability to detect power failures, save register contents, and restart automatically when the power is recovered is provided and whether this is standard or optional.

Real-time Clock or Internal timer - whether a real time clock or internal timer is available and whether this is standard or optional.

Micro-programming - whether micro-programming capability is provided.

Assembler - whether a software assembler is available and whether it assembles object codes in one or two passes.

Relocatable Assembler - whether the memory location of the assembler can be relocated or not.

Min. Core Size necessary to use Relocatable Assembler - the minimum memory capacity required in the computer if the relocatable assembler is to be used.

Macro Assembler Capability - whether a macro assembler is provided or not.

SMALL COMPUTER CHARACTERISTICS

TABLE G-1 (continued)

Clarification of Terms Used in Table G-1 (continued)

Real-time Exec. Monitor Available - whether a real time executive monitor is provided or not.

Disc Operating System Avail. - whether a disc operating system is available or not.

Peripherals Available - peripheral equipments offered for which interfaces to the computer are provided.

Magnetic Tape Available - whether magnetic tape is available or not.

Mass Storage Device Available - whether a mass storage, such as a disc or drum, is available or not.

High Speed Paper Tape Reader - whether a high speed paper tape reader is available or not.

Speed - the speed of the paper tape reader in characters per second if one is available.

High Speed Paper Tape Punch - whether a high speed paper tape punch is available or not.

Speed - the speed of the paper tape punch in characters per second if one is available.

Because of communication terminal applications similar to the Library of Congress terminal requirements, several computer manufacturers have developed an eight bit word machine in the last year which is compatible with the eight bit character interface used over standard voice grade lines at present.

The chart in Table G-1 compares the features of computers grouped into the following categories:

Memory
Read-only memory
CPU characteristics
I/O capability
Microprogramming
Software
Basic mainframe costs
Peripherals

Until recently twelve and sixteen bit word length machines dominated the small computer market but in 1968 and 1969 several eight bit word length machines were introduced. These minicomputers, as they are sometimes called, are priced below $10,000. Their most obvious advantage is that of a smaller word length which costs less in storage, registers, and logic. Also the eight bit machines offer the advantages of manipulating data on an eight bit byte basis which is usually the way communications line controllers work to adjust between the terminal modules and communications interface. Many of the twelve and sixteen bit machines have added features to their organization that facilitate handling operations on an eight bit byte basis; hence, they are also well suited to use as a controller.

Read-only (R-O) memories are used to implement in hardware a set of instructions which act as a stored program to cause the machine to follow a predetermined programmed sequence. This allows faster execution and a greater degree of protection than conventional core memory, but this

R-O memory usually cannot be modified easily. This capability provides custom program sequences to meet special requirements in the particular application for which it is programmed. Also, the cost of read-only memory is usually less than that for read/write memory of equivalent speed. This type of memory is referred to as permanent or semi-permanent since the contents ordinarily cannot be changed without physically replacing the R-O memory card.

Some "read-only" memories are electrically alterable so that physical replacement is not required. These are sometimes called "read-mostly" memories. The read-only memory is used to store microprograms - i.e., stored logic - which control formatting, buffering, and sequencing of information from the terminal modules to the communications interface.

The CPU features of any small computer organization determine the flexibility and efficiency with which program sequences can be executed. The number of registers available to do operations with is an important factor since more registers minimize memory accessing. The CPU organization also affects to a large extent the addressing capabilities and the speed and ease with which subroutines and dots can be branched to or manipulated in carrying out the particular program sequence desired. Since small computers will be used as a controller in the Library's application and not as a scientific computer, the arithmetic operation speeds and hardware multiply-divide execution times are not included in Table G-1. They are not important to the use of small computers in a controller environment. The Library of Congress requirements are not computation oriented. Storage, control, and communication capabilities are of more importance in this application.

Of major significance and importance in the evaluation of small computers for a control operation is their capability to handle input/output (I/O) operations efficiently and easily. In particular, an I/O capability for eight bit byte oriented data transfers is important. It is very important to note that direct memory I/O data transfer refers to data transfer between either the terminal modules or the telephone line directly into the memory bus, without necessarily being under CPU control for each data byte transferred.

Of particular importance in evaluating I/O capabilities of a small computer is whether the computer has a fully buffered channel which means that each channel has two registers associated with it to hold the necessary data and control information so that the CPU is not tied up waiting for a data transfer. This buffering then permits several I/O channels to operate concurrently. The type of channel most commonly used in these applications is frequently called a direct memory access (DMA) channel. With a DMA, the channel data transfer rates approach the maximum data transfer rate of the computer's main memory because this channel is tied directly on the memory bus.

A minimal of CPU overhead and programming should be associated with transferring data between the external computer and the memory bank associated with that computer. In addition to this it is very important that the external I/O operations be associated or triggered by external inputs to the small computer so that there is no delay or bottleneck when data is to be transferred over the data communications line and/or to the terminal peripheral modules. Capable interrupt systems are important for these reasons. Note that the data rates associated with the DMA channel are shown as the maximum speeds so that data throughput computations can be estimated in order to quickly evaluate whether the computer can maintain the data transfer speeds necessary to make this system fully operational with terminals. In carefully analyzing the small computer requirements for terminals of these kinds, it becomes extremely important to evaluate the I/O capability of the computer to be used. One major problem in comparing the I/O channel configurations offered by different manufacturers is that one computer may have much more hardware capability, thus requiring the use of fewer instruction sequences, than another machine for carrying out the same I/O data transfers. For example, some machines provide the programmer with one instruction to execute input or output automatically, while in other machines additional programming is required, such as testing program loops to see if the channel is busy, providing the address of the external device, etc.

Two other very important features are the real-time clock option available with most of the systems. This feature allows immediate access to current timing information which can be used to control and synchronize all operations. It provides time of day information and facilitates keeping track by the executive program of time intervals since a given event or time elapsed between given events. Another important feature is the power failure and automatic restart capability which insures that if a power failure occurs there will be a safe orderly shutdown. In this case, the contents of the CPU registers are saved so that the program can be restarted at that point in an orderly fashion when power is restored.

Microprogramming is a special technique in which the organization structure of the machine allows various special instructions to be implemented by the subcommand structure of the computer. Different terms such as micro-instructions, micro-operations and machine subcommands are used to refer to these types of operations. Only a few of these machines presently offer the ability to bring the wires controlling these subcommand operations out to the connector so the user can provide logic to generate certain desired micro-operations. In these machine s each bit in the address field of the register-to-register instruction format might refer to a register operation such as complementing, shifting, etc. With these subcommands, several additional operations not already available in the basic computer repertoire can be implemented. Microprogramming is sometimes associated with read-only memories where these special memories are used to store predetermined program sequences that interpret and execute a set of micro-instructions which make up macro-instructions particularly suited to the application at hand.

Software,which is the next category of characteristics presetned in the survey chart, is particularly important from the applications point of view.

It is the software and programming that permits the operation of the small computer to be tailored to meet all the requirements in the terminal module controller. In particular, terminal and controller applications would be implemented in assembly language to be most efficient and to minimize time and memory requirements. A very powerful and expedient method used frequently now is to assemble a small computer program using a larger computer system, such as the IBM 360 or another large system, so that the program can be written and debugged before it is tried out on the actual small computer equipment itself. In this way, the lead time in developing and delivering the running program can be in parallel with the hardware check-out so that the total slapsed time for these two items is minimized.

Characteristics of these small computers with respect to higher level languages, such as FORTRAN and conversational compilers, are not included because such software is not relevant to the use of a small computer as a terminal controller. The real-time executive monitors available with these small computers vary greatly depending to a large extent upon how much memory is required and whether it is used in more than one application rather than a single dedicated application. Therefore this monitor may not in itself be directly used in the terminal or controller, but it could aid in debugging the program faster and in determining how the interrupts and I/O structure can best be tied into the program structure of the controller or terminal. Similarly, a disc operating system might be of interest in terms of other considerations in using the computer but the disc operating system as such would probably not be used in the terminal or controller.

Cost of these machines with 4,096 and 8,192 (4K and 8K) word memory increment are included along with the price for a standard teletype I/O device. In addition, the peripheral devices available and their approximate cost are also included in case it is necessary to have some peripheral device associated with the computer system. No peripherals may be needed once the final installation is made, but that will not necessarily be the case; hence these are included in order to keep options open for the trade-off analyses.

APPENDIX H

SUMMARY AND COMPARISON OF PRESENTLY AVAILABLE DEVICES FOR ENTRY, DISPLAY, AND PRINTING OF ORIENTAL LANGUAGES

This Appendix discusses devices and techniques that have been developed or that are under development for handling oriental languages. The discussion of a device or technique in this Appendix should not be interpreted as meaning that the device is fully developed or commercially available at a reasonable price. Most of these devices are in a developmental stage, or in one or two cases an early pre-production stage. For several, only one to three units have been built. Hence, cost for initial units would probably be quite high.

1. The Chinese Typewriter

The principle of operation of the Chinese typewriter is extremely simple. The type faces are on individual slugs which are stored separately in compartmented boxes with the faces visible. The location of the individual slugs is given by a diagram in which the characters are arranged in a semi-mnemonic order. The individual slugs are removed from the box and placed into position on the typewriter. A key stroke provides the impact to imprint the character through a ribbon and the carriage is automatically advanced. The slug is then replaced.

The speed of operation is roughly comparable to forming the character with brush strokes. The primary advantage is uniformity of character size and spacing. Attempts are being made to adapt the "selectric" principle with multiple type balls but with little success. Automation of the typewriter and its use as an input/output device is not practical.

2. The RCA Ideographic Composing Machine (ICM)

This is a limited production device (2 - 3 models) built by RCA for Army use. The keyboard is modified typewriter. The entry and output principles have been described earlier. A repertoire of 10,000 characters is available on any one photo image plate. The speed is not explicitly given since it depends on operator skill but the machine is said to be comparable in with a "conventional English typewriter."

The machine has been modified to use a holographic image plate in place of the photo image plate. The advantage of the holographic technique is primarily one of size and weight. No additional speed is provided. The size and spacing of the characters are selectable. The machine is large and relatively expensive, about $100,000. Further information may be obtained from Applied Research, Defense Electronic Products, RCA, Camden, New Jersey.

3. The ITEK Chicoder

This is believed to be a limited production machine, built by the Itek Corporation of Lexington, Massachusetts. A speed of 40 ideographs per minute is cited. The initial vocabulary was 10,518 characters with extension to 30,000 characters said to be possible. An 18 bit code is used. Impartial sources describe the output as having poor legibility. The principles of operation are based on feature selection. The operator identifies a pair of top and bottom features by two keystrokes. All ideographs containing these features are displayed and the operator selects one of them by means of a third keystroke. Further information may be obtained from Itek Corporation, Lexington, Massachusetts.

4. The SINCO System

The SINCO system developed at the University of Kansas, uses typewriter keys to describe the element of the characters. As such it can be used as an input device. SINCO is an acronym, "Synthetic Index Nomenclature for Chinese Orthography." SINCO permits the composition of variably serial logographs, such as Chinese characters, from a small number of simple elements using mechanical, electromechanical, or electronic techniques. A simple typewriter keyboard is used. The output of the keyboard provides the machine compatible string incorporating all morphological features of the original graph. Since this system is truly synthetic, memory requirements are no greater than for other simpler orthographics. In one demonstration of this system, a standard keypunch keyboard was used and the data was analyzed by a GE 635 computer which produced taped writing instructions. The computer analysis included determination of the appropriate juxtapositional mode according to built-in orthographic rules and the sizing of the alphabetic elements. The taped writing instructions produced by the computer were used to drive a plotter which drew each syllabic character in an 0.2" square. A sample of this output is shown in Figure H-1. Finer resolution is expected in the future.

The SINCO system should be followed closely as a possible solution to the oriental language problem but it is unlikely that it will be in an adequate state of development for the Library of Congress applications by 1972. No information is available on potential costs for this system.

Current state is still experimental. The work is being performed by Professor Carl Leban at the University of Kansas.

진달래꽃

나보기가 역겨워 가실때에는
말없이 고이 보내 드리오리다

영변의 약산 진달래꽃
아름따다 가실길에 뿌리오리다

가시는 걸음 걸음 놓인 그 꽃을
사뿐히 지레밟고 가시옵소서

나보기가 역겨워 가실때에는
죽어도 아니 눈물 흘리오리다

김 소 월

SAMPLE OF ORIENTAL LANGUAGE PRINT-OUT PREPARED BY SINCO SYATEM FROM STANDARD KEYBOARD INPUT USING COMPUTER ANALYSIS AND PLOTTER DRAWING OF THE ORIENTAL LANGUAGE CHARACTERS.

FIGURE H-1

5. The Kanji Teletypewriter

This is a thoroughly workable device being used by the Japan Information Center of Science and Technology for bibliographical purposes. Information is available from the JICST, Tokyo, Japan.

It is limited to 2496 input and 3071 output characters. The difference is due to the inclusion of boldface and italics for the Katakana, Hiragana, Russian, Roman, and Greek alphabets and the Arabic and Roman numerals which it can also handle. It has been incorporated into an operational library data processing system by JICST. The line printer is capable of handling all of the languages listed, but it is more expensive to use this device for languages, such as Russian which can be handled with less expensive devices such as flexowriters. Software for conversion of the flexowriter code to the Kanji Teletypewriter code are available. The working system of the JICST uses the hardware complement shown in Table H-1 which includes alphanumeric and Russian flexowriters as well as Kanji teletypewriters. Characteristics of the Kanji Teletypewriter are given in Table H-2.

6. The Chinese Teleprinter

This device permits the encoding and punching into paper tape codes for 2400 characters and is thus comparable with the Kanji Teletypewriter in capability. In its original form no provision for Roman, Greek or other special alphabets exists. It is useful primarily for communication purposes in which the messages can be rephrased into the limited vocabulary available (compare with basic English, for example). It is not sufficiently versatile for literary or scientific work.

A new version capable of handling 4600 Chinese plus 200 other special characters is being readied for sale. There are 600 keys plus an eight

Computer (1)	FACOM230-50	1
Memory unit	F2520B 65kw	1
Magnetic tape unit	F603D 60 kc/sec	8
Magnetic drum unit	F624 2 mega bytes	1
Magnetic disc unit	F631B 67 mega bytes	1
Console Typewriter	F2540B	1
Line printer	F642B 100-500 line/sec	1
(alphanumeric and Kana, printable characters 128)		
Card reader (80-column)	F664A 800 card/min.	1
Paper tape punch	F767A 100 c/sec	1
Paper tape reader	F748A 1000 c/sec	1
Typewriter	E791A (128 characters)	4
Computer (2)	FACCM 270-20	1
Memory unit	F7220A 16 kw	1
Magnetic tape unit	F603D 60kc/sec	3
Paper tape reader	F748A 1000 c/sec	1
Typewriter	F801A (128 characters)	1
High/speed Kanji line printer	JEM 3800 (printable characters:3071)	2
Film recorder	PT200 5-6 line/sec	2
Soft printer (Electrofax)	PT-600 5-6 line/sec	1
	PT-700 5-6 line/sec	1
Kanji teletypewriter	SCK-201 2496 characters	40
Alphanumeric flexowriter	F802A	9
Russian flexowriter	F802A	3
Paper tape reader punch	PTS	1
IBM Card punch with Katakana	Model 10029 A12	1
IBM Printing card punch	0029 A22	2
IBM Card verifier	0059 002	1
IBM Sorter	0083 001	1

HARDWARE CONFIGURATION FOR JICST SYSTEM

TABLE H-1

	INPUT			OUTPUT	(TYPE FACE)
	Kanji tele-typewriter	Flexowriter			
		Alpha-numeric	Russian		
Kanji	1861			1861	(regular)
Katakana	81			162	(regular, boldface)
Hiragana	77			154	(-dc-)
Roman alphabet	65	52		195	(regular, italic, boldface)
Russian alphabet	66		63	198	(-dc-)
Greek Alphabet	33			99	(-dc-)
Arabic numerals	10	10	10	30	(-dc-)
Roman numerals	20			40	(regular, italic)
symbols	199	31	17	248	(regular, partly italic, boldface)
space	6	1	1	6	
reserve	78			78	
Total	2496	94	91	3071	

CHARACTERS, LETTERS, SIGNS, AND SYMBOLS

FOR A KANJI TELETYPEWRITER

TABLE H-2

position shift. Printing is by mechanical impact and up to five carbons can be prepared. Characters outside the standard repertoire generally can be replaced by a sequence of the two or three characters of which they are a composite without loss of intelligibility. Information may be obtained from the Chinese Teleprinter Corporation, Taipei, Taiwan.

7. The Fujitsu Electrostatic Printer

Fujitsu Limited of Japan has been working an Electrostatic Printer capable of multiple copies for a number of years. The hardware problems appear to have been solved, but the software problems are formidable. This is because the characters are formed on a 16 x 24 dot matrix. As has been pointed out earlier, memory requirements for decoding into the dot matrix form are excessive. The simpler Khana characters can be printed on a 5 x 7 matrix if desired, but since the Kanji and Katakana usually are combined in text no real saving is possible.

8. The Harvard/American Mathematical Society Plotter and Scanner

Input to the system is by RAND tablet. Sheets of paper containing ruled squares each containing a character are placed on the tablet. The operator designates the identification number of the sheet and points to the desired character. Software is provided to convert the character location on the RAND tablet to the correct straight line stroke combination. A PDP-1 computer performs the output conversion.

APPENDIX I

This Appendix contains a complete manufacturer address list for each type of equipment included in Appendices A through G.

Keyboards and Keyboard/Printers (Appendix A)

Manufacturers Included in this Appendix:

Keyboards

1. George Risk Industries
   672 - 15th Avenue, Columbus, Nebraska 68601
   (402 564-2777

2. Datanetics Corporation
   2828 Spreckles Street, Redondo Beach, California 90278
   (213) 542-4355
   Richard Gerlach

3. Microswitch Inc.
   A Division of Honeywell
   Freeport, Illinois 61032
   (815) 232-1122

4. Connecticut Technical Corporation
   3000 Main Street, Hartford, Connecticut 06120
   (203) 522- 6167
   Harold M. Kneller

5. Synergistics Inc.
   10 Tech Circle, Natick, Massachusetts 01760
   (617) 655-1340

6. Licon, Div. of Illinois Tool Works Inc.
   6615 West Irving Park Road, Chicago, Illinois 60634
   (312) 282-4040

7. IKOR, Inc.
   Northwest Industrial Park, Burlington, Massachusetts 01803
   (617) 272-4400
   William E. Polley

8. Clare-Pendar Company
   P.O. Box 785, Post Falls, Idaho 83854
   (208) 773-4541

9. Invac Corporation, A Division of Digitronics Corp.
   26 Fox Road, Waltham, Massachusetts 02154
   (617) 899-2380

10. Control Research Corporation
P.O. Box 5037, 11762 Western St., Garden Grove, Calif.
(714) 892-9415
Kurt Stevens

11. Friden Inc.
2350 Washington Avenue, San Leandro, California 94577
(415) 357-6800
S. W. Terry

12. Navcor Inc., A Division of KDI Corporation
Valley Forge Industrial Park, Norristown, Pa., 19401
(215) 542-3835
Bill Taylor

13. Mechanical Enterprises, Inc.
3127 Colvin Street, Alexandra, Va. 22314
(703) 549-3434
Richard A. Thomas

14. Keykode, A Division of Nutronics
P.O. Box 72, Paramus, New Jersey 07652
(201) 652-4220

15. Transistor Electronic Corp.
P.O. Box 6191, Minneapolis, Minnesota 55424
(612) 941-1100
A. V. Klizas

16. Transducer Systems Inc.
Easton and Wyandotte Roads, Will Grove, Pa. 19090
(215) 657-0655
Burbon F. Drill

Keyboard Printers

1. Anderson Jacobson Inc.
2235 Mora Drive, Mountainview, California 94040
(415) 968-2400
George Fish

2. Computer Transceiver Systems Inc.
123 Pleasant Avenue, Upper Saddle River, New Jersey 07458
(201) 825-0220
John Powers

3. Connecticut Technical Corporation
300 Main Street, Hartford, Connecticut 06120
(203) 522-6167
Harold Kneller

4. Data Products Corporation (formerly Stelma)
6219 De Soto Avenue, Woodland Hills, California 91364
(213) 887-8000
Ed Rosland

5. Datel Corporation
1 Tysons Corner Center, McLean, Virginia 22101
(703) 893-3700
T. A. Jenkins

6. Dura, A Division of Intercontinental Systems Inc.
2600 El Camino Real, Palo Alto, California 94306
(415) 328-5660
Steve Bishop

7. Invac Corporation, A Division of Digitronics Corp.
26 Fox Road, Waltham, Massachusetts 02154
(617) 899-2380

8. Computer Equipment, Division of
Electronic Engineering Company of California
1601 E. Chestnut Avenue, Santa Ana, California 92702
(714) 547-5501

9. Friden, Division of Singer Corporation
2350 Washington Avenue, San Leandro, California 94577
(415) 357-6800
S. W. Terry

10. General Electric Company
Communication and Control Devices Dept.
Waynesboro, Virginia 22980
(703) 942-8161

11. IBM Corporation
Data Processing Division
112 E. Post Road, White Plains, New York 10601
(914) 949-1900

12. Kleinschmidt, Division of SCM Corporation
Deerfield, Illinois 60015
(312) 945-1000
Robert O. Carlson

13. Microdyne, Inc.
1600 So. Hicks Road, Rolling Meadows, Illinois 60008
(312) 774-9022
L. R. Coffey

14. MITE Corporation
445 Blake Street, New Haven, Connecticut 06515
(203) 387-2572
Ralph M. Hirsch

15. Teletype Corporation
5555 Touhy Avenue, Skokie, Illinois 60076
(312) 676-1000
Michael Harris

16. Terminal Equipment Corporation
750 Hamburg Turnpike, Pompton Lakes, New Jersey 07442
(201) 839-3000
James J. Hopkins

17. Texas Instruments Inc.
The Industrial Products Division
P.O. Box 66027, Houston, Texas 77006
(713) 494-5115
W. E. Gott

18. Novar Corporation
2370 Charleston Road, Mountain View, California 94040
(415) 964-3900
William C. Bennett

19. Omnitec, Electronic Products Division
903 North Second Street
Phoenix, Arizona 85004
(602) 258 8246

Manufacturers contacted but excluded because their equipment products were not applicable to the Library of Congress requirements:

1. ACS Industries
13726 Saticoy, Van Nuys, California
(213) 873-1193
Mr. Lachman

2. All Data Processing Machines, Inc.
105 Hinricher Street, Willow Springs, Illinois 60480

3. American Communications Corporation
178-15 Eleventh Road, Jamaica, New York

4. American Computer & Communications
2576 W. Carson Street, Torrance, California 90503

5. Burroughs, OEM Sales Department
1649 Wilshire Blvd., Los Angeles, California

6. California Electro Scientific Corporation
2203 South Grand Avenue, Santa Ana, California

7. Combined Data Group, Inc.
180 Broadway, New York, New York 10038

8. Com Data Corporation
7544 Oakton Street, Niles, Illinois 60648

9. Communitype Corporation
767 Fifth Avenue, New York, New York

10. Compiler Systems Inc.
Laurel Lane, Ridgefield, Connecticut 06877

11. The Computer Exchange, Inc.
30 East 42nd Street, New York, New York 10017

12. Computer Micro-Data Systems
16561 Ventura Boulevard, Suite 215E,
Encino, California 91316

13. Computer Processing Inc.
200 Manhattan Building, Muskogee, Oklahoma 77401

14. Computerware, Inc.
131 East 23rd Street, New York, New York 10010

15. Computronics Engineering
4949 Hollywood Boulevard, Los Angeles, California

16. Connecticut Consolidated Industries
60 Cambridge Street, Meriden, Connecticut

17. Control Data Corporation, Rabinow Division
1425 Research Boulevard, Rockville, Maryland 20850

18. Creed and Company, Ltd.
Hollingbury, Brighton BN1.8 AL, England

19. Cummins-Chicago Corporation
4760 North Ravenswood Avenue, Chicago, Illinois 60640

20. Data Communications Systems Div.
Carterfone Communications Corporation
4230 Central Avenue, N.E., Minneapolis, Minnesota 55421

21. Data Copy Company
760 Bryant Street, San Francisco, California 94107

22. Data Trends Inc.
1259 Route 46, Parsipanny, New Jersey 07054

23. Datron Systems Inc.
21 North Hamilton Avenue, Greensburg, Pennsylvania 15601

24. Decitek, Inc.
15 Sagmore Road, Worchester, Massachusetts 01605

25. DI/AN Controls Inc.
944 Dorchester Avenue, Boston, Massachusetts 02125

26. Dimensions, Inc.
93 Madison Avenue, Hempstead, New York 11550

27. Direct Access Computing Corporation
24175 Northwestern Highway, Southfield, Michigan 48075

28. Display Control Division
Luminator, Inc., Box 278, Plano, Texas

29. Diversified Numeric Applications
Division of Avnet, Inc., 9801 Logan Avenue, South, Minneapolis, Minnesota 55431

30. Dynamco, Ltd.
Chertsey, Surrey, England

31. Elbit Computers, Ltd.
88 Hagiborim Street, Haifa, Israel

32. Elec-Trol, Inc.
21018 Soledad Canyon Road, Saugus, California

33. Electronic Data Systems
1300 EDS Center, Exchange Park, Dallas, Texas 75235

34. Facit-Odhner, Inc.
501 Winsor Drive, Secaucus, New Jersey 07094

35. Ferranti-Packard, Ltd.
Electronics Division, 121 Industry Street, Toronto 15, Ontario, Canada

36. Fjuitsu, Ltd.
Furekawa Building 8, Marunouchi 2, Chiyoda-ku, Tokyo, Japan

37. Geo Space Systems, Inc.
6301 49th Street North, St. Petersburg, Florida

38. Hallmarkets Internationl, Ltd.
55 West 42nd Street, New York, New York 10036

39. Information Control Systems, Inc.
109 East Madison, Ann Arbor, Michigan 48108

40. Information International, Inc.
545 Technology Square, Cambridge, Massachusetts 02139

41. Information Machines Corporation
8024 John Trowers Avenue, Santee, California 92071

42. Information Research Associates, Inc.
3065 Rosecrans Place, San Diego, California 92110

43. International Computer Equipment
1231 25th Street, N. W., Washington, D.C. 20037

44. International Datacon, Inc.
15158 South Cicero, Oak Forest, Illinois 60452

45. International Scanatron Systems Corporation
1623 Straight Path, Wyandanch, New York

46. Interstate Computer Services, Inc.
754 4th Avenue, Brooklyn, New York 11232

47. Litton Industries, Automated Business Systems Division
600 Washington Avenue, Carlstadt, New Jersey 07022

48. Litton Industries
Datalog Division, 343 Sansome Street, San Francisco, Calif.

49. Loral Electronic Systems
Division of Loral Corporation, 688 White Plains Road, Scarsdale, New York 10583

50. Measurement Research Center, Inc.
Division of Westinghouse Learning Corporation, Box 30, Iowa City, Iowa 52240

51. Mergenthaler Linotype Company
One Mergenthaler Drive, Plainview, Long Island, N.Y. 11803

52. Metro Processing Corporation of America
64 Prospect Street, White Plains, New York 10606

53. Milgo Electronics Corporation
7620 N. W. 36th Avenue, Miami, Florida

54. Milli-Switch Corporation
Box 67, Gladwyne, Pennsylvania

55. Nanosecond Systems, Inc.
176 Linwood Avenue, Fairfield, Connecticut 06430

56. National Cash Register Company
Publix Relations Department, Dayton, Ohio 45409

57. National Computer Systems
1015 South 6th Street, Minneapolis, Minnesota 55415

58. Nippon Electric New York Inc.
200 Park Avenue, New York, New York

59. Northern Scientific Inc.
2551 West Beltline, Middleton, Wisconsin

60. Novar Corporation
2370 Charleston Road, Mountain View, California 94040

61. Nuclear Enterprises Ltd.
Edinburgh 11, Scotland

62. Nutronics, KeyKode Division
Box 72, Paramus, New Jersey 07652

63. Oki Electronics Industries, Ltd.
202 E. 44th Street, New York, New York 10017

64. Olivetti Underwood Corporation
One Park Avenue, New York, New York 10016

65. Philco-Ford Corporation
3900 Welsh Road, Willow Grove, Pennsylvania 19090

66. Philips-Electrologica, N. V.
P.O. Box 345, Apeldoorn, Holland

67. Pinlites, Inc.
1275 Bloomfield Avenue, Fairfield, New Jersey 07006

68. Potter Instrument Co., Inc.
Bethpage Road, Plainview, New York

69. PPM Inc.
7016 Euclid Avenue, Cleveland, Ohio

70. Raytheon Company
Industrial Components Operation
465 Center Street, Quincy, Massachusetts

71. Realist, Inc., Microform Products Division
N93 W16288 Megal Drive, Minomee Falls, Wisconsin 53057

72. Republic Advanced Technology Systems
9754 Deering Street, Chatsworth, California 91311

73. Scientific Data Systems
701 South Aviation Boulevard, El Segundo, California

74. Scope, Inc.
1860 Michael Faraday Drive, Reston, Virginia 22070

75. SEACO Computer Display, Inc.
2714 National Circle, Garland, Texas 75040

76. Siemens America, Inc.
350 Fifth Avenue, New York, New York 10001

77. Sierra Research Corporation, Computer Products Department
167 Bedford Street, Burlington, Massachusetts 01803

78. Soroban Engineering, Inc.
P.O. Box 1690, Melbourne, Florida 32901

79. Transcom, Inc., Subsidiary of HI-G Inc.
Spring Street and Route 75, Windsor Locks, Connecticut

80. Tyco Instrument Division
16 Hickory Drive, Waltham, Massachusetts

81. Ultronic Systems Corporation, Subsidiary of Sylvania
Electronic Products, Mt. Laurel Park, Moorestown, New Jersey

82. Univac Division, Sperry-Rand
P.O. Box 8100, Philadelphia, Pennsylvania 19101

83. Vernitron
50 Gazza Boulevard, Farmingdale, New York 11735

84. Viatron Computer Systems Corporation
Department M-1

85. Victor Comptometer Corporation, Business Machine Group
3900 North Rockwell, Chicago, Illinois 60618

86. Wang Labs, Inc., Department 6AC
836 North Street, Tewksbury, Massachusetts

87. Wyle Labs
128 Maryland Street, El Segundo, California

Badge Readers (Appendix B)

Manufacturers Included in this Appendix:

1. Friden, Inc.
2350 Washington Avenue, San Leandro, California 94577
(415) 357-6800
S. W. Terry

2. G. E. Information Service
4000 N. W. 39th Street, Box 123. 3, Oklahoma City, Oklahoma 73112
(405) 946-5421

3. Hickok Electrical Systems
Cleveland, Ohio
(216) 541-8060
Robert Kerzman

4. IBM - Systems Development Division
9045 Lincoln Boulevard, LosAngeles, California 90045
(213) 670-8350

5. Key Data Machines
310 East 44th, New York, New York 10017
(212) 686-4986
Bradley Welsh

6. Kimball Systems Div.
Belleville, New Jersey
(201) 759-6500
Don O'Brian
Bill Smythe

7. Sealectro Corporation
Mamaroneck, New York 10543
(914) 698-5600
Howard F. Gordon

8. Synergistics, Inc., Ten Tech Circle
East Natick, Massachusetts 01760
(617) 655-1340
George Rice

9. Addo-X Inc.
437 Madison Avenue, New York, New York 10022
(212) 758-9171
Tom Kibby

10. American Computer and Communications
2576 West Carson Street, Torrance, California 90503
(213) 320-8810
Tom C. McGeary
Bill DeVore
Mark Kimmel

11. AMP Incorporated
Harrisburg, Pennsylvania 17105

12. Audac Corporation
175 Bedford Street, Burlington, Massachusetts 01803
(617) 272-6720
Peter Bryan

13. Control Data Corporation
8100 34th Avenue So., Minneapolis, Minnesota 55440
(612) 888-5555

14. Credit Systems Inc.
1350 Broadway, New York, New York 10018
(212) 736-7927
J. Frank

15. Data Pathing Incorporated
370 San Aleso Avenue, Sunnyvale, California 94086
(408) 734-0100
Bob Vanderburg

16. Digital Identification Systems
3074 Miraloma Avenue, Anaheim, California 92808
(714) 630-1350
Alfiero F. Balzano

Manufacturers Contacted but Excluded because their equipment products were not applicable to the L. O. C. requirements:

1. Franklin Fibre-Lamitex Corp.
901-905 East 13th Street, Wilmington, Delaware

2. Isotopes
50 Van Buren Avenue, Westwood, New Jersey

3. Landauer, R. S. Jr. & Co.
Science Road, Glenwood, Illinois

4. LTV Electro Systems, Inc., Garland Division
Box 6118, Dallas, Texas

5. National Laminating Mfg. Co.
339 South Robertson Boulevard, Beverly Hills, California

6. Nuclear Equipment Chemical Corp.
165 Marine Street, Farmingdale, New York

7. U.S. Testing Co., Inc.
1415 Park Avenue, Hoboken, New Jersey

Alphanumeric CRT Displays (Appendix C)

Manufacturers Included in this Appendix:

1. A. B. Dick Company
5700 Touhy Avenue, Chicago, Illinois 60648
(312) RO 3-1900
Charles Hurst

2. Atlantic Technology Corporation
7th & New Hampshire, Sommers Point, New Jersey 08244
(609) 927-8131
Jim Foy

3. Bolt Beranek & Newman Inc.
15808 Syandotte, Van Nuys, California 91406
(213) 781-8350
D. S. Siegel

4. Bunker Ramo Corporation
445 Fairfield Avenue, Stamford, Connecticut 06904
(203) 348-4291

5. Burroughs Corporation
The Defense Space & Special Systems Group
Central Avenue, Paoli, Pennsylvania 19301
(215) NI 4-4700

6. Computer Communications Inc.
701 W. Manchester Blvd., Inglewood, California 90301
(213) 674-5300
Vess Vilips

7. Computer Terminals Inc.
Pentagon Park, 4815 W. 77th Street, Minneapolis, Minn. 55435
(612) 920-2784
Ray Merwin

8. Computer Terminal Corp.
P.O. Box 6967, San Antonio, Texas 78209
(512) 696-4520
Jack Jones

9. Conrac Corp., Conrac Division
600 N. Rimsdale Avenue, Covina, California 91722
(213) 966-3511
A. L. Landesperger

10. Control Data Corporation, Data Display Division
2401 North Fairview Avenue, St. Paul, Minnesota 55113
(612) 633-0371
C. S. Morell

11. Courier Terminal Systems Inc.
2202 East University Drive, Phoenix, Arizona 85034
(602) 258-7271
Albert Hagan

12. Data Discs Inc., Display Division
1275 California Avenue, Palo Alto, California 94304
(415) 326-7602
Chuck McEwan

13. Delta Data Systems Inc.
Woodhaven Industrial Park, Cornwalls-Heights, Pa. 19020
(215) 639-9400
H. Barry Maser

14. General Electric Company, Information Devices Dept.
P.O. Box 12313, Oklahoma City, Oklahoma 73112
(405) WI 6-5421
Byran R. Hays

15. IBM, Data Processing Division
112 East Post Road, White Plains, New York 10601

16. Spiras Systems Inc.
332 Second Avenue, Waltham, Massachusetts 02154
(617) 891-7300
Richard A. Hendrickson

17. National Cash Register Co., Industrial Products Division
Main and K Streets, Dayton, Ohio 45409

18. Philco-Ford Corporation, Philco Houston Operations
1002 Gemini, Houston, Texas 77058
(713) 488-1270

19. Radiation Inc., Systems Division
P.O. Box 37, Melbourne, Florida 32901
(305) 727-4000
C. G. Dawdy

20. Raytheon Co., Equipment Division
40 Second Avenue, Waltham, Massachusetts 02154
(617) 899-8400
John S. Barber

21. RCA, Electro Magnetic & Aviation Systems Division
8500 Balboa Boulevard, Van Nuys, California 91409
(213) 894-8111
Len Hess

22. Sanders Associates Inc.
Daniel Webster Hwy., So., Nashua, New Hampshire 03060
(603) 885-4220
Jack Margolies

23. Stromberg Carlson, Data Products Division
P.O. Box 2449, San Diego, California 92112
(714) 298-8331

24. Transistor Electronics Corp.
P.O. Box 6191, Minneapolis, Minnesota 55424
(612) 941-1100
A. V. Klizas

25. Ultronics Systems Corp., Subsidiary of Sylvania Electric
Products, Inc., Mt. Laurel, Industrial Park
Morrestown, New Jersey 08057
(609) 235-7300

26. Univac, Division of Sperry Rand Corp., OEM, Marketing Dept.
P.O. Box 8100, Philadelphia, Pennsylvania 19101
(215) 646-9000

27. Wyle Laboratories, Systems Division
128 Maryland Street, El Segundo, California 90245
(213) 678-4251
John Herring

28. Xerox Data Systems
1649 17th Street, Santa Monica, California 90404
(213) UP 1-0960
Kas Terhorst

29. Infoton Inc.
Second Avenue, Burlington, Massachusetts 91803
(617) 272-6660
John McFail

30. Video Systems Corporation
5300 North Crescent Boulevard, Pennsauken, New Jersey 08110
(609) 665-6688

31. Alphameric Data Corp.
Princeton-Highstown Road, Cranbury, New Jersey 08152
(609) 799-1599

32. Sugarman Laboratories Inc.
295 Northern Boulevard, Great Neck, New York 11021
(516) 466-0080

33. Beehive Electrotech Inc.
1473 South Sixth West, Salt Lake City, Utah 84104
(801) 487-0741

34. Lear Siegler Inc., Electronic Instrumentation Division
714 North Brookhurst Street, Anaheim, California 92803
(714) PR 4-1010
Lee R. Couts

35. Honeywell Inc., EDP Division
60 Walnut Street, Wesley Hills, Massachusetts 02181
(617) 235-7450
Clark Neill

36. Computer Displays Inc.
223 Crescent Street, Waltham, Massachusetts 02154
(617) 899-0480
Robert H. Stotz

37. Computek Inc.
143 Albany Street, Cambridge, Massachusetts 02139
(617) 864-5140
Don Herring

38. Computer Optics Inc.
Berkshire Industrial Park, Bethel, Connecticut 06801
(203) 744-6720
Edward J. Shaughanssy

Manufacturers Contacted but Excluded because their equipment products were not applicable to the L. O. C. requirements:

Data Terminal, Display and Visual Input/Output Devices

1. A. D. Data Systems
830 Linden Avenue, Rochester, New York 14625
(716) 381-2370

2. All Data Processing Machines, Inc.
105 Hinricher Street, Willow Springs, Illinois 60480
(312) 839-5164

3. American Computer & Communication Co.
2576 W. Carson Street, Torrance, California 90503
(213) 320-8810

4. Ampex Corp., Videofile Information Systems
1020 Kifer Road, Sunnyvale, California 94086
(408) 738-4910

5. Applied Peripheral Systems Inc.
7120 Harwin Dr., Houston, Texas 77036
(713) 785-5040

6. Applied Systems Corp.
18325 W. McNichols, Detroit, Michigan 47219
(313) 535-5800

7. BFA, Inc.
1309 Inca Street, Denver, Colorado 80223
(303) 744-3301

8. California Computers Products, Inc.
305 N. Muller Street, Anaheim, California 92803
(714) 774-9141

9. CPU, Inc.
7750 N. W. 7 Ave., Miami, Florida 33150
(305) 693-3623

10. Chicago Cash Register Co.
1201 West Madison Street, Chicago, Illinois 60607
(312) 666-5555

11. Clary Corp.
408 Junipero Serra Drive, San Gabriel, California 91776
(213) 287-6111

12. Colorado Video, Inc.
250 Pearl Street, Boulder, Colorado 80302
(303) 444-3972

13. Combined Data Group Inc.
180 Broadway, New York, New York 10038
(212) 964-1084

14. Comdata Corp.
7544 West Oakton Street, Niles, Illinois 60648
(312) 692-6107

15. Compat Corp.
177 Cantiague Road, Westbury, New York 11590
(516) 822-1320

16. Computer Acquisitions Co.
P.O. Box 29185, Atlanta, Georgia 30329
(404) 636-8090

17. Computer Consoles, Inc.
317 Main Street, Rochester, New York 14445
(716) 381-0479

18. Computer Power Systems Inc.
722 East Evelyn Avenue, Sunnyvale, California 94086
(408) 738-0530

19. Computer Products Inc.
2801 East Oakland Park Blvd., Fort Lauderdale, Florida 33306
(305) 565-9565

20. Computer Test Corp.
3 Computer Drive, Cherry Hill, New Jersey 08034
(609) 424-2400

21. CTC Computer Corporation
1018 Palo Alto Office Ctr., Palo Alto, California 94301
(415) 328-5630

22. Computrols, Inc.
1470 Doolittle Drive, San Leandro, California 94577
(415) 562-7779

23. Data Central Inc.
200 South Hanley Road, St. Louis, Missouri 63105
(314) 863-4000

24. Data Interface Corp.
18455 Burbank Boulevard, Tarzana, California 91356
(213) 345-8723

25. Data Processing Supplies Inc.
1216 East McMillan St., Cincinnati, Ohio 45206
(513) 961-0776

26. Data Products Corp.
6219 De Soto Avenue, Woodland Hills, California 91364
(213) 887-8000

27. Data Systems Analysts Inc.
Cooper Parkway Office Bldg., North Park Drive
Pennsauken, New Jersey 08109
(609) 665-6088

28. Data Vox, Division of Data Technology Corp.
1050 East Meadow Circle, Palo Alto, California 94303
(415) 321-0551

29. Datanetics Corp.
2828 Spreckels Lane, Redondo Beach, California 90278
(213) 542-4355

30. Dataq Inc.
6709 North Olie, Oklahoma City, Oklahoma 73116
(405) 842-1313

31. Datarol Inc.
Kane Industrial Drive, Hudson, Ma. 01745
(617) 562-3422

32. Datron Systems Inc.
100 Route 46, Mountain Lakes, New Jersey 07046
(201) 334-4521

33. Decca Radar Canada Ltd.
23 Six Point Rd., Toronto 18, Ontario, Canada
(416) 239-1161

34. Dialight Corp.
60 Stewart Avenue, Brooklyn, New York 11237
(212) 497-7600

35. Digi, Inc.
37 West 2950 South, Salt Lake City, Itah 84115
(801) 487-0753

36. Digital Equipment Corp.
146 Main Street, Maynard, Ma. 01754
(617) 897-5111

37. Digital Logic Corp.
1853 Raymond Avenue, Anaheim, California 92801
(714) 871-4653

38. Digital Scientific Corp.
11661 Sorrento Valley Road, San Diego, California 92121
(714) 453-1534

39. Digital Systems Corp., University Circle Research Center
11000 Cedar Avenue, Cleveland, Ohio 44106
(216) 721-3334

40. Direct Access Computing
24175 Northwestern Highway, Southfield (Detroit), Mich. 48075
(313) 358-5000

41. Discon Corp.
1150 N. W. 70th Street, Ft. Lauderdale, Florida 33309
(305) 933-4551

42. Diversified Numeric Applications, Div. of Avnet, Inc.
9801 Logan Avenue S., Minneapolis, Minnesota 55431
(612) 884-4777

43. Dynatronics Operation, Electronics Division of General Dynamics
P. O. Box 2566, Orlando, Florida 32802
(305) 838-6161

44. Ecco Business Sytems Inc.
50 E. 42nd Street, New York, New York 10017
(212) 682-3244

45. Electronic Associates Inc.
185 Monmouth Pkwy., West Long Branch, New Jersey 07764
(201) 229-1100

46. Fairchild Space & Defense Systems
Division of Fairchild Camera & Instrument Corporation
300 Robbins Lane, Syosset, New York 11791
(516) 931-4500

47. Ferranti Electric Inc.
East Bethpage Road, Plainview, New York 11803
(516) 293-8383

48. Foto Mem, Inc.
2 Mercer Road, Natick, Ma. 01760
(617) 655-4600

49. Four Phase Systems Inc.
991 Commercial Street, Palo Alto, California 94303
(415) 327-7444

50. HF Image Systems Inc.
11244 Playa Ct., Culver City, California 90230
(213) 390-3378

51. Houston Instrument, Div. of Bausch and Lomb, Inc.
4950 Terminal Avenue, Bellaire, Texas 77401
(713) 667-7403

52. Hughes Aircraft Co.
Centinela Avenue and Teale Street, Culver City, Calif. 90230
(213) 391-0711

53. Hydra Computer Corp.
4208 Six Forks Road, Raleigh, North Carolina 27609
(919) 782-1051

54. Imlac Corp.
296 Newton Street, Waltham, Massachusetts 02154
(617) 891-1600

55. Industrial Electronic Engineers Inc.
7720 Lemona Avenue, Van Nuys, California 91405
(213) 787-0311

56. Inforex Inc.
15 Lunda St., Waltham, Massachusetts 02154
(617)899-6634

57. Information Development Corp.
30 Merz Boulevard, Akron, Ohio 44313
(216) 836-0221

58. Information Displays Inc.
333 North Bedford Road, P.O. Box 688, Mt. Kisco, New York 10549
(914) 241-1000

59. Information International Inc.
11161 West Pico Boulevard, Los Angeles, California 90064
(213) 478-2571

60. Information Network Corp.
3003 North Central Ave., Suite 1211, Phoenix, Arizona 85012
(602) 264-9721

61. Information Research Assoc.
3065 Rosecrans Pl., San Diego, California 92110
(714) 224-3797

62. Interdata, Inc.
2 Crescent Pl., Oceanport, New Jersey 07757
(201) 229-4040

63. Intermec Inc.
5503 232nd S.W., Mountlake, Terr., Wa. 98043
(206) 774-4156

64. International Automation Co.
1687 Tuille Cir. N.E., Suite 206, Atlanta, Georgia 30329
(404) 633-4239

65. International Computer Equipment Inc.
1231 25th St., N.W., Washington, D.C. 20037
(202) 293-3910

66. International Datacon Inc.
15158 South Cicero, Oak Forest, Illinois 60452
(312) 687-5550

67. Kendick Manufacturing Co.
1025 Goshen Ave., P.O. Box 2692, Fort Wayne, Ind. 46808
(219) 484-3111

68. Limited Fours Unltd. (LFU)
2895 East College #47, Boulder, Colorado 80302
(303) 443-9103

69. Litton Industries Inc., Data Systems Division
8000 Woodley Avenue, Van Nuys, California 91406
(213) 781-8211

70. Logic Corp.
15 East Euclid Avenue, Haddonfield, New Jersey 08033
(609) 428-4626

71. Management Data Corp.
1424 Walnut Street, Philadelphia, Pennsylvania 19102
(215) 546-6600

72. Marketing Operations Inc. (Mark/OPS)
475 Commonwealth Avenue, Boston, Massachusetts 02215
(617) 266-1930

73. NARS Computer Systems Inc.
65 North Orange Avenue, Orlando, Florida 32801
(305) 841-6500

74. Nanosecond Systems Inc.
176 Linwood Avenue, Fairfield, Conn. 06430
(203) 255-1008

75. Naybor, E. V. Laboratories, Inc.
26 Manorhaven Boulevard, Port Washington, New York 11050
(516) 767-4300

76. Ochman, Edward, Systems
Box 141, Fairfield, Connecticut 06430
(203) 259-1927

77. Optomechanisms Inc.
40 Skyline Drive, Plainview, New York 11803
(516) 433-8100

78. Paragon Systems Inc., Subsidiary of Scientific Resources Corp.
2803 Buffalo Speedway, Houston, Texas 77006
(713) 621-7250

79. Penn Keystone Corp.
Division Street, Ansonia, Connecticut 06401
(203) 734-3301

80. Pennsylvania Research Associates, Inc.
101 North 33rd Street, Philadelphia, Pennsylvania 19104
(215) 382-8500

81. Pinlites Inc.
1275 Bloomfield Avenue, Fairfield, New Jersey 07006
(201) 226-7724

82. RADC/EMIIF
Griffess Air Force Base, Rome, New York 13440
(315) 330-4824

83. Raycon Inc.
2097 Chartier, Dorval 760, Quebec, Canada
(514) 636-1903

84. Rayonic Corp.
1934 East Hagert Street, Philadelphia, Pennsylvania 19125
(215) 634-6970

85. Redcor Corp.
7800 Deering Avenue, P.O. Box 1031, Canoga Park, Calif. 91304
(213) 348-5892

86. Schultz Instruments Inc.
P.O. Box 13385, Gainesville, Florida 32601
(904) 378-1750

87. Scientific Resources Corp.
7320 Old York Road, Philadelphia, Pennsylvania 19126
(215) 635-5100

88. Scope Inc.
1860 Michael Faraday Drive, Reston, Virginia 22070
(703) 471-5600

89. Seaco Computer Display Inc.
2714 National Circle, Garland, Texas 75040
(214) 271-2521

90. SEFAC
761 Miami Cir. N.E., Atlanta, Georgia 30324
(404) 261-4168

91. Sierra Research Corp., Computer Products Dept.
167 Bedford Street, Burlington, Ma. 01803
(671) 272-6534

92. Source Data Automation
19 West 44th Street, New York, New York 10036
(212) 869-1140

93. Systems Concepts Inc.
200 Second Street, Cambridge, Massachusetts 02142
(617) 864-4423

94. Systems Engineering Labs, Inc.
6901 W. Sunrise Blvd., Ft. Lauderdale, Florida 33313
(305) 587-2900

95. TLW Computer Industries
4 Executive Park E., N. E., Atlanta, Georgia
(404) 633-2579

96. Telecomputing Inc.
1626 Edison Street, Dallas, Texas 75207
(214) 748-0751

97. Theta Instrument Corp.
Fairfield, New Jersey 07006
(201) 227-1700

98. Time Share Peripherals Corp.
90 Danbury Road, Wilton, Ct. 06897
(203) 762-3348

99. Timeshare Devices Inc.
225 Crescent Street, Waltham, Massachusetts 02154
(617) 899-3560

100. Trans Data Co.
6394 Freeport Boulevard, Sacramento, California 95822
(916) 421-8285

101. Tymshare Inc.
525 University Avenue, Suite 220, Palo Alto, Calif. 94301
(415) 328-5990

102. Vanguard Data Systems
3835 Birch Street, Newport Beach, California 92660
(714) 540-7640

103. Western Data Services Inc.
99 East Magnolia Boulevard, Suite 315, Burbank, Calif. 91502
(213) 848-4151

104. Zehntel, Inc.
1450 Sixth Street, Berkeley, California 94710
(415) 527-5440

105. CBS Laboratories
227 High Bridge Road, Stamford, Connecticut 06905
(203) 327-2000

106. Data Trends
1259 Route 46, Parsippany, New Jersey 07054
(201) 334-1515

107. Dumont Electron Tubes Div., Fairchild Camera & Instr. Corp.
7750 Bloomfield, Clifton, New Jersey 07015
(201) 773-2000

108. Hancock Telecontrol
320 Park Avenue, New York 22, New York
PLaza 2-5630

109. Informatics
5430 Van Nuys Boulevard, Sherman Oaks, California 91401

110. Interface Mechanisms
5503 232 S. W., Mountlake Terr., Wa. 98043

111. International Computers Ltd.
ICT Huuseputney, London, SW 15 England

112. Laboratory for Electronics
1075 Commonwealth Avenue, Boston, Massachusetts 02215

113. Norden
Helen Street, Norwalk, Conn. 06856
(203) 838-4471

114. Philco - Ford Corp., Houston Operations
1002 Gemini, Houston, Texas 77058

115. Planning Research
1101 Glenden Avenue, Los Angeles, California 90024

116. Singer General Precision Corp.
1150 McBridge Avenue, Little Falls, New Jersey 07424

117. Tasker
7838 Orion Avenue, Van Nuys, California 91409
(213) 781-3150

118. Texas Instruments
P. O. Box 5474, Dallas, Texas 75222

119. Thomas Electronics
100 Riverview Drive, Wayne, New Jersey 07470
(201) 696-5200

120. Viatron Corp.
1720 Military Road, Buffalo, New York 14217
(716) 874-3300

121. Zenith Integrated-DP Inc.
950 Fulton Avenue, Sacramento, California 95825

122. Hendrix Electronics
Old Wilton Road, Milford, New Hampshire 03055
(603) 673-4560

123. Hypertech
7343 West Wilson Avenue, Harwood Heights, Illinois 60656

Remote Printers (Appendix D)

Manufacturers Included in this Appendix:

1. A. B. Dick Co.
5700 Touhy Avenue, Chicago, Illinois 60648
(312) RO 3-1900
Charles Hurst

2. Computer Terminals Inc.
Pentagon Office Park, 4815 W. 77th St., Minneapolis, Minn. 55435
(612) 920-2784
Roy L. Merwin

3. Codamite Corp.
11822 Western Avenue, Stanton, California 90680
(714) 894-3535
R. W. Johnson

4. Clevite Corp., Graphics Dept.
E. 37th & Perkins Avenue, Cleveland, Ohio 44114
(216) 361-3315
John F. Staggs

5. Datamark Inc.
Cantiague Road, Westbury, L. I., New York 11590
(516) ED 3-8910
Carl I. Wassermann

6. Data Printer Corp.
225 Monsignor O'Brien Hwy., Cambridge, Mass. 02141
(617) 492-7484

7. Data Products Corp.
6219 De Soto Ave., Woodland Hills, Calif. 91364
(213) 887-8000
Ed Rosland

8. Digitronics Corp.
Albertson, Long Island, New York 11507
(516) 484-1000
Don F. Novak

9. General Electric Co., Information Devices Dept.
P.O. Box 12313, Oklahoma City, Oklahoma 73112
(405) 946-5421

10. Gulton Industries Inc., Computer Systems
13041 Cerise Ave., Hawthorne, California 90250
(213) 679-0111
Marvin Lawrence

11. Honeywell, Inc., Electronic Data Processing Peripheral
Device Operations, OEM Sales
300 Concord Road, Billerica, Mass. 01821
(617) 667-3111

12. IBM, Data Processing Division
112 E. Post Road, White Plains, New York 10601

13. Mohawk Data Sciences Inc., OEM Marketing
122 E. Ridgewood Avenue, Paramus, New Jersey 07652
(201) 265-7333

14. Motorola Instrumentation and Control Inc.
P.O. Box 5409, Phoenix, Arizona 85010
(602) 959-1000
M. D. Shapiro

15. National Cash Register Co., Industrial Parks Division
Main and K Streets, Dayton, Ohio 45409

16. Nortec Computer Devices Inc.
94 Nickerson Road, Ashland, Mass. 01721
(617) 881-3160
Richard Holzman

17. Potter Instrument Co., Inc.
715 E. Mission Drive, San Gabriel, California 91776
(213) 283-8177
Donald C. Squires

18. Tally Corp., Computer Products Div.
1222 E. Pomona Street, Santa Ana, California 92707
(714) 542-1196

19. Teletype Corp.
5555 Touhy Avenue, Skokie, Illinois 60076
(312) 676-1000
Michael Harris

20. Univac, Division of Sperry Rand, OEM Marketing Dept.
P.O. Box 8100, Philadelphia, Pennsylvania 19101
(215) 646-9000

21. Vogue Instrument Corp., Shepard Division
131st Street at Jamaica Ave., Richmond Hill, New York 11418
(212) 641-8800
B. Wagner

22. Control Data Corp.
1480 N. Rochester Road, Rochester, Michigan 48063
(313) 651-8810
Harrison Craig

Manufacturers Contacted but Excluded because their equipment products were not applicable to the L.O.C. requirements:

1. Advanced Space Age Products Inc.
4308 Wheeler Avenue, Alexandria, Virginia 22304
(703) 751-3320

2. All Data Processing Machines, Inc.
105 Hinricher Street, Willow Springs, Ill. 60480
(312) 839-5164

3. American Computer and Communication Co.
2576 West Carson Street, Torrance, California 90503
(213) 320-8810

4. Anadex Instruments, Inc.
7833 Haskell Avenue, Van Nuys, California 91406
(213) 833-6620

5. Applied Data Processing, Inc.
155 Whitney Avenue, New Haven, Connecticut 06510
(203) 787-4107

6. Beurmann-Marshall Corp.
821 Kalamazoo Street, Lansing, Michigan 48903
(517) 484-4455

7. Burroughs Corp.
6071 Second Avenue, Detroit, Michigan 48232
(313) 875-2260

8. California Electro-Scientific
2203 S. Grand Avenue, Santa Ana, California 92705
(714) 546-9550

9. Clary Corp.
408 Junipero Serra Drive, San Gabriel, California 91776
(213) 287-6111

10. Comdata Corp.
7544 West Oakton Street, Niles, Illinois 60648
(312) 692-6107

11. Compiler Systems, Inc.
Laurel Lane, Ridgefield, Ct. 06877
(203) 438-4736

12. Computer Acquisitions Co.
P.O. Box 29185, Atlanta, Ga. 30329
(404) 636-8090

13. Computer Communications, Inc.
701 West Manchester Blvd., Inglewood, California 90301
(213) 674-5300

14. Computer Data Sciences, Inc.
1276 West Third Street, Cleveland, Ohio 44113
(216) 241-3990

15. Computer Exchange, Inc.
30 East 42nd Street, New York, New York 10017
(212) 661-5870

16. Computer Supplies Co.
2301 Fifth Avenue, Seattle, Washington 98121
(206) 623-2413

17. Computer Time-Sharing Corp.
1018 Palo Alto Off. Ctr., Palo Alto, California 94301
(415) 328-5630

18. Computer-Link Corp.
P.O. Box 373, Waltham, Massachusetts 02154
(617) 899-3750

19. Custom Data Processing Service
2931 North 30th Ave., Phoenix, Arizona 85017
(602) 272-9371

20. Cyber-Tronics, Inc.
4 Nevada Drive, New Hyde Park, New York 11040
(416) 488-1300

21. Data Automation Computing Co., Inc.
7501 John W. Carpenter, Dallas, Texas 75247
(214) 637-6340

22. Data Copy Co.
760 Bryant Street, San Francisco, California 94107
(415) 391-1811

23. Data Processors Supply Co.
Box 3263, Huntsville, Alabama 35810
(205) 852-2295

24. Datagraphics, Inc.
740 Rush Street, Chicago, Illinois 60611
(312) 944-2166

25. Decitek, Inc.
15 Sagamore Road, Worcester, Ma. 01605
(617) 757-4577

26. Digital Equipment Company
146 Main Street, Maynard, Ma. 01754
(617) 897-5111

27. Digital Scientific Corp.
11661 Sorrento Valley Road, San Diego, California 92121
(714) 453-1534

28. Foto-Mem, Inc.
2 Mercer Road, Natick, Ma.
(617) 655-4600

29. General Radio Co.
300 Baker Avenue, Concord, Ma. 01781
(617) 369-4400

30. Hewlett-Packard Co.
1501 Page Mill Road, Palo Alto, California 94034
(415) 326-7000

31. Hickok Electrical Instrument Co.
10514 Dupont Avenue, Cleveland, Ohio 44108
(216) 541-8060 X212

32. Infotran, Inc.
860 Fifth Avenue, New York, New York 10021
(212) 535-7500

33. International Automation Co.
1687 Tuille Cir. N.E., Suite 206, Atlanta, Ga. 30329
(404) 633-4239

34. International Computer Equipment, Inc.
1231 25th Street, N.W., Washington, D.C. 20037
(202) 293-3910

35. Keltron Corp.
225 Crescent Street, Waltham, Ma. 02154
(617) 894-0525

36. Kleinschmidt, Div. of SCM Corp.
Lake-Cook Road, Deerfield, Illinois 60015
(312) 945-1000

37. Monroe International, Div. of Litton Bus. Sys. Inc.
955 Waterman Ave., E. Providence, R.I. 02914
(401) 434-4207

38. Nanosecond Systems, Inc.
176 Linwood Avenue, Fairfield, Ct. 06430
(203) 255-1008

39. Newton Electronic Systems, Inc.
225 Crescent Street, Waltham, Ma. 02154
(617) 891-6770

40. Non-Linear Systems, Inc.
P.O. Box N, Del Mar, California
(714) 755-1134

41. Optomechanisms, Inc.
40 Skyline Drive, Plainview, New York 11803
(516) 433-8100

42. Philips-Electrologica, N.V.
P.O. Box 245, Apeldoorn, Holland
(05760-30123

43. RCA Information Systems Div.
Route 38, Cherry Hill, N.J. 08034
(609) 963-8000

44. Radiation, Inc.
P.O. Box 37, Melbourne, Florida 32901
(305) 727-4000

45. Scope, Inc.
1860 Michael Faraday Dr., Reston, Virginia 22070
(703) 471-5600

46. SEACO Computer-Display Inc.
2714 National Circle, Garland, Texas 75040
(214) 271-2521

47. Standard Processing Co., Inc.
225 W. Park, Pharr, Texas 28577
(512) 787-1717

48. Systems Engineering Laboratories, Inc.
6901 West Sunrise Blvd., Ft. Lauderdale, Florida 33313
(305) 587-2900

49. TLW Computer Industries, Inc.
4 Executive Park E., NE, Atlanta, Georgia 30329
(404) 633-2579

50. Technitrend, Inc.
7300 N. Crescent Blvd., Pennsauken, New Jersey 08110
(609) 665-4910

51. Typagraph Corp.
7525 Convoy Ct., San Diego, California 92111
(714) 279-5690

52. University Computing Co.
1300 Frito-Lay Tower, Dallas, Texas 75235
(214) 350-1211

53. Western Data Services, Inc.
99 E. Magnolia Blvd. #315, Burbank, California 91502
(213) 848-4151

54. Addressograph Multigraph Corp.
1200 Babbitt Road, Cleveland, Ohio 44117
(216) 731-8000

55. Bull Corp. of America
1 E. 57th St., New York, New York 10022

56. Bunker Ramo
445 Fairfield Ave., Stamford, Conn. 06904

57. Computer Measurements
12970 Bradley Ave., San Fernando, California 91342

58. Consolidated Electronics Industries Corp.
100 E. 42nd St., New York, New York 10017

59. DI/AN Controls Inc.
944 Dorchester Ave., Boston, Massachusetts 02125
(617) 288-7700

60. Franklin Electronics Inc.
E. Fourth St., Bridgeport, Pa. 19405
(215) 272-4800

61. Information Control Systems Inc.
327 S. 4th Ave., Ann Arbor, Michigan 48108

62. Interface Mechanisms
5503 232nd St., SW, Mountlake Terrace, Wash. 98043

63. Litton Systems, Datalog Division
One Executive Park, Suite 29, Englewood, Colorado 80110
(303) 771-2010

64. Photon Inc.
355 Middlesex Ave., Wilmington, Mass. 01887

65. Presin Co.
Trap Falls Road, Shelton, Conn. 06484

66. Tele-Dynamics Div., American Bosch Arma Corp.
5000 Parkside Ave., Philadelphia, Pennsylvania 19131

67. Xerox Corp.
Rochester, New York 14603

68. Computer Solutions
50 Washington Terrace, East Orange, New Jersey 07017
(212) 349-1531

69. Peripheral Data Machines Inc.
1546 E. Chestnut St., Santa Ana, California 92701
(714) 835-3636

70. Syner-Data Inc.
Route 128, Brimball Avenue, Beverly, Mass. 01915

Machine Readable Unit Document Devices (Appendix E)

Manufacturers Included in this Appendix:

Optical and Magnetic Character Recognition and Mark Sense

1. Burroughs Corporation
1818 East First Street, Santa Ana, California 92702
(714) 541-4111
E. J. O'Brien

2. Control Data Corporation
Rabinow Labs - 1455 Res. Blvd., Rockville, Maryland 20850
(301) 762-5310
Dave Rabinow

3. Farrington
5881 Leesburg Pike, Falls Church, Va. 22041
(703) 354-5000
A. L. Kaplan

4. General Electric Co., Information Devices Department
4000 N.W. 39th Street, Oklahoma City, Oklahoma 73112
(405) 946-6421
Jerry L. Crosby

5. General Electric Co./Bull
4000 N.W. 39th St., Oklahoma City, Oklahoma 73112
(405) 946-6421
Jerry L. Crosby

6. Honeywell - EDP
60 Walnut Street, Wellesley Hills, Massachusetts 02181
(617) 235-7450
R. C. Bishop

7. IBM - Ind. Products, Federal Systems
18100 Frederick Pike, Gaithersburg, Maryland 20760
(301) 840-6622
Dave Lyman

8. National Cash Register, Industrial Products Division
3100 Valleywood Drive, Dayton, Ohio 45429
(513) 449-6751
Jim Glanville

9. Optical Scanning Corp.
P.O. Box 40, Route 332 East, Newtown, Pa. 18940

10. Philco-Ford, Communication and Technical Services Div.
3900 Welsh Road, Willow Grove, Pennsylvania 19090
(215) 659-7700
George W. Rees

11. Recognition Equipment Inc.
1500 West Mockingbird Lane, Dallas, Texas 75235

12. Scan-Data
800 East Main Street, Norristown, Pennsylvania 19401
(215) 277-0500

13. Hewlett Packard, Cupertino Division
11000 Wolfe Road, Cupertino, California 95014
(408) 257-7000
Fred Waldren

14. Motorola, Information Systems, Instrumentation and Control Inc.
P.O. Box 5409, Phoenix, Arizona 85010
(602) 959-1000

15. Potter Instruments Company
East Bethpage Road, Plainview, New York
(516) 694-9000
Joel Levine

Manufacturers Contacted but Excluded because their equipment products were not applicable to the L.O.C. requirements:

1. AMP Incorporated
Box 3608, Harrisburg, Pennsylvania

2. Bendix Corporation, Electro-Optics Division
1975 Green Road, Ann Arbor, Michigan

3. Digital Instruments, Inc.
13735 Victory Blvd., Van Nuys, California

4. Litton Industries, Electron Tube Division
960 Industrial Road, San Carlos, California

5. Nippon Electric, New York Inc.
200 Park Avenue, New York, New York

6. RCA, Elec. Data Processing Division
1730 West Olympic, Los Angeles, California

7. Western Union Telegraph Co.
215 N. Broadway, Santa Ana, California

8. Cognitronics Corporation
549 Pleasantville Road, Briarcliff, New York 10510

9. Scan-Optics Inc.
100 Prestige Park Road, East Hartford, Conn. 06108

Tape Devices for Machine Readable Media (Appendix F)

Manufacturers Included in this Appendix:

A. Magnetic Tape Cassettes and Cartridges

1. Tri-Data Corp.
800 Maude Avenue, Mountainview, California 94040
(415) 969-3700
John Craver

2. International Computer Products Inc.
P.O. Box 34484, Dallas, Texas 75234
(214) 239-5381

3. Sykes Datatronics Inc.
375 Orchard St., Rochester, New York 14606
(716) 458-8000
Paul A. Mallon

4. Dicom Industries
684 West Maude Avenue, Sunnyvale, California 94086
(408) 732-1060
Richard Lewis

5. Computer Terminal Corp.
P.O. Box 6967, San Antonio, Texas 78209
(512) 696-4520
Jack Jones

6. Cipher Data Products
7655 Convoy Ct., San Diego, California 92111
(714) 277-8070
Frank W. Loeschner

7. Universal Data Acquisition Co., Inc.
3928 Hartsdale Drive, P.O. Box 36166, Houston, Texas 77036
(713) 782-5761

B. Incremental Mag Tape Recorders

1. Cipher Data Products
7655 Convoy Ct., San Diego, California 92111
(714) 277-8070
Frank W. Loeschner

2. Digi-Data Corp.
4315 Baltimore Ave., Baldensburg, Md. 20710
(301) 277-9378

3. Kennedy Co.
540 W. Woodbury Road, Altadena, California
(213) 798-0953
David S. Krueger

4. Precision Instrument Co.
3170 Porter Drive, Palo Alto, California 94304
(415) 321-5615

5. Peripheral Equipment Corp.
9551 Irondale Ave., Chatsworth, California 91311
(213) 882-0030

Manufacturers Contacted but Excluded

None

Calculating Unit and Controller-Small Computers (Appendix G)

Manufacturers Included in this Appendix:

1. Computer Automation Inc.
895 W. 16th St., Newport Beach, California 92660
(714) 642-9630
Dave Methvin

2. Data General Corp.
Southboro, Mass. 01772
(617) 485-9100
Ed Decastro

3. Datamate Computer Systems Inc.
P.O. Box 310, Big Spring, Texas 79720
(915) 267-8766
Allan Fulmer

4. Redcor Corp.
P.O. Box 1031, Canoga Park, California 91304
(213) 348-5892

5. GRI Computer Corp.
76 Rowe St., Newton, Massachusetts 02166
(617) 969-7346
Irwin M. Stone

6. Hewlett Packard
11000 Wolf Road, Cupertino, California 95014
(408) 257-7000
William Davidow

7. Honeywell Computer Control Division
Old Connecticut Path, Framingham, Mass. 01701
(617) 879-2600
J. A. Ridgeway

8. Information Technology Inc.
164 Wolfe Road, Sunnyvale, California 94086
(408) 245-8772
James T. Chao

9. Interdata Inc.
2 Crescent Place, Oceanport, New Jersey 07757
(201) 229-4040
Victor Spencer

10. Lockheed Electronics Co., Data Products Division
6201 E. Randolph, Los Angeles, California 90022
(213) 722-6810
Robert Miller

11. Raytheon Computer
2700 S. Fairview, Santa Ana, California 92704
(714) 546-7160
William A. Tracey

12. Systems Engineering Laboratories
6901 West Sunrise Boulevard, Ft. Lauderdale, Florida 33310
(305) 487-2900

13. Tempo Computers Inc.
1550 S. State College Blvd., Anaheim, California 92806
(714) 633-3660
Ed MacAteer

14. Varian Data Machines
2722 Michaelson Drive, Irvine, California 92664
(714) 833-2400
Vernon Smith

15. Digital Equipment Corp.
146 Main Street, Maynard, Massachusetts 01754
(617) 897-4111

16. General Automation Inc.
706 W. Katella Avenue, Orange, California 92667
(714) 633-1091
Burton A. Yale

17. Motorola Instrumentation & Control Inc.
P.O. Box 5409, Phoenix, Arizona 85010
(602) 959-1000
George Sickler

18. Business Information Technology Inc.
5 Strathmore Road, Natick, Massachusetts 01760
(617) 237-2930

19. Micro Systems Inc.
644 E. Young Street, Santa Ana, California 92705
(714) 540-6730
William Roberts

Manufacturers Contacted but Excluded because their equipment product information is too preliminary or it was not applicable to the L. O. C. requirements:

1. Multi-Data
15142 Golden West Circle, Westminster, California 92683
(714) 892-8347
Bruce Chancelor

2. Compiler Systems Inc.
P. O. Box 366, Ridgefield, Conn. 06877
(203) 438-0488

3. Computer Development Corp.
3001 Daimler Street, Santa Ana, California 92705
(714) 557-9720
Lambuth Cox

4. Uni-Comp
18219 Parthenia Street, Northridge, California 91324
(213) 886-7722

5. Transistor Electronics Corp.
P. O. Box 6191, Minneapolis, Minn. 55424
(612) 941-1100
A. V. Klizas

6. Digital Scientific Corp.
11455 Sorrento Valley Road, San Diego, California 92121
(714) 453-6050

7. Clary Datacomp Systems Inc.
404 Junipero Serra Drive, San Gabriel, California 91776
(213) 283-9485
Scott P. Davis

8. Xerox Data Systems
1649 17th St., Santa Monica, California 90404
(213) UP 1-0960

9. Spiras Systems Inc.
332 Second Avenue, Waltham, Massachusetts 02154
(617) 891-7300
Richard A. Hendrickson

10. Digital Equipment Corp.
146 Main Street, Maynard, Massachusetts 01754
(617) 897-4111

11. Control Data Corporation
4455 Eastgate Mall, La Jolla, California 92037
(714) 453-2500
D. L. Baker

12. Electronic Associates Inc.
185 Monmouth Park Hwy., W. Long Branch, N.J. 07764
(201) 229-1100

13. Electromechanical Research Inc.
8801 Bloomingham Fwy., Minneapolis, Minnesota 55420
(612) 888-9581
Carl A. Larson

14. Honeywell, Inc.
Old Connecticut Path, Framingham, Mass. 01701
(617) 879-2600
J. A. Ridgeway

15. IBM
112 E. Post Road, White Plains, New York 10601
(914) 949-1900

16. Systems Engineering Laboratory
6901 West Sunrise Blvd., Ft. Lauderdale, Florida 33310
(305) 487-2900

17. Westinghouse, Westinghouse Electric Corp.
Hagan/Computer Systems Division
200 Beta Drive, Pittsburgh, Pennsylvania 15238
(412) 782-1730
Bates Murphy

18. General Electric, Process Computer Department
2255 West Dessert Cove Road, Phoenix, Arizona 85029
(602) 943-2341