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Minimum cost data collection techniques for circulation control at the University of Missouri at Rolla Library

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MINIMUM COST DATA COLLECTION TECHNIQUES FOR CIRCULATION CONTROL AT THE UNIVERSITY OF MISSOURI AT ROLLA LIBRARY

BY

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A

THESIS

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ABSTRACT

Data collection is beginning to assume increased importance in the field of data processing. This thesis investigates a method for quantitatively selecting a portion of the library to place on an automated circulation control system that uses data collection as an entry into a data processing system.

The circulation function of the library was considered to be an inventory problem. Titles were considered as items of inventory and circulation of that title was considered to be a "sale" of that item. The IMPACT method was used to distribute items (titles) in a sample by age. Various ages were found to be responsible for different percentages of circulation. (For example, less than 30% of the volumes accounted for almost 80% of the circulation.) This provides a quantitative guide for automating select portions of the library. The method involved using a sample to estimate load requirements on an automated system. Then the estimate was used to predict conversion requirements. This results in a minimum cost conversion for a particular level.

Queueing theory was used to calculate effectiveness under a new system as opposed to the old. This information can also be used to justify data collection because of the additional service provided the borrower and the library.

The application of queueing theory to the circulation function indicates that an automated system will speed up the charging process fivefold, while cutting the waiting period to 1/11 of the manual system.

It was concluded that this experimental approach is quantitatively consistent with observed improvements provided by implementing data collection equipment at other libraries.

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to Dr. J. G. Harris and Professor W. J. Murphy, his major professors, for their help in the selection of this subject and for their assistance and encouragement during the work.

Special thanks are due the staff of the University of Missouri at Rolla Library particularly Messrs. Randolph and Williams Librarian and Assistant Librarian respectively for their guidance and suggestions while making the investigations. The assistance of the Rolla Free Public Library was also quite valuable.

The computer produced bibliography of General Electric, the publications of IBM, and the literature and press releases of Univac and Honeywell contributed materially to the preliminary investigations and were invaluable.

Members of the Computer Science Center were most helpful in guiding the author in techniques of data manipulation for presentation in graphical form.

The author is also deeply indebted to his wife and family for their encouragement and continuous moral support.

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I. INTRODUCTION

Librarians have endeavored for a number of years to develop satisfactory criteria and standards for automating the library environs. Because of their endeavors, a relatively small number of logical systems have evolved for certain facets of library management and control, particularly in circulation management and new book acquisitions. Unfortunately, most of these conventional methods are quite expensive in terms of manpower, money, materials and machines.

In 1964, the IBM 357 Data Collection Unit* was proposed for a host of manufacturing applications, and many people connected with libraries realized that this unit met the requisite requirements for putting data into machine-readable form for library usage (6)**. The data collection system's workability is relatively inexpensive and is not contingent on prior or later automation. Because of its tremendous potential, this particular system was welcomed by the library fraternity.

The apparent simplicity of the IBM 357 method has generated a need for further investigations into its applicability at a college library of the type encountered

* The IBM 357 is representative of data collecting systems by virtue of the number installed. However, other companies do make data collection equipment.

** Parenthesis ( ) represents references cited.

here at the University of Missouri at Rolla.

The purpose of this study, therefore, was to investigate the feasibility of applying and adopting punched card data processing techniques to the control of the University of Missouri at Rolla Library.

In a discussion with Mr. Earl Randolph, the librarian at the University of Missouri at Rolla Library, concerning the general lack of automation in the library, the author was asked to undertake a study of the feasibility of automation at Rolla and report this information to him. This thesis is an outgrowth of that project.

II. FEASIBILITY STUDY

The dichotomy between the desirable and the economically feasible is a concern of the greatest magnitude to any librarian who must account to those who supply his funds. Consequently, it was necessary to ascertain whether certain factors could lead to the anticipated or actual conclusion that automation should be attempted. Otherwise, the library would not support any additional study.

A preliminary investigation was undertaken with the following criteria used as a basis for extrapolating requirements to the future:

1. undergraduate enrollment, Figure 1,
2. graduate enrollment, Figure 2,
3. PhD enrollment, Figure 3, and
4. library circulation figures, Figure 4.

It was necessary to project future needs for two reasons:

1. if an increase in various enrollments is of sufficiently large magnitude, this increase would put an additional burden on the extant system so as to cause its unworkability, and
2. any proposed system to replace the extant system would have to handle the projected workloads without increasing non-professional student help.

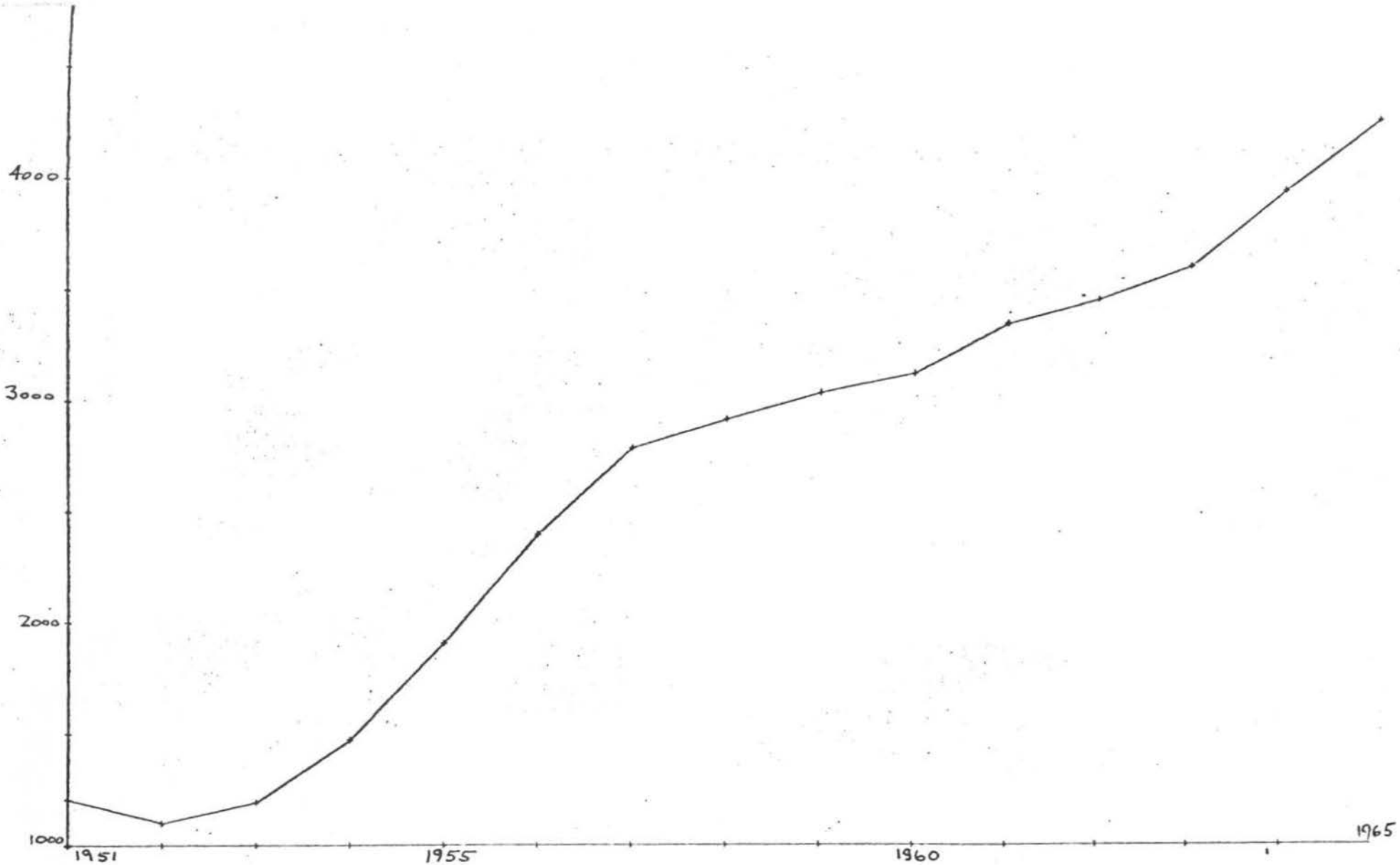


Figure 1. Undergraduate Enrollment vs. Years

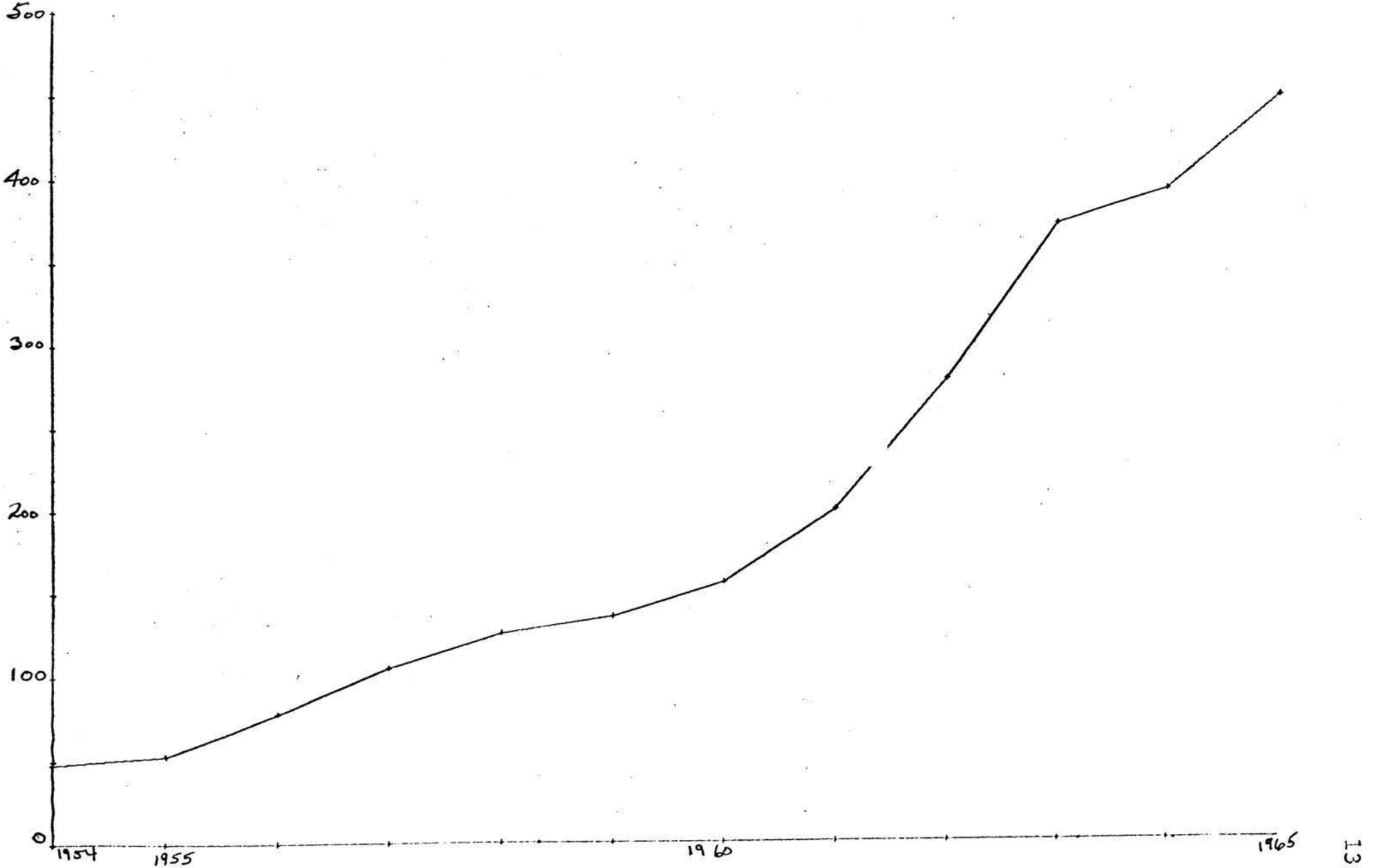


Figure 2. Graduate Enrollment vs. Years

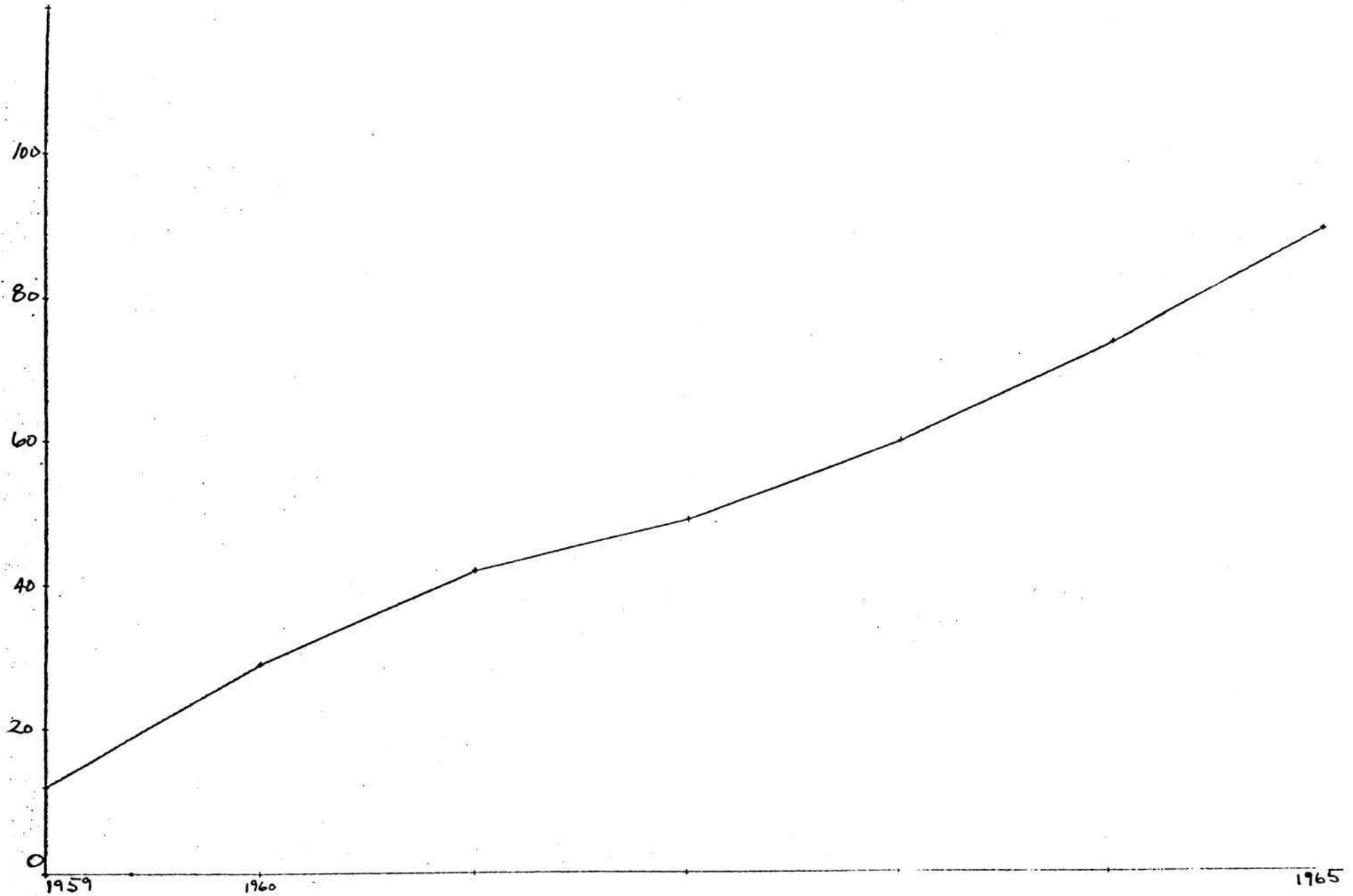


Figure 3. Doctoral Enrollment vs. Years

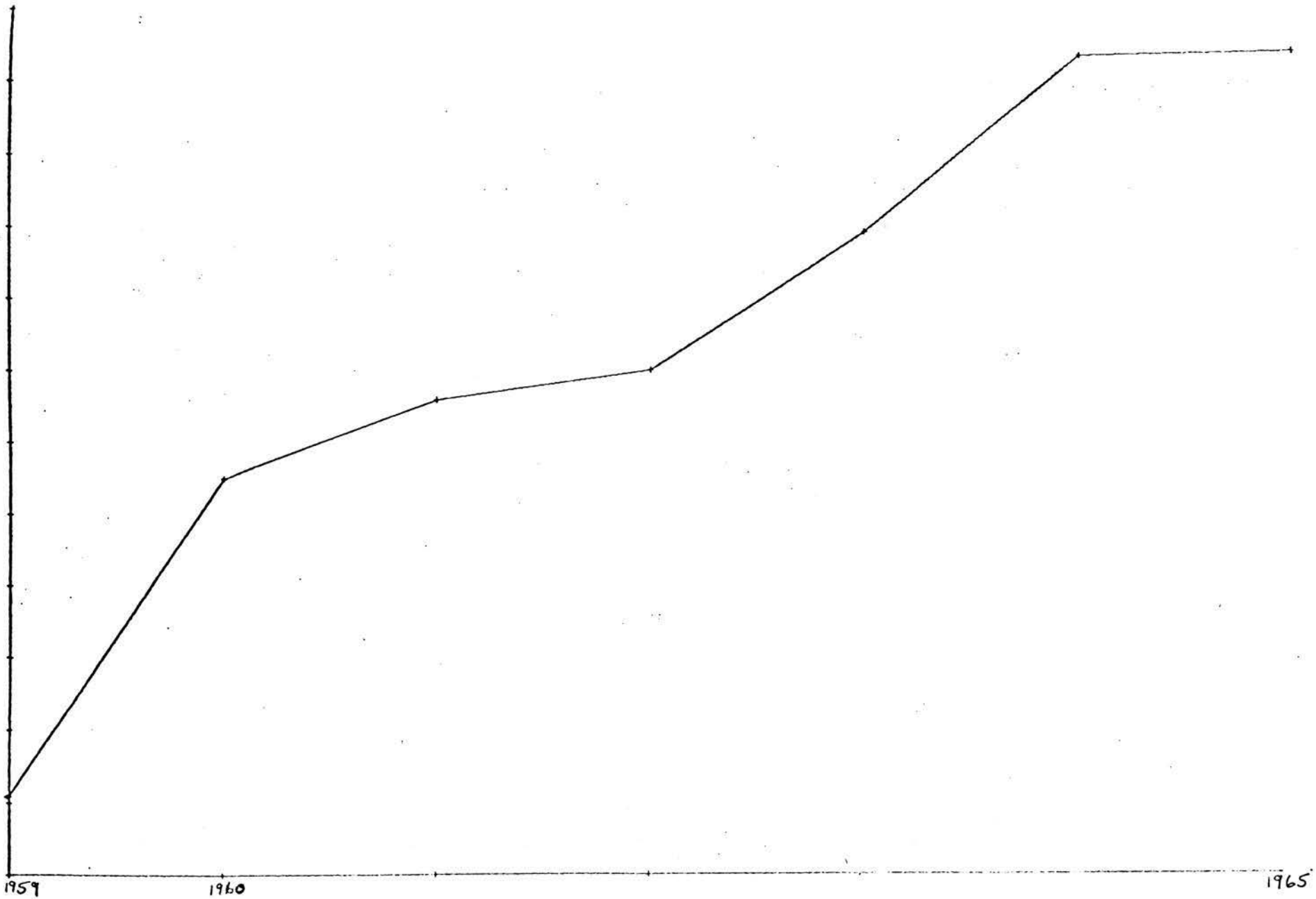


Figure 4. Circulation vs. Years

Figures 1, 2, 3, and 4 are provided for qualitative interpretations only. No attempt was made to predict quantitatively the future. The emergence of generalized trends indicates that if history is to be used as a predictor of the future, then all indications are for increased enrollment and circulation.

The Librarian and Assistant Librarian indicated that the increases will lead to difficulties in library control. The author was then asked to continue with the study.

III. INTRODUCTION TO LITERATURE REVIEW

More than ever before, the 1960's represent an era of change and specialization, an era of computation and automation. Yet, while industry automates as rapidly as feasable, one segment of our society has remained relatively unaffected by this new type of technology. This is the school library. In this, the day of the hydrofoil, a few libraries are still utilizing methods as out of date as square-rigged ships. However, this does not mean that all libraries have not looked at automation. In fact, many librarians who have said automation will never work in the library are surprised when reminded that the lowly typewriter was the precursor of more automation to come. In 1873 the Remington^{R} typewriter was first marketed commercially (7). Just four years later a visionary group of librarians attending a meeting in New York under the auspices of the Conference of Librarians grasped the concept of automation applied to the library by believing that the typewriter could aid in cataloging (15). However, it was not until the advent of the punched cards of Hollerith, in the early 1900's, for the Bureau of the Census that the first commercial application of data processing using punched cards was undertaken. In the 1930's Missouri University's present librarian, Dr. Ralph Parker, was the first to see the applicability of the punched card for circulation control. The results of his experimentation as circulation librarian at the

University of Texas led to his implementation of what is considered today to be the first working model of the punched card circulation system in libraries (14). Shortly thereafter, the Montclair, New Jersey, Public Library followed suit and was automated (punched card circulation control) in 1941 (16).

Even though these two pioneering efforts were made, librarians were slow in adopting some of these techniques. The big breakthrough and resurgence of interest came in 1960 when IBM published Henry Birnbaum's definitive information manual concerning a punched card circulation system utilizing IBM equipment at the Brooklyn College Library (2).

A. METHOD OF PARKER (University of Missouri at Columbia)

In October, 1965 the author had the privilege of visiting the University of Missouri at Columbia's Library and discussing in detail their system not only with the professional staff but with the data processing department as well.

The history of Missouri University's automated circulation control effort started in May of 1958 when Dr. Parker instituted a punched card system (18). Revisions and updating of this system were instituted in 1964. The result was the rental of an IBM 357 Data Collection System, Figure 5, with its attendant

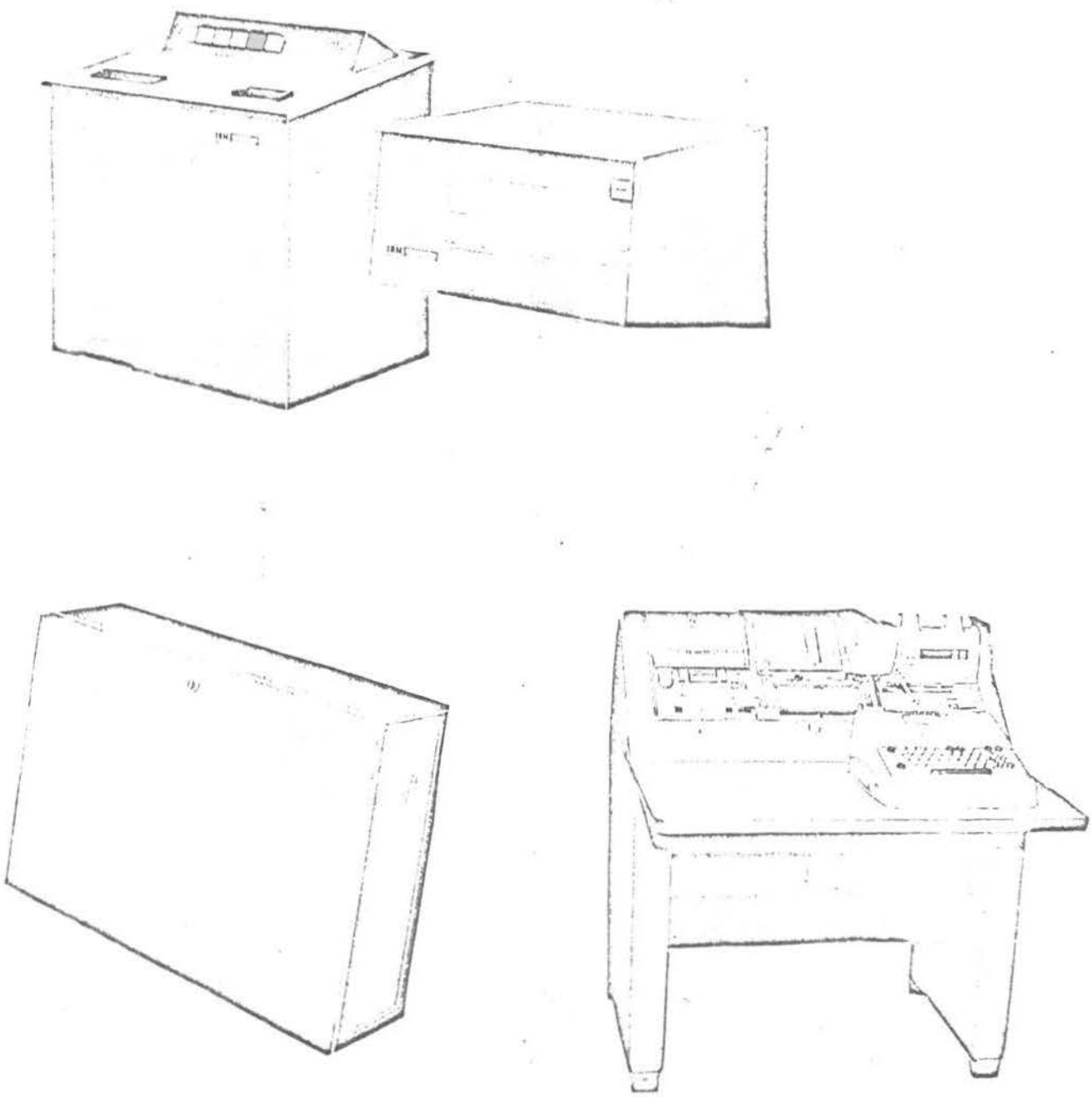
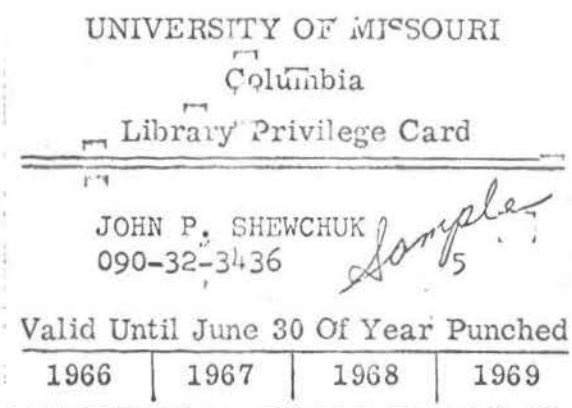


Figure 5. A Data Collection System

peripheral equipment. The installation of this equipment necessitated a change in the method of identification of borrowers. For effective implementation of the Data Collection System it was found necessary to present students and faculty with plastic laminated identification cards measuring 3½ by 25/16 inches. These wallet-sized cards provided an identification of the borrower in both visual and machine readable form.

Each student's card has a college assigned unique student number. In contrast, the identification cards of faculty and others who have library privileges utilize the person's social security number. Figure 6 is an example of a faculty identification card. Although the dimensions are critical, especially thickness, no difficulty is usually involved in laminating any school's present identification card provided all its information can be miniaturized. This includes those schools like the University of Missouri at Rolla and the University of Missouri at Columbia that presently have a photograph of the owner on the paper card.

Missouri University's system operates in this manner. Each book is provided with a book card that contains specific information about that book, see Figure 7. It lists the following essentials for identification of the volume: accession number, call number, (which at the University of Missouri at Columbia is a Library of Congress


UNIVERSITY OF MISSOURI
Columbia
Library Privilege Card

JOHN P. SHEWCHUK
090-32-3436

Valid Until June 30 Of Year Punched

1966	1967	1968	1969

Figure 6. Faculty Identification Card

Figure 7. Bookcard

classification), title, and usually author abbreviated or shortened because of card space limitations. The arrow on the card in Figure 8 is a guide for the operator, showing him the correct edge of the punched card to insert into the reading-sensing mechanism of the 357 unit. When a book is checked out, the book card plus the borrower's plastic identification card are placed into the 357 system; the result is the generation of another punched card which is a record of the transaction. It is also possible to manually override the system and key in the borrower's identification number if he does not have his plastic badge but can provide other suitable identification. The generated card (Figure 9) has more information than the sum of the information on the identification badge and book card, because additional information can also be entered through the 357 device. This additional information, for example, might be time expressed in Julian Calendar days, date due, or type of transaction. This generated or transaction card now becomes a permanent record, and, consequently, it can be used as an entree' into a semi-automatic "unit record" installation or a large scale digital computer system.

B. METHOD OF BLACK (University of Hawaii)

For entry of data into their information processing system, the University of Hawaii took a logical, but nevertheless, novel approach. The uniqueness of Hawaii's

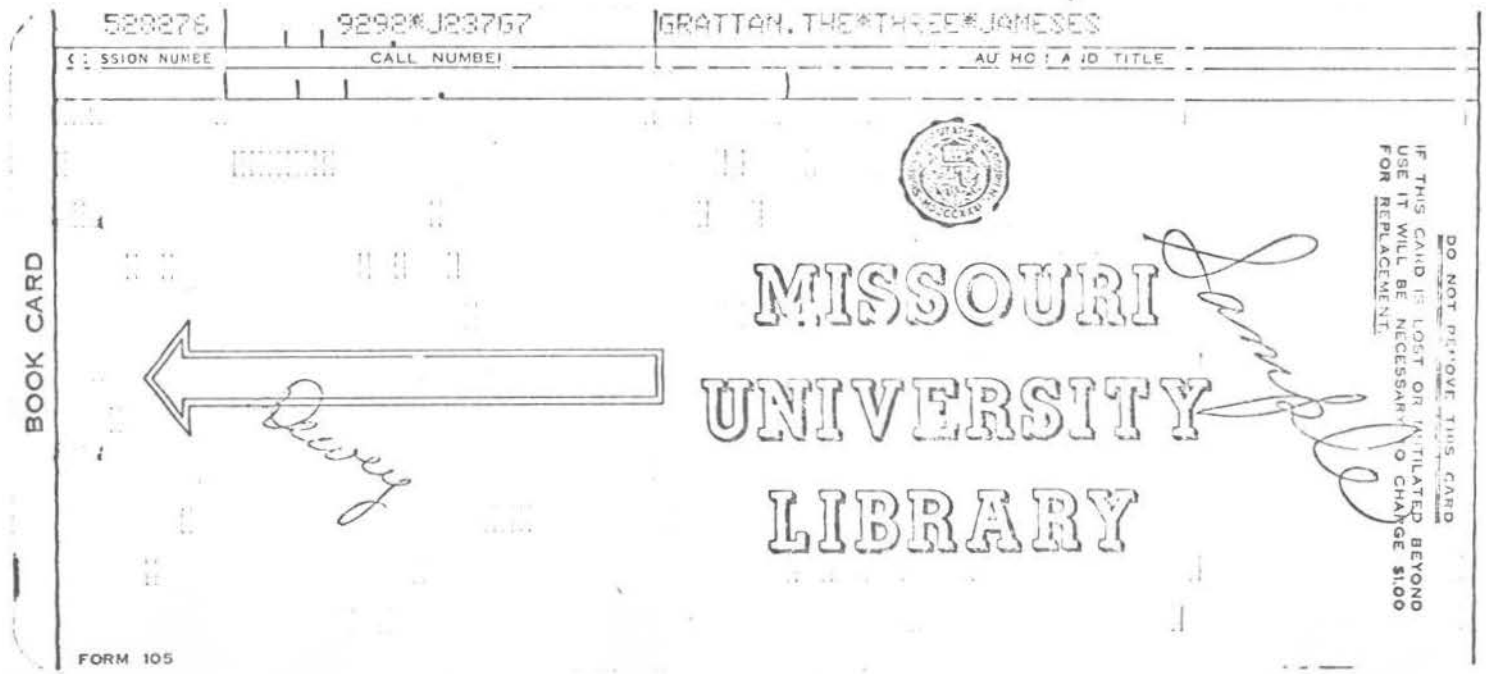


Figure 8. Operator Guide on Bookcard

Figure 9. A Generated Card

experimental mode of circulation control centers around a system which employs an IBM developed, Data Collection Unit numbered 1001 (4).

The primary reasons for the installation of the IBM 1001 are the system's low cost (approximately $15 a month for the 1001 without accessory equipment) and its ability to stand alone and act as a remote data entry device (19). In this context it would mean that the 1001 could be located at a circulation desk and the data processing equipment could be housed in the next room or even in the next town, the only consideration being cost of lease time for the telephone circuitry necessary for the transfer of information from the circulation area to the data processing area.

The 1001 system is technically designated as simplex. Simplex is defined as one way transmission, not capable of being reversed because of the design of the terminal. Therefore, the 1001 uses a tone control device to warn the operator that incorrect transmission was sent regardless of whether this is operator error or faulty transmission. Therefore, the tone control is necessary since the data processing area cannot initiate any communication using the machine.

The system operates in this manner. Each student is issued a 51 column punched card instead of a normal 80 column card (IBM) or 90 column card (Univac). This 51

column card, known as a stub card, is very similar to the oil company credit card invoice that one receives when purchasing gasoline on credit. (Figure 10 is a 51 column card used in the oil industry. Figure 10 is used to illustrate size only.) The student stub cards are designed so that they may be folded for easy insertion into a wallet. The general feeling at the University of Hawaii is that paper identification cards are easy to replace in case of attrition through loss or wear. The cards are reissued each semester.

The concept of the punched stub card is also carried over into the area of book identification. The book cards are punched with an entire call number, an identifying code that signifies the duration of the loan period, and a code for identification of how the book was collected. It is important to note that the University of Hawaii uses an abbreviated title and author and has this information on the card in printed form, but it is not punched into the card. The inability to handle a full title and author is one of the drawbacks of the 51 column card.

Borrowing a book is quite simple. While the borrower is presenting the "circulation desk" with his uniquely numbered identification card, the "circulation desk" is removing the book card from each individual book. The borrower's identification card is placed into the sliding carriage of the 1001. A phone call is initiated or is

Figure 10 A Stub Card

left open from the previous checkout. The carriage is pushed in and the encoded data in the borrower's stub card is transmitted over the telephone circuitry. It takes only about as long as it takes to read this sentence, about three seconds. The borrower's card is then followed by the book cards. Normally, the borrower's card must be reinserted prior to the insertion of each book card. By making use of a check digit or code, the system will charge all books to the first identification card it receives and continue charging to that account until another identification card is presented to the machine. Consequently, the 1001 will check out multiple books without the necessity of reinserting the identification card after each book. After replacing the book card in the proper volume and returning the student's card, the "circulation desk" then adds a date due slip to each book pocket. That concludes the entire charging sequence as far as the borrower is concerned.

For circulation, the result of this book borrowing is the generation of a punched card containing all essential transaction information such as status of borrower (ie. freshman, faculty, etc.), identification number, call number and the various codes needed to insure efficient operation.

The discharging of the loan occurs in a very similar manner. The book is returned to bins which have been

deployed for the purpose of collecting the due books. The book cards are removed and processed using the 1001. As previously pointed out, the transmission is simplex and cannot be connected to the same punching device that the circulation desk employs. The automatic duplicating feature of the IBM 026, (Figure 11), key punch to which the "return 1001" is connected allows for punching a date for all returns for later comparisons. The absence of an identification card as in the borrowing routine is no handicap. The 1001 is given a "dummy" identification card which suffices for all returns. The return book clerk destroys the date due slip and the volume is considered available for prior requests (holds) or can be reshelved. It should seem apparent that any problems encountered within the system can be located by punching up a coded card matching the characteristics of the card sought. The files can then be searched at machine speeds for the duplicate, updated, and then returned to its appropriate place in the file or purged. Figure 12 is a combination schematic-pictorial provided as an aid for visualization of the system and its various components.

C. METHOD OF McCOY AND DEJARNETT (Southern Illinois University)

Southern Illinois University has successfully adapted six IBM 357 Data Collection Input Units to handle circulation at the Carbondale campus. The implementation of

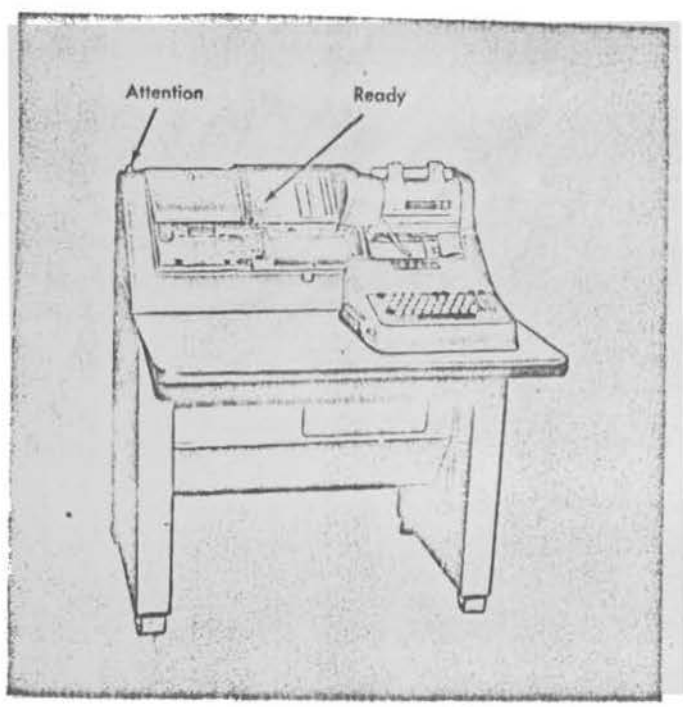


Figure 11. IBM Keypunch

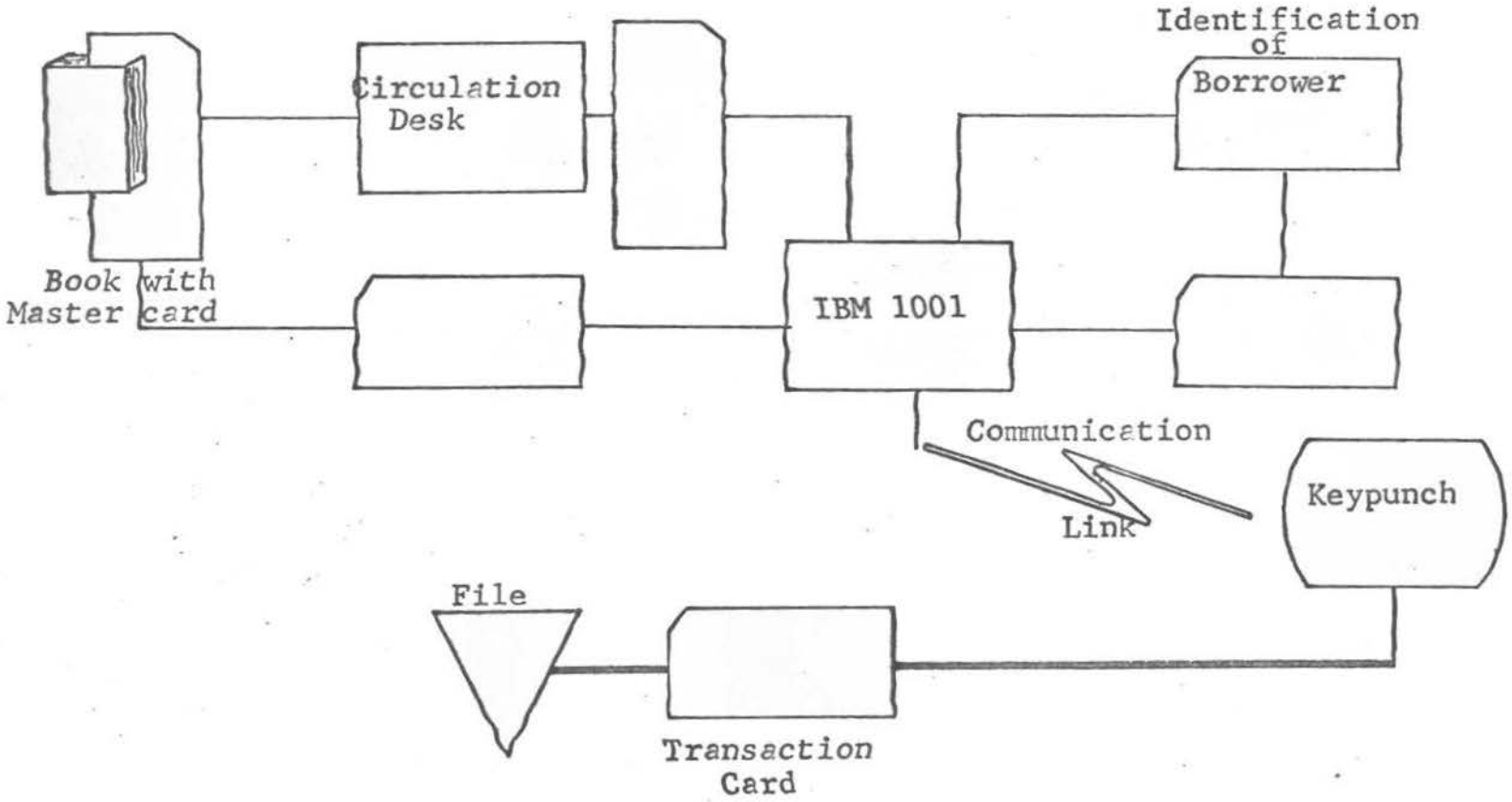


Figure 12. Diagram of 1001 System

this system was necessary because the old semi-automated system was not functioning well under increasing loads (13).

One of the most appealing parts in the Southern Illinois University approach is the use of a cartridge reader, which is a machine that will accept a cartridge that can be inserted into the unit for the purpose of entering the due date. It is also possible to have these cartridges preset for different classes of borrowers. Figure 13 is a cartridge. For example, it may be a policy of the library to grant all faculty members with an unlimited loan period. One cartridge could be preset with this data. However, undergraduates may be limited to two weeks. Hence, the cartridge may be set once each new day for a two week period. This eliminates the possibility of clerical error when beseiged by a large, diverse group of people, all clamoring for checkouts and each with a different loan period.

A common denominator exists for the system at Southern Illinois University and the system at the University of Hawaii, both employ the 51 column stub card. Southern Illinois University has found that the stub card works well since it is only 4 7/8 inches long. Therefore, it fits most of the 600,000 volumes in the central collection without too much difficulty.

The checkout procedure employed at Southern Illinois University is a particularly feasible one, especially

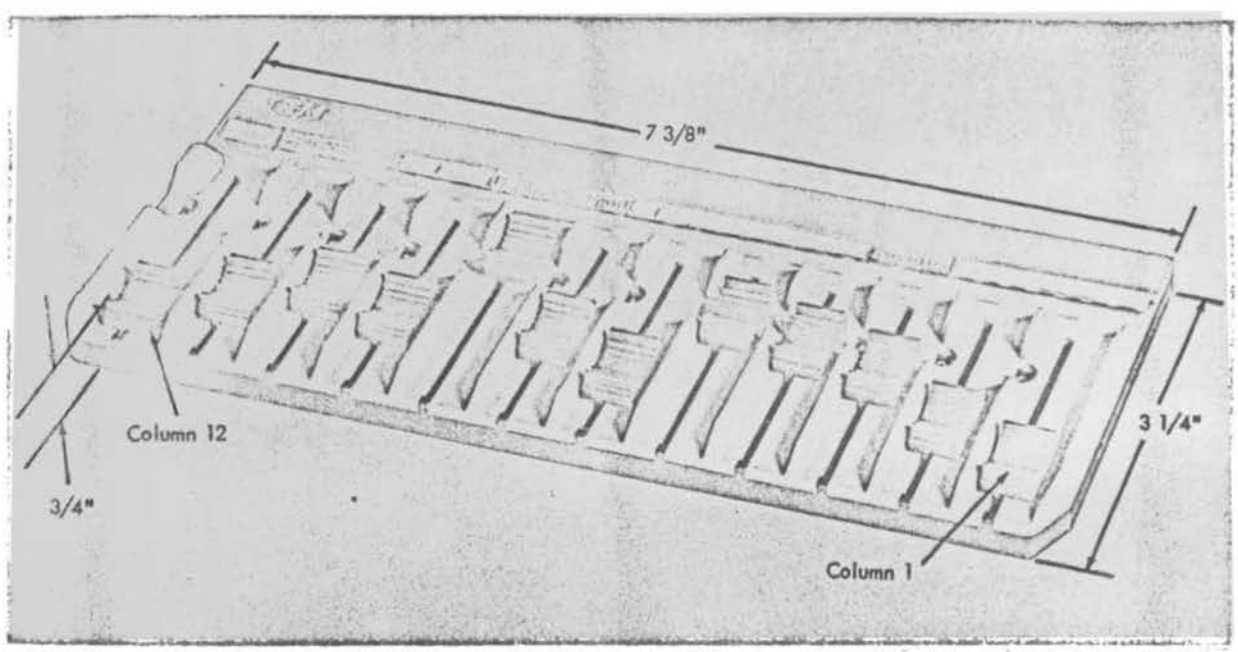


Figure 13. A Cartridge

for the library that has suffered collection attrition through other than normal wear and tear. The student identification card is unlike that of the University of Missouri at Columbia. While both are encoded so that they can be machine read, Southern Illinois University's borrower identification card also has embossed lettering similar to any major gasoline credit card. This required a minor modification to the hardware to compensate for the extra thickness of the card due to raised lettering. Figure 14 shows raised lettering on a plastic card.

The borrower card, plus the book card, plus the right code on the cartridge for loan period are the necessary variables that go into Southern Illinois University's equation for simple checkout. When these variables are assembled, they go into the IBM 357 unit and generate two duplicate punched cards. One of these cards is kept as a record of the transaction; the other, a different color, is placed in the book along with the book card. It is then possible to have a guard check each book visually and quickly as a borrower leaves the library. However, a judgement must be made concerning this approach because to give the borrower a generated card, the keypunch must be close to the circulation desk. Keypunches can be noisy and should not be adjacent to the reading area.

It is very important to note that Southern Illinois

Figure 14. Raised Lettering on a Badge

University's system requires about 20 seconds per transaction and functions well as a high volume system. It is at present handling a circulation of over a thousand volumes a day (13). Returning a book is much simpler than at Hawaii. No run through the system is necessary. All that must be done is to see that the proper colored card and book card have been returned. After verifying that the book is not overdue, the colored card is removed, the book shelved, and the process of deleting the record of returned books is undertaken.

D. METHOD OF HAEUSLEIN, DICKISON AND HAAS (Oak Ridge National Laboratory)

Ostensibly, the reason for installation of a data processing system at Oak Ridge National Laboratory's Central Research Library was to relieve the library staff of the clerical filing and copying operations which were becoming an increasing burden (9). However, one of the major advantages that accrued with the usage of this equipment was the ability to handle demands (9). It is advantageous to discuss demands according to the methods of Oak Ridge National Laboratory Library because of the applicability to all college libraries.

Demands are of two types: demand on special copy and demand on person. A demand on special copy is made if a user requests a book being read by another borrower. This situation can be acute in a large research laboratory.

A demand on person is made if a person leaves the employ of the Oak Ridge National Laboratory and the library needs a list of all the books he has charged out. This is analagous to the college situation where there are graduates every semester. It would be misleading to say the IBM 357 is responsible for the ability to handle demands, since the actual demand work is done by computer. However, the 357 system is certainly compatible with this approach.

The badge identification system works well at Oak Ridge National Laboratory since each man is required to have a security badge visible at all times. Because of the heavy usage of current books, the Oak Ridge National Laboratory approach centers around the entry of data into the 357 using the security badge because this allows them considerable leeway in assigning codes for many different types of charge-outs. They use a variable keyboard.

The value of the Oak Ridge method, then, is the ability of the system to handle increasing workloads without causing a circulation bottleneck; the ability to generate a large amount of statistical data for control purposes, and a viable method for handling demands.

IV. EXPERIMENTAL

A. PRESENT METHOD

At present the University of Missouri at Rolla Library employs a completely nonautomated system for exercising control over its circulation. The library employs about 20 students to assist in this manual approach to circulation control.

The present system operates in this particular way. First, the borrower is polled at checkout time to see which of the following class of borrowers he is a member of: 1.) undergraduate, 2.) graduate, 3.) faculty, 4.) Bureau of Mines employee, 5.) local resident with library privileges or 6.) special. The borrower is then given a checkout card corresponding to his status, (Figure 15 represents a faculty card). The checkout cards are color coded, enabling visual separation at a later time, since it is necessary to separate checkouts into groupings to facilitate assigning loan duration codes. (It is important to note that faculty and graduate students may borrow books for an entire semester, while undergraduates are limited to a two week loan duration.) The borrower then fills out a borrower card for each volume to be checked out. The card contains the following information: student identification number, name, local address, status, department and the entire Dewey decimal shelf number. This process must be followed for every book for every borrower

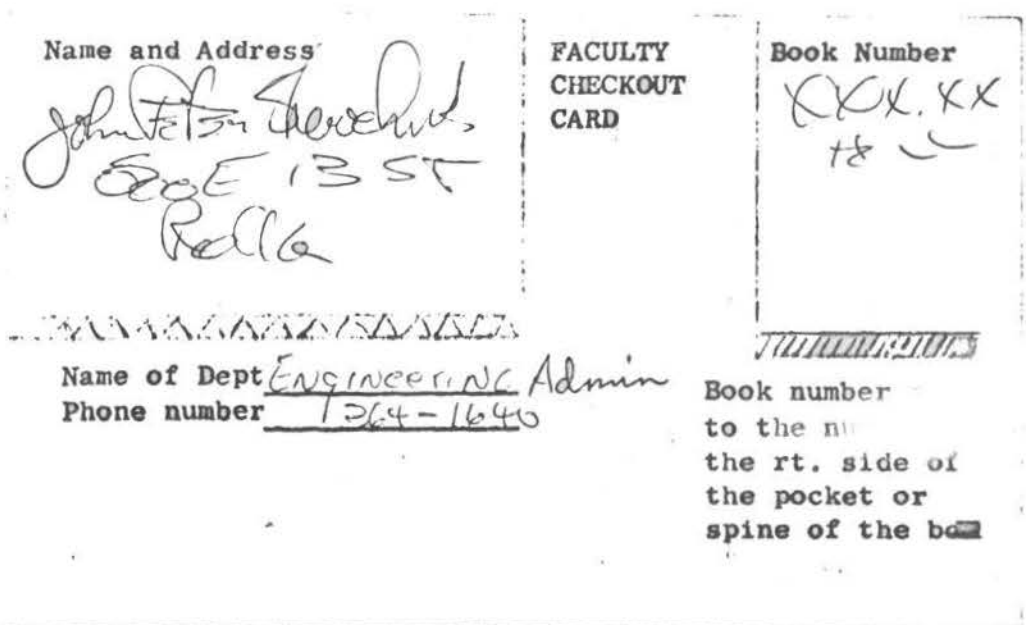


Figure 15. Faculty Checkout Card

and thus queues build up around circulation desks. Two borrowers with five books apiece will cause as much as six and seven minute waits for the person next in the circulation checkout sequence. As the size of the queue grows, the manual system bogs down.

When the circulation clerk is free, the checkout cards are batched and then verified for accuracy with the bookcards based on the accession number. Periodically the bookcards are manually collated into the "out file" by Dewey decimal sequence. The checkout card is then collated into the "student-numbered out file". These two files are used in this manner. The bookcard file is in actuality an inventory of out books with only the student name, student number and book identification information. By manually interrogating the file, on demand from a borrower, it is possible to find out who has the book and his student number. However simple this may seem, actual observance shows it does not work very efficiently. Random observation of the files shows two to nine percent errors in actual filing. This is probably the result of filing under pressure of large work loads coupled with inattentive student help. The implications of this method are two fold.

1. If the bookcard is properly located in the bookcard file, then that book is checked out.
2. If the book card is not in the file, it is on the shelf.

In reality these two implications are the source of one of the major problems facing the University of Missouri at Rolla Librarian. It is axiomatic that in an engineering library the location of a book should be known at all times so that if it becomes necessary to fetch that book for any reason it then becomes possible with a minimal expenditure of resources. Many times the bookcard is misfiled and, therefore, implication number two is invoked, that the book is on "the shelf." If the student cannot locate it, he then becomes disenchanted with library service. However, some of the time a browsing student has simply misshelved the book and it will never be reflected in the inventory of bookcards.

If a book is not located on the shelf, nor a bookcard available, it could mean that the book is in the process of being shelved, in the reading room, or stolen. It is almost impossible for the University of Missouri at Rolla Library to inventory its holdings because of the huge amount of time involved (21). Therefore, the bookcard file will never accurately reflect the actual condition of the library holdings. From observed information available to anyone working at the circulation desk, it is possible to suggest that the library has had some attrition by nonsystematic stealing. The extent of stealing has not been measured formally in this thesis. This should be considered when designing a circulation system.

The library at present has found it necessary, in order to keep up with those graduating each semester, to allocate clerks with the specific task of searching the borrower status file by student number and requesting all overdue books be returned immediately. The author has systematically kept books out three months in excess of the allotted loan period for the purpose of finding the length of the detection time. The clerks who handle this phase of circulation control simply cannot keep up with the ever increasing work loads, and even after three months have not yet detected certain overdues.

When a book is finally received, the discharging of the loan is brought about in this manner. The bookcard is retrieved from the bookcard file (again, if it is misfiled a major crisis is the result and students are forced to wait). The bookcard's accession number is visually verified with the returned book's accession number. If they match, the bookcard is inserted into the jacket pocket and is now ready to be shelved. Subsequently, the borrower's status card is purged from the borrower file. All of the above maneuvers require careful verification at each step of the process. For example, under a student number such as 1158, which is unique, there may be a large number of cards representing multiple checkouts. The interrogator of the file must then manually scan all of the cards under that student number for the correct card to distinguish among the

volumes that the borrower has previously charged. That card must be destroyed. This then completes the checkout. The charging and discharging of a loan utilizes a bookcard file about two feet by two feet. Only one person can work efficiently at the file at one time. Consequently, it is very difficult to charge and discharge books at the University of Missouri at Rolla Library circulation desk. Figure 16 is a flowchart indicating the decisions and steps in the above process.

Three other areas of the manual system are of interest when explaining how the University of Missouri at Rolla Library proceeds under its manual system. These are:

1.) accession book preparation,

2.) statistical circulation figure preparation,

3.) book identification card preparation.

One of the dictums of the library is that the accession book be kept up to date. With an expanding acquisition budget, this places a severe strain on a clerk who must spend most of her time filling out the name of the book, the author, the cost, from whom it was purchased, the date received and its cataloging decimal number. It is not the purpose of this report to determine whether this is a necessary job but only to say it is a time consuming one and the accession book is used very, very infrequently for control or informational purposes.

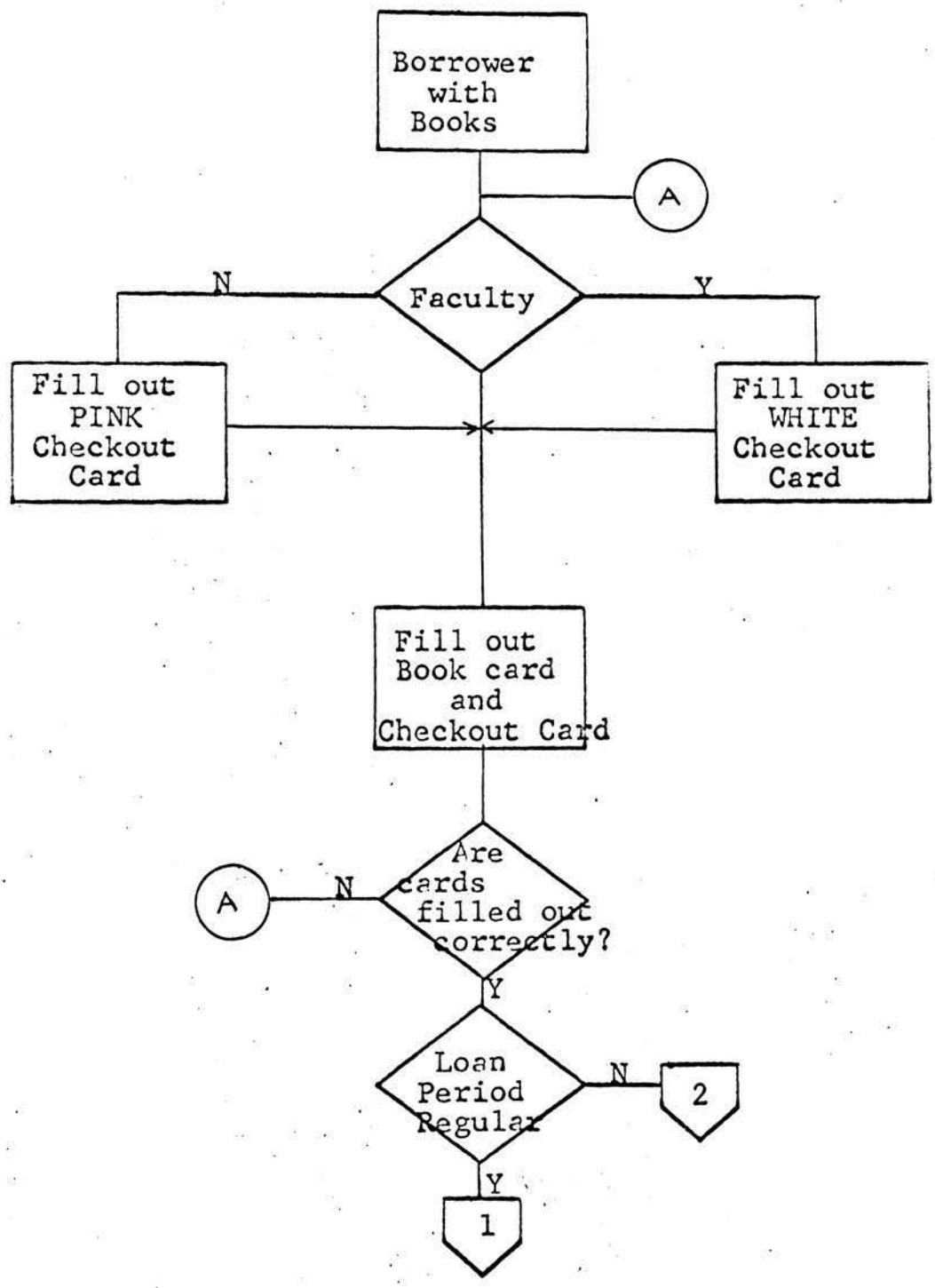


Figure 16-a. Flowchart of Present Methods

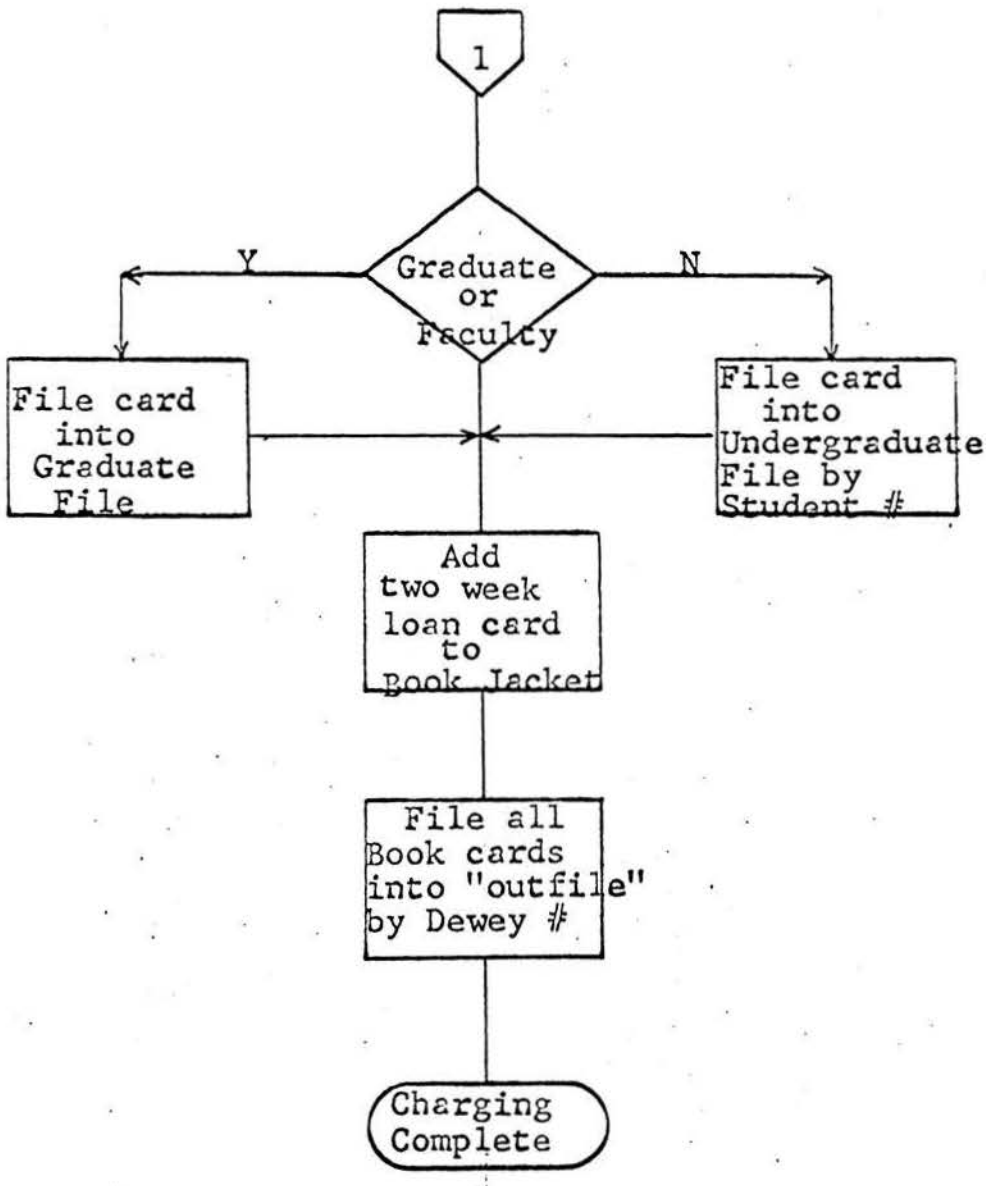


Figure 16-b. Continuation

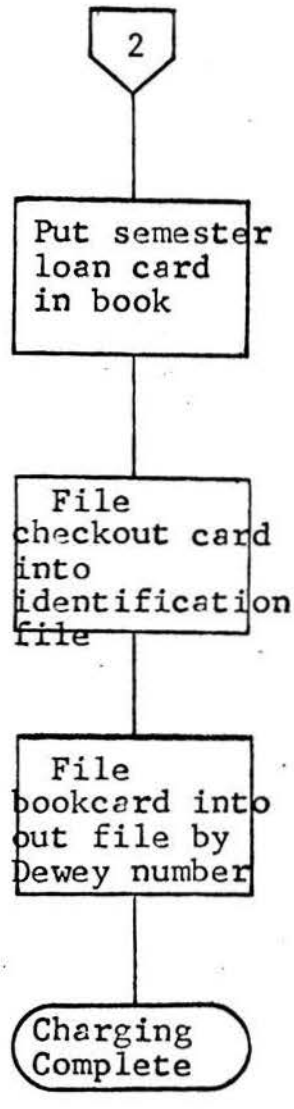


Figure 16-c. Continuation

Statistical circulation figure preparation is a laborious repetitive task performed daily by measuring the height of a pile of book checkout cards. There exists an empirical conversion factor for converting inches to number of cards, unfortunately it does not allow for frayed cards. Nevertheless, this primitive method is fairly accurate but is not necessarily perfect. Monthly circulation figures cannot usually be provided until one month has elapsed. It is then difficult to spot trends and patterns within the circulation function, (namely such things as a 10% increase in circulation may prompt a need for an additional student assistant at the circulation desk). The statistics which other schools deem necessary are the number of graduate students using the library, faculty borrowers expressed as a percentage of the whole, and freshman using the library. But, because of the cost of extracting this data, this is just not economically justifiable at the University of Missouri at Rolla. Hence, this statistical method for effectively controlling the library is not readily attainable by the University of Missouri at Rolla Library. Figure 17 is an example of the type of daily circulation statistics the University of Missouri at Columbia uses for control.

The book identification card, (see Figure 18), is the card that is to be placed in the book jacket.

LOCATION		PERSONAL LOANS									TOTAL
1		2	3	4	5	6	7	8	9	0	CARD
Charge	Discharge	Return	Home	Home	1-Day	1-Day	2-Hour	3-Day	3-Day	2-Hour	COUNT

RECAPITULATION

Home Use (3 + 4)_____

One Day (5 + 6)_____

Reserves:

Three day (8 + 9)_____

Two Hour (7 + 0)_____

TOTAL _____

Figure 17. Daily Statistics At Columbia

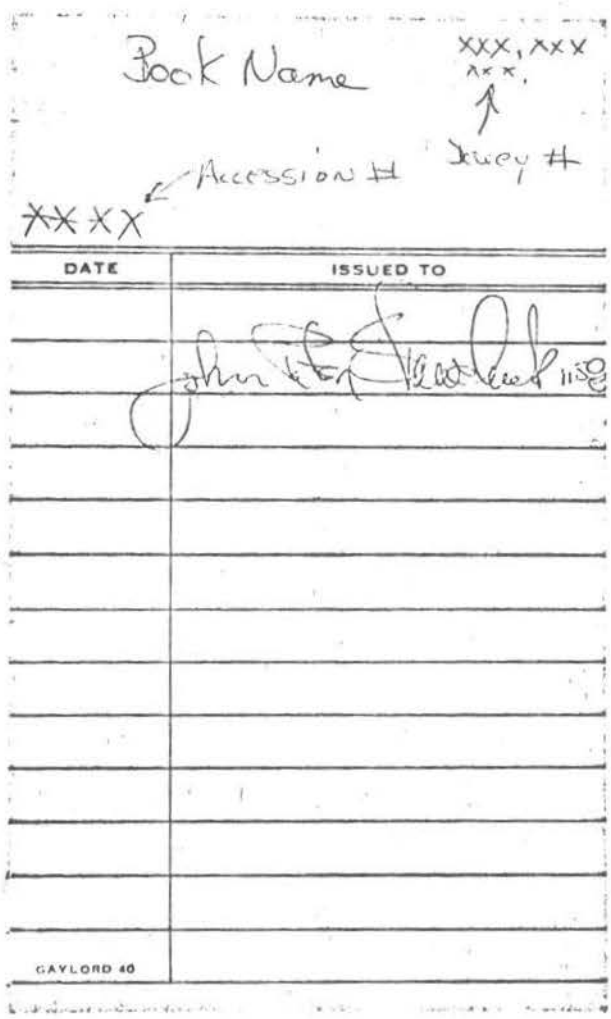


Figure 18. Book Jacket Card

These cards must be made individually on the typewriter after the book has been received and processed through cataloging. This area is usually a bottleneck in the sense that cataloging releases books in a group to the bookcard maker. The reasoning is that the bookcards cannot be made prior to the catologing function because of the necessity of assigning the proper catalog codes. The same repetitive information (Dewey number, cutter number) is then placed on book spines. To get the information on the spines, (see Figure 19), requires typing one label per copy of the book. These then, are the basic parts of the present methods at the University of Missouri at Rolla.

B. METHODOLOGY OF SYSTEM ANALYSIS

In the previous section, considerable detail was developed showing the present methods for circulation control at the University of Missouri at Rolla. The task now is to describe how a replacement system can be designed. The basic method will be systems analysis. As Becker (1) points out, "the word 'system' may be defined as a group of people, operations and procedures brought together to perform a specific activity. In the same context, the word 'analysis' refers to the study of the component parts of a system with the object of determining what must be accomplished by each part, and how." System analysis, therefore, presents the overall view rather than the constraints of the particular

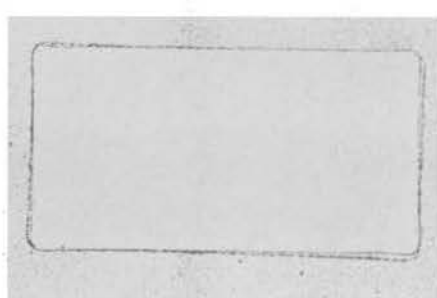


Figure 19. Label

task at hand. The methodology employed in the study of the University of Missouri at Rolla Library consisted of four major steps:

1.) seeking out the design requirements,

2.) synthesizing and experimenting to finalize the design requirements,

3.) designing the system, and,

4.) evaluating the system.

1. DESIGN REQUIREMENTS

Before any structured formal plan could crystalize, it was necessary to have the library staff identify the salient feature of an idealized system. A good system, therefore, would be the one that could fulfill more of the important expectations than any other system of approach, subject to cost minimization. With that in mind the library staff helped evolve the three requirements for consideration. These three areas were termed design criteria. The design criteria were:

a.) minimum system requirements in relation to the borrower,

b.) minimum system requirements in relation to the library, and,

c.) other requirements for idealization of the system.

The category of minimum systems requirements in relation to the borrower is the category that contains most of the original planned objectives of the manual system. Right now a major drawback of the system at

the University of Missouri at Rolla is that an identification card is not always needed to charge books. Without identification it is very easy to understand why all books are not brought to the desk for charging. Therefore, it would be mandatory that the new system require an identification card of some sort for every borrower. It should be pointed out that the system could have a means of overriding the absence of an identification card but it should be of sufficient difficulty and complexity to make it obvious that the identification media makes things much easier for the borrower. This last part about an overriding system would be included in "other requirements for idealization of the system."

Once the borrower has been properly identified to the satisfaction of the "circulation desk", the next step would be to charge the borrower with the appropriate materials. It is at this point that another minimum requirement exists. It would be best if the borrower could do a minimum amount of work, such as filling out his name and address.

This then is the first point in the minimum system requirements for the borrower; a foolproof method of identification and the means for simply charging loans to that person. (This incidentally is one of the requisites for any good charging system) (8). Second, an effective method for periodic followup on overdues is necessary. The

present system does not do a good job in this area because of the volume of undergraduate overdues and the inability to decipher the student's name or number on the card. It is not unusual for a clerk to go through the entire enrollment roster looking for a name which is illegible. Many times the registrar's office must help out by trying to track down names. Right now it is difficult to follow up on the two week overdues, and these are neglected at the expense of "turning over the book inventory". By this is meant that if a book is in circulation and overdue it cannot be borrowed. This calls for a system that would be compatible with on time, efficient catching of overdues, so that more books are in the library and available to a potential borrower.

Third, the system should have a simple approach to discharging of the loan. It might very well be that bins could be placed in the building for books that are not overdue and they could be discharged away from the queue at the charging desk. At any rate what is necessary is a viable discharging procedure. Since fines at present are very rarely imposed, the system would have to be sympathetic with a discharging system that could handle fines without difficulty if it became necessary to do so.

Fourth, the system would have to be capable of fully supporting a method for securing books on a demand

basis. As pointed out in the literature section on Oak Ridge National Laboratory Library, demands are probably the most important facet of library control in an engineering or scientific library. Because of the need for the latest works in a particular field, it might be possible to suggest that all recently acquired books have a set week loan duration and all other books another set period. However, regardless of the time allotted for loan duration, the system must have the ability to be compatible with demands for any loan period whatever it might be.

The second category for consideration in the design requirements was the minimum system requirements in relation to the library staff. The collective feeling of the staff is that the system must be simple and inexpensive to operate. They suggest this as a necessity because they must train part-time student assistants. Many of these students are from other countries and an easy system would facilitate their training. Since future additions to the staff would be of a clerical nature, it also would benefit the library to have a simple system. More important, however, especially in the eyes of the librarian, is the interrelationship between cost, service and budget. The library feels, naturally, that any money not spent on acquisitions must be justified. The library would also like to assume only the workload that is subject to error in circulation

control and leave any error free work to the student.

The third category consists of those elements of a system that would tend to make the system ideal. As previously mentioned in the first category, it would be convenient if the system could work with many different classes of borrowers and many different loan durations. The necessity for extracting valuable statistics has plagued the University of Missouri at Rolla Library for a long time. An idealized system would be compatible with the techniques for providing statistics on a more sophisticated basis than by measuring heights of book-cards. It would be beneficial to have the circulation control system designed so that it easily could become part of a total system. (A system becomes a subsystem when it is realized that the entire system can be transferred intact to become a smaller part of another system with a larger scope. As an analogy, a completely automated University of Missouri at Rolla Library would be adjudged a total system. However, if the library was then controlled from another location such as the University of Missouri at Columbia, the Rolla campus library would then become a subsystem.) It is important, therefore, to design a system that can function in a larger library environment.

2. SYNTHESIS AND EXPERIMENTATION

In general, it is possible to enumerate three distinct methods for systhesizing a system:

a.) copy a successful system used at another library,

b.) develop a system that is comprised of many different elements from many different successful systems, and

c.) develop a totally new system that would be classed as state of the art.

Copying a successful system is probably the most common method for building a circulation control system. All that is required is to find a university library with approximately the same number of students, same basic budget and same basic problems, then modify that into a successful system based on the particular needs of the University of Missouri at Rolla. An example of this method would be the adaptation of the Dewey classification. Each library, instead of inventing its own system is content to modify or copy a system that has already proven its worth. This approach succeeds because of its intrinsic simplicity. However, the simplicity is also the root cause of the main difficulty in employing this method. No system that is contrived by someone outside of the University of Missouri at Rolla Library will ever be very well suited for the University of Missouri at Rolla Library. This is so because of the difficulty encountered in understanding the complexity of the Rolla

system.

The method of developing a system by extracting good points from many diverse systems is one that lends itself very well to the task at the University of Missouri at Rolla. In this case, the designer can look around and utilize all the techniques, tricks, gimmicks and equipments that are available. By developing from these existing building blocks, the designer can then patch these together to make a coordinated system. It might be said that for this system to work, the designer would have to know all about the thousands of different kinds of building blocks. As Bourne (3) pointed out, "it is usually not necessary to check all possible designs since one can take advantage of the fact that for some range of function, one component is better than all the other alternatives possible, (for example, one best keypunch), and can be suggested without considering all the other possible alternatives."

The state of the art system is really a misnomer because almost all systems that are state of the art are heuristic in that they are simply extensions of already known information, not really intrinsically new. The so called original inventions that comprise this group would be difficult for an ordinary designer to implement for the University of Missouri at Rolla Library because of the expense involved. This then is often considered to be the main drawback of this particular type of

system.

The method of developing a system by extracting good points of many different systems would be the best for the library at the University of Missouri at Rolla. This is so because of three reasons:

a.) a system so designed probably will be reasonably inexpensive since much of the developmental work will have been done by other pioneering libraries,

b.) a system so designed will probably work well in an environment where everyone knows that the system has worked well elsewhere. This is important when introducing automation in general, and

c.) the ability to evaluate certain elements of the system while in operation at other libraries, gives a clue to what the behavior of the system will be when installed at the University of Missouri at Rolla.

After the library staff decided that punched cards provide an avenue of approach to automated circulation control, it was necessary to design an experiment that would help to synthesize the method for making the punched cards. This problem looms quite large when conversion to a punched card system is being considered. Using the University of Missouri at Rolla as an example, it is possible to calculate the cost of making a punched card for each volume.

The cost associated with the preparation of punched bookcards can be calculated if the following assumptions

are made:

a.) no cost for training

b.) no materials cost

c.) no cost for equipment purchase or rental and

d.) compensation is an estimate of salary and fringe benefits.

The punching time is calculated this way,

$$Pt = TV \times A \times B \times H \qquad (1)$$

where:

Pt = punching time, hours
TV = 117,000, volumes
A = 1, card/ volume
B = 50, columns/ card
H = 0.00025, hours/ column.

Substitute numerical values in equation (1),

$$Pt = 117{,}000 \times 1 \times 50 \times 0.00025$$
$$= 1462.5 \text{ hours}$$

The total cost for the keypunching must also take into account handling time which is approximately 20% and the fact that the information must be verified (a process similar to keypunching). The necessary equation for calculating handling time is,

$$Ht = a \times Pt \qquad (2)$$

where:

Ht = handling time, hours
a = 0.2

Substitute numerical values in equation (2)

$$Ht = 0.2 \times 1462.5$$
$$= 292.5 \text{ hours}$$

To calculate cost the time involved is doubled to account for verification and then multiplied by the compensation. The cost equation is

$$TC = (Ht + Pt) \times d \times C \qquad (3)$$

where:

TC = total cost, dollars
d = 2, a constant to account for the verification process
C = 3, dollars / hour

Calculating total cost is accomplished by substituting in equation (3) so that,

$$TC = (1755) \times (2) \times (3)$$
$$= \$10,530$$

The cost associated with hiring a keypuncher for converting to punched cards is $10,530. However, this is not the entire problem. For the University of Missouri at Rolla, the conversion period would be 35,100 hours or almost 440 working days. However, with a continually increasing backlog of new acquisitions, the problem would even be more complex. Cox (5) has proposed and successfully carried out a conversion using an IBM 1232 optical scanner. By filling out a sheet similar to Figure 20 and running it through a machine that converts the data to punched cards, the keypunching is eliminated. DeJarnett at Southern Illinois University also did the same thing for their 600,000 volumes (6).

It is possible to find some comfort in an old mathematical axiom. It states that, "the whole world is

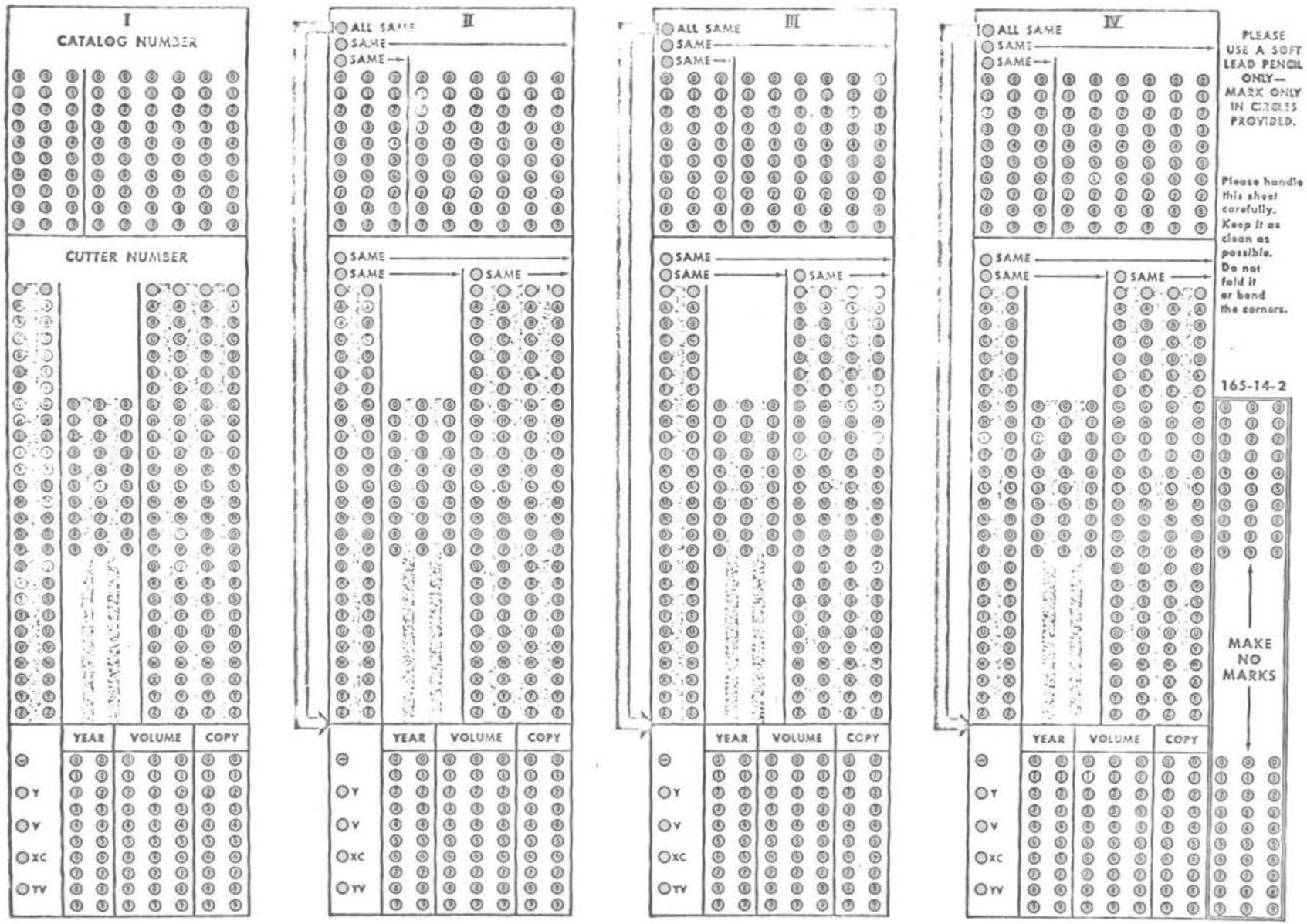


Figure 20. Optical Scanning Sheet

an inventory problem", and it especially lends itself to the books in the University of Missouri at Rolla Library. According to Leffler (12), "Some techniques borrowed from the industrial inventory control specialists will help... answer questions...posed by library management". IBM is quite well known for its inventory program called IMPACT which is an acronymn for inventory management program and control techniques. In the IMPACT application manual, IBM devotes an entire chapter to the characteristics of inventory (11). One of these characteristics is item distribution by value, or the so called ABC analysis (11). See Figure 21. Using this method a company would distribute items by annual sales. Then it would figure the percentage of the total sales by that item. It would then be possible to show inventory information like: the upper X% of the items account for X ∤ Y% of the total sales. In fact this is the basis for the so called 80 - 20 rule of thumb, namely, that ordinarily 80% of the inventory sales are provided by 20% of the items in inventory. Transforming these techniques to the library and considering titles as items and circulation as sales, it would be possible to show that a small portion of a library's holdings account for a significant disproportionate amount of circulation. With that in mind a study was made of inventory characteristics of the University of Missouri at Rolla Library. This technique is similar to the method of Trueswell, the essential difference in this study is the application of the IMPACT approach based on the

Item No.	Item (Card) Count	%	Annual Units	Unit Cost	Annual $ Sales	Cumulative $ Sales	%
T 7061	1	.01	51,553	3.077	158,629	158,629	.48
S 6832	13	.12	243,224	.317	77,102	1,652,385	5.0
S 7036	43	.39	98,406	.470	46,251	3,304,769	10.0
G 9655	81	.74	6,768	4.876	33,001	4,957,154	15.0
T 3320	93	.85	4,250	7.369	31,318	5,254,583	15.9
K 8946	99	.9	44,560	.675	30,078	5,618,107	17.0
K 5322	110	1.0	8,680	3.286	28,522	5,882,489	17.8
K 2026	132	1.2	27,581	.930	25,650	6,609,538	20.0
16267	176	1.6	3,428	5.900	20,228	7,600,969	23.0
H 1981	209	1.9	52,765	.379	19,998	8,261,923	25.0
G 9282	308	2.8	1,105	14.676	16,217	9,914,307	30.0
N 8565	330	3.0	23,908	.640	15,301	10,443,070	31.6
G 2034	352	3.2	2,690	5.475	14,728	11,004,881	33.3
G 9102	538	4.9	11,378	.980	11,150	13,219,076	40.0
S 5678	549	5.0	244,690	.045	11,011	13,252,124	40.1
H 9339	626	5.7	22,224	.450	10,001	14,276,602	43.2
G 2109	879	8.0	7,391	1.054	7,790	16,523,845	50.0
2620	978	8.9	2,089	3.540	7,396	17,184,799	52.0
S 5251	1099	10.0	56,304	.115	6,475	18,209,277	55.1
M 7868	1352	12.3	9,984	.556	5,551	19,828,614	60.0
S 5843	1648	15.0	3,756	1.234	4,635	21,414,903	64.8
H 3762	1747	15.9	21,683	.205	4,445	21,844,523	66.1
S 5634	1835	16.7	23,796	.181	4,307	22,042,809	66.7
S 5799	2055	18.7	33,743	.113	3,813	23,133,383	70.0
S 6121	2198	20.0	7,239	.490	3,547	23,662,146	71.6
K 2018	2615	23.8	3,571	.840	3,000	25,050,149	75.8
P 9986	2747	25.0	14,774	.190	2,807	25,413,674	76.9
M 6621	3198	29.1	1,500	1.650	2,475	26,438,152	80.0
G 2774	3296	30.0	1,212	1.876	2,274	26,834,724	81.2
N 3501	3659	33.3	9,967	.209	2,083	27,429,583	83.0
M 2643	3747	34.1	1,138	1.720	1,957	27,793,107	84.1
S 7822	4395	40.0	3,509	.450	1,579	29,015,872	87.8
46381	4802	43.7	243	5.729	1,391	29,445,492	89.1
K 2174	4934	44.9	1,042	1.256	1,309	29,742,921	90.0
S 5904	5494	50.0	2,337	.475	1,110	30,403,875	92.0
G 2601	5791	52.7	2,857	.350	1,000	30,536,066	92.4
S 6219	6593	60.0	15,360	.050	768	31,395,306	95.0
K 2068	7329	66.7	3,494	.176	615	31,891,021	96.5
G 7413	7692	70.0	1,904	.282	537	32,122,355	97.2
H 3772	8790	80.0	2,842	.120	341	32,618,070	98.7
N 9773	9098	82.8	2,439	.123	300	32,717,213	99.0
T 6613	9241	84.1	2,670	.103	275	32,783,308	99.2
M 2613	9889	90.0	3,750	.048	180	32,915,499	99.6
G 2605	10,439	95.0	198	.505	100	32,998,118	99.85
T 6562	10,900	99.2	210	.143	30	33,034,471	99.96
S 6132	10,966	99.8	0	.062	0	33,047,690	100.0
M 3742	10,988	100.0	0	.073	0	33,047,690	100.0

Figure 21. ABC Analysis

ABC analysis.

Trueswell (20) suggests that two factors are important when analyzing circulation control:

a.) the length of time the book has been in the library, and,

b.) the last previous circulation date.

Data was taken on three different days until the sample size reached 403 items for analysis. A computer program was written to analyze the circulation on the basis of the accession number of each circulated volume. The upper and lower limits for the accession number for each particular year was taken from the accession book. The computer program eliminated much of the laborious sorting and totaling that would have been necessary to find the age of a particular book in the sample. The age of a book is simply the amount of time that the book has been available to the library for circulation. It is not connected in any way with the date that the book was published or copywrited. For example, assume a book published in 1831 was purchased by the library in 1966 and given the next accession number. If after one week of being on the shelf, a student decides to borrow it, the accession is recorded for the data. Then the number is looked up in the accession book. It will show that the book was made available for circulation last week. The age of the book at circulation time is one week. The use of the computer obviated the necessity for looking up data for subsequent manipulation. The next section

describes the computer program and the results it gave. That section is immediately followed by a complete analyzation of the circulation control function.

a.) COMPUTER PROGRAM DISCUSSION

This section presents a general Fortran program for sorting by accession number into age groups. The program is based on the push down principle of sorting whereby the smallest accession number is pushed to the bottom of a list in the computer, then the next smallest number is pushed down into the next to last position and so on. The frequency distribution by age is accomplished by the use of the IF statements.

The program is written in Fortran II computer language. Fortran II (FORmula TRANslation) is a coding system that closely resembles the language of mathematics. It is designed for scientific digital computing devices such as the IBM 1620, 704, 709, 7070, 7090, 7094, Control Data Corporation's 1604, 3600, 6400, 6600, 6800, Honeywell's 800 and General Electric's entire 600 series. Using the University of Missouri at Rolla computing center entails programming the IBM 1620 with punched card input--printer output, a minimum of 40,000 positions of coding storage and floating point hardware. The program has been run on the IBM 1620. However, with minor changes the program will run on practically any of the above computers.

```
*LIST PRINTER
*ALL STATEMENT MAP
C  C***50649SSX001  SHEWCHUK JOHN        05/09/66 FORTRAN 2     0003 015 0
C      ****   PROGRAM TO EVALUATE THE  INVENTORY APPROACH ******
C   DIMENSION DESCRIBES THE SIZE OF THE DATA ARRAYS
      DIMENSION VOL(26),AVOL(26)
C       AVOL = CUMULATIVE PERCENT HOLDINGS
C      A =  THE NUMBER OF  BOOKS  PURCHASED IN A YEAR
C VOL = PERCENT  OF HOLDINGS
      DIMENSION X(450)
      DIMENSION A(66)
      DIMENSION CNT(66)
C    PC, PU,PO ARE PERCENT,PERCENT UNDER,AND PERCENT OVER RESPECTIVELY
      DIMENSION PC(66),PU(66),PO(66)
C      T,E,AND V  = ACCESSION LIMITS FOR  THAT YEAR
      T1=115947.
      T2=111875.
      T3=108700.
      T4=105300.
      T5=102175.
      T6= 99325.
      T7= 97075.
      T8= 94375.
      T9= 91455.
      E1= 89000.
      E2= 86140.
      E3= 84380.
      E4= 83000.
      E5= 81280.
      E6= 79520.
      E7= 77400.
      E8= 74600.
      E9= 71920.
      V1=69120.
      V2=66041.
      V3=64140.
      V4=62040.
      V5=60514.
      V6=58644.
      V7=57180.
      V8=54660.
      V9=52580.
      A(1)=T1-T2
      A(2)=T2-T3
      A(3)=T3-T4
      A(4)=T4-T5
      A(5)=T5-T6
      A(6)=T6-T7
```

Figure 22-a. Computer Program Information

```
      A(7)=T7-T8
      A(8)=T8-T9
      A(9)=T9-E1
      A(10)=E1-E2
      A(11)=E2-E3
      A(12)=E3-E4
      A(13)=E4-E5
      A(14)=E5-E6
      A(15)=E6-E7
      A(16)=E7-E8
      A(17)=E8-E9
      A(18)=E9-V1
      A(19)=V1-V2
      A(20)=V2-V3
      A(21)=V3-V4
      A(22)=V4-V5
      A(23)=V5-V6
      A(24)=V6-V7
      A(25)=V7-V8
      A(26)=V8-V9
      TVOL=115947./100.
      DO 375 I=1,26
  375 VOL(I)=A(I)/TVOL
      AVOL(1)=VOL(1)
      DO 801 I=2,26
  801 AVOL(I)=AVOL(I-1)+VOL(I)
C     *** INITIALIZATION OF FREQUENCY BY YEAR, 1939-1966 ***
      Y1966=0.
      Y1965=0.
      Y1964=0.
      Y1963=0.
      Y1962=0.
      Y1961=0.
      Y1960=0.
      Y1959=0.
      Y1958=0.
      Y1957=0.
      Y1956=0.
      Y1955=0.
      Y1954=0.
      Y1953=0.
      Y1952=0.
      Y1951=0.
      Y1950=0.
      Y1949=0.
      Y1948=0.
```

Figure 22-b. Continuation

```
      Y1947=0.
      Y1946=0.
      Y1945=0.
      Y1944=0.
      Y1943=0.
      Y1942=0.
      Y1941=0.
      Y1940=0.
      Y1939=0.
C     FORMAT STATEMENTS INDICATE HOW DATA IS PUT INTO MACHINE
   10 FORMAT (F6.0)
    1 FORMAT(I3)
C     READ STATEMENT TELLS IN THIS CASE THE SIZE OF DATA ARRAY
C  M TELLS THE NUMBER IN THIS SAMPLE
      READ 1,M
      READ 10 , (X(I), I=1,M)
      DDS =M
C   DO SUGGESTS WHICH VALUE OF THE SAMPLE IS TO BE TESTED
      DO 101 I=1,M
C *** TESTING  FOR FREQUENCY DISTRIBUTION BY ACCESSION AGE ***
C     EACH IF STATEMENT REPRESENTS AN ATTEMPT TO FIND THE PARTICULAR
C     AGE OF EACH VOLUME(DATA) IN THE ARRAY
C   X(I) IS THE VARIABLE THAT IS TESTED FOR AGE IN THE  IF  STATEMENT
      IF(X(I)-T1)21,21,61
   61 DDS=DDS-1.
      GO TO 101
   21 IF(X(I)-T2)22,22,62
   62 Y1965=Y1965+1.
      GO TO 101
   22 IF(X(I)-T3)23,23,63
   63 Y1964=Y1964+1.
      GO TO 101
   23 IF(X(I)-T4)24,24,64
   64 Y1963=Y1963+1.
      GO TO 101
   24 IF(X(I)-T5)25,25,65
   65 Y1962=Y1962+1.
      GO TO 101
   25 IF(X(I)-T6)26,26,66
   66 Y1960=Y1960+1.
      GO TO 101
   26 IF(X(I)-T7)27,27,67
   67 Y1959=Y1959+1.
      GO TO 101
   27 IF(X(I)-T8)28,28,68
   68 Y1958=Y1958+1.
```

Figure 22-c. Continuation

```
      GO TO 101
   28 IF(X(I)-T9)29,29,69
   69 Y1957=Y1957+1.
      GO TO 101
   29 IF(X(I)-E1)30,30,70
   70 Y1956=Y1956+1.
      GO TO 101
   30 IF(X(I)-E2)31,31,71
   71 Y1955=Y1955+1.
      GO TO 101
   31 IF(X(I)-E3)32,32,72
   72 Y1954=Y1954+1.
      GO TO 101
   32 IF(X(I)-E4)33,33,73
   73 Y1953=Y1953+1.
      GO TO 101
   33 IF (X(I)-E5)34,34,74
   74 Y1952=Y1952+1.
      GO TO 101
      IF (X(I)-E6)35,35,75
   75 Y1951=Y1951+1.
      GO TO 101
   35 IF(X(I)-E7)36,36,76
   76 Y1950=Y1950+1.
      GO TO 101
   36 IF(X(I)-E8)37,37,77
   77 Y1949=Y1949+1.
      GO TO 101
   37 IF(X(I)-E9)38,38,78
   78 Y1948=Y1948+1.
      GO TO 101
      IF(X(I)-V1)39,39,79
   79 Y1947=Y1947+1.
      GO TO 101
   39 IF(X(I)-V2)40,40,80
   80 Y1946=Y1946+1.
      GO TO 101
   40 IF(X(I)-V3)41,41,81
   81 Y1945=Y1945+1.
      GO TO 101
   41 IF(X(I)-V4)42,42,82
   82 Y1944=Y1944+1.
      GO TO 101
   42 IF(X(I)-V5)43,43,83
   83 Y1943=Y1943+1.
      GO TO 101
```

Figure 22-d. Continuation

```
   43 IF(X(I)-V6)44,44,84
   84 Y1942=Y1942+1.
      GO TO 101
   44 IF(X(I)-V7)45,45,85
   85 Y1941=Y1941+1.
      GO TO 101
   45 IF(X(I)-V8)46,46,86
   86 Y1940=Y1940+1.
      GO TO 101
   46 IF(X(I)-V9)87,87,87
   87 DDS=DDS-1.
   47 GO TO 101
  101 CONTINUE
      JOB=0
  279 JOB=JOB+1
      GO TO (3,4),JOB
    3 T=1.
      KA=1
      GO TO 272
    4 T=DDS/100.
      KA=2
  272 PC(65)=Y1965/T
      PC(64)=Y1964/T
      PC(63)=Y1963/T
      PC(62)=Y1962/T
      PC(61)=Y1961/T
      PC(60)=Y1960/T
      PC(59)=Y1959/T
      PC(58)=Y1958/T
      PC(57)=Y1957/T
      PC(56)=Y1956/T
      PC(55)=Y1955/T
      PC(54)=Y1954/T
      PC(53)=Y1953/T
      PC(52)=Y1952/T
      PC(51)=Y1951/T
      PC(50)=Y1950/T
      PC(49)=Y1949/T
      PC(48)=Y1948/T
      PC(47)=Y1947/T
      PC(46)=Y1946/T
      PC(45)=Y1945/T
      PC(44)=Y1944/T
      PC(43)=Y1943/T
      PC(42)=Y1942/T
      PC(41)=Y1941/T
```

Figure 22-e. Continuation

```
      PC(40)=Y1940/T
      GO TO (601,602),KA
  601 DO 277 I=40,65
  277 CNT(I)=PC(I)
      GO TO 279
  602 CONTINUE
      PU(66)=0.
      J=66
      DO 329 I =1,26
      J=J-1
      PU(J)=PC(J) +PU(J+1)
  329 PO(J)= 100.-PU(J)
      AGE=0.
      YEAR =1966.
      J=66
      PRINT 214
  214 FORMAT(1H1,17HDATA DISTRIBUTION,//////)
      DO 821 I= 1,26
      YEAR=YEAR-1.
      AGE=AGE+1.
      J=J-1
  821 PRINT 727,YEAR,AGE,CNT(J),PC(J),PU(J),PO(J),VOL(I),AVOL(I)
  727 FORMAT(1X,F9.0,F5.0,F6.0,F7.1, F11.1,5X,F11.1,F10.1,F10.1)
      PRINT 496,DDS
  496 FORMAT(1X,25X,F10.0 )
      CALL EXIT
      END
```

Figure 22-f. Continuation

Figure 22 is the result of the experiment to investigate the distribution by age of the circulation sample. Column four represents the percent of the sample that is of that particular age. For example, in the sample there were 64 books one year old, representing 15.8% of the total sample. In other words, 15.8% of the books circulated by the library are one year old or less. Column five represents the cumulative percentage over a specific age. For example, 1960 represents the year the book became available. The six in column two represents the fact that the book is six years old. The fifth column for that entry shows that 51.3% of all the books circulated are less than six years old. Thus, if a book master card was prepared for all books six years of age or younger, 51.3% of borrowers would have a book with a book master card in it. The sixth column simply shows the percentage of books that would not have a book master card at circulation time. The last column, column eight, tells the librarian what percentage of his library he must automate to achieve the results desired. For example, to achieve the 51.3% level that is being discussed, the librarian will look in column eight and find that 16.2% of his total holdings account for 51.3% of circulation. Column seven illustrates the percentage of the library's holdings for any particular age group. This column is important when used in conjunction with column four. By way of example, to pick up an additional 3.7% (1957-1956), it is

DATA DISTRIBUTION

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year Avail.	Age	# in Smpl.	% of Smpl.	Cumulative % Over age	Under age	% of Holdings	Cumulative % of Holdings
1965.	1.	64.	15.8	15.8	84.1	3.5	3.5
1964.	2.	37.	9.1	25.0	74.9	2.7	6.2
1963.	3.	41.	10.1	35.2	64.7	2.9	9.1
1962.	4.	37.	9.1	44.4	55.5	2.6	11.8
1961.	5.	0.	0.0	44.4	55.5	2.4	14.3
1960.	6.	28.	6.9	51.3	48.6	1.9	16.2
1959.	7.	20.	4.9	56.3	43.6	2.3	18.6
1958.	8.	23.	5.7	62.0	37.9	2.5	21.1
1957.	9.	26.	6.4	68.4	31.5	2.1	23.2
1956.	10.	15.	3.7	72.2	27.7	1.8	25.1
1955.	11.	10.	2.4	74.6	25.3	1.6	26.7
1954.	12.	9.	2.2	76.9	23.0	1.6	28.4
1953.	13.	10.	2.4	79.4	20.5	1.4	29.8
1952.	14.	11.	2.7	82.1	17.8	1.5	31.4
1951.	15.	15.	3.7	85.8	14.1	1.8	33.2
1950.	16.	6.	1.4	87.3	12.6	2.4	35.6
1949.	17.	9.	2.2	89.5	10.4	2.3	37.9
1948.	18.	9.	2.2	91.8	8.1	2.4	40.3
1947.	19.	10.	2.4	94.2	5.7	2.6	43.0
1946.	20.	3.	.7	95.0	4.9	1.6	44.6
1945.	21.	1.	.2	95.2	4.7	1.8	46.4
1944.	22.	2.	.4	95.7	4.2	1.3	47.8
1943.	23.	1.	.2	96.0	3.9	1.6	49.4
1942.	24.	7.	1.7	97.7	2.2	1.2	50.6
1941.	25.	7.	1.7	99.5	.4	2.1	52.8
1940.	26.	2.	.4	99.9	0.0	1.7	54.6

403. = Sample

Figure 22-g. Results of Program

only necessary to automate 1.8% more of the library's holdings. These figures allow the librarian to select various load levels for the new system. Conversely, the figures tell what percentage of the library will remain on the old system if a certain percentage of the library is automated. This distribution by age is of major importance to the conversion effort because it represents, for any desired load level, the minimum cost.

The age nine level looks favorable as a basis for conversion. This means that approximately seven out of ten (actually 68.4%) borrowers will initially fit into the automated circulation system. This can be accomplished by automating only 23.2% of the library (all volumes nine years or younger). The examples here are not necessarily optimal for the library because the resources available to them have not been taken into consideration. The library must make these decisions based on money available or fundable. If new acquisitions are converted as soon as received, the percentage of books on the automated system will increase by a very large amount (books one year old now account for 15.8%. Next year new acquisitions should boost it about that much.) However, each succeeding year the increase will decrease somewhat but the cumulative percentage on the automated system will rise toward 100% each year.

3. DESIGN OF THE SYSTEM

For an initial attempt at automation it is often best to make the system less sophisticated than is necessary. In other words, at the University of Missouri at Rolla Library, the emphasis should be on designing a system that will handle the major part of the circulation. Then, as the staff becomes more familiar with the equipment and its capabilities, new areas of library automation can be approached. But, at the very beginning, the system should be easy to install and simple to operate.

The system recommended consists of the following components:

a.) IBM 357, Model 6, (card reader and badge reader),

b.) IBM 374, (cartridge reader),

c.) IBM 358, (control unit), and

d.) IBM 026, (printing output keypunch).

It is not proper for anyone but an IBM representative to quote lease or purchase prices, because prices are subject to change. Education discounts have increased and special devices may be necessary to satisfy particular needs. However, the entire system described is less than the cost of a clerk, less than $3000 a year (10).

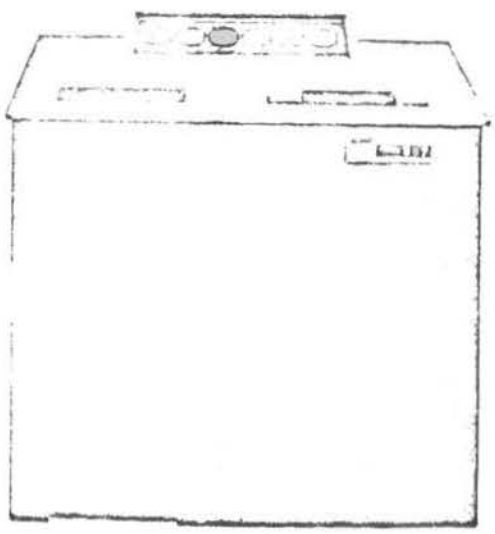
The following is a description in detail of each device and how it operates as a component of the system. Each device has a physical planning chart associated with

it. This chart should help a person to physically understand the components.

The card and badge reader is best described as an input device. The particular model suggested reads the punched book master card and the borrower's badge. Once the book master card and badge are inserted into the machine, the control unit, (described later in this section), turns off the "ready" light and turns on the "in process" light. When the control unit is sure the keypunch (described later) is ready to accept data, it signals the card reader to begin reading the card. Certain codes on the book master card signal specific operations. For example, a code on the book master card will signal the badge reader to commence reading. At that time the badge will be read and its information transmitted. The book master card will then transmit a code to signal the data cartridge (described later in this section) to transmit the loan duration period. Figure 23 is the planning chart.

The IBM 374 Cartridge Reader is also an input device and provides the library with a convenient method for altering the loan duration period. With two cartridges, one set for semester loans (graduates and faculty) and the other for two weeks, it is possible to accommodate the loan periods now used. Figure 24 is a cartridge. If in the future any changes are made to loan periods, all that is necessary is changing the data in the cartridge.

IBM 357 Input Station, Models 4, 5, 6



1. Installation recommendations:

   — Wall-mount the 357 using four (4) customer-supplied ¼" American Standard hex-head bolts.

   — Height: Floor-to-lower-mounting bolts, 37½" (Add 12" for upper mounting bolts). This will place the top of the card receiver 49" from the floor.

2. Service and general-access clearances:

   — Each side — 8"
   — Front — 30"
   — Top — 12"
   — Bottom — 12"

3. Maximum weight, 67 lbs.

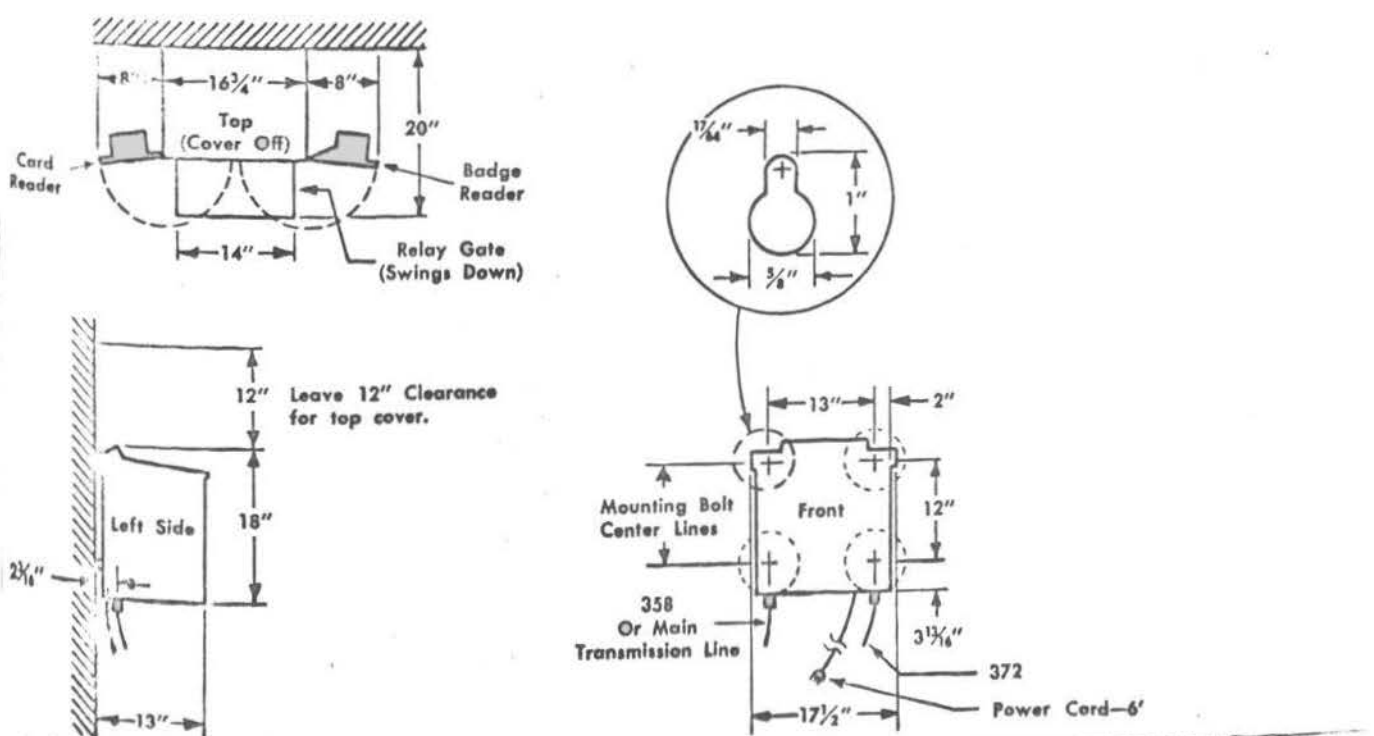


Figure 23. Planning Chart for a Card and Badge Reader

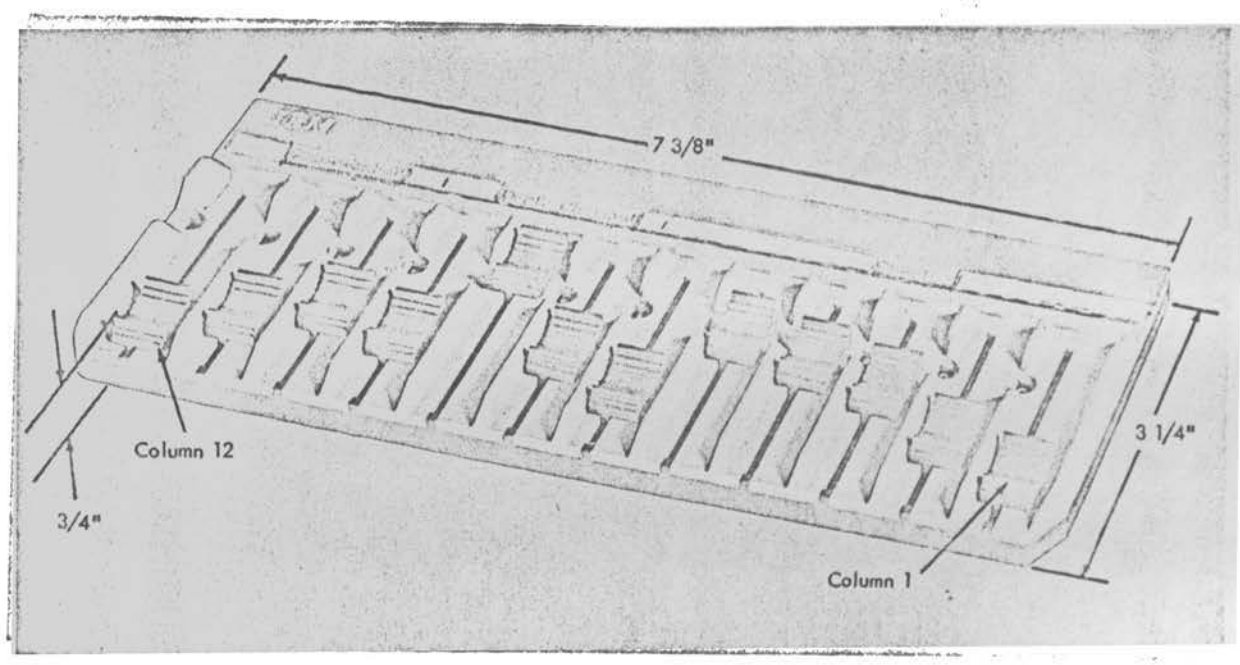


Figure 24. A Cartridge

The cartridge will hold twelve character (columns) of numerical information. By using six columns for date due, (month, day, year), it is possible to use the other six columns for borrowers that can provide identification but have not brought their badges. The Data Cartridge Reader (see Figure 25) will accept the cartridges only if placed in the machine correctly. During reading the cartridge cannot be removed inadvertently. It is locked in until the transmission is terminated. As mentioned previously, the cartridge reader is commanded to read by codes in the book master card. A special feature called the controlled reset allows multiple charges to the same student whenever common data, (loan period and borrower number) is used. Figure 26 is the planning chart.

Associated with the input units are lights and controls that help the operator to avoid errors, refer to Figure 27. These lights and controls are:

a.) Ready Light (green), indicates power is on and the system is ready to accept a borrower. It goes off when the station has an interruption in the power supply or another light goes on,

b.) In Process Light indicates that the data cartridge reader, card reader or badge reader is in operation,

c.) Remove Card Light and Eject Badge Key (yellow) indicates that the card has been read and released. When the card is removed, the light goes off. The key can cause the badge to be ejected for any reason. Normally the badge is released after reading,

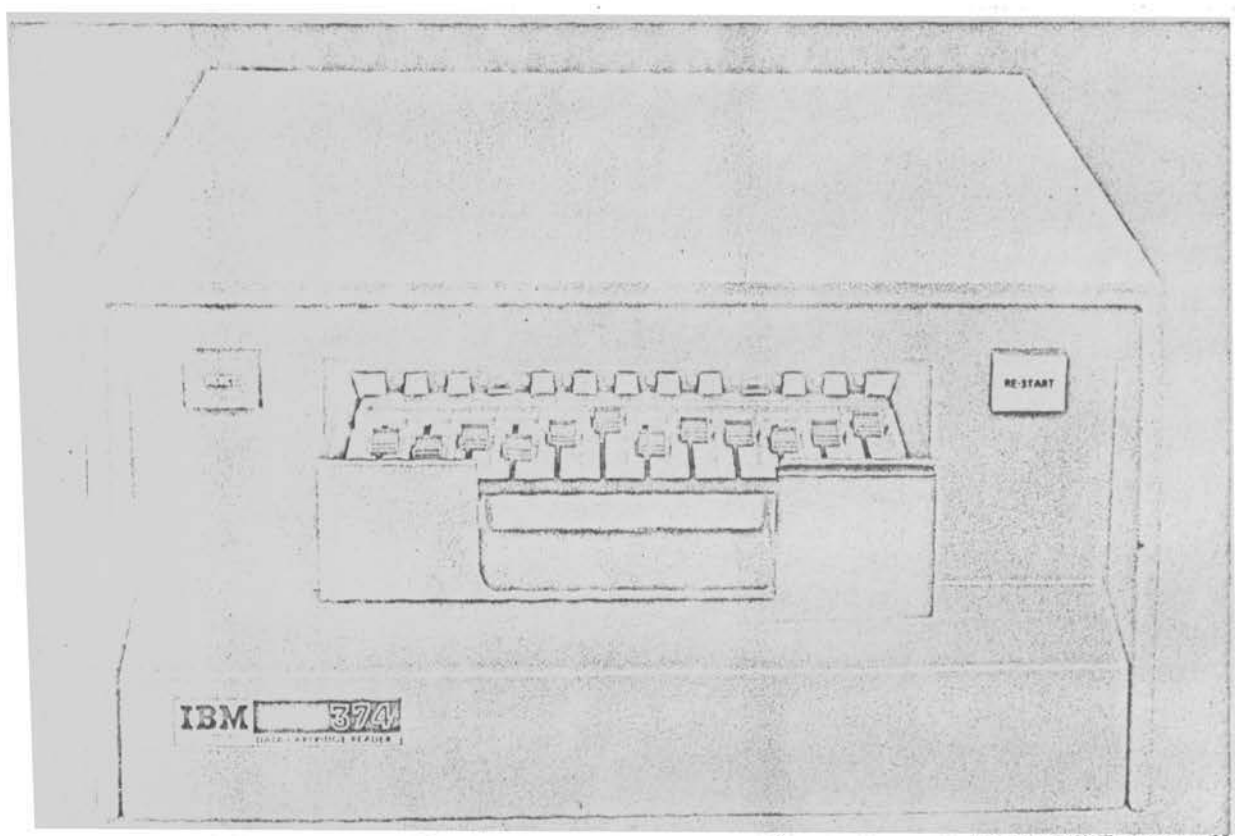
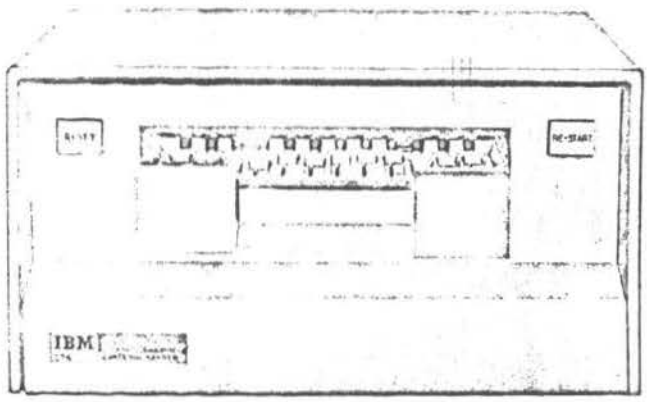


Figure 25. Data Cartridge Reader



1. Installation recommendations:

   — Wall-mount the 374 using three (3) customer-supplied ¼" American Standard hex-head bolts.

   — Height: Floor-to-lower-mounting bolts, 45" (add 5⅜" for upper mounting bolts). This places the top of the unit approximately 52" from the floor.

2. Service and general access clearances:

   — Side — A minimum of 12" must be provided between the IBM 374 and the IBM 357 for servicing.

   — Front — 24"
   — Top — 12"
   — Bottom — 12"

3. Maximum weight, 40 lbs.

4. The 3½' cable attached to the cartridge reader, permits installation of this unit to the right of the input station. A special-length cable must be ordered from IBM if the cartridge reader is to be installed to the left of the input station.

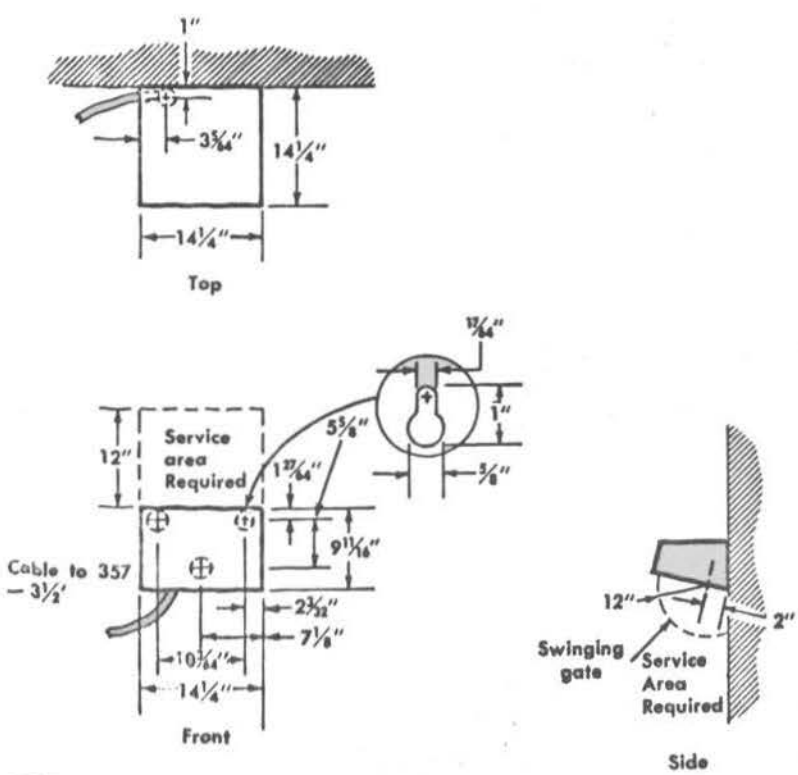


Figure 26. Planning Chart for a Cartridge Reader

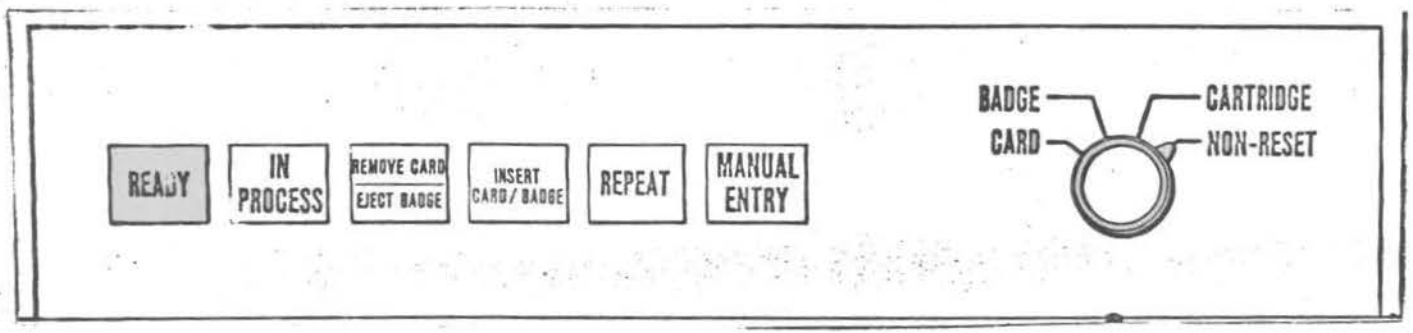


Figure 27. Lights and Controls on IBM 357

d.) Insert Card / Badge Light (green), indicates that either the badge or card has not been placed in the machine. After more than fifteen seconds elapse after the light has gone on, the repeat light comes on,

e.) Repeat Light (red) indicates an error. The light can be turned off by repeating the transaction,

f.) Manual Entry Light (green) indicates improper information in a data cartridge or no cartridge in the cartridge reader, and

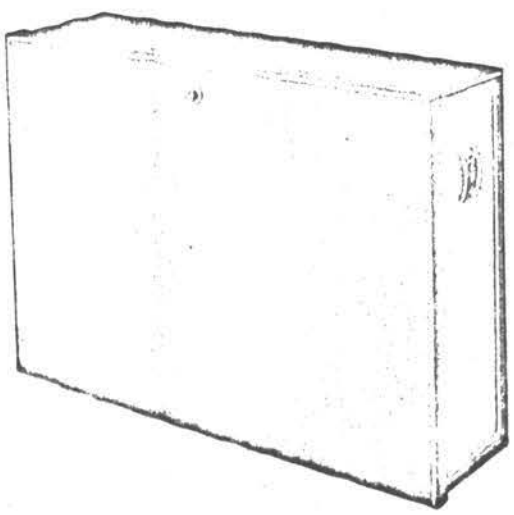
g.) Mode Switch, "Card", indicates a normal transaction. "Badge" indicates that no book master card is available and the transaction can be completed by using just the badge.* "Cartridge" is not used in this application. "Non-reset" indicates multiple charges to the same borrower number. The badge and cartridge are not released until all the book master cards are run through the 357. Then the switch is turned to "Card" and releases the badge and cartridge. This feature speeds up multiple charges.

The Control Unit selects the input station (if more than one) that is to transmit data to the keypunch. This unit also receives the codes in the book master card and directs the operation of the lights and controls. The Control Unit also acts as an efficiency checker. If more than 15 seconds elapse between documents for a transaction, the timer in the Control Unit will turn on the repeat light. Figure 28 is the planning chart.

The output station is a modified keypunch. It is

*The operator will write the accession number on the card. A keypuncher will make the book card master, while the book is circulating.

IBM 358 Input Control Unit



1. Installation recommendations:

   — Wall-mount the 358 using four (4) customer-supplied ¼" American Standard hex-head bolts.

   — Height: Top of the 358 should be 37" from the floor to provide an optimum height for servicing the unit and proper drop clearance for the front cover.

   — It is preferable to install the 358 behind the 24/26 to permit interconnection of the two units by the 10' connector cable from the output station. A 36" clearance between the 358 and 24/26 should be maintained for proper access.

2. Service and general-access clearances:

   — Right side — 6"
   — Front — 36" (This also provides adequate clearance to the back of the 24/26.)
   — Bottom — 18"

3. Maximum weight, 88 lbs.

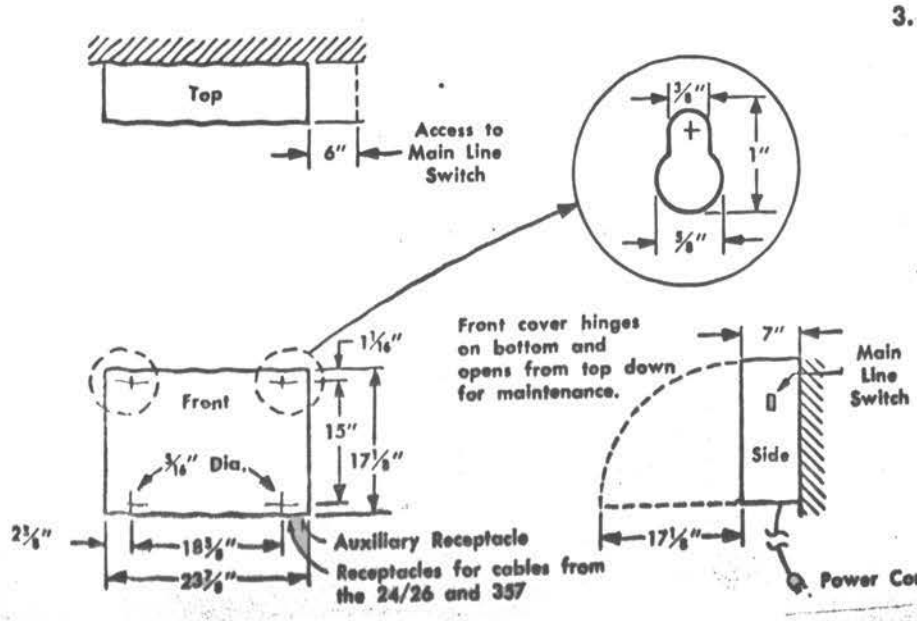


Figure 28.

Control Unit

modified in the sense that it can accept transmitted data from the Control Unit. However, the keypunch can also be used for manual keypunching. The queueing theory applied to the library did not account for peak loads at certain times of the day. A special device will allow high speed switching between two keypunches. If it is found necessary, this would be a technique to use for avoiding the leasing of another 357 unit. At non peak times manual keypunching could be done by disconnecting the extra keypunch. As a manual keypunch, the modified 026 can do anything that a keypunch is normally used for. When connected to the 358, constant attention is not necessary for the keypunch; it will signal if it is out of cards. Anything requiring attention is indicated by a buzzer on the keypunch. Also an attention light (red) goes on when any problem occurs. When the problem is eliminated a ready light (white) is switched on. These then are the main components of the data collection system proposed for the University of Missouri at Rolla Library. The output from this data collection system is used as the input for the data processing system. The data collection system detailed in this section is shown schematically in Figure 29.

Now that the capabilities of the equipment have been presented, all that is necessary to clarify the system is to follow the borrower through the automated data collection. A borrower presents his plastic identification

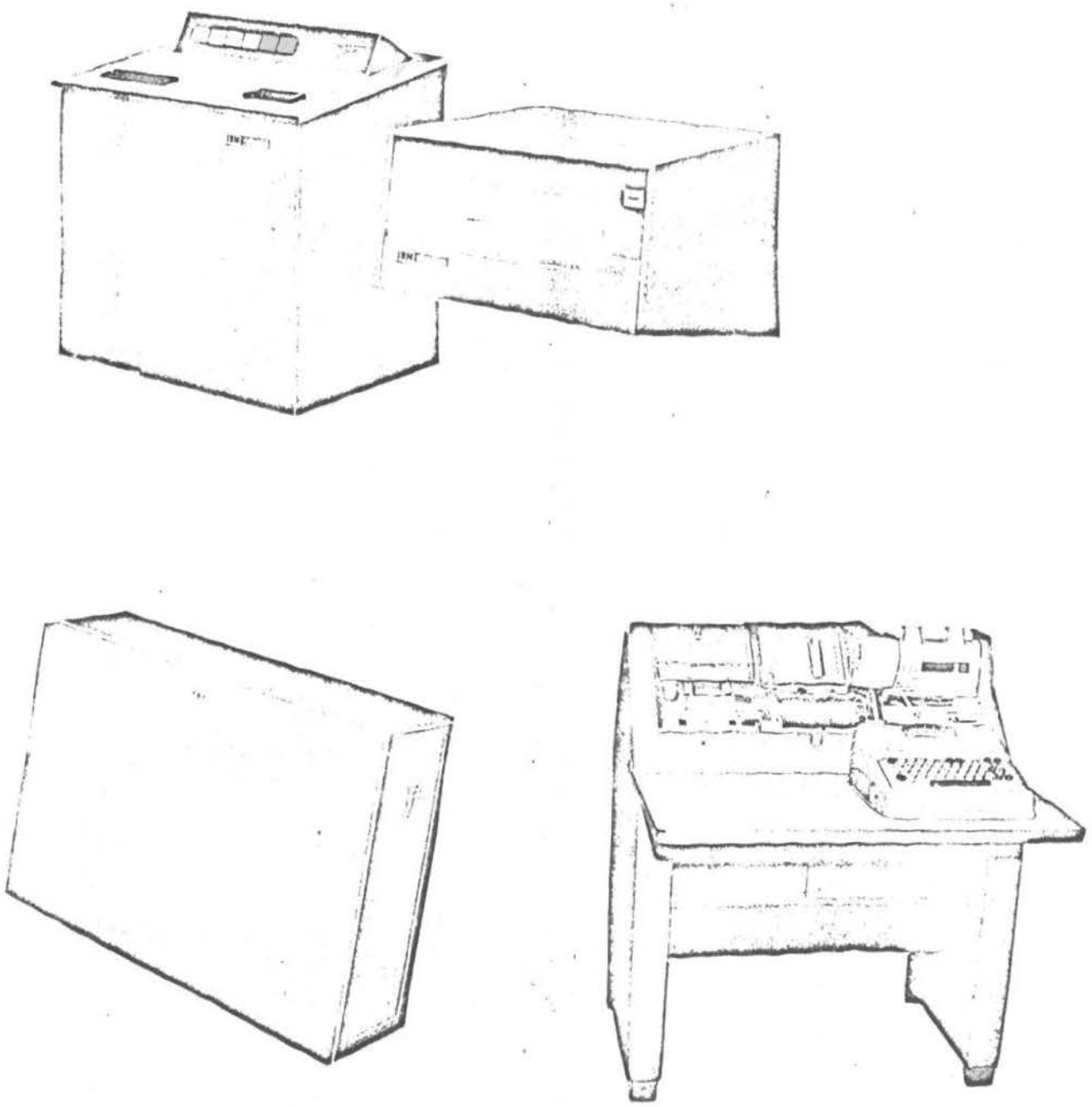


Figure 29. Data Collection Schematic

card to the "circulation desk". The last seven digits of the Social Security number are assigned to faculty members in lieu of a student number. All student borrowers have a seven digit student number. A check digit also indicates borrower status. The book is presented to the "desk" with the badge (identification card). The clerk notes the borrower status and selects the appropriate preset cartridge (two weeks or a semester) and places the cartridge into the cartridge reader. The clerk then places the badge into the badge reader and the book master card into the card reader. The machine takes over and generates two duplicate cards. One card (charge card) is retained as a record. The book card master plus the other card (verification card) is placed in the jacket. A guard at the exit then checks the accession number on the verification card with the accession number labeled on the book pocket to assure each book leaving the library has been properly charged. The charge card is then entered into the data processing system. The processing system can be of three different types. The first way is to use a manual system similar to the present method. The possibility of recording data erroneously is almost impossible since no writing has occurred. Punched cards are cheaper per thousand than the cards now being used and can be duplicated easily. Filing could continue to be done by Dewey numbers or can be converted to accession numbers. This latter way is preferable since a unique six digit

number identifies a book. The charge card will show date due and the student number of the borrower. This is what is being accomplished now except for elimination of transcription errors. A second way would be to use "unit record" equipment. The computer center on campus has typical unit record equipment. An example of using unit record equipment would be the collating of new charges into the charging file instead of doing this manually. Returns could be placed in one feed of a collator, charges in the other feed. Both feeds would be in numerical sequence and run against each other. Matches (same card in both feeds) represent returns not overdue. The unmatched charges represent overdues. All overdues could then be collated against a name and address file or department file and "overdues" prepared on the accounting machine. Holds can be run against the returns, matches in both feeds represent a borrower that desires that particular return. The chief advantage of this method is that the library staff could arrange to use the Computer Center's unit record equipment. Another method would be to use the computer equipment available at the Computer Center. For example, by setting up sectors on disk packs for each student, it would be possible to access randomly information contained in the computer.

The unit record and the computer approach both lend themselves to rapid searching of files to allow clearance

for graduation. In the unit record method a high speed sorter with a card matching device or a collator could be used to match a card with the student number of those graduating against charge outs. In fact this listing could be on labels which could be glued to a postcard, or the accounting machine can print this information on postcard stock ready for mailing.

These are only a few of the options that are available to the University of Missouri at Rolla Library.

4. SYSTEM EVALUATION

It is possible to evaluate the 357 from two different viewpoints: a.) a performance evaluation, and b.) an economic evaluation. It is true that the two are somewhat interrelated, however, it is procedurally simpler to discuss them separately.

The evaluation of performance can also be approached in two ways:

1.) evaluation of one specific advantage that the system has over other systems,

2.) a composite evaluation based on the sum of various elemental evaluation.

One specific advantage is flexibility. The system proposed can and will operate as a subsystem for a later attempt at major automation. It is also flexible enough to stand alone and operate just in the circulation environs. Later on, if acquisition is automated, the 357

will be compatible. The fact that the machines are mobile, (can be placed on a dolly and moved around), contributes greatly to the overall effectiveness of the equipment. The system can be started on fairly small (badge reader, keypunch and control unit) and later accessory equipment can be added on to facilitate major expansion. Additional badge readers, cartridge readers, and clock readouts can be rented or purchased as needed or deleted if circumstances should warrant. In terms of other charging systems the IBM 357 offers the most flexibility in the areas of card design, accuracy and reliability. The system is very uncomplicated. It is flexible enough to be operated by a person with just a few minutes training. The elimination of any writing by the borrower is part of the inherent flexibility of this system.

A composite evaluation would show that the system has worked very well elsewhere for handling volumes of work in excess of the load handled at the University of Missouri at Rolla. The 357 system at Southern Illinois University consists of six units to handle 600,000 volumes. This is equivalent to one unit per 100,000 volumes. With the 357 increasing workloads are not a problem because up to 20 separate units could be deployed throughout the library to handle increasing circulation.

One of the major aspects in the evaluation of this

system is that service levels can be predicted. The basis for these predictions are well grounded in the management of waiting lines (queueing theory) that is a fundamental part of operations research. The underlying philosophy concerning the management of waiting lines is this, "If the laws governing arrivals, servicing times, and the order in which arriving units are taken into service are known, then the nature of this waiting situation can be studied and analyzed mathematically" (17).

It is necessary first to make several general assumptions about the nature of the queue before the theory can be applied:

a.) arrivals must be of a random nature but clustered or scattered in some fashion called Poisson. This "Poisson assumption" says that the arrivals at a facility are random, independent of time, not dependent on queue, length or any other property of the queue,

b.) service times vary, some taking more time and others less. Statistically speaking, an exponential distribution of service times is assumed (Figure 30), and

c.) the first person in the line is the first person to be serviced.

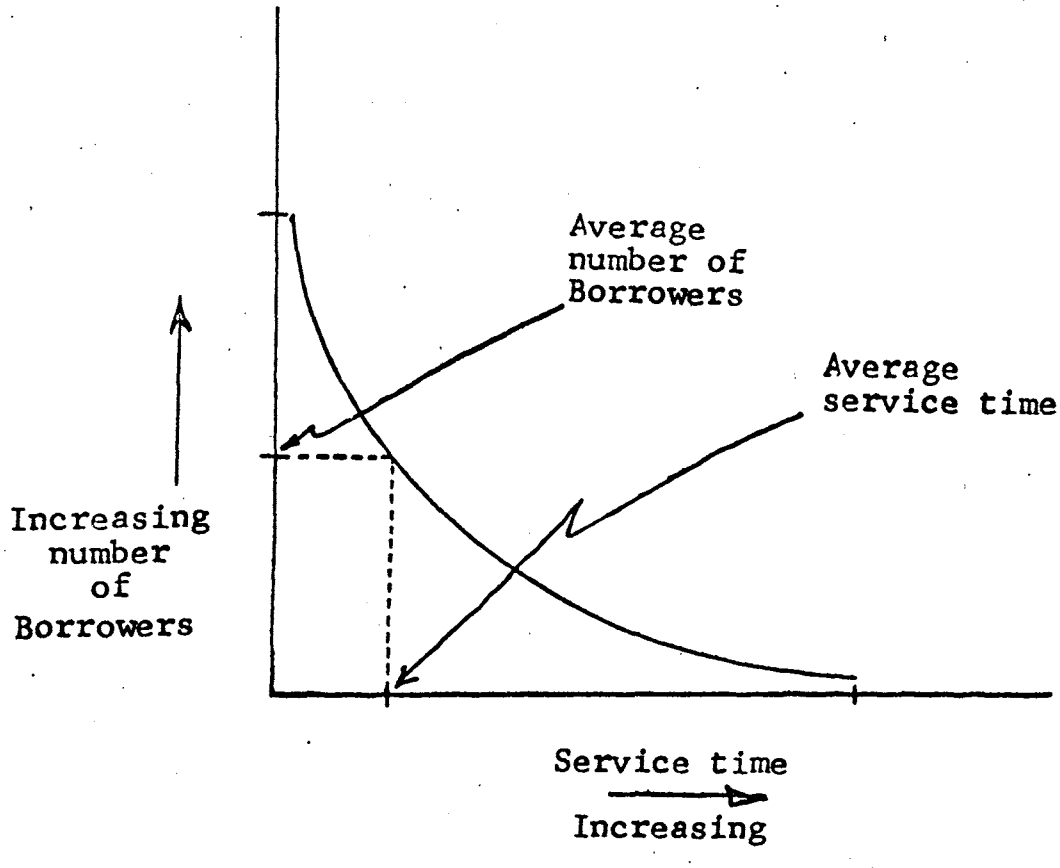


Figure 30. Exponential Distribution

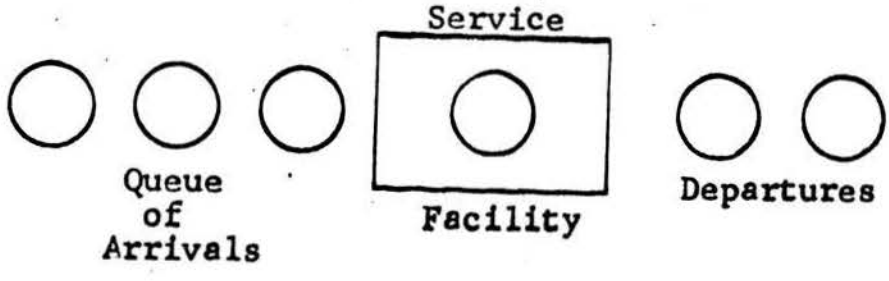


Figure 31-a. Computer Produced Queueing Information

```
C  C####6097ZSSX001  SHEWCHUK JOHN          05/09/66 F02.0          0004 008 000
C  THIS PROGRAM PROVIDES AN ANALYTIC SOLUTION TO QUEUE PROBLEMS
C  ENCOUNTERED AT THE UNIVERSITY OF MISSOURI AT ROLLA LIBRARY.
C  POISSON DISTRIBUTION (ONE OF THE ASSUMPTIONS MADE) IS DESCRIBED
C     MATHEMATICALLY BY ONE PARAMETER-THE AVERAGE OR MEAN-
C     THEREFORE, THIS PROGRAM USES THE AVERAGE ARRIVAL RATE(ARATE)
C     AND THE AVERAGE SERVICE RATE(SRATE) FOR SOLVING QUEUE PROBLEMS
      SRATE=0.41
C     SRATE CALCULATED THUSLY...40 SAMPLES OF SERVICE AVERAGED
C     2.47 MINUTES. SRATE=1/2.47= SERVICES PER MINUTE
      ARATE=0.25
C     IN 81 MINUTES, 20 ARRIVALS WERE COUNTED OR AN AVERAGE
C     OF 1 ARRIVAL EVERY 4 MINUTES. A MINUTE HAS 0.25 ARRIVALS
C     AQL=AVER. QUEUE LENGTH
C     ALNEQ=AVER. LENGTH OF NON EMPTY QUEUES
C     AVNSY=AVER NUMBER OF PEOPLE IN LINE AND IN SERVICE
C     AVWS=AVER WAITING TIME  OF AN ARRIVAL
C     PWAIT=PROBABILITY THAT A PERSON ARRIVAING MUST WAIT
C     ATSY=AVER TIME FOR ENTIRE CIRCULATION FUNCTION
C     THE FOLLOWING EQUATIONS ARE USED WITHOUT PROOF AND CAN
C     BE OBTAINED FROM MOST OPERATIONS RESEARCH TEXTBOOKS (  )
      JOB =1
    9 DIF=SRATE-ARATE
      PWAIT= ARATE/SRATE
      AQL=(ARATE**2)/(SRATE*DIF)
      ALNEQ=SRATE/DIF
      AVNSY=ARATE/DIF
      AVWS=ARATE/(SRATE*DIF)
      ATSY=1./DIF
      GO TO (1,2),JOB
    1 PRINT 100
    2 GO TO (3,4),JOB
    4 PRINT 500
    3 PRINT 200,PWAIT,AQL,ALNEQ
      PRINT 300,AVNSY,AVWS,ATSY
  100 FORMAT(1X,37HRESULTS ARE FOR PRESENT MANUAL SYSTEM///)
  200 FORMAT (5X,6HPWAIT=,F5.2,4HAQL=,F5.2,6HALNEQ=,F5.2 )
  300 FORMAT (5X,6HAVNSY=,F5.2,5HAVWS=,F5.2,5HATSY=,F5.2,/////// )
      JOB=JOB+1
C     UNDER 357 SYSTEM SRATE=1.0  ESTIMATED ON BASIS OF
C     TRANSACTION TIMES AVAILABLE FROM IBMS 357 MANUAL (  )
      SRATE=1.0
C     ARATE FOR COMPARISON STAYS THE SAME.
  500 FORMAT(1X,28HRESULTS FOR AUTOMATED SYSTEM,//// )
      GO TO (12,12,41),JOB
   12 GO TO 9
   41 STOP
```

Figure 31-b. Continuation

```
C  C***50972SSX001  SHEVCHUK JOHN          05/09/66 FORMO          0004 000 000

      END

 RESULTS ARE FOR PRESENT MANUAL SYSTEM

      PWAIT=  .61AQL=  .95ALNEQ= 2.56
      AVTSY= 1.56AVW8= 3.81ATSY= 6.25



 RESULTS FOR AUTOMATED SYSTEM

      PWAIT=  .25AQL=  .08ALNEQ= 1.33
      AVTSY=  .33AVW8=  .33ATSY= 1.33



 STOP END OF PROGRAM AT STATEMENT 0041 + 00 LINES.
```

Figure 31-c. Continuation

The results of the analytical investigation of the queue should be interpreted as follows. The average borrower under the present manual system has a 61% probability of waiting if he decides to go into the circulation queue. The odds are that throughout the day there will be almost always one person ahead of him. If a queue exists at the circulation desk when the borrower arrives, it will probably be 2.56 people in length. (These are average figures.) The average borrower will wait 3.8 minutes in the sequence from the moment he enters the queue until completion of the charging process.

In contrast to this, a glance at the figures for the automated system with one 357, (Reference 20 also contains formulas for evaluating more than one service facility), shows some striking increases in service levels. In particular, the probability of waiting is reduced to 0.25. Most important, however, is the fact that the average borrower will spend only 1.33 minutes from the moment he enters the queue until completion of his transactions. This is almost a fivefold increase in service. Equally important is the figure illustrating that the average waiting time has been lowered from 3.81 to 0.33 minutes. That is a reduction to 1/11 of the original waiting time.

These calculations show that the Data Collection System will provide service comparable to the present system far into the future. This can be interpreted as

saying that a fivefold increase in circulation in the future will still allow the library to maintain its present levels of service to the borrower.

An economic evaluation is quite simple. This system, as already pointed out, requires an investment of about $3,000 a year for the hardware. Badges are relatively inexpensive and should be a large fixed cost initially. Thereafter, only new borrowers are added. Supplies, in general, based on quantity discounts, are comparable and probably cheaper. Punched cards can be purchased for a dollar a thousand or about ten for one cent. The equipment, which costs less than the salary for an additional clerk, needs no additional personnel outside of a keypuncher. For the benefits derived, this system is quite reasonable.

V. ACQUISITIONS

Figure 32 is a flowchart that suggests a method for handling acquisitions. A request from a faculty member for a particular volume is typewritten on a four part form. The first copy is sent to the order clerk and the person ordering the book keeps the fourth copy as a record. The third copy is returned to the faculty member to signify ordering has taken place. If the book is not to be ordered, the reason is written on the returned third copy. The original is used as a source document and sent to key-punching. When the book is received, the faculty member is notified on the second copy. The value of this to the library is the shifting of the correspondence burden to the orderer of the book. As soon as possible after the request has been approved, a keypuncher will make a card for the acquisition function. The card will contain author, title, publisher code, cost, and possibly a vendor code.

If the library plans to continue letting bids, the punched cards can be used to prepare a book bid list. If the library staff returns to purchasing from vendors, then vendor name and address cards can be prepunched and collated into the acquisition file. All purchase orders can then be written using an accounting machine. The acquisition cards are then placed into the "on order file" to await

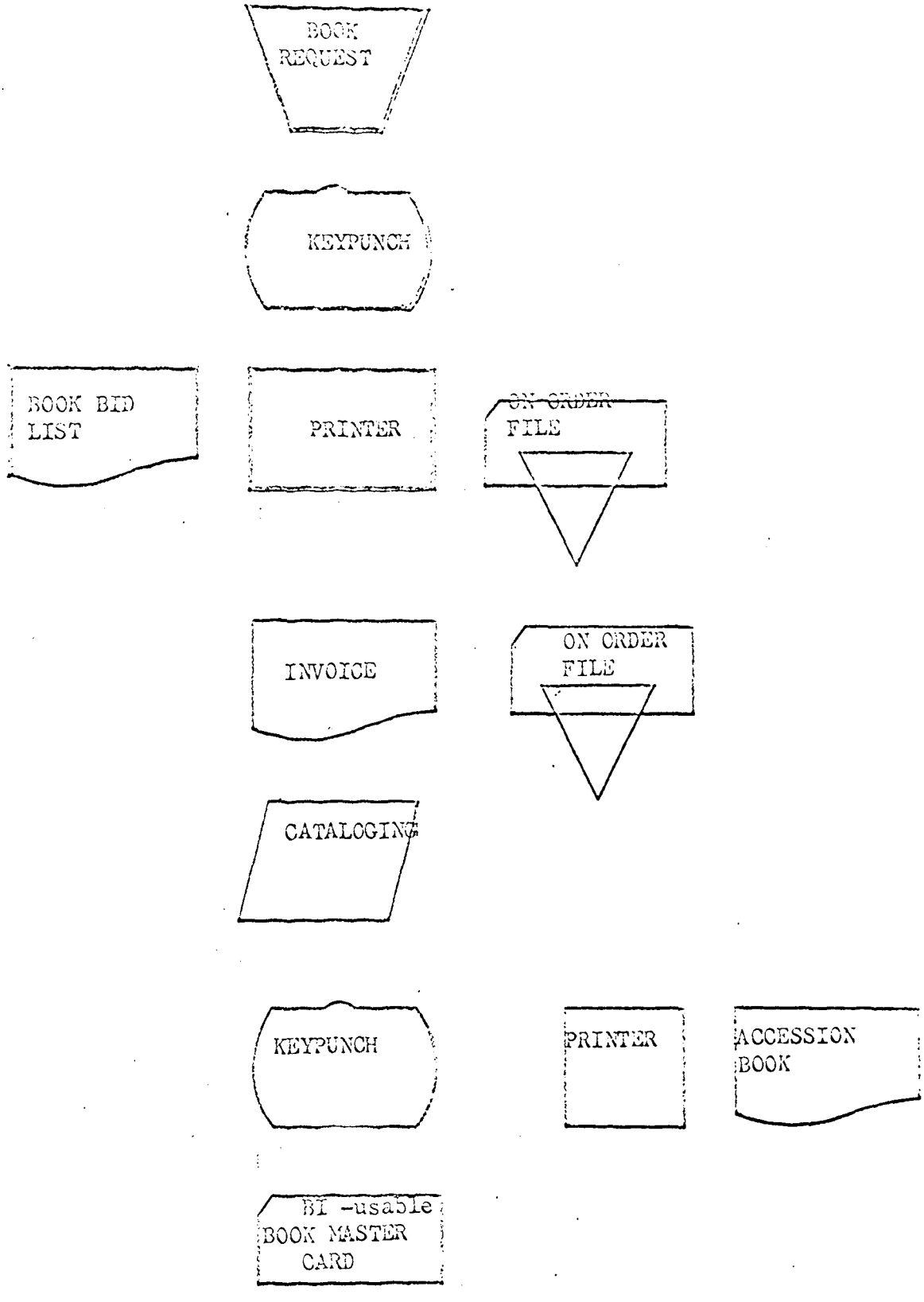


Figure 32. Acquisitions Flowchart

receipt of the books.

When the book is received, the acquisition card is removed from the "on order file," reproduced, and placed in the "in process file". The duplicate is placed in the book and sent to cataloging. When the book is received from cataloging, it will contain the Dewey number and the accession number handwritten on the duplicated acquisition card. The keypuncher will then punch the handwritten information into the card. This card will remain always with the book and is called the book master card. The book is now ready for circulation. Notification of the faculty member occurs at this time. This is accomplished by using the first copy which is in the possession of the order clerk.

The acquisition card can be used to provide a vendor analysis if needed. For example, by sorting the cards into groups based on vendor code, it is possible to determine the amount of business given to a vendor. By punching date ordered and date received it is possible to extract information on service or on items that need to be followed up. This is a very simple acquisition procedure and would be a straight, foward approach to tying in the acquisition and circulation function. The book master card punched as part of the acquisition function provides an entree into the circulation control function.

VI. BOOK CATALOG

The punched card prepared in the acquisition function contains all the necessary information to provide a simplified book catalog. The purpose of this catalog would be to eliminate the necessity for leaving a department to investigate the availability of a particular title or author in the library. This book catalog could be printed on multiple-part forms. (This would allow distribution of a book catalog to each department and to local agencies). The basic information, title and author, can be manipulated into practically any format the library staff desires. Figure 33 represents a sample page of a book catalog illustrating classification by author. Figure 34 is an example of a book catalog classification by title. The important point is that examples were prepared from the same punched card that would be made in the acquisition function. It is possible to prepare an abstract card for insertion in the book catalog. This can be accomplished by encoding additional information into a punched card. Periodically, new acquisitions would be hand filed into the catalog file and new catalogs produced.

The accession book is very similar to the book catalog entry and could be produced at no extra cost to the library. Again, this information has been generated from the initial cards prepared in the acquisition function. It will usually

AUTHOR	PUBL.	DEWEY #	TITLE
BOURNE,C.P.	SRART	519.7	INFOR.SYSTEMS WORKSHOP
COPI,I.M.	MACM	160.	INTRO TO LOGIC
DEAN,SASIENI,GUPTA	WILEY	658.01	MATH FOR MODERN MANAGEMENT
MORSE,P.M.	WILEY	519.	QUEUES,INVENTORY,MAINTAINENCE
FEINBERG,M.R.	P HAL	137.3	EFFECTIVE PSYCHOL.FOR MANAGERS
SHUBIK,M	WILEY	300.18	GAME THEORY,RELATED APROACHES

Figure 33. Book Catalog By Author

TITLE	AUTHOR	DEWEY #
EFFECTIVE PSYCHOL.FOR MANAGERS	FEINBERG,M.R.	137.3
GAME THEORY,RELATED APPOACHES	SHUBIK,M	300.18
INFOR.SYSTEMS WORKSHOP	BOURNE,C.P.	519.7
INTRO TO LOGIC	COPI,I.M.	160.
MATH FOR MODERN MANAGEMENT	DEAN,SASIENI,GUPTA	658.01
QUEUES,INVENTORY,MAINTAINENCE	MORSE,P.M.	519.

Figure 34. Book Catalog By Title

be necessary to batch together accession cards for printing pages at a time. By deleting, (not printing data encoded in the punched card), certain items of information, the accession list could be printed on a matte or stencil. The stencil could be run off to produce the "newly acquired books" list similar to the one produced now. This would prevent repetative typing since all the information was prepared at acquisition time. Figure 35 is an illustrative example of a few entries in an accession book.

TITLE/SUBJECT	AUTHOR/COST	PUBL.	DEWEY/CUTTER	ACCESSION
EFFECTIVE PSYCHOL.FOR MANAGERS	FEINBERG,M.R.	P HAL	137.3	116388
PSYCH,MANAGEMENT,HUMAN RELAT.	6.85		F327E	116388
GAME THEORY,RELATED APPROACHES	SHUBIK,M	WILEY	300.18	112316
SOCIAL BEHAVIOR, OPER RES	6.72		SH9 G	112316
INFOR.SYSTEMS WORKSHOP	BOURNE,C.P.	SPART	519.7	106691
SYSTEMS DESIGN	6.25		AM35I	
INTRO TO LOGIC	COPI,I.M.	MACM	160.	115933
LANG.REASON,PROBABILITY	6.02		C791I	
MATH FOR MODERN MANAGEMENT	DEAN,SASIENI,GUPTA	WILEY	658.01	106523
MGR SCI,OPER.RES,FINANCE	6.30		D344M	106523
QUEUES,INVENTORY,MAINTAINENCE	MORSE,P.M.	WILEY	519.	093728
OPER.RESEARCH,IND.ENGIN.	6.10		M8380	093728

Figure 35. Accession Book Entry

VII. DISCUSSION AND CONCLUSIONS

The combination of inventory control and punched card techniques applied to the University of Missouri Library has demonstrated and highlighted the need for a viable circulation control system. This is necessary to keep pace with increasing loads on personnel. Other universities have faced this problem and solved it using data collection. The implications of the inventory approach to circulation analysis are fourfold:

1. a conversion to an automated system at the University of Missouri at Rolla can be attempted with a basis for knowing what to expect in terms of load on a new system and in terms of load on the manual system,

2. the cost associated with converting to any desired load level can easily be calculated. In fact, once the load level is determined, the cost for providing that particular level of service will be the absolute minimum cost for keypunch conversion,

3. rough approximations can be made to determine the elapsed time necessary to achieve the next desired plateau or load level, and

4. simple comparisons can be employed to determine whether the additional cost of automating an incremental portion of the library is worth the extra portion that will be placed on the automated system.

The job of a manager is usually to engineer change of some sort. That manager must take all precautions to minimize the uncertainty of that change. Successful library management demands a method that will provide information concerning change. This method for knowing what to expect in a

conversion to automated circulation allows for a maximum amount of planning and budgeting for equipment, personnel and supplies. Using the inventory method, the library staff can run a parallel operation, (part on the automated, part on the manual). They then have an additional pulse to judge the effectiveness of the system and can proceed as rapidly or as cautiously as they see fit.

Cost levels are normally calculated in the same way that the cost for preparing book master cards was achieved in the experimental section. However, keypunching by its very nature is the most expensive part of the conversion. In the recommendation section a less costly method will be explained for initial conversion. However, book master cards for new acquisitions will always have to be keypunched.

The ability to calculate the approximate time involved in the process of increasing the service level to a higher level can readily be calculated from the sum of the results of equation (1) and equation (2). Utilizing the results of that calculation, the library could then estimate costs involved. Once the library staff knows the additional time involved, they can make pertinent decisions on student help, additional employees and so on, with the assurance that their decisions are based on a good foundation of information.

The last point allows the library to investigate the benefits of further automation. For example, if another

two percent of the volumes receive book master cards and the net increase in automated books is five percent, then the staff can say that the additional benefits are worth the effort. However, if that same percent only provides a one percent increase, then the effort may not be worthwhile.

The inventory approach to circulation control overall, is a fast, flexible method. It gives the library staff the prerogative of selecting levels for both the new system and the manual system and implementing the new system with a minimum cost.

The basic procedures outlined in this thesis include not only circulation control but the related activities. The implementation of the system described represents an overall scheme. The implementation of all or part is recognized as being equally acceptable. All of the areas mentioned should not be automated at one time. (This is uneconomical from a statistical point of view). The automation of the library at the University of Missouri at Rolla will provide distinct advantages over the present manual system. The inherent advantage of punched cards is that no information is manually punched into cards more than once. The information punched in the acquisition card can be machine duplicated or machine reproduced into other cards. This eliminates a major problem of the University of Missouri Library, multiple errors that occur in transcribing information. The elimination of these errors results

in savings of time, money and manpower. The preparation of the book bid list, the accession book and the author and the title catalogs indicate a substantial savings in duplication of efforts. The stencils that can be used on the printer can provide book bibliographies, reading lists, bulletins and other library information processing that can be distributed to library patrons. All the advantages offered in the related activities can be considered "free byproducts" of the circulation control effort.

VIII. RECOMMENDATIONS

Realizing that it is presumptuous of anybody but the library staff to decide on the various levels of service and loads that the circulation system is to carry, it is still necessary to specify the equipment and personnel required.

The author's recommendations are that the library take the four steps outlined next. (1) Implement a data collection capability immediately, consisting of two IBM 357's, one IBM 358, one 026 and two IBM 374's, (refer to DESIGN OF A SYSTEM section for description and features). (2) Decide on levels of conversion. After this is done, prepare to order an IBM 1232 for a week. Have the IBM representative instruct the clerical staff on how to mark the sheets, (sheets will be similar to Figure 36). This was mentioned previously as the alternative to keypunching. (3) Convert, using the present accession catalog, back to the year that will give the desired service level. (4) In considering the implementation of the data processing system (as opposed to the data collection system) every consideration should be given to the equipment already installed and being used for other functions at the computer center. If, however, a separate system is desirable, there is a wide availability of different systems and configurations put out by the various manufacturers.

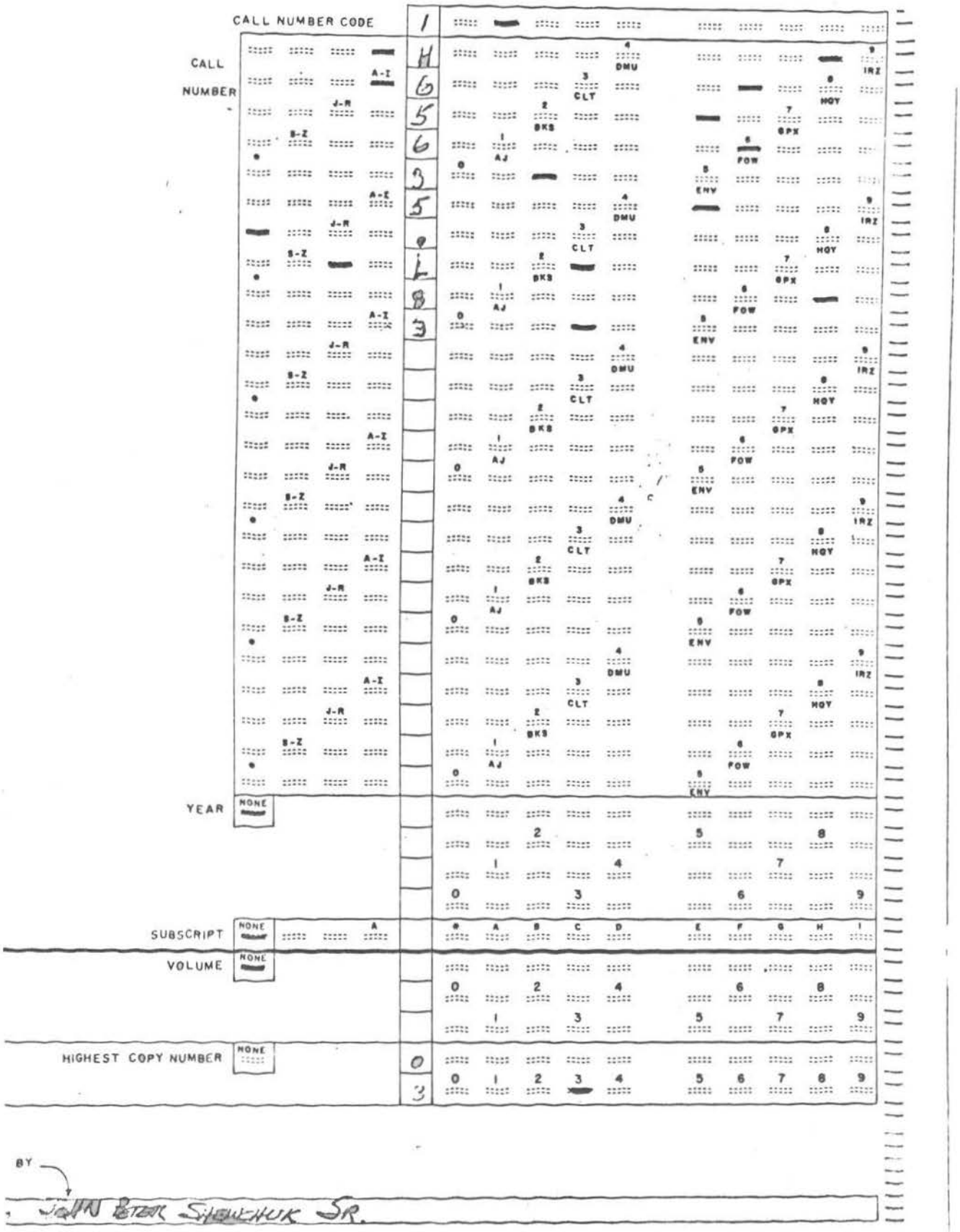


Figure 36. Sample Sheet for IBM

If these steps are executed, the library will have a basic automated system that will carry them well into the foreseeable future. Consult Figure 37 for an overall scheme of preinstallation planning.

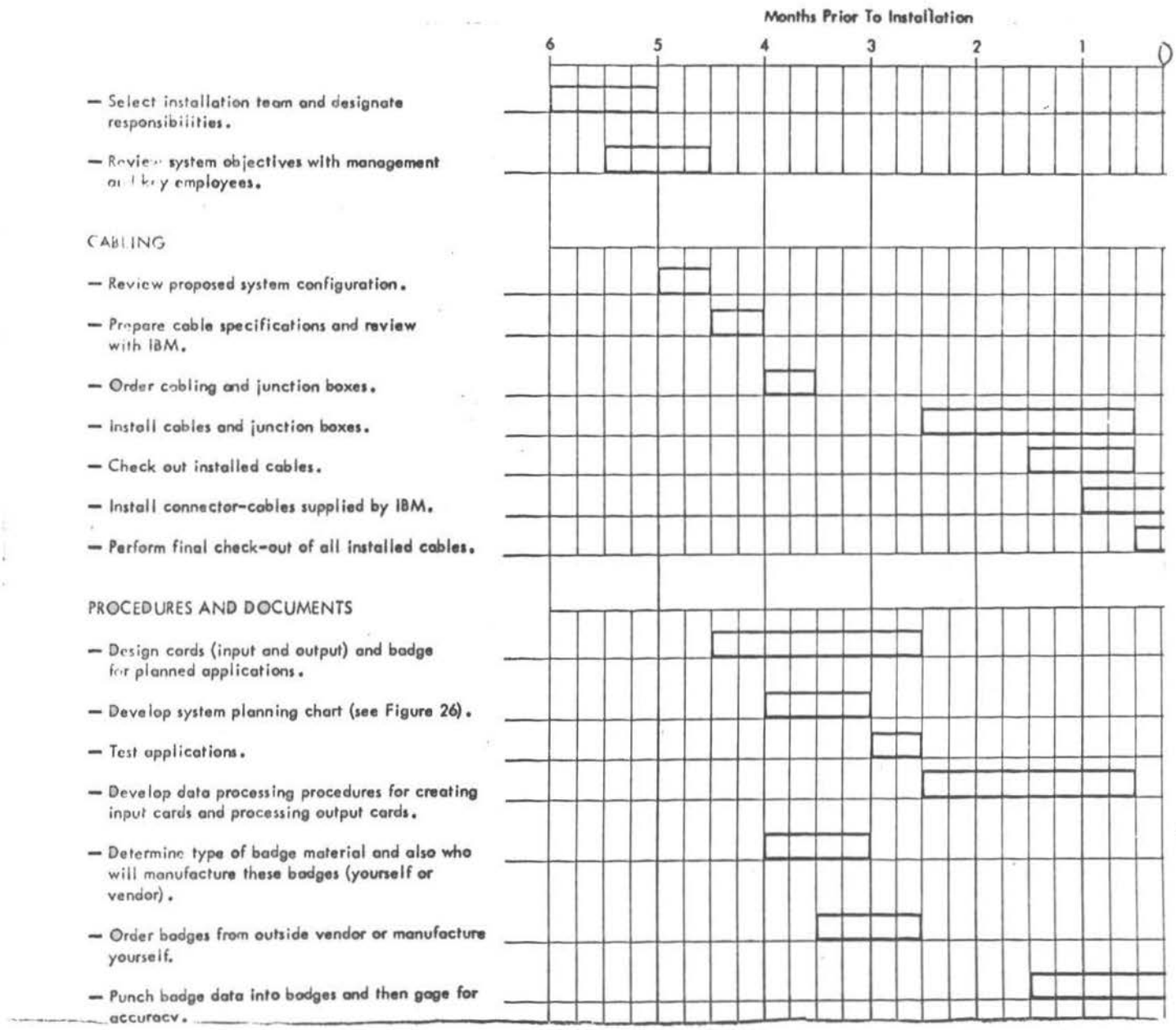


Figure 37. Preinstallation Planning Chart

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X. VITA

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