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DEVELOPMENT OF THE CARD-AUTOMATED REPRODUCTION AND DISTRIBUTION SYSTEM (CARDS) AT THE LIBRARY OF CONGRESS

Most of you probably think of the Library of Congress Card Division as a place from which you get a lot of cards–or from which you *do not* get a lot of cards. In a way, these are the two reasons why the Library is now engaged in a full-scale effort to automate the card division: there are a lot of cards involved, and a lot of other things–that is, to say, there is more than enough volume to make automation feasible and desirable–and not enough cards have been getting to libraries quickly enough.

Without actually seeing the day-by-day operations of the card division, it may be difficult for you to appreciate its complexity, but a few statistics will convey the key fact that the enterprise is a large one. It is large not only in terms of the number of cards involved (last year the division distributed over 110 million cards, or about a thousand cards every minute of every working day, and cards for almost five million separate titles are in stock) but also in terms of the number of orders received–about 50,000 every day. It is large in terms of the number of people involved–almost 500 people currently serve on the staff–and in the amount of space required for its activities–approximately an acre. It also has a large budget–over seven million dollars this fiscal year. Finally and most importantly, it is large in terms of its significance to the profession: over 25,000 libraries around the world depend on its services.

The division has been facing increasingly large problems as well, however. An acre of space is not as large as it sounds, and as the Library catalogs more and more titles each year, the card division must print and store more and more titles. This means that fewer and fewer copies of each title can be stocked, and therefore the persons filling card orders find more and more often that when they get to a drawer of cards to fill an order, the stock has been exhausted. This now happens 30 to 40 percent of the time, and each time it happens the order must be returned or held until more stock can be printed.

The division has also faced other problems: rising costs (in this case not only increased staff costs but increasing printing costs), and a chronic problem of recruiting and retaining adequate staff. Steadily rising demands for its services coupled with significant fluctuations in demand from day to day and from year to year have also contributed to the growing inefficiencies of a purely manual system.

For all of these reasons, the Library began some time ago to investigate the possibility of automating the card division's operations. Analysis indicated that it was particularly susceptible to automation, since most of the operations are repetitive and many of them are clerical. There were obvious areas where mechanization could be immediately effective: the arranging unit, for example, where sixty-one people manually arranged orders either in alphabetical order or in numerical order, and the billing unit, where thirty-seven people not only checked the work of the persons filling orders but manually prepared bills. What was not so obvious at first but which later became apparent was that the central problem lay in the stock itself, for as long as it was necessary to maintain a large inventory of catalog cards and fill orders manually from this stock, many of the most serious problems—space, staffing and the out-of-stock situation—would remain unsolved. If, on the other hand, we could eliminate the inventory and print card copies automatically, on demand, we could solve most of these problems and at the same time improve both the speed and efficiency of the division's services.

The project divided naturally into two parts, which (inevitably) came to be called Phase I and Phase II. Phase I included the things we could do immediately, primarily the necessary input operations of converting orders to machine-readable form, mechanization of the billing and accounting functions, and certain other data handling operations. Phase II encompassed the output operations, including the development of what we at first called "Machine X": a machine or system which would store in machine-readable form the information now printed on the cards in stock and produce printed cards from this information on demand, in response to particular orders. The interface between Phase I and Phase II would be a daily magnetic tape containing order information in machine-readable form, which would tell Phase II what cards to print, in what quantities, and where to send them. It was obvious that Phase II would require a large-scale development effort and protracted negotiations, and work on it was therefore begun at the same time as Phase I.

Since Phase I would be implemented first, however, it was desirable that it function as a stand-alone system as well as part of the eventual total system. This meant two general requirements for the Phase I system: it must economically, reliably and speedily convey incoming orders to machine-readable form for further processing, and it must provide paper-handling capabilities which would improve the manual system of filling orders while we were waiting for Phase II.

In addition to these general requirements, however, there were some unusual system constraints. In the first place, the orders we receive are unlike most business documents: they are roughly 3" x 5", and on paper rather than cards. The information is recorded in a multiplicity of typewriter fonts and, in a significant number of cases, in handprinting. More importantly, many libraries incorporate a card order slip as part of a multi-part form used to order books; this meant that unless we were to require libraries to change their acquisitions system in order to prepare two forms instead of one, the card orders would have to remain the same size and approximate thickness and be capable of incorporation into a multi-part form.

Secondly, many libraries either require or desire that the original order form be returned to them with the catalog cards themselves; some use a control number on the forms to match the cards with the books when the cards arrive, and others have a legal requirement for return of the order. It was also desirable that we be able to use the original order throughout the order-filling process, since it contains bibliographic information valuable in searching for the card stock number or in verifying the accuracy of the order-filling operation. If we could not use the original order document throughout, we would be faced with the prospect of converting most of this information to machine-readable form in order to reproduce it on a secondary stock ticket or order-pulling document, and we would still have to match the filled orders with the original order documents before mailing them to the customer. In short, we wanted to use an order form as much like the old one as possible, and use it throughout the order-filling process.

A great many systems were designed on paper, but most of the obvious ones were discarded because of these two constraints. Keypunching the order information (or keyboarding it on a paper-tape or magnetic-tape typewriter) and then generating a listing of what cards were to be sent to whom would have required keying too much of the bibliographic information, the high error rate involved would have required virtually complete verification, and at any rate there was little prospect (in the Washington labor market) of being able to hire enough keyboard operators to do the job. Fifty-one column punched cards with the customer number prepunched would be too difficult to incorporate into multi-part forms. Mark-sense documents require too much space to record too little data. Magnetic ink imprinted documents, such as bank checks, turned out to be too expensive to incorporate in multi-part forms, and so forth.

To make a long story shorter, it became increasingly apparent as the analysis proceeded that direct optical scanning techniques offered the most promising possibilities for meeting all of the requirements, and our investigation of such equipment was therefore intensified. All major manufacturers of optical character-recognition equipment were consulted, and several submitted proposals. Sample forms were printed and tested, and the National Bureau of Standards and the General Services Administration were asked to help. To shorten the story again, however, the Library and both of these other agencies agreed in the end that only one manufacturer combined the ability to read multiple typewriter fonts and hand-printing with the high-speed paper-handling capabilities needed for this application. This manufacturer was Recognition Equipment, Inc., of Dallas, Texas, otherwise known as REI.

With this much established, then, we began a detailed study of how a system built around REI equipment might function. The first step was to get more information about the orders themselves and the data conversion job involved. Specifically, we needed to know how many typewriter fonts libraries were using on order forms and in what proportion. A sample of over 540,000 order slips was drawn for the study, and with REI's help the typewriter used to produce each one was laboriously identified. The results are reproduced in Table I. Briefly stated, the study showed that handprinting and twenty-five commonly used typewriter fonts (listed in Table II) accounted for all but 1.8 percent of the sample. Handprinting appeared on almost half of the forms surveyed, but in most cases only the card number was printed, presumably by searchers in the ordering libraries after the rest of the information had been typed.

Detailed system design followed, and it was soon clear that a substantial increase in efficiency and some reduction in costs would result if REI could build us a system that would read these twenty-five fonts and handprinting, quickly, economically, and reliably; that would convert the basic information on the order slip to machine-readable form and use it to produce bills, monthly statements, accounting documents and other statistical and management reports; and that would arrange the order slips themselves, once read, into sequences that would improve the manual order-filling operation.

They could, and did. In May 1968, purchase orders for some twenty-two pieces of equipment were issued; in August 1968, the equipment was delivered; in September 1968, installation was completed; and on October 2, 1968, less than five months after the purchase orders were issued, the first actual catalog card orders were processed through the system.

The way the system works is illustrated in Figure 1. A new order form (Figure 2) places the information to be converted–the subscriber number, the type of handling desired, and the stock number of the card–in a single band at the top of the card. The subscriber number and the handling code are preprinted by the card division for customers using single-part forms, and by the forms supplier for customers using multi-part forms. The card stock number is typed by the library, or (alternatively) handprinted in specially-designed boxes at the bottom of the form. Other boxes on the bottom of the form provide space for card division staff to indicate special handling or billing procedures.

Order slips are placed in the feed of the OCR device as they arrive from subscribers, and an air-and-vacuum transport system starts them through the machine at a constant rate of 1,200 documents per minute. At this speed, they become a dim blur to the human eye, but the machine sees them and reads them in a fashion directly analogous to the eye. Light is bounced off the face of the order slip, and each character in turn is reflected, magnified and projected through a "light tunnel" onto an "electronic retina." The "retina" is composed of 576 tiny photo-cells which simulate the rods and cones of the human retina. A single wire projects from the back of each cell, like a nerve from a rod or cone cell in the eye, and light striking a cell generates a voltage along this wire proportional to the intensity of the light. These wires lead to a "recognition unit," just as nerves lead to the visual recognition centers of the brain. Note that up to this point the system is functioning as an analog computer, not a digital computer; in the recognition unit, however, the varying voltage patterns are analyzed, matched against hundreds of circuits representing "known" voltage patterns, a "decision" is made as to the identity of the character, and the digital code for that character is generated. Actually,

TABLE I

FONT ANALYSIS AND EXPECTED REJECT RATES

Based on a survey of over 500,000 order slips received during the four weeks beginning February 19, 1968

Category	No. of Slips	% of Total	Read (Estimated)		Reject (Estimated)	
			% of Category	% of Total	% of Category	% of Total
1. Typewritten (10- and 12-Pitch)	296,799	51.3	97.0	49.8	3.0	1.5
A. 12-Pitch (Elite)	(255,778)	(44.2)				
B. 10-Pitch (Pica and 1403 Line Printer)	(41,021)	(7.1)				
2. Handwritten	270,858	46.9	94.0	44.0	6.0	2.9
A. By Subscriber	(143,662)	(24.9)				
B. By Searchers	(127,196)	(22.0)				
3. Other (Script type, proportionately spaced type, etc.)	10,475	1.8	0.0	0.0	100.0	1.8
TOTAL	578,132	100.0		93.8		6.2

thousands of electronic analyses are made of each character before a final decision on its identity (or lack of it) is made.

The recognition unit contains about 150 circuits (or "masks," as they are called) representing the characters in its "vocabulary" of typewriter fonts, and almost 300 for hand-printed characters. In this system, only numerals are recognized, because letters occur only infrequently in our card stock numbers and it was desirable to use the available storage space to recognize as many fonts as possible; the equipment is capable of recognizing letters and other symbols, however, if "masks" for them are ordered as part of the "vocabulary." Only 150 masks are required for the ten digits in each of the twenty-five fonts (rather than 250) because the similarity of some digits in various fonts allows the system to recognize that digit in several different fonts with only one mask; many more circuits are required for handprinting, on the other hand, because of the variety of ways human beings make numerals.

The contract with REI requires the equipment to read the "defined" typewritten characters–that is, the ten digits in the twenty-five selected fonts–with a document reject rate of 3 percent or less. During the acceptance tests, however, it rejected (for lack of recognition) only a little more than 1 percent of the order slips, and in practice we find that the reader will interpret many other fonts besides those listed in Table II, including proportional spacing (the twenty-five listed, however, are still the most likely to be read reliably). We had also anticipated that one pass would have to be made for 12-pitch (elite) type and one for 10-pitch (pica) type, because of the different

TABLE II

TYPEWRITER FONTS

Which can be read by the REI Electronic Retina Computing Reader used in the Library of Congress Automated Catalog Card Distribution System

Elite (12 Pitch)	Pica (10 Pitch)
IBM Cloister Elite	IBM Large Pica
IBM Prestige Elite	IBM Prestige Pica
IBM Scribe	IBM Standard Manifold Pica
IBM Standard Elite	R.C. Allen Pica
R.C. Allen Elite	Remington Pica
Remington Elite	Royal Contemporary Pica
Remington New	Royal Standard Pica
Royal Canterbury	Royal Windsor Pica
Royal Contemporary	Smith Corona Standard Pica
Royal Oxford	Underwood Distinctive Pica
Royal Standard Elite	
Smith Corona Elite Modified	**Other**
Smith Corona Elite Regular	
Underwood Distinctive Elite	1403 Line Printer

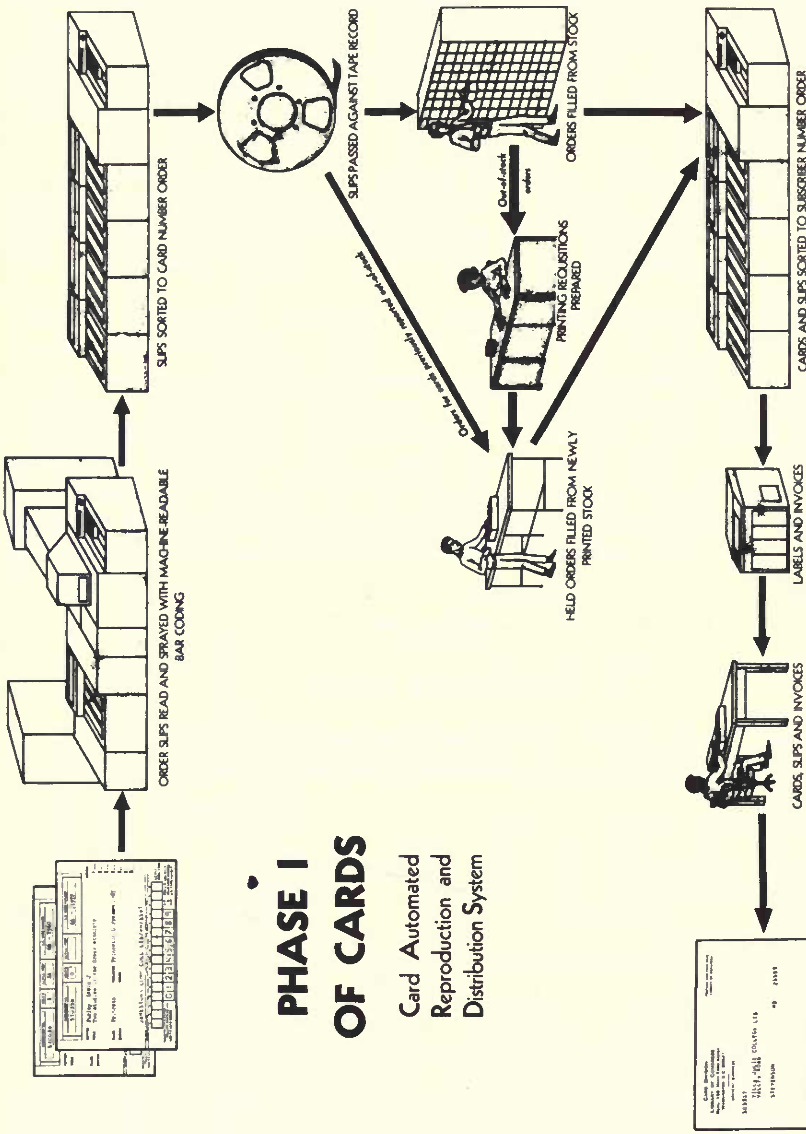


Figure 1 — Phase I of Cards: Card-Automated Reproduction and Distribution

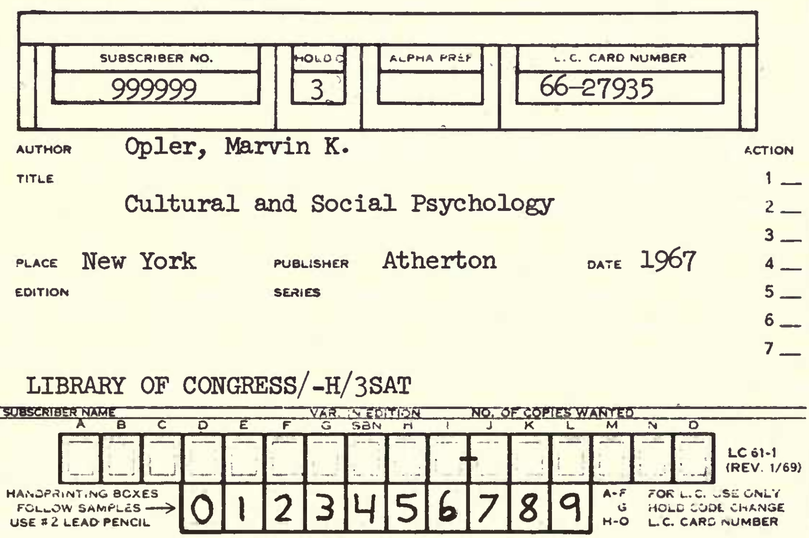
timing required to locate each successive character; in practice, however, we read both 12-pitch and 10-pitch characters in the same pass.

Once the recognition unit identifies a character, the information is converted from analog to digital form and transmitted to one of three small-scale computers and from there to a small but complex device called an ink-jet printer. This unit is installed on the document transport about half-way along the path traveled by each order slip and resembles a small hypodermic needle. It oscillates at about 48,000 oscillations per second, breaking up a stream of fluorescent red ink into tiny droplets, and spraying tiny bars on the back of each order slip as it passes by. The bars are printed in an octal code representing the information read from the front of the order slip, and will be used in the sorting process later on.

The computer also transmits the order information to an 1,100 line-per-minute drum printer, which prints out the information to initiate an audit trail (the same printer is used for pre-printing the subscriber numbers on the order slips).

Depending on what information is read or not read from the front of the order slips, they fall finally into one of several pockets. Those which have been read and sprayed are sent on to the sorters, as described below; those without a card number are sent to the searchers to have the number looked up (and handprinted in the boxes on the bottom of the slip); those which were rejected are passed through the reader a second and (if necessary) a third

Figure 2 – New Order Form Placing Information to be Converted at Top of Card



SUBSCRIBER NO. 999999 | HOLD C 3 | ALPHA PREF | L.C. CARD NUMBER 66-27935

AUTHOR Opler, Marvin K.

TITLE Cultural and Social Psychology

PLACE New York PUBLISHER Atherton DATE 1967

EDITION SERIES

ACTION 1 __ 2 __ 3 __ 4 __ 5 __ 6 __ 7 __

LIBRARY OF CONGRESS/-H/3SAT

SUBSCRIBER NAME VAR. IN EDITION NO. OF COPIES WANTED

A B C D E F G SBN H I J K L M N O

LC 61-1 (REV. 1/69)

HANDPRINTING BOXES FOLLOW SAMPLES → USE # 2 LEAD PENCIL 0 1 2 3 4 5 6 7 8 9

A-F FOR L.C. USE ONLY
G HOLD CODE CHANGE
H-O L.C. CARD NUMBER

time, and most of them are then read and sprayed; those which still cannot be read and those which contain other errors (strikeovers, incomplete erasures, or erroneous numbers on which the check digit arithmetic does not work) are sent to staff members who imprint the information on the back of the slip and return it to be read with the next batch.

Sooner or later, then, all slips are read and sprayed with fluorescent bar coding on the back. The slips are then placed in one of four large sorting machines, called bar-code reader-sorters. These devices have a transport system similar to the character reader, and thirteen pockets, just like an IBM punched-card sorter. The sorting logic is the same as an IBM sorter, the difference being that these machines read bar codes instead of punched holes. They also handle paper documents as well as cards, and can handle documents of intermixed sizes and thicknesses; like the character reader, they operate at a constant rate of 1,200 documents per minute.

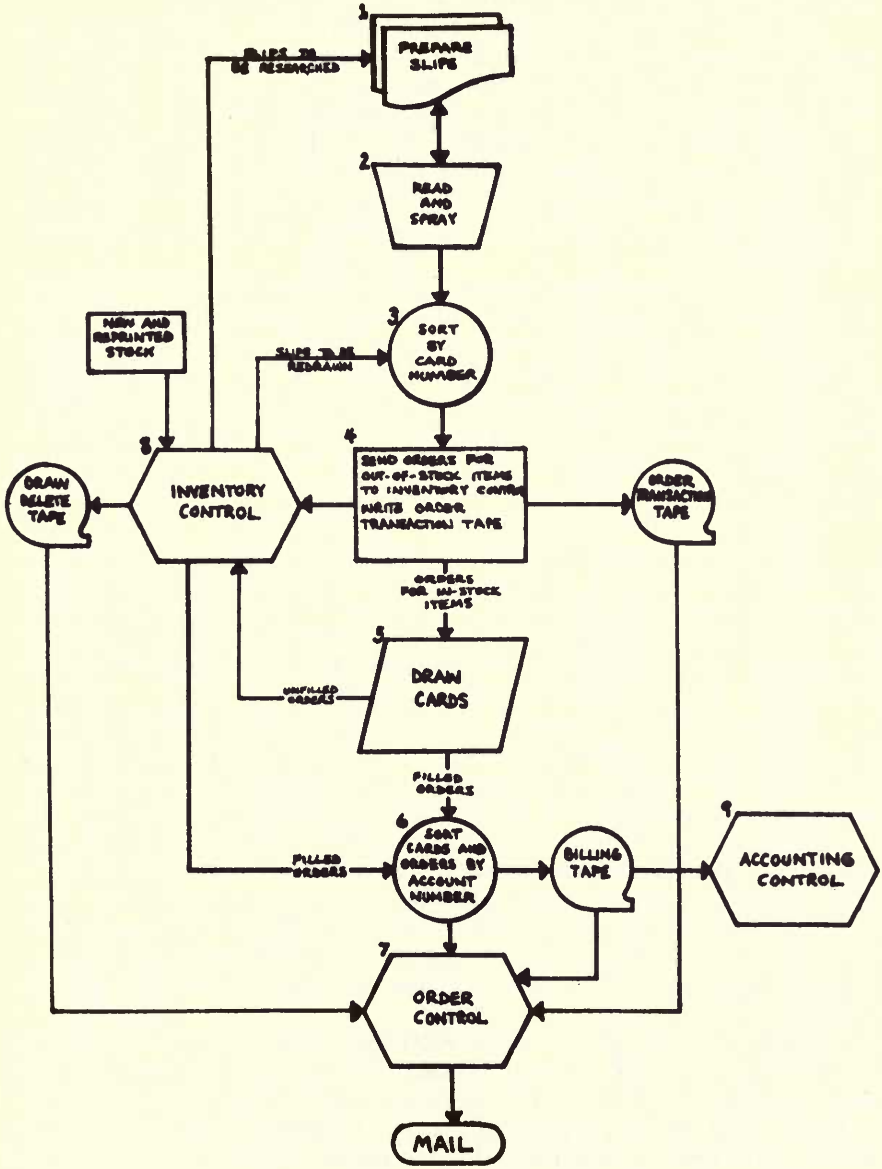
On these machines, the slips are first sorted into sequence by card stock number. The information from each order is then written on a daily transaction tape which is used for billing and accounting purposes and is also cumulated at weekly and monthly intervals for statistical and management information purposes (most importantly, the cumulative information on ordering activity indicates how much stock should be reprinted for particular titles, in order to reduce the out-of-stock rate). At the same time, the slips are compared with another magnetic tape listing of those card numbers known to be out of stock; orders for these cards are sorted out to be sent directly to the reprint unit and await the printing of new stock, thus bypassing the main order filling unit and effectively reducing the workload of that unit by about 25 or 30 percent.

The main purpose of sorting the slips into numerical sequence, however, is to improve the efficiency of order filling in another way. Now that all orders for the same title are together, they can be filled at the same time, and all orders to be filled from one drawer can be filled with one opening of the drawer; this technique alone has so far increased productivity in order filling by over 60 percent.

As the orders are filled, the order fillers place the required catalog cards behind each order slip. The intermixed order slips and catalog cards are then returned to the sorting machines and sorted into sequence by subscriber number, so that all of the slips and cards to be mailed to a particular subscriber are brought together, ready for mailing. Modification of the sorting equipment to enable it to handle intermixed order slips and cards was one of the main technical accomplishments of the project. Once the orders are thus arranged for mailing, address labels and invoices for each shipment are printed out on the line printer and the orders are wrapped and shipped.

A general flow chart of the Phase I system is reproduced as Figure 3. Each numbered block in this diagram summarizes a set of flow charts for major subsystems (or major manual operations), and some of these deserve further mention. Block 8 represents the inventory control subsystem, which includes not only passing the order slips against the magnetic tape listing of cards known to be out of stock, (as indicated in Block 4), but also procedures for adding new numbers to the out-of-stock tape (or deleting them, in the

Figure 3 – Flowchart of Phase I System



case of newly-printed stock), procedures for creating documents which initiate the reprinting cycle, and procedures which produce printed registers of titles in the reprinting cycle by card number and by subscriber number.

Block 7 indicates the order control subsystem, which provides an automatic means of insuring that all orders received at the beginning of the system are accounted for, and that subscribers are not billed erroneously. Block 9 represents the accounting control subsystem, which not only creates the invoices packed with each shipment but also produces the monthly statements and a variety of other necessary fiscal documents. Not shown on the chart but also important are other programs and procedures for producing statistical analyses and management reports which help control and regulate the entire operation.

This then is the Phase I system now in operation. So far it has enabled us to eliminate the manual billing operation, to mechanize much of our accounting work, to increase productivity in the key activity of order-filling by about 100 percent, to gain better inventory control, to obtain valuable statistical and analytical information not available before, and, most importantly, to reduce the time required to fill a regular order (provided cards are in stock) from three to four weeks to seven days. That is to say, orders received on the new order forms for which cards are in stock are now shipped within seven calendar days, rather than in three or four weeks as before.

You will notice that the improved performance results only if cards are in stock; if cards are out of stock, a delay still results because of the time required to print more stock. The Phase I system helps control the process, but the real solution to this problem lies in eliminating the process altogether by printing cards only on demand, automatically, from a machine-readable store. This is the function of Phase II, as indicated earlier.

Because of the development effort required in Phase II, a Request for Proposals (RFP) was issued in October 1967 to over 100 firms; the specifications in the RFP called for a system capable of storing the information on six million catalog cards, retrieving this information on demand for up to 100,000 orders per day, and reproducing up to 600,000 cards per day to fill these orders. The specifications also called for reproduction in type fonts similar to those presently used on cards, including non-Roman alphabets and other characters now used to print cards in some 125 languages, and they required reproduction on paper of archival quality, at close tolerances, and with a minimum resolution of 4.5 line pairs per millimeter (about 254 lines per inch).

Eight proposals were received in January 1968, and were extensively analyzed by a Technical Proposal Evaluation Group. In March 1968, cost bids were requested on three of the proposed systems, and after evaluating the technical merits of the competing proposals as compared with their cost, the Library determined in May 1968, that the system proposed by RCA was the most advantageous. In April 1969, the Library received formal permission from the Joint Committee on Printing to proceed with acquisition of the system, and we hope to have it operating early next year.

Figure 4 illustrates the way in which the total system will operate once Phase II is implemented; Phase I, as it will function in the total system rather

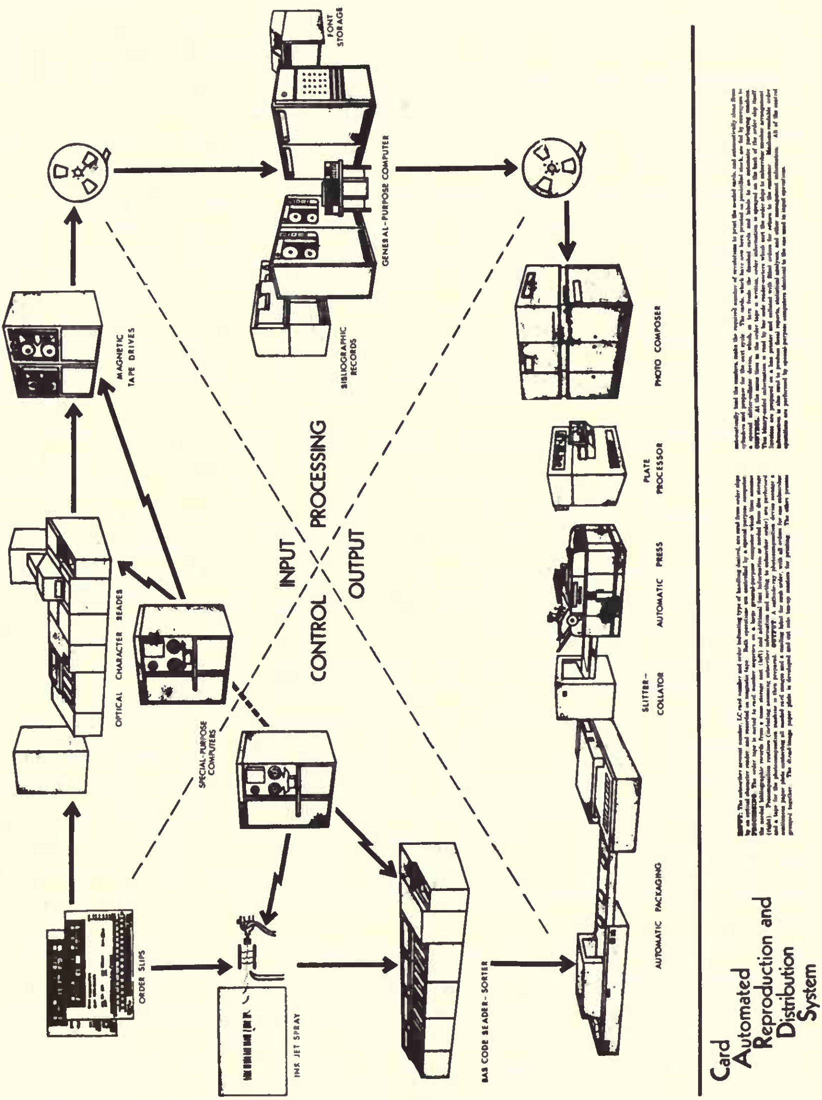


Figure 4 – Operation of Total System

than as a stand-alone system, is represented in the top and leftmost segments of the diagram, and Phase II is in the right and bottom segments. Some sorting of the actual order slips will still be necessary to arrange them by subscriber number for return to the individual subscribers, but sorting the slips by card number and sorting the catalog cards will no longer be necessary. Instead, the magnetic tape containing the order information in machine-readable form will be read by a Spectra 70/45 computer, which will then retrieve from mass storage units the digitized catalog records needed to fill that day's orders. The computer will then obtain from magnetic disk storage the digitized images of each character needed for these particular cards, and assemble the records with the digitized images of each needed character on another magnetic tape. This magnetic tape will in turn be read by one of two RCA Videocomp Model 830 photocomposition machines, each of which contains its own computer and memory as well as a cathode ray tube imaging device and a sophisticated optical system. The Videocomps will compose continuous photographic masters (see Figure 5) each containing ten card images, in appearance almost identical to the cards now printed by letter-press and more conventional methods; composition will be done at several thousand characters per second, and at a very high resolution (450 lines per inch).

From this point, the succeeding steps take place in assembly-line fashion. The masters are developed by a continuous plate processor, cut into individual ten-up masters, and dropped into the feed trays of automatic offset presses. These presses automatically load the masters in turn, revolve the number of times required to produce the correct number of copies of particular cards, automatically eject each master, go through a cleaning cycle, and then load the next master. In the meantime, the printed sheets of cards travel to another station on the line (see Figure 6), where they are cut by rotary knives into separate cards, and then stacked, with each customer's order in a separate stack and an address card on top. The cards then pass through a shrink-wrap packaging station, which wraps each order with a thick polyethylene film, seals the package, and then drops it into the mail bag. You will see by this description and the chart that with full implementation we will have achieved the goal of automating the entire process, from the receipt of the order in the incoming mail to the shipment of the order in the outgoing mail.

As I indicated earlier, the initial implementation of this part of the system will be completed some time in 1970. Full implementation will require conversion of the catalog cards now in stock to machine-readable form, but the data base available from the MARC project will enable us to make fairly full utilization of the initial system, since the MARC records are for current English-language materials and it is these cards which are most in demand. Those orders which cannot be handled by the Phase II system will be handled by the Phase I system described above, but as the conversion effort proceeds (perhaps in conjunction with other conversion efforts) the volume processed through the full system will rise rapidly, even though it may be several years before all orders are handled in this way.

Figure 5 – Photographic Masters of Card Image

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[1968]
can Revolution)
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during the late Ameri-
67–29033
MARC

Mesa Lago, Carmelo.
The labor sector and Socialist distribution in Cuba. New York, Published for the Hoover Institution on War, Revolution, and Peace by Praeger [1968]

xix, 250 p. illus. 24 cm. (Praeger special studies in international economics and development)
Hoover Institution publications, 71.

Bibliography: p. 239-250.

1. Wages and labor productivity—Cuba. 2. Socialist competition. 3. Cuba—Economic policy. I. Stanford University. Hoover Institution on War, Revolution, and Peace. II. Title.

HD4945.M43 338.97291 67–29436

Library of Congress MARC

nent function, by
nd Management,
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d in 1963 as Research
itle: Job enlargement,
y. Center for Labor
67–64542
MARC

Leading men in American transportation. New York, Transport Publishers Corp. [c1967]

164 p. 29 cm.

1. Transportation—U.S.—Biography. I. Transport Publishers Corporation.

HE151.5.A2L4 380.5'0922 68–4217

Library of Congress MARC

Edited with an
Wagnalls [1968,
3-138)—Walt Whit-
a Ward Howe.—Mr.
stion.—Coatesville.—
68–4225
MARC

Junior yachting: the program and the student. New York, Yachting Pub. Corp., 1968.

110 p. illus. 23 cm.

"The editors of Yachting magazine have compiled this book from articles which have appeared on its pages."
Bibliography: p. 109-110.

1. Yachts and yachting—Addresses, essays, lectures. I. Yachting.

GV813.J84 797.1'24 68–4465

Library of Congress MARC

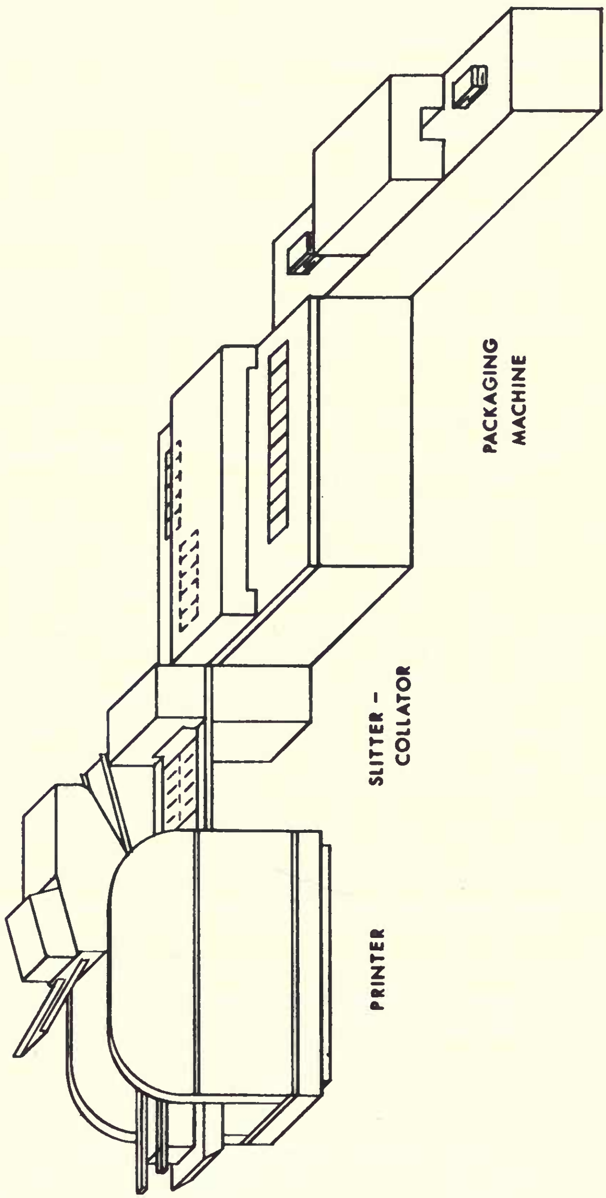

Figure 6 – Library Card Packaging System

When Phase II has been implemented, the space required to maintain large stocks of printed cards will be eliminated, the time required to fill orders will be reduced still further (particularly for those which now enter the reprinting cycle), and hopefully the cost of the cards will be reduced. At that time, in short, we will be much closer to our goal of providing the best catalog card service possible to meet the needs and demands of the nation's libraries.