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Report to the Congress; by Elmer B. Staats, Comptroller General.

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The preparation of data for processing by computers--data entry--has been dominated by the keypunch and the punched card for years. Better methods now exist, and both large and small Government computer installations can benefit from adopting them. Findings/Conclusions: The keypunching method of data entry is costly, error prone, and time consuming. The three basic procedures of advanced data entry are key entry, automatic reading, and source data sensing. Changed data entry techniques, with or without changed equipment, may achieve many benefits. Careful analysis and selection of proper devices, techniques, and procedures can save money through increases in productivity with better devices, faster data entry into the computer, and fewer errors in the data entered. The failure of agencies to be consistent in the way they select data entry devices and their reluctance to evaluate the cost and effectiveness of selections made and methods installed result from a lack of guidelines for selecting advanced data entry methods. The Secretary of Commerce is authorized to provide technical advisory services to agencies and to undertake necessary research in automatic data processing systems. The Administrator of the General Services Administration is responsible for coordinating and providing for the effective acquistion and management of Federal automatic data processing equipment. Recommendations: The Secretary of Commerce should direct the National Bureau of Standards to develop and issue guidelines on selecting and evaluating advanced data entry systems. Federal agency and department heads should require internal auditors to review changes in data entry techniques both before and after they are made. (Author/SC)

7028

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

New Ways Of Preparing Data For Computers Could Save Money And Time And Reduce Errors

Preparing data for processing by computers--data entry--has been dominated by the keypunch and the punched card for years. Better methods now exist, and both large and small Government computer installations can benefit from adopting them.

These benefits can include cost savings, increased productivity, better accuracy, and time saved. GAO found that agencies seldom make data entry studies either to determine potential or to determine results after buying new equipment.

The National Bureau of Standards should develop guidelines for agencies' data entry studies, agency heads should require such studies, and agencies' internal auditors should review data entry studies and procurements.

FGMSD-78-39
JULY 18, 1978

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-115369

To the President of the Senate and the
Speaker of the House of Representatives

This report discusses modern methods of preparing data for computers, the potential of these methods for improving Federal automatic data processing, and the need for guidelines for their selection and evaluation.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We have not included official agency comments because we received them informally. However, pertinent oral comments of agency officials were recognized in the report.

We are sending copies of this report to the Director, Office of Management and Budget; the Secretary of Commerce; the Administrator of General Services; and the heads of all other Federal agencies and departments.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

NEW WAYS OF PREPARING DATA FOR COMPUTERS COULD SAVE MONEY AND TIME AND REDUCE ERRORS

D I G E S T

Advanced data entry methods could reduce labor, errors, and the time involved in preparing data for processing by Government computers. These new methods could save millions of dollars. (See pp. 26 to 28.) On the other hand, the keypunching method that has dominated data entry for years is costly, error prone, and time consuming.

The three basic procedures of advanced data entry are key entry, automatic reading, and source data sensing. (See ch. 2.)

Changed data entry techniques, with or without changed equipment, may achieve many benefits. Careful analysis and selection of proper devices, techniques, and procedures can save money through increases in productivity with better devices, faster data entry into the computer, and fewer errors in the data entered. (See pp. 23 to 28.)

A representative of the largest supplier of punchcard equipment told GAO that the company no longer manufactures the equipment new. Advances in data entry methods were undoubtedly a factor in this decision. However, he believes that his firm will continue maintaining equipment in the foreseeable future. Also, General Services Administration representatives told GAO that

--several other sources exist for both equipment and maintenance and

--the General Services Administration has an active program to provide supply and maintenance for equipment discontinued or about to be discontinued.

Since General Services Administration representatives recently told GAO that they now have such a program, this report contains no further recommendations to it. We suggest that the General Services Administration maintain a strong program concerning obsolete automatic data processing equipment.

According to the statistics GAO gathered, the Federal Government may be behind the private sector in using newer devices. The agencies GAO contacted were not consistent in the way they selected data entry devices; they were reluctant to evaluate the cost and effectiveness of selections made and methods installed. GAO attributes this situation to a lack of guidelines for selecting advanced data entry methods. Such guidelines could contribute to better device selection, which could yield greater efficiency and lower costs.

Under the Brooks Act, Public Law 89-306, the Secretary of Commerce is authorized to provide technical advisory services to agencies and to undertake necessary research in automatic data processing systems. The Administrator of the General Services Administration is authorized and directed to coordinate and provide for the effective acquisition and management of Federal automatic data processing equipment.

RECOMMENDATIONS

GAO recommends that

--the Secretary of Commerce direct the National Bureau of Standards to develop and issue guidelines on selecting and evaluating advanced data entry systems and

--Federal agency and department heads require internal auditors to review changes in data entry techniques both before and after they are made.

Contents

ABBREVIATIONS

ADP	automatic data processing
GAO	General Accounting Office
GSA	General Services Administration
MICR	magnetic ink character reader
NBS	National Bureau of Standards
OCR	optical character reader
OMR	optical mark reader

CHAPTER 1

INTRODUCTION

Data entry, the preparation of data for computer processing, is critically important because computer processing results are only as accurate as the data processed. In a recent report 1/ we identified data problems as one of two major causes of incorrect actions--such as overpayments--by Federal computer applications. To get data into a form that the computer can read, the data generally must be (1) recorded at its sources, (2) converted to machine-readable form, (3) verified and validated for errors, (4) reformatted or otherwise edited, and (5) transferred to intermediate computer-readable storage, such as magnetic tape or disk. Traditional keypunch methods require that steps 2 and 3 above be performed by two persons, each keying essentially, if not all, the same data. The machine-readable form (medium) is the punched card.

Data entry operators may type either application data, such as hours worked from employee timecards, or computer program statements.

Besides equipment and site preparation, the cost factors of data entry involve not only labor but also error rate. Errors in both keying data to be processed and keying computer program statements can be very costly to clients of automated systems. Perhaps the worst errors of the latter type are those which, though errors, produce a program that runs on the computer but does not act as intended. Such unintended actions may cause a disaster before being detected.

Advanced data entry methods (see ch. 2) offer ways to (1) eliminate part of the keying, (2) reduce the operations required to convert source data 2/ to computer-readable form, (3) verify data more accurately, and (4) reformat or otherwise edit data during entry rather than during processing steps. The product of advanced data entry methods is

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1/"Improvements Needed in Managing Automated Decisionmaking by Computers Throughout the Federal Government," (FGMSD-76-5), Apr. 23, 1976.

2/Source data are data in the form in which the user ("the public") generates them, such as timecards, cash register receipts, and bills of lading.

normally tape, disk, or direct input to computers. Advanced data entry methods can reduce labor and the number of processing steps required and produce savings. Examples are detailed in chapter 2. (See app. I for comparison of possible processing steps of punchcard and advanced data entry keying methods.)

Today, almost all agency functions are influenced by automatic data processing (ADP). As more functions are performed wholly or partly by computers, converting human-readable information to machine-usable data becomes more important. The data must be complete, accurate, and available when and where needed. The real success of an ADP organization is measured by (1) user satisfaction with the services it renders and (2) whether those services, including data entry, are supplied at reasonable cost.

COSTS OF DATA ENTRY

We have estimated that the Federal Government is spending over $10 billion annually on ADP and related areas. This amount includes costs of system design, equipment, acquisition, software development, installation, operation, and data entry. Data entry costs are frequently estimated to account for between 30 and 50 percent of total ADP costs, depending on the nature of the specific application. (See exhibit 1.)

For example, data entry costs in a payroll system would encompass (1) the process of getting timecards to employees, (2) entering and approving hours worked, (3) returning timecards to a central point, (4) keying this information into a computer-readable medium (for example, punchcards, paper tape, or magnetic tape), (5) verifying the keyed information, (6) developing control totals (for comparison with computer-generated totals), and (7) verifying that all necessary information is included in proper formats (by applying edit/limit/range checks). 1/ The input data is then ready to be read into a computer for processing by the payroll application program.

1/An example of an edit check is checking to see that alphabetic characters are not entered where numbers are supposed to be. An example of a limit check is checking to see that a number is not over a certain maximum value. An example of a range check is checking to see that a number falls in a range, i.e., above a minimum and below a maximum. All three checks can be automated with edit programs--computer programs which scan data for, and report on, errors.

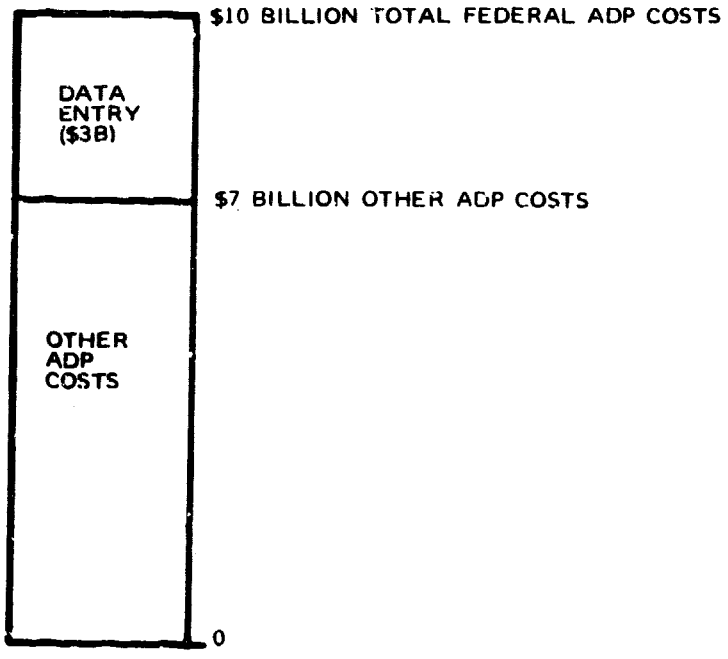


EXHIBIT 1 MAGNITUDE OF FEDERAL DATA ENTRY COSTS

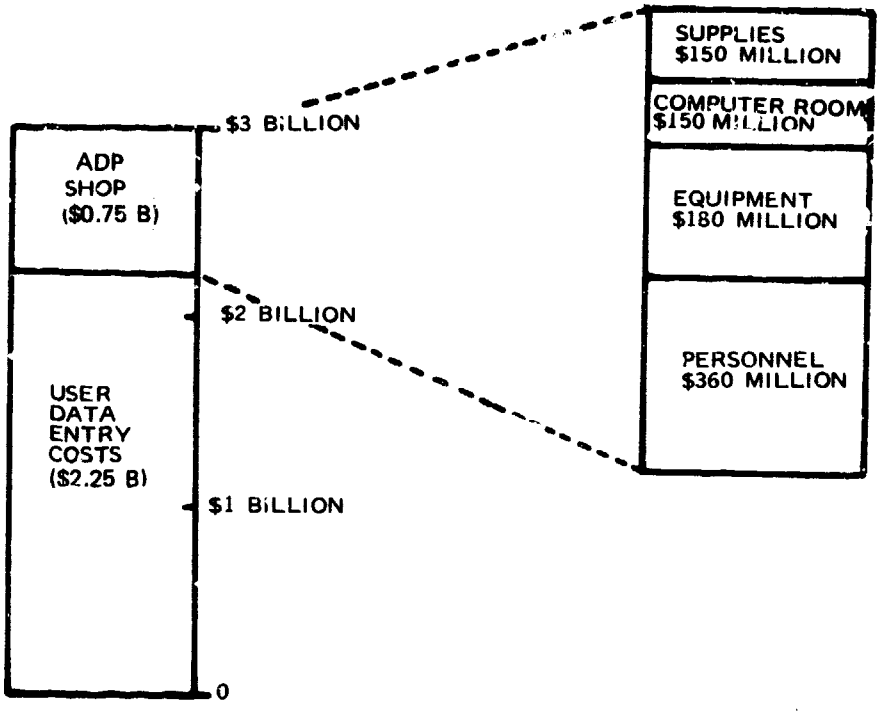


EXHIBIT 2 FEDERAL DATA ENTRY COSTS SUBDIVIDED ACCORDING TO A VENDOR'S ESTIMATE OF COMPONENTS' PERCENTAGES

Payroll is a relatively straightforward example; others may be considerably more complex. The point is that many costly and time-consuming functions must be done before a computer can process data. If incorrect data does enter the computer, strange results occur. For example, an aircraft cleaner (private sector employee) was paid, for a short while, $365 per hour rather than $365 per month due to an incorrect pay rate entered into the computer. This error was not caught until the paychecks were cashed.

Data entry costs can be divided between those incurred by the user and those incurred by the data processing installation. In the payroll system example cited above, user costs of normal data entry are those incurred before keying the data into cards, such as steps 1 through 3 above, while data processing installation costs encompass keying and subsequent steps, such as 4 through 7 above. Exhibit 2 shows one vendor's estimate of the relative sizes of the data entry tasks.

SCOPE

The purposes of this review were to (1) assemble information on advanced data entry processes and related costs, (2) report trends and benefits of advanced data entry, and (3) discuss ways to select, use, and evaluate such methods. During this review, we contacted manufacturers of data entry equipment and users, as well as data processing installations which had changed data entry techniques. The manufacturers were selected from those with home offices in Boston, New York, San Francisco, and Washington, D.C.; the users we contacted were generally in the same areas. In all, we conducted reviews at 25 installations.

CHAPTER 2

ADVANCED DATA ENTRY TECHNIQUES AND THEIR IMPACTS

We estimate the current annual Federal costs for data entry to be at least $3 billion per year. Based on the cases we reviewed, we believe that the Federal Government could save millions of dollars annually by using advanced data entry methods. (Our reasons for this belief are discussed on pp. 26 to 28.)

TRENDS IN DATA ENTRY

Many data entry devices and techniques are now available; data entry methodologies have become numerous. Data entry techniques can be classified in many ways but there are three basic categories, shown below with examples.

Entry categories	Devices
Keying	Key punch (note a) Verifier (note a) Key to paper tape (note a) Buffered card processor (note b) Key to magnetic tape Key to disk (disc) Key to diskette Key to cassette
Automatic reader	Optical character reader (OCR) Optical mark reader (OMR) Bar code reader Magnetic ink character reader (MICR) Magnetic stripe reader
Source data sensing	Scales Counting Voice recognition

a/Traditional keying devices--the others listed are advanced.

b/Also called "buffered keypunch." This device holds keystrokes for a single card in a small magnetic storage or "holding area" until the entire card is keyed. The operator can backspace and correct errors before allowing the card to be actually punched.

Some devices could fit easily into more than one of the three categories. For example, some optical character readers are equipped with a keyboard and visual screen for quick manual correction of data the machine cannot read. Also, some devices read more than one medium. For example, some optical character readers also read marks. In these cases, we classified the device in what we consider to be its primary category.

KEY ENTRY DEVICES

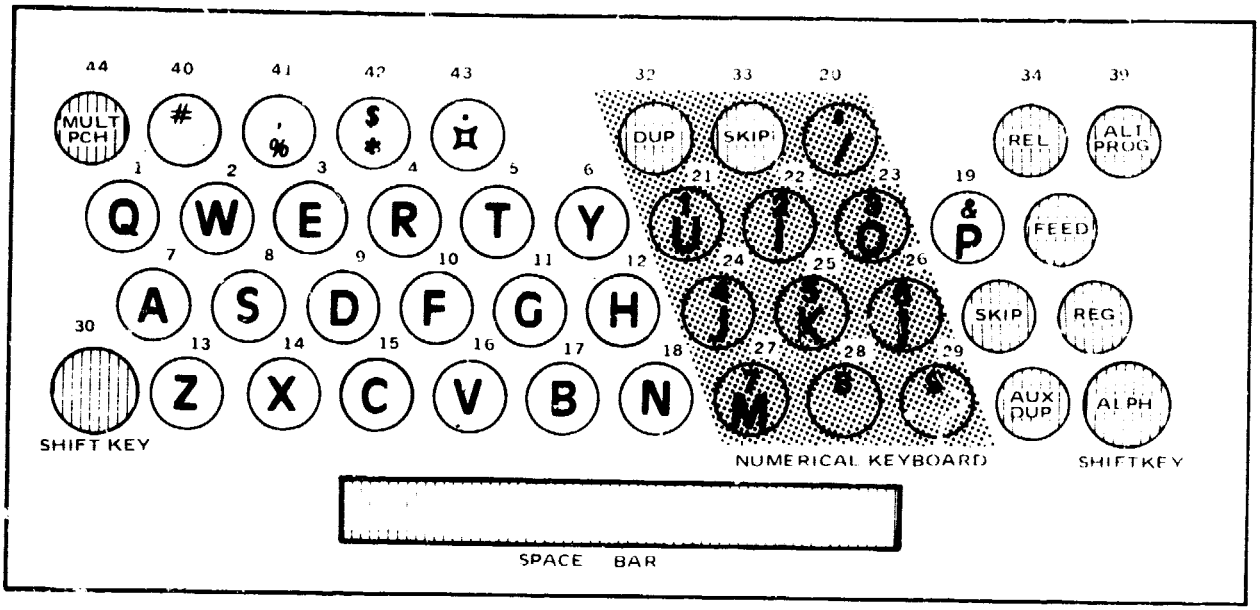
All of these devices have typewriter-like keyboards (see exhibit 3), but differ in the storage medium used. The older keypunch belongs to this group, but advanced techniques differ in the (1) increased speed and accuracy possible at entry time, (2) ease of error correction, and (3) elimination of verification by rekeying.

Older data entry devices and techniques

Keypunch: Data is read from a document--called a key entry document--by the keypunch operator. The operator types the data, which is recorded as punched holes in a pasteboard card. The card is limited to storing a fixed number of characters--normally 80--and is easily damaged (making it unsuitable for computer input) or lost. A keypunch normally requires a companion machine--a verifier. (See exhibit 4.)

Verifier: With a verifier, a second operator keys the same cards over from the key entry document. The verifier compares what this operator is keying to what is already on the cards (the first operator's work.) The verifier signals its operator when the two disagree.

Advanced data entry methods use the traditional keypunch only when the cards are used as turnaround documents. For example, an employee's timecard could be prepared by a computer system with the employee's name, location, and number already punched in the card and sent to the employee's work station. This individual would write on the card the number of hours worked by project and return it to the ADP installation. The installation would punch the project



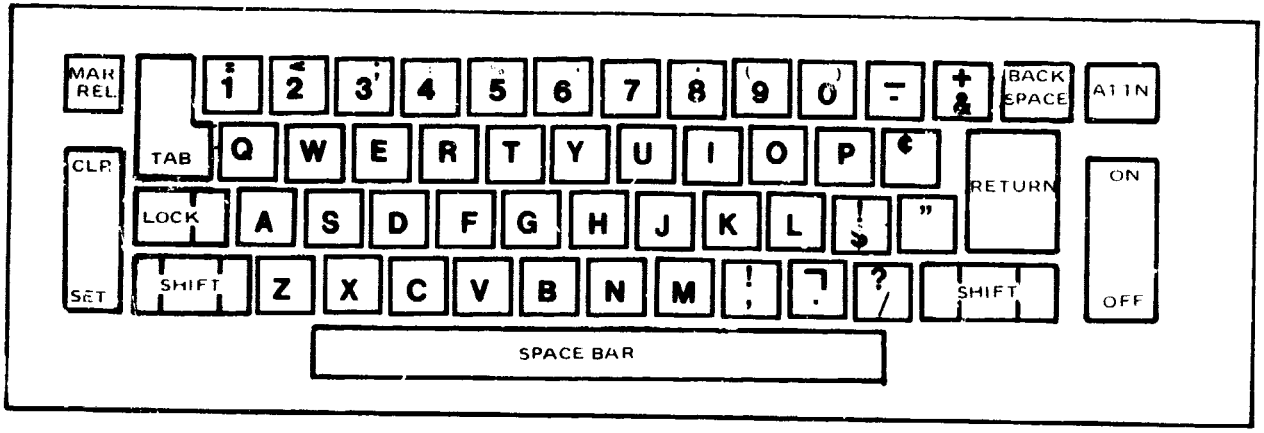


EXHIBIT 3 REPRESENTATIVE DATA ENTRY KEYBOARDS

KEY ENTRY DOCUMENT
(CODING FORM)

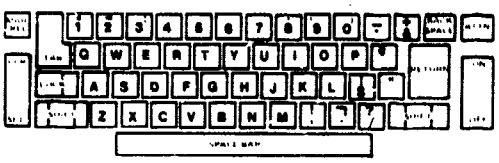
DOE	JOHN	40	333333333
DOE	MARY	40	222222222

SOURCE DOCUMENTS
(TIME CARDS)

DOE MARY 40HRS SSN 222-22-2222

DOE JOHN 40HRS SSN333-33-3333

KEYPUNCH
(MANUAL KEYING)



DOE MARY 40 222222222

DOE JOHN 40 333333333

CARDS

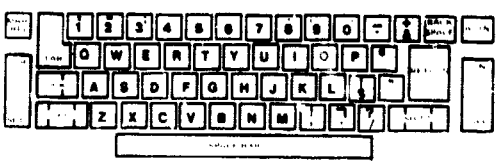
JOHN DOE
$320.00

USERS' OUTPUT
(PAY CHECKS)

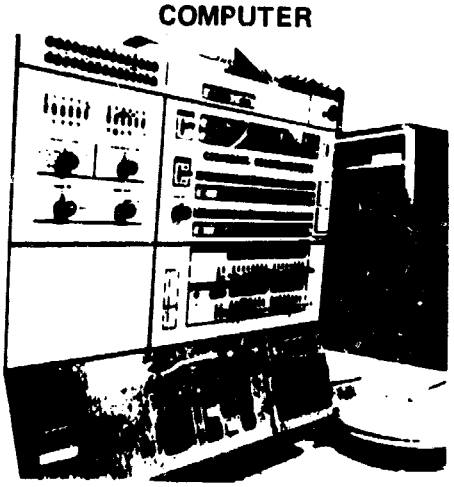
MARY DOE
$320.00

VERIFIER

(MANUAL KEYING AGAIN)



COMPUTER



DOE MARY 40 222222222

DOE JOHN 40 333333333

VERIFIED CARDS

EXHIBIT 4 A SCHEMATIC OF THE TRADITIONAL DATA ENTRY PROCESS WITH PUNCHED CARDS

number(s) and hours on the card and then use the completed card to compute pay and project status reports. Savings are produced and errors are reduced because the employee's name, number, and location need not be manually punched and verified. The card is called a "turnaround document" because it is returned for further processing.

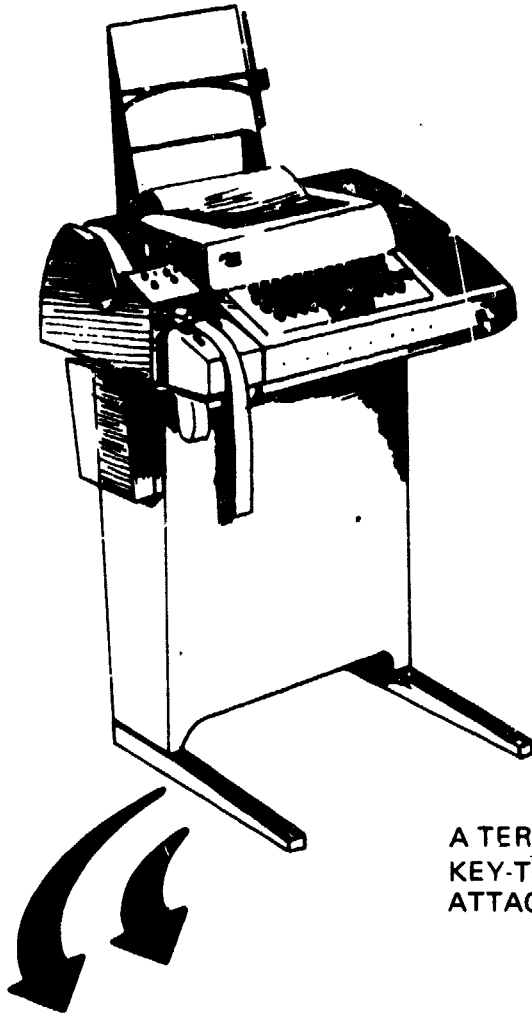
Traditional card data entry equipment is still quite common in the Government. (The General Services Administration (GSA) reported over 18,000 traditional, unbuffered keypunches in 1976.)

Key to paper tape: This device stores data as punched holes in reels of paper tape. Unlike the card, a roll of paper tape does not have a limit of 80 characters. Paper tape can be punched far from the computer site and the data transmitted via communications lines to another paper tape machine at the computer site. A special reader is needed to convert data on paper tape to computer-compatible magnetic media, such as magnetic tape, or to enter it directly into the computer. (See exhibit 5.)

All of the above card and paper tape devices are similar in that they require slow mechanical movement. Also, such media (cards and paper tape) may not be erased and reused for other data. Once punched, the medium may be reused only if the same data must be reread.

Newer key entry devices and techniques

Buffered card processor: (buffered keypunch) This device punches cards but differs from the traditional keypunch in three ways.
1. The same device may be modified (at some cost) so that it may be used both as a key punch and key verifier.



A TERMINAL WITH
KEY-TO-TAPE
ATTACHMENT

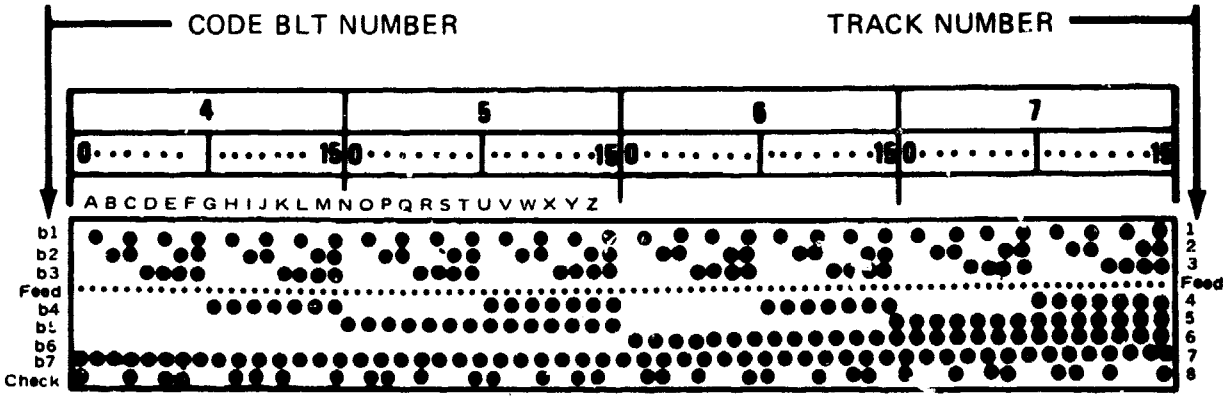


EXHIBIT 5 DATA ENTRY WITH PUNCHED PAPER TAPE

2. As the data is keyed, it is stored in an area called a buffer until the desired positions (80 maximum) are keyed. The card is then punched. Any errors sensed by the operator during keying can be corrected before the card is actually punched.

3. Keying is faster because it need not wait for the mechanical punching of each column of the card before the next column is keyed. (See exhibit 6.)

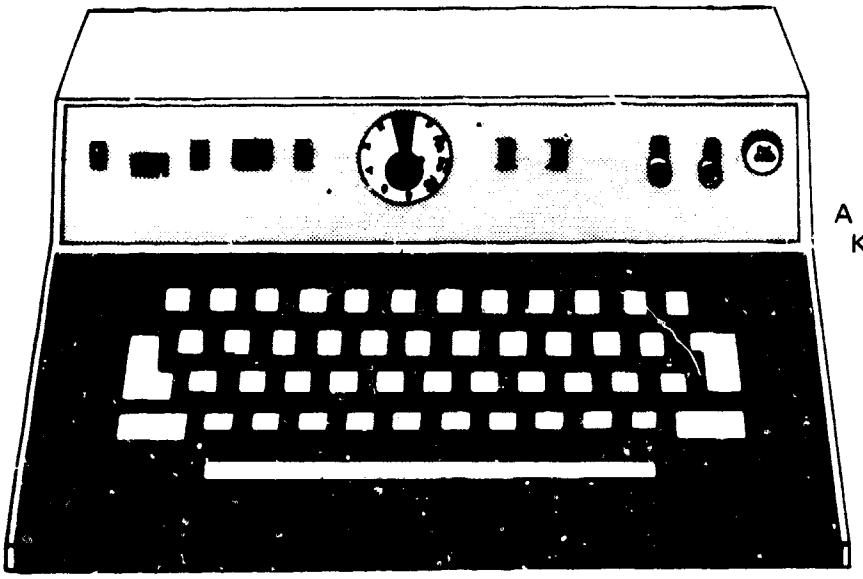
Key to (magnetic) tape: This device stores data as magnetized spots on 1/2-inch-wide plastic tape with a special coating (similar to audio tapes). (See exhibit 7.)

Key to disk: This device stores data as magnetized spots on a round recordlike rigid platter. (See exhibit 8.)

Key to diskette: This device stores data as magnetized spots on a flexible recordlike platter. The platter is called a flexible disk, or "floppy." (See exhibit 9.)

Key to cassette: This device stores data as magnetized spots on a cassette (similar to audio cassettes). (See exhibit 10.)

All of the newer devices are primarily electronic and are considered 20 to 50 percent faster than mechanical key entry devices in the typical use environment. Other benefits of the newer devices vary from manufacturer to manufacturer as well as from device to device, depending on the software (computer programs) that can be written for, or comes with, the equipment. Such software can include programs with various functions including (1) automating some



A BUFFERED KEYPUNCH

LAYOUT OF PUNCHED CARD

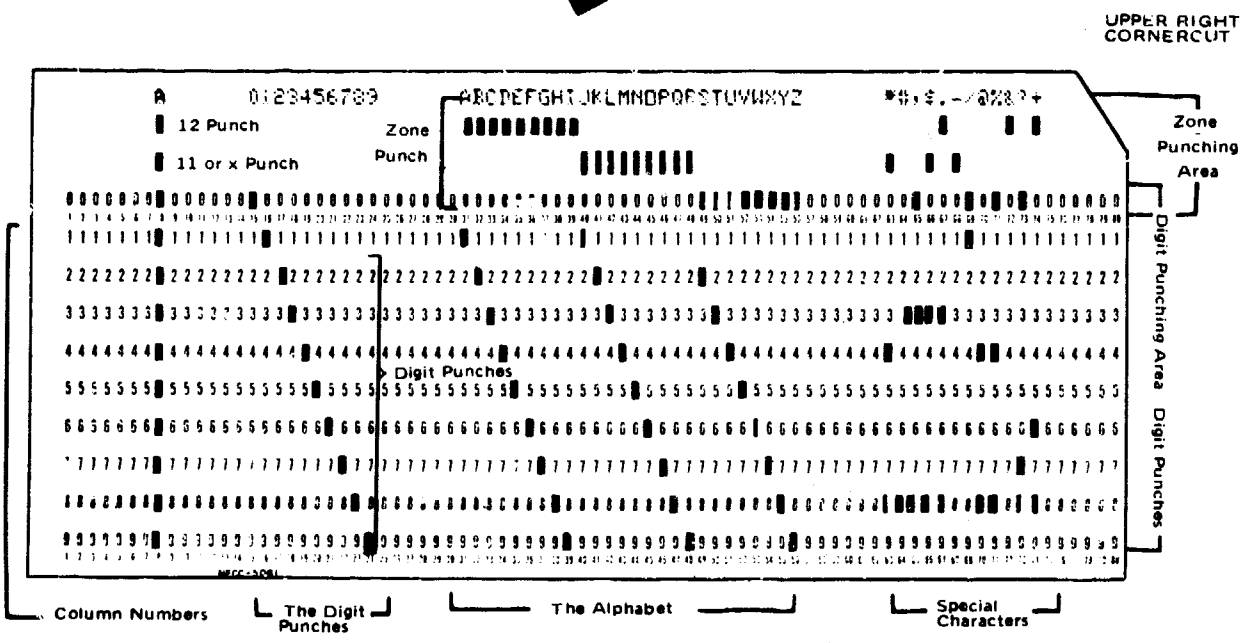
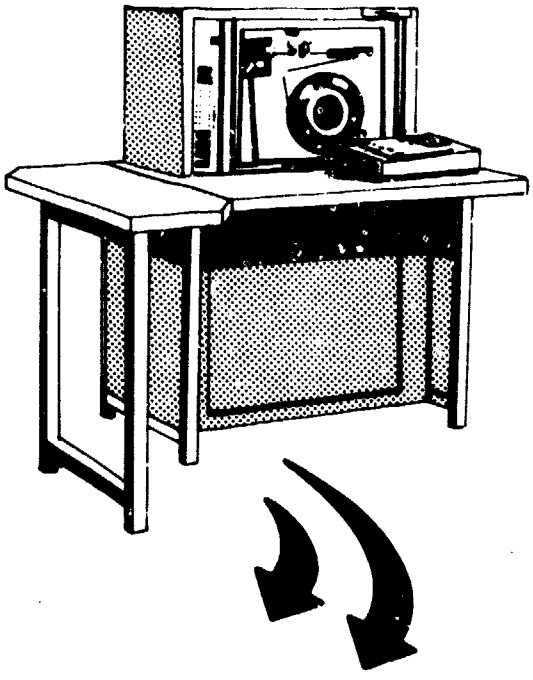
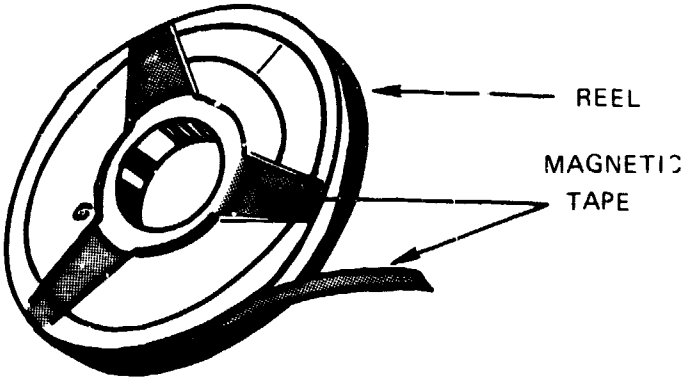
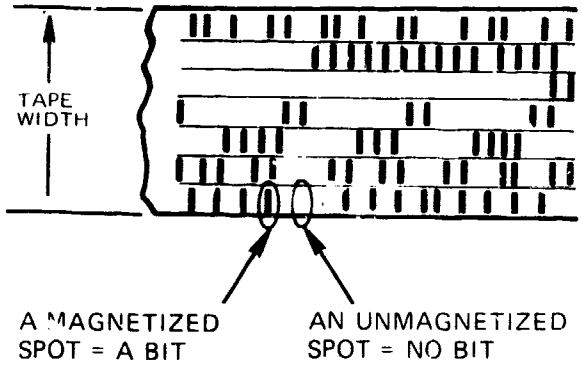


EXHIBIT 6 ADVANCED DATA ENTRY WITH A BUFFERED KEYPUNCH



A KEY-TO-TAPE
WORK STATION





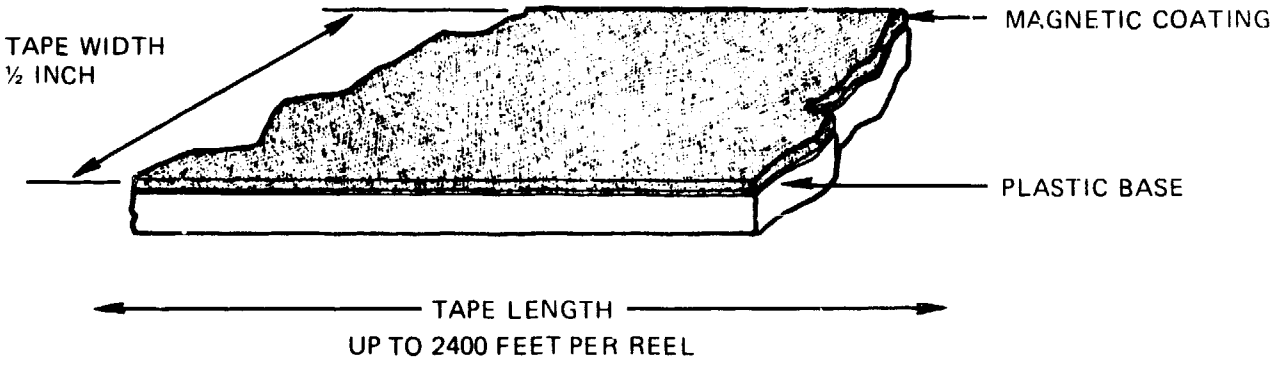
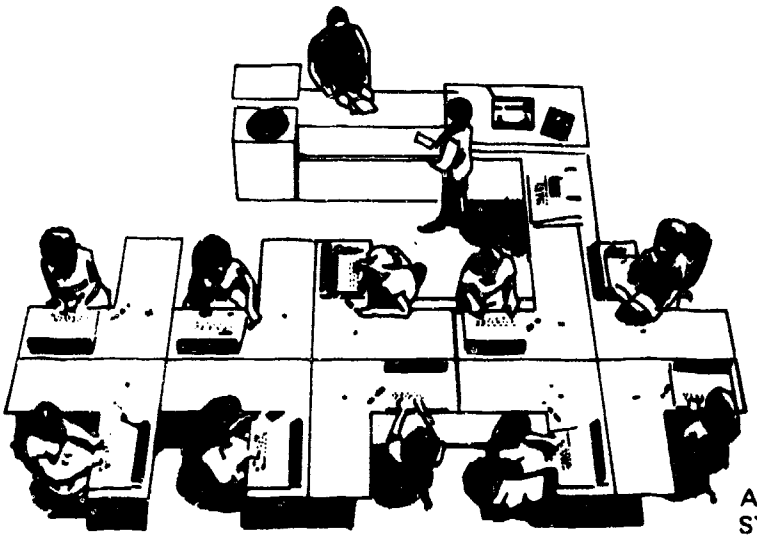
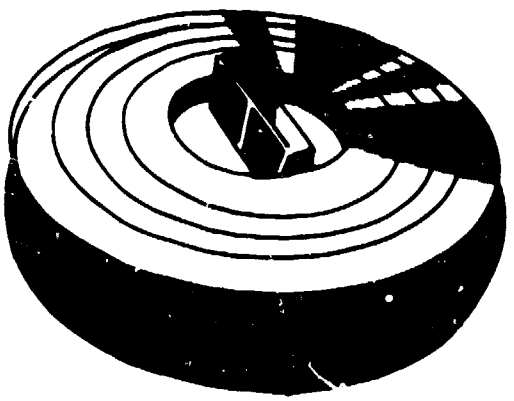


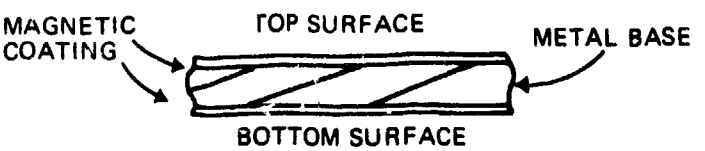
EXHIBIT 7 ADVANCED DATA ENTRY WITH KEY-TO-TAPE



A TYPICAL KEY-TO-DISK SYSTEM WITH TEN OPERATOR WORK STATIONS AND A SUPERVISORY STATION (TOP).

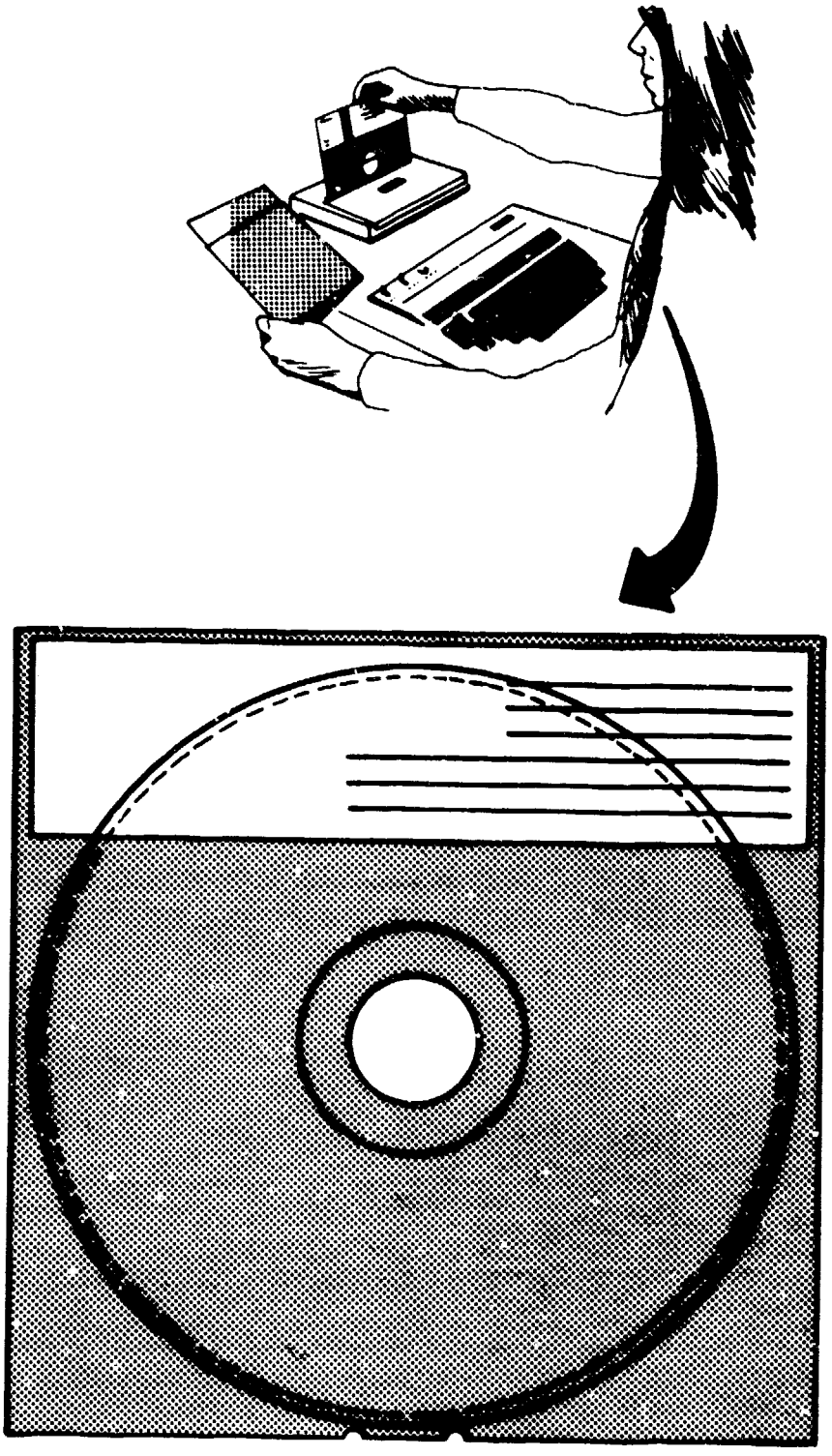


DISK PACK (REMOVABLE)



CROSS SECTION OF A DISK ELEMENT

EXHIBIT 8 ADVANCED DATA ENTRY WITH KEY-TO-DISK



THE DISKETTE ("FLOPPY DISK") IN PROTECTIVE COVER

EXHIBIT 9 ADVANCED DATA ENTRY WITH A KEY-TO-DISKETTE SYSTEM

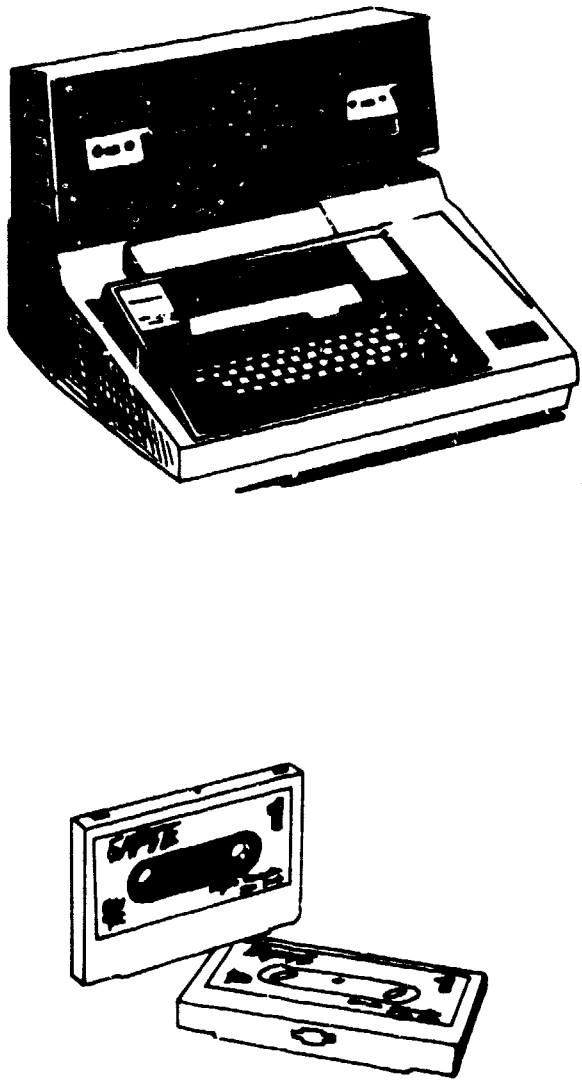


EXHIBIT 10 ADVANCED DATA ENTRY WITH A KEY-TO-CASSETTE SYSTEM

of the keying, such as storing tables of values (such as pay rates), so that they need not be keyed, (2) rearranging data from the way it is shown on the source document to the format needed for the processing program, (3) providing flexible record length, which can vary from 125 to 4,096 characters on magnetic media, (4) checking data entered for accuracy or for consistency with other data, (5) storing helpful messages to the operators, such as what data is to be entered next, (6) keeping operator and job statistical records, such as amount and rate of production, and (7) balancing to control totals.

All key entry devices are labor intensive. Thus, a 20- to 50-percent increase in productivity can greatly reduce salary and overhead costs. The salary alone is typically about $8,200 per year per operator. (See p. 28.)

AUTOMATIC READING OF CHARACTERS AND CODES

With this method, the data may be manually typed or machine generated. These devices read one or more of the following:

--Typewriter characters (usually stylized, such as optical character recognition--A font (OCR-A)). (See app. II.) This allows ordinary typewriters to serve as data entry devices.

--Imprinted characters, such as gasoline or other credit slips.

--Preprinted characters, such as bank transit and customer account numbers. (See app. II.)

--Codes, such as bar codes now being used to identify and price grocery items.

--Pencil marks, such as the marks made on the answer sheet of a test.

--Handprinting.

Some examples follow:

OCR:	A device that uses light to recognize typewritten, imprinted, preprinted, or handwritten characters and marks.

	Data is either sent to a computer or stored on computer-processable media. (See exhibit 11.)
OMR or optical mark sensing:	A device that uses light to recognize pencil marks on paper or cards. Data is normally stored on computer-processable media. (See exhibit 12.)
Bar code reader:	A device that uses light and recognizes bar codes such as those on grocery items. It normally sends the data to a computer either directly or through a communications device. The bar codes may be typed on the labels with a special typeball.
MICR:	A device that recognizes magnetized characters, such as those on checks and deposit slips, and normally sends the results to a computer. (See exhibit 13.)
Magnetic stripe reader:	A device that recognizes coded data on a strip of magnetic recording tape affixed to one side of a plastic card, such as the cards used to withdraw funds from a bank account. The information is normally sent to a computer.

These devices often record data without any manual intervention, but, in some cases, a limited amount of keying--for example, of the amount of cash deposited or withdrawn--is needed to complete the transaction. Usually these devices are less labor intensive at entry time than any of the primarily key entry devices. Many of the readers themselves can enter data at speeds of 600 to 4,000 characters per second compared to normal key entry speeds of less than 6 characters per second. Given equal accuracy of transcription, substantial savings in data entry costs are

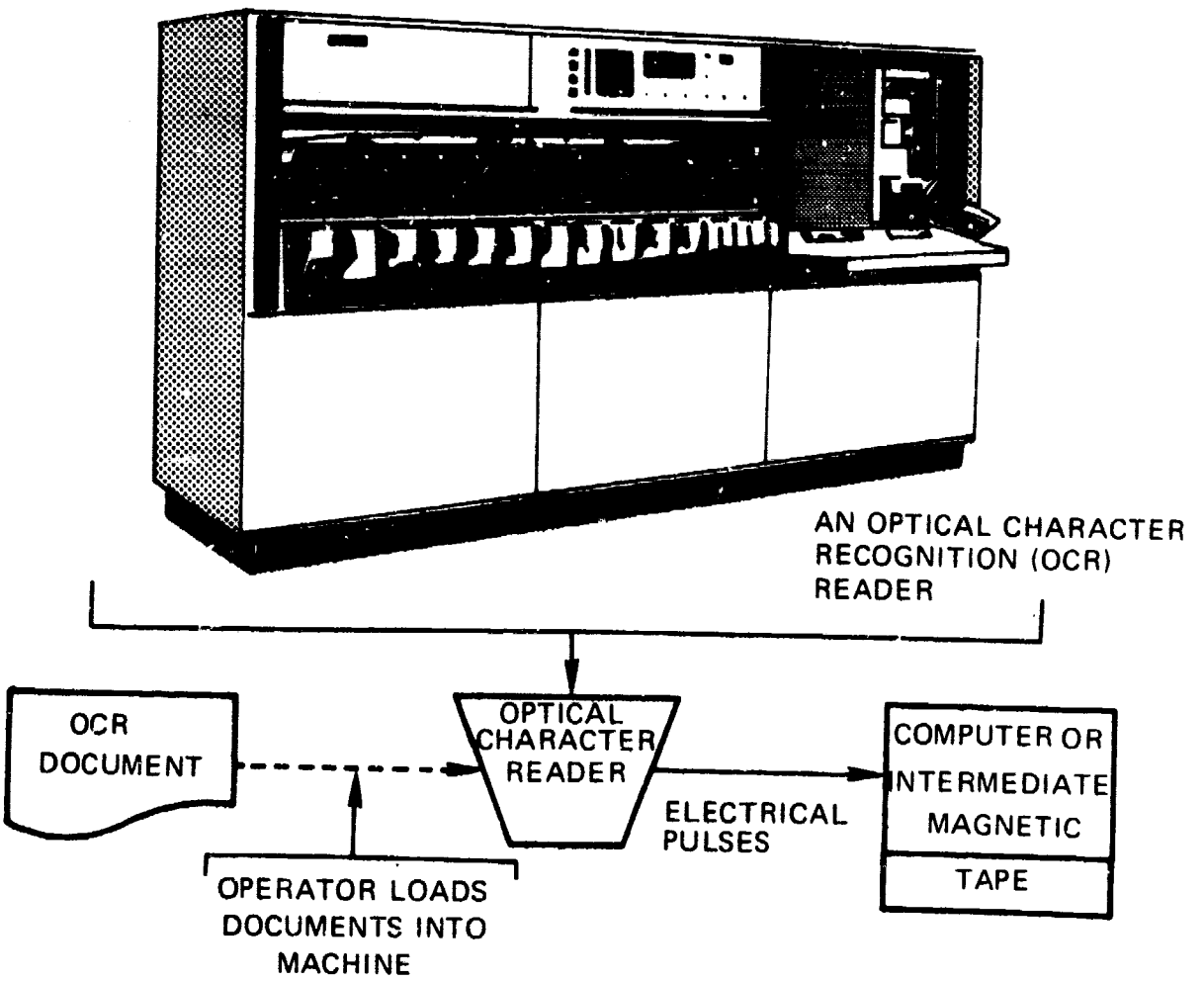
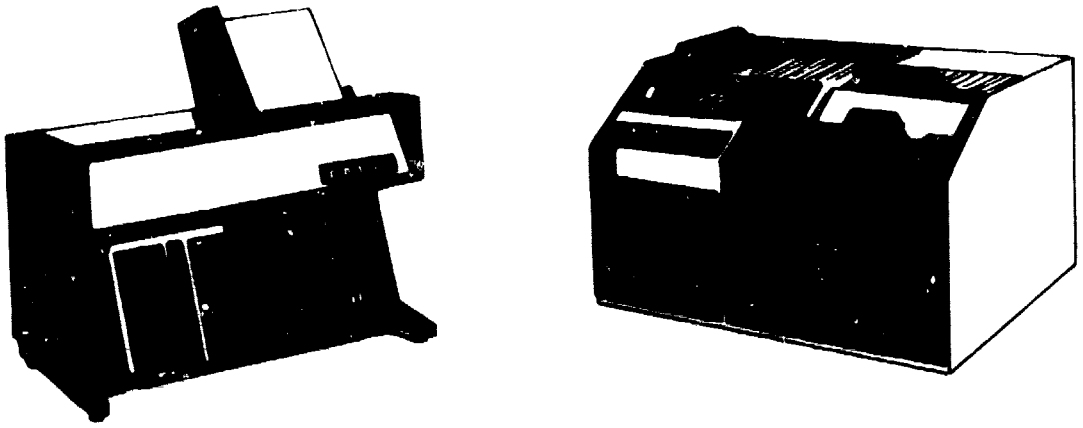
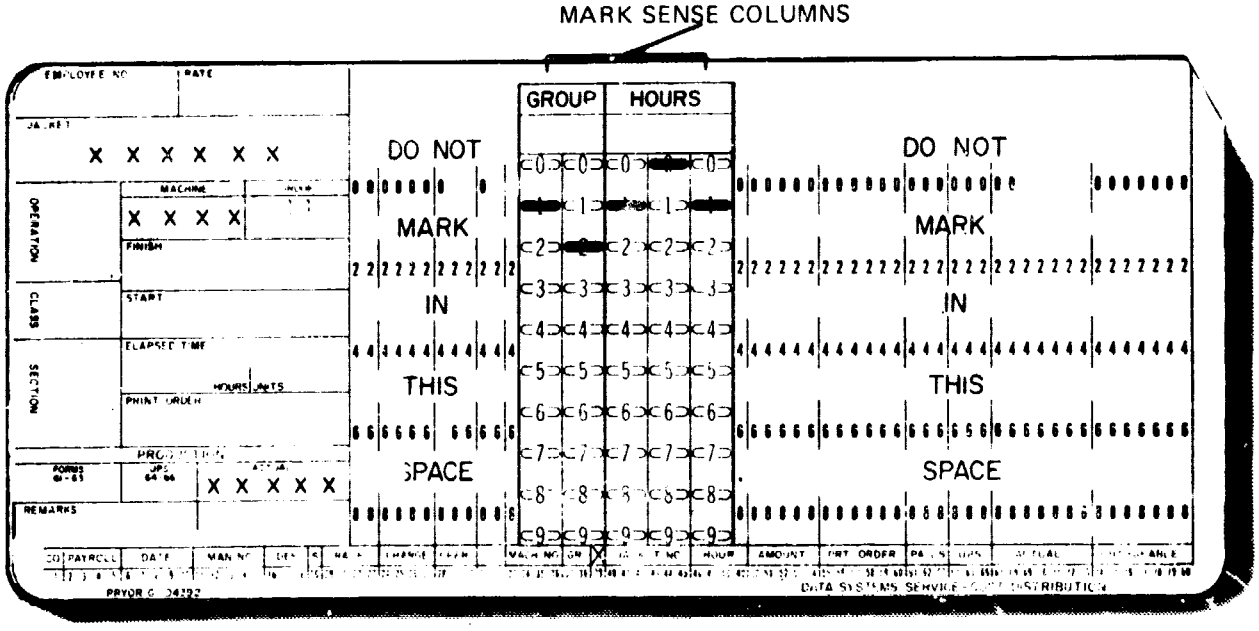


EXHIBIT 11 ADVANCED DATA ENTRY WITH OPTICAL CHARACTER RECOGNITION (OCR)



2 DIFFERENT OPTICAL MARK READERS



A SAMPLE CARD WITH MIXED
MARK–SENSE AND PUNCH COLUMNS

EXHIBIT 12 ADVANCED DATA ENTRY WITH OPTICAL MARK SENSING

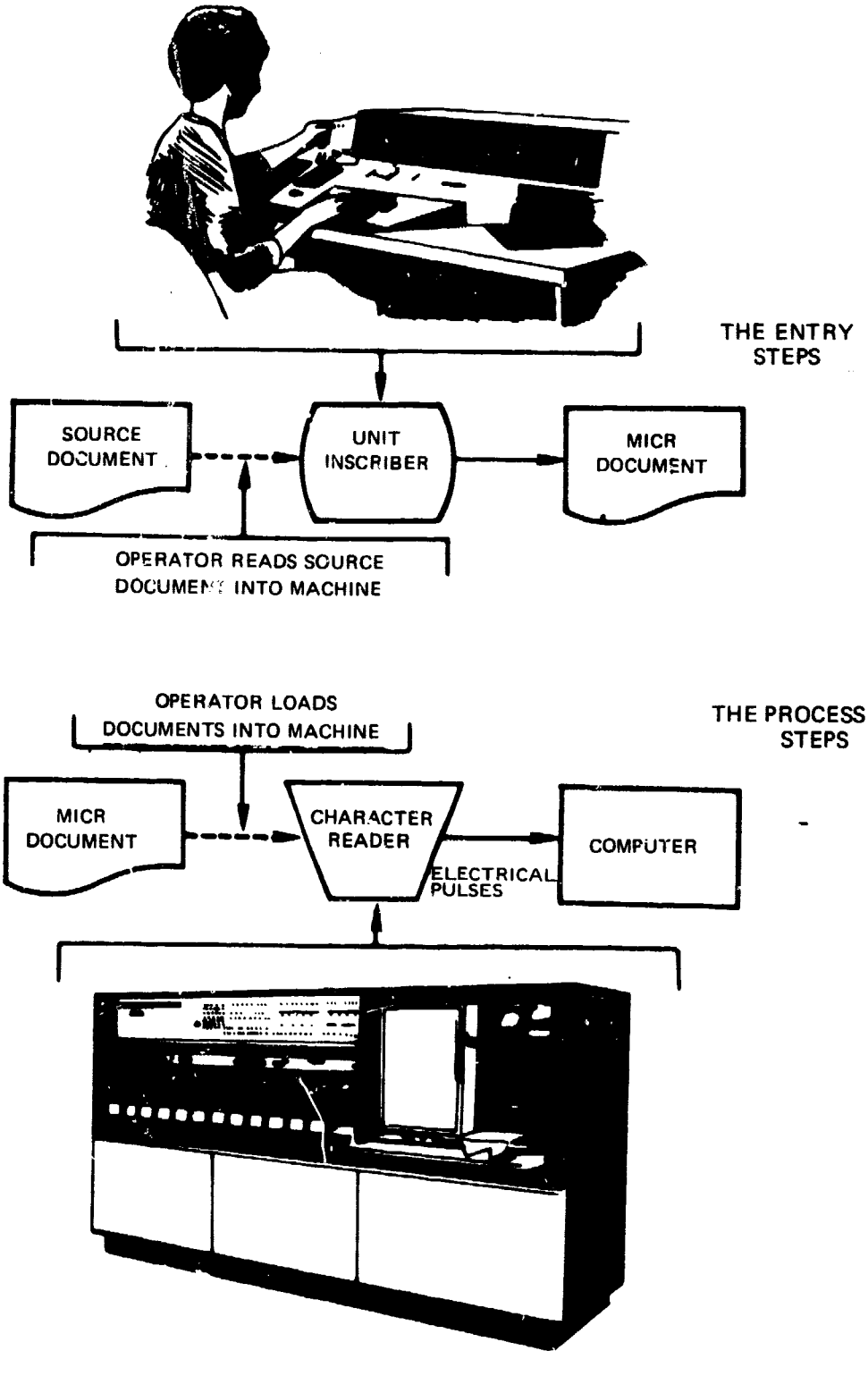


EXHIBIT 13 ADVANCED DATA ENTRY WITH MAGENTIC INK CHARACTER RECOGNITION (MICR)

possible when large volumes of data are being recorded, both the manual keying for the first entry and the second keying for verification are eliminated.

If the original document can be machine read rather than transcribed to another document for later keying, labor savings accrue from the elimination of (1) transcription and (2) keying.

CAPTURING MACHINE-READABLE DATA AT THE SOURCE

Sometimes computers get readings directly from measuring devices or other sources, including the human voice.

Scales:	Devices that measure weights can be read by sensing devices that transmit the data to a computer. One example would be weighing mail to calculate how many mail sorters are needed.
Counting device:	A device that can count objects passing a specific point such as a production line station. Information from various locations can pinpoint bottlenecks in the production process.
Voice recognition:	A device used to translate the human voice to computer compatible information. Currently, it is used in airline baggage handling and in some stock exchange transactions. At the stock exchange, an order given to buy or sell updates the stock transaction board immediately and the person on the trading floor can verify the accuracy of the transaction.

The above devices automatically send data directly to a computer. This technique--called source data automation--greatly reduces human involvement, can prevent many errors, and can speed data entry. It may reduce the costly error-correction techniques now required. In a

recent report 1/ we discussed the application of source data automation to Federal industrial activities, including inventory control and authorized personnel access.

BENEFITS CAN MEAN SAVINGS

Numerous benefits may be achieved through a change in technique, with or without a change in equipment. Careful analysis and selection of the right combination of device(s), techniques, and procedures can lead to more economical data entry through

--increases in productivity,

--faster input, and

--more accurate input.

Although other benefits may be cited to justify a new technique, we feel the benefits listed above are important because they, as well as their costs, can be measured. These benefits are mutually supporting since increased productivity should reduce costs and may give faster input. The accuracy attained can also improve the speed of input and data entry costs. Top management can control these matters by requiring data processing organizations to study and report on them.

Productivity can be increased

There are several ways to calculate increased production. One of the most popular methods is based on numbers of characters or records produced. However, other methods are sometimes used. Regardless of the measure used, productivity increases usually result from reduced labor, such as:

--Reduction or elimination of key strokes.

--Elimination of processing steps.

--Advances in error-correction techniques.

1/"Planning For Source Data Automation in Government Industrial Activities--Coordination Needed" (LCD-77-441), Sept. 23, 1977.

--Increases in flexibility (speed, software, and memory size) of the equipment.

Increases in productivity attributed to advanced entry techniques will vary, but the change in total output over time is most important. This is illustrated by the following studies.

1. In one 2-year study, statistics were gathered on data entry for one application using three different input devices: (a) a buffered keypunch, (b) a key-to-diskette system, and (c) a key-to-disk system. The last was used in both regular and computer-assisted modes. The application required entering and verifying 270 characters from a two-page financial document. The results, by actual characters entered, follow.

Device	Key strokes per hour	Percent increase over buffered keypunch
Buffered keypunch	6,130	-
Key to diskette	10,000	63
Key to disc	11,200	83
Computer-assisted key to disc	16,000	161

It will be seen that having the equipment automatically fill in certain values--computer-assisted data entry--offers significant productivity gains by reducing the material that must be manually keyed.

2. At a non-Government installation, productivity was increased on three applications by 56, 30, and 38 percent. These increases were shown by statistics from typical months before and after conversion to advanced data entry. For a fourth application, where daily statistics were gathered, advanced data entry increased productivity from 28 to 43 documents per hour--more than 50 percent.

These examples show that significant increases in productivity are possible with advanced data entry techniques.

Faster input

When verified machine-usable input can get into and out of the computer faster, the user gets his or her

output more quickly, and, thus, is more satisfied. For many ADP-service organizations, customer satisfaction with service time is essential.

One way to reduce processing time is to move some of the processing away from the central computer to the data entry equipment. This can be done by placing editing capability (special programs which check data for errors before it is input to the processing programs) in the data entry equipment. When such an entry device is used by the data originator, it allows corrections to be made by those most familiar with the data--the originators--and reduces later edit runs on the central computer. Reduced edit runs on the central computer can improve turnaround time and free the central computer for other processing. One manufacturer claimed a customer reduced edit runs on a central computer by 80 to 90 percent through use of the company's key-to-disk equipment with editing capability.

One user found it advantageous to have the operator key in data in the format recorded on the source document and have the data entry system automatically augment the data and rewrite it in a format that the central computer could use. By so doing, the keying operation was eased. For example, pay rate and grade level for each employee would be stored in the computer system. Upon entry of name and time information, the system could create the salary that was needed for payroll processing, thus reducing the coding and keying steps.

Improved accuracy

One of the most necessary qualities of input data is accuracy. One key-to-disk manufacturer's representative said that, in the company's experience, changing from keypunch to the key-to-disk method had reduced input errors from 5 to 8 percent on the keypunch down to 1 percent. Errors cost varying amounts of time and money to correct, depending on when they are found. Generally, the longer an error remains in the data, the more it costs to correct. Data entry errors can be detected at the following points, which range from the least to the most expensive to correct:

--Time of entry by the original operator or by data entry editing features.

--Time of verification.

--Time of balancing or checking input.

--Time of comparison of computer outputs to control totals.

--Time at which the user gets the computer output.

One of the techniques that was most promising and prominent in our study was that of data entry by the users. Of the 25 installations visited, 17 mentioned that they already had, or planned to have, the user enter the data. Their chief reason is apparently the belief that the users know the value of their data and will notice and correct errors more readily than an employee of a centralized data entry shop. This concept appears to be valid, and its use may significantly improve data entry in situations appropriate for its use.

Reduced costs reported range from 5 to 47 percent.

One agency reported that it proposed to save (and budget allotments confirmed that it did save) over $25,000 the first year and over $91,000 the second year after replacing keypunches with OCR equipment. These savings amounted to 16 percent the first year and 47 percent the second year. The keypunch staff changed from 12 full-time and 11 part-time keypunch operators to 4 full-time operators.

Another installation, which reduced its staff and equipment from 36 operators and keypunch machines to 28 operators and key-to-disk equipment, claimed savings of $70,000 to $80,000 per year.

One small installation that replaced four keypunch machines and operators with four key-to-disk terminals reported saving 5 percent annually.

The full effect of changing to advanced data entry methods is difficult to determine because different installations' studies are not readily comparable. In fact, labor, which is the major shop data entry cost, was considered by only 7 of the 13 preinstallation studies that we saw.

WHY WE BELIEVE THE TOTAL SAVINGS POTENTIAL IS LARGE

The potential for savings in data entry can be divided into: (1) productivity savings and (2) avoidance of the impact of errors on applications. Productivity savings would

be those which result from getting the data entered more cheaply, for example, with fewer workers and lower salary costs due to personnel displacement. Savings from avoiding the impact of errors would be those resulting from avoiding overpayments and catastrophes.

Even in the productivity area, data does not exist to allow a rigorous calculation of the total potential for savings.

In the area of avoidance of errors, we can only speculate on what the Government might save if data entry errors were avoided or reduced. Similarly, we do not know how many could be avoided if the entire Government used better data entry methods. However, our cases of costly or catastrophic errors, coupled with the lower error rates reported with some advanced data entry methods, show a large potential for savings from avoidance of errors. We believe that the savings available from the impact of avoiding errors on user applications may be far larger than data entry production savings. However, we cannot estimate that potential now.

Some examples which we were able to document convinced us that the potential for total Federal savings through wider use of advanced data entry techniques is large.

--Avoidance of errors: In a recent report 1/ we discussed one case where incorrect input data caused an automated application to make overpayments of approximately $700,000. Still more serious than overpayments is the potential for disaster from errors in computer programs or data which control moving objects like aircraft and spacecraft. The literature 2/ reports that the first U.S. Venus mission was lost because a period was used instead of a comma in one of the statements in a computer program. The resulting program was operable but did not act as intended. This case illustrates the type of catastrophes that can result from undetected typographical errors in the creation of computer programs.

1/"Improvements Needed in Managing Automated Decisionmaking By Computers Throughout the Government," (FGMSD-76-5) Apr. 23, 1975, pp. 16 and 17.

2/Glenford J. Myers, "Software Reliability," Wiley, 1976, pp. 7, 254, and 275.

--Productivity: One aspect of productivity is a reduction in labor costs to perform the same data entry applications with new equipment. The labor savings may be partly offset by the greater cost of the more effective equipment. For a few of the installations we studied, enough data were available for us to calculate a net savings in terms of equivalent operator staff-years. Dividing the net savings in equivalent operator staff-years by the number of operators needed with the old equipment gave us a net personnel reduction percentage. The installations where we were able to calculate this net personnel reduction percentage showed these ranges of values:

	Reduction range	
	From	To
	(percent)	
Private sector	24.0	84.0
Federal	5.6	33.3

Applying the above Federal percentages to the 15,193 data entry staff-years reported by the General Services Administration in 1976 shows from about $3 million to about $15 million annual savings in the general management category alone. 1/

We feel that the above figures are much lower than the true savings potential of advanced data entry methods. They do not include the savings due to reduced errors--impossible to measure but believed to be very large--or the benefits to the public of getting services more quickly.

KEYPUNCH EQUIPMENT USAGE IS DECLINING

In January 1977 a representative of the major manufacturer of keypunch equipment told us that the firm would no longer produce new keypunch machines. It now furnishes machines that are reconditioned and warranted new. About 95 percent of all keypunches/verifiers listed in the June 30,

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1/Using the typical salary as $8,149.00 (GS-3, step 4 in Oct. 1976), 50 percent overhead, and assuming that one-fourth of the operators reported are not already on advanced equipment (that is, using only one-fourth of the operators as a basis for savings).

1976, General Services Administration inventory were manufactured by this firm. We were also told that, although the firm has no policy of maintaining obsolete equipment, its representative personally felt that it would maintain the keypunches as long as there are still enough of them used.

However, the firm has notified the users of certain of its computers, which are much more expensive than keypunches, that it will maintain them only as long as parts are available after January 1, 1980. The GSA inventory of June 30, 1976, indicated that there were 20 of these computers in use in Federal agencies.

It is not clear as to how long the manufacturer will continue to maintain its keypunches. There are many more keypunches than the computers mentioned above, and they cost far less to rent, buy, or maintain (by contract) than the computers. However, the major manufacturer's discontinuance of production of new keypunch equipment indicates that alternative sources of equipment and maintenance should be identified.

Recently, GSA representatives told us that it now has an active program to monitor obsolete data entry equipment and other ADP equipment. This program includes a requirement that manufacturers notify GSA as soon as discontinuance of production or maintenance of an item is published. They also told us that several alternate sources are already selling keypunch equipment and maintenance to Federal agencies, including maintenance for the major manufacturer's equipment.

CHAPTER 3

GOVERNMENT AGENCIES LACK GUIDANCE FOR CHANGING TO ADVANCED DATA ENTRY

The predominance of the keypunch is slipping, as we indicated earlier. One vendor's representative told us that the company's recent market analysis showed that the total number of installed keypunches, including the newer buffered variety, was down 5.4 percent in 1975 compared to 1974. The representative predicted that keypunches would decrease by another 41.9 percent by 1980. However, the GSA inventory indicates that the traditional punched-card equipment (keypunches and verifiers) reported by Federal agencies decreased only 1.3 percent from 1974 to 1975 and 5.6 percent from 1974 to 1976. This indicates that the Federal Government may be behind in converting to the newer devices.

We believe the Federal Government may be behind private industry in changing to advanced data entry techniques due to poor methods of selecting data entry equipment and lack of interest in measuring successful installations.

HOW INPUT DEVICES ARE SELECTED

The Federal Government does not use a standard procedure for selecting data entry devices. Appendix III shows that some agency managers pay far less attention to this area than others. Some agencies prepared requests for proposals, others did not. Those agencies that prepared such requests generally (1) performed preinstallation or feasibility studies and (2) leased and tested the new equipment or performed an acceptance test before purchasing. When new equipment for more than one location was to be purchased, a test was usually made at one location, and if the test (called a pilot test) succeeded, the rest of the equipment was ordered.

We do not know of any cost analyses or audits by agencies' internal auditors of the procedures used to select data entry equipment. However, we believe that these auditors should do such work.

The steps followed in the selection process were in four general categories in two processes. These are:

1. Preliminary process.

   --General familiarization.

   --Preorder studies.

   --Acceptance testing.

2. Action process.

   --Final decisions or actions.

Reasonable requirements in each of the four general areas may be defined as follows:

General familiarization: One must be aware of the available alternatives before an intelligent selection can be made. While vendors' demonstrations, users' experience, and employees' knowledge of ADP are useful, care must be taken to rule out prejudices. Guidelines concerning devices and results of tests may be appropriate.

Preorder studies: Feasibility or preinstallation studies are imperative. These studies should include economic analyses and identify benefits expected. While all benefits are good, quantifiable benefits such as production rates, error rates, and processing times, are more of a management aid to control, without the requirement that the manager be an ADP specialist. Guidance is needed on acceptable rates and general cost of error correction by the various types of equipment at the different stages of production.

Acceptance testing: The usual forms of acceptance testing are the benchmark (one or more applications are tested to see if they can be accomplished), the pilot test (most or all applications are run on a trial basis at

one installation to see if the workload and application can be accomplished within a specified time), and parallel operations (the old and new system perform the same or similar work in the same time period). Guidance is needed to spell out the pitfalls as well as the advantages of using these techniques. We believe the pilot test is the most correct (although expensive) way to determine that the right equipment is selected. Yet, two of the four installations that chose this method concluded at first that the tested equipment should be ordered for the other installations. Later evaluation indicated these decisions were wrong. In one case, the main application was not normally performed at the pilot site, and at the second installation, the problems appeared only after a large volume of devices was put into production.

Final decisions or actions:

The actual installation and conversion of the full data entry system are at times difficult and time consuming but can be done successfully. We believe the key is the preparation of detailed plans and setting of goals and objectives at various stages of the conversion process with comparison of actual to planned progress. Unless goals are quantified, however, there is no way to measure success. The final report should be a post-implementation study which compares achievement to the goals and benefits expected.

SELECTION PROCEDURES ARE INEFFECTIVE AS USED

We feel that standardized general guidelines are needed for the selection and acceptance of data entry devices. We

believe that the National Bureau of Standards of the Department of Commerce is the most appropriate agency to develop such guidelines in accordance with its responsibilities under the Brooks Act (Public Law 89-306).

We studied 12 Federal installations. Their procedures are detailed in appendix III. We found that:

--Most importantly, only 4 of the 12 did post-installation reviews to evaluate the effectiveness of the new equipment. The lack of proof of success does not, of course, mean failure, but it does leave room for doubt.

--11 of the 12 performed preinstallation studies, but none considered all relevant costs, and 5 did not consider personnel costs. Personnel costs should be considered because they are normally over 40 percent of the data entry costs incurred by the ADP shop.

NEED FOR AGENCY GUIDANCE

Federal agencies' computer acquisitions are controlled by directives and regulations issued by the Office of Management and Budget, GSA, and, in some cases, by the agencies themselves. These control mechanisms provide detailed guidance to the agencies to insure that approved approaches are taken. However, the guidance given on acquiring computer data entry equipment is minimal. This lack of guidance has spawned the wide variations in approaches taken, discussed earlier and detailed in appendix III. Under such circumstances, there is little assurance that proper steps are in fact being pursued, which in turn means that some of the potential benefits of advanced data entry may not be attained.

We feel that the best way to resolve this situation is publishing technical guidelines for agency use by NBS. Publication of such guidelines would be in agreement with responsibilities assigned the Department of Commerce by the Brooks Act, would tell agency managers how to study alternatives adequately, and would give agency auditors criteria against which to measure agency actions. After our discussions with NBS, we learned that it plans to contract for development and publication of such a document. Publication is tentatively set for late 1978.

CHAPTER 4

CONCLUSIONS, RECOMMENDATIONS, AND AGENCY COMMENTS

We are convinced that there are opportunities for use of more efficient and economical advanced data entry techniques in many Federal agencies. Adopting such techniques at each agency should be based on careful study, considering the costs and benefits involved--both tangible and intangible. Criteria for the conduct and content of such studies should be developed to validate them. We believe NBS is the logical organization to publish the criteria, and NBS officials agree.

The guidelines will also give agencies' internal auditors a standard for reviewing data entry studies. We feel that independent reviews by internal auditors can help management make correct decisions about advanced data entry techniques.

While the problem of potential unavailability of manufacturer maintenance support for keypunch equipment is not of immediate concern, GSA should continue to monitor it closely to protect the Government's future interests.

RECOMMENDATIONS

We recommend that the Secretary of Commerce direct NBS to develop guidelines for agencies to use when reviewing their data entry methods or when planning to change them. We have been advised that NBS has begun work on preparing such guidelines.

We also recommend that Federal agency heads have data entry in their organizations studied to insure that proper advantage is being taken of the most appropriate methods now available and have these studies reviewed by their internal auditors. If an agency is already planning a change to advanced data entry methods, we recommend that the internal auditors review the matter before final decisions are made. Pending issuance of definitive guidelines by NBS, we suggest that economic analysis of all significant components of cost and assessment of claimed benefits be scrutinized for reasonableness and verified where possible.

AGENCY COMMENTS

We asked Commerce (NBS) and GSA to comment on our draft report. To expedite the publication, we asked for and got informal comments. These comments were addressed in preparing the final report.

Both NBS and GSA agreed generally with our conclusions and recommendations.

NBS concurred with our conclusion that significant savings are available in data entry and agreed that it should provide technical advice. NBS also said that it expects to publish the first guideline on data entry early in fiscal year 1979. Other detailed NBS comments were addressed in the report as appropriate.

GSA representatives told us that:

--GSA concurs with us that it should continue to have a plan of action for data entry equipment that is no longer maintained by its manufacturer or may soon reach that status.

--GSA now has an active program--relatively new--to monitor obsolete ADP equipment, including computers and peripherals as well as data entry equipment, to notify agencies of discontinuances by the original manufacturers and to encourage alternate sources of supply and maintenance.

--Several alternate sources already sell keypunch equipment and maintenance to Federal agencies. These include the largest manufacturer's equipment.

--Keypunch data entry equipment will be significant in the Federal Government for years to come. Since the Federal market will remain large, it will encourage alternate suppliers to come forth.

APPENDIX I

COMPARISON OF POSSIBLE PROCESSING STEPS OF TWO KEY ENTRY METHODS WITH DIVISION OF RESPONSIBILITIES BETWEEN ADP AND USER SHOWN

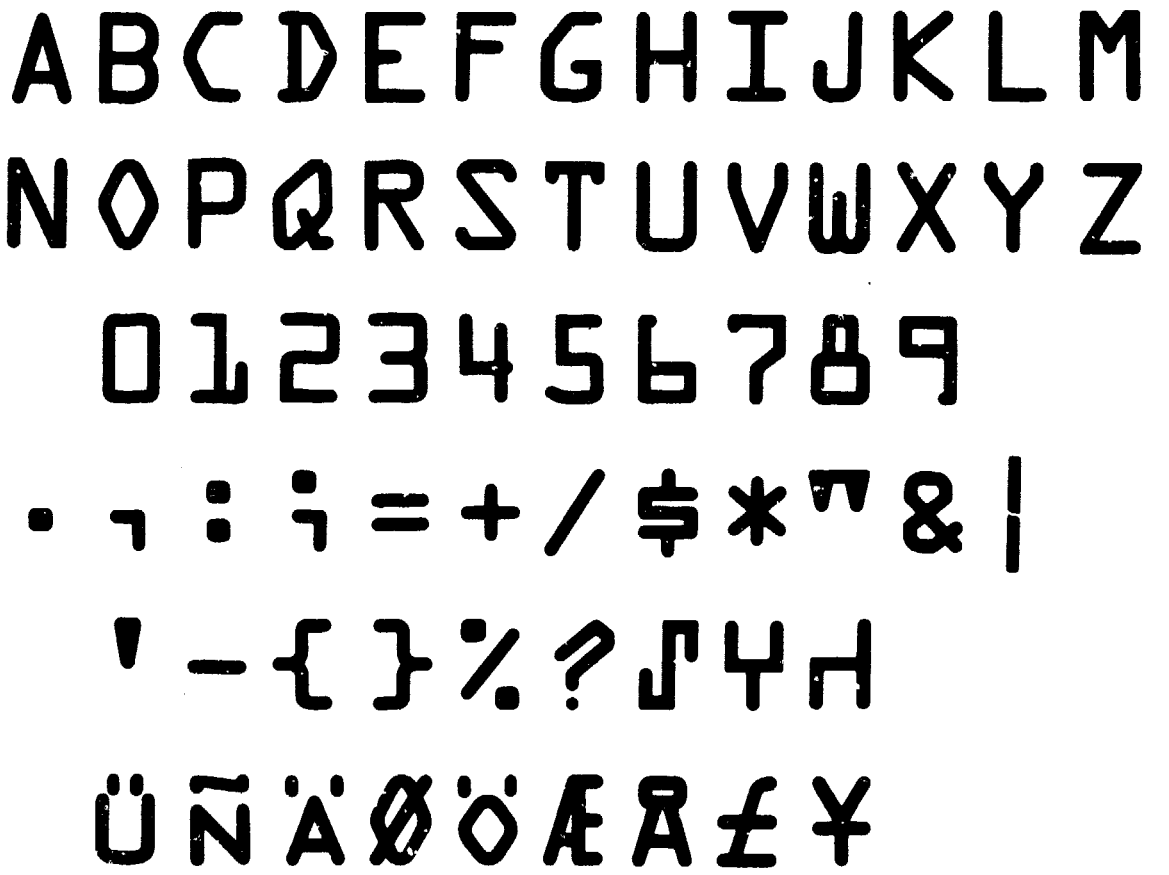
POSSIBLE PROCESSING STEPS

	TRADITIONAL KEYPUNCHING METHODOLOGY	ADVANCED DATA ENTRY (USER ENTERS DATA)
1.	(USER) Record on source document	1. (USER) Record on source document
2.	(USER) Prepare batches of work with control totals	2. (USER) Prepare control totals
3.	(USER) Prepare keypunch documents	
4.	(USER) Balance keypunch documents to control totals	
5.	(USER) Prepare cover control sheet for batch of documents	
6.	(USER) Mail or ship to ADP	
7.	(ADP) Record receipt of block and totals	
8.	(ADP) Schedule for keypunching	
9.	(ADP) Keypunch	3. (USER) Enter data on magnetic media verification, balancing, and edit errors corrected as the work proceeds.
10.	(ADP) Schedule for verification	
11.	(ADP) Verify	
12.	(ADP) Correct & verify errors	
13.	(ADP) Schedule balancing and editing run	
14.	(ADP) Convert cards to magnetic media	
15.	(ADP) List editing and balancing errors	
16.	(USER Locate errors as needed	
17.	(ADP) Correct errors as needed	
18.	(ADP) Reschedule balancing and editing run if needed	
19.	(ADP) Correct magnetic media records	
20.	(ADP) Relist editing and balancing errors	
	Steps 16 thru 20 may be repeated any number of times until all work is accepted as accurate	
21.	(ADP) Correct any controls as necessary	4. (USER) Inform ADP that work is ready for the central computer
22.	(ADP) Schedule report	5. (ADP) Schedule computer run
23.	(ADP) Print report or reports	6. (ADP) Reformat work for central computer with no human intervention except to start job.
24.	(ADP) Balance reports	
25.	(ADP) Ship all reports, original documents and error lists to users	7. (ADP) Print report or reports 8. (ADP) Ship reports to users
26.	(USER) Balance reports to control totals	9. (USER) Balance reports to control totals
	NOTE: Reports that do not balance may require recycling back to step 17.	NOTE: Reports that do not balance may require recycling back to step 3.

APPENDIX II

TYPICAL READER TYPE FONTS

TYPICAL TYPE FONTS FOR OCR AND MICR READERS



THE OCR–A TYPE FONT FOR OPTICAL CHARACTER RECOGNITION

APPENDIX II

MAGNETIC INK CHARACTER RECOGNITION TYPE FONT

ZERO

ONE

TWO

THREE

FOUR

FIVE

SIX

SEVEN

EIGHT

NINE

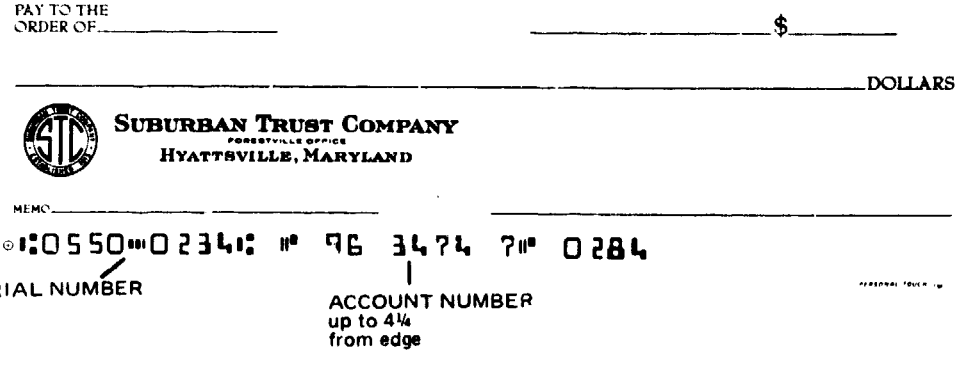
AMOUNT SYMBOL

ON US SYMBOL

TRANSIT NUMBER SYMBOL

DASH SYMBOL

DATA FIELD LOCATION FOR MCR ON A CHECK



APPENDIX III

PROCEDURES FOLLOWED BY TWELVE FEDERAL AGENCIES IN SELECTING ADVANCED DATA ENTRY EQUIPMENT

■ = Actually done
● = Planned
N = Neither done nor planned

	AGENCY											
	1	2	3	4	5	6	7	8	9	10	11	12
GAINING FAMILIARITY												
Review available alternatives	N	N	N	N	■	N	N	N	N	N	N	N
Demonstration by vendor	■	N	N	N	N	N	N	N	N	N	N	N
Talk to others using equipment	N	N	N	N	N	N	■	N	■	N	N	N
Previous knowledge of ADP	N	■	N	■	N	N	N	●	N	■	N	N
PRE-ORDER STUDIES												
Leased or tested equipment	■	N	■	N	■	■	N	N	N	N	N	N
Comparison to old equipment	N	N	N	N	■	■	■	N	N	N	N	N
Workload analysis	■	N	N	N	N	N	N	N	N	N	N	N
Feasibility or preinstallation study	■	■	■	■	■	■	■	■	■	N	■	■
Request for proposal	■	N	■	■	N	■	■	N	N	N	■	N
ACCEPTANCE TESTING												
Accepted existing contract	N	N	N	N	N	N	N	N	■	N	N	N
Approval obtained	N	■	N	■	■	■	■	■	■	N	■	N
Looked at equipment	N	N	N	N	N	N	N	N	N	N	N	N
Benchmark	■	N	■	N	N	N	■	N	N	N	N	N
Pilot test	■	N	■	N	N	■	N	N	N	N	■	■
Implementation test	N	N	N	N	N	N	N	■	N	N	■	N
Parallel operation	N	■	N	N	N	N	N	N	N	N	N	N
FINAL DECISION OR ACTION												
Ordered remainder	N	N	N	N	N	N	N	N	N	N	■	N
Installed remainder	■	N	●	N	■	N	N	N	N	N	N	■
Problems encountered	N	N	N	■	N	N	N	N	N	N	N	N
Accepted vendor's offer	N	N	N	■	N	N	N	N	N	N	N	N
Post-installation evaluation	N	N	■	N	N	■	●	N	N	N	■	■
Compared output from time to time	N	N	N	N	N	N	N	N	N	■	N	N

APPENDIX IV

SOME SOURCES OF INFORMATION ABOUT DATA ENTRY

1. Meetings with others interested in the advancement of data entry, such as DEMA (the Data Entry Management Association), which was organized in 1976 for the purpose of advancing data entry.

2. Studies by "Computerworld," DATAPRO (user evaluations), Auerbach, and many others.

3. Manufacturers' brochures and presentations.

4. GSA's National Archives and Records Service's program of paperwork modernization, including the use of source data automation techniques.

5. Courses by organizations such as the American Management Association and the Data Processing Management Association.

6. The organizations' own data entry, data processing, or user personnel. They may be an excellent source of information in some cases.

APPENDIX V

DATA ENTRY VOCABULARY

Coding form:	Also called keypunching or data entry form. The form from which the keypuncher enters data. It may be the same as, or separate from, the source document. (See below.)
Data editing:	Procedures to check for errors in input data.
Edit:	To modify the format of data, including deleting unwanted data, selecting pertinent data, or input.
Input:	(1) The data entered into a computer for processing. (2) The process of entering data. (3) Pertaining to the devices that enter data.
Source document:	The user's application document, which is a source of data eventually processed by the computer program. Examples include time cards, vouchers, and bills of lading.
Throughput:	The amount of raw material (data) processed within a given time.

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