1969

Evaluation of data processing centers and the services they provide

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AN EVALUATION OF DATA PROCESSING CENTERS

AND THE SERVICES THEY PROVIDE

By

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B. A. Washington State University, 1964

Presented in Partial Fulfillment

of the Requirements for the Degree of

Master of Science

UNIVERSITY OF MONTANA

1969

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June 27, 1969

Date

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PREFACE

The increasing importance of automatic data processing is one of the interesting aspects of the business world of today. To consider the impact upon the economy, one needs only to glance at the short history of automatic data processing and at the diversified uses to which the processing has been applied.

The purpose of this paper is to examine the feasibility of using data centers for those who cannot afford to buy or to lease a computer as a means of utilizing the benefits of automatic data processing. These data centers are used in the preparation of business reports and in the solution of complex business problems.

THE HISTORY OF AUTOMATIC DATA PROCESSING

The concept of data processing, older than most people think, was recognized first about 186 years ago. In 1786, J. H. Mueller wrote a paper on automatic computing machines that discussed almost all the basic principles which are in modern computers. The mechanical technology of that day did not permit the construction of Mueller's models.[1] "In 1830, an English mathematician, Charles Babbage, generally conceded to be the father of the modern electronic digital computer, built what he called an analytical engine."[2] This machine was purely mechanical and utilized cog wheels, gears, and rotating shafts. In 1834, Babbage began work on a more advanced general purpose computer which could perform the arithmetical operations of a wide range of algebraic formulas in automatic sequence. Technology hindered Babbage, and he never completed a working model of the sequential computer. Nevertheless, experts who examined his blueprints felt that the design was sound.

The time and expense involved in developing the new ideas about automatic computers was shared by only a few because the economies of the eighteenth and nineteenth centuries were dominated by agriculture. Little demand or use, therefore,

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[1]William E. Perry, Jr., "Don't Be Afraid to Use a Computer," Administrative Management, Vol. 24, (Jan. 1963), p. 47.

[2]Ibid.

was apparent for high-speed data processing machines.

The need for data processing machines was first evident in 1885 when the bulk of the census data of 1880 still was being processed. The sheer volume of data made it apparent that, in the future, the census data would take additional time to classify. At the same time Dr. Herman Hollerith, a statistician with the census bureau, worked out a system which allowed census information to be processed by machines. Dr. Hollerith's system consisted of recording data on long strips of paper.[3] The information was recorded by punching holes in paper in a planned pattern so that each hole or combination of holes denoted a specific item. These strips of paper were then fed over a sensing device that was able to examine the holes and electrically perform the tabulation. In 1890, this system was used in processing census data. Although the population had increased by twelve million since 1880, the use of machines allowed the data to be evaluated in two and one-half years.[4] With improved transportation and with increased business complexity, a need for additional and more rapid information gathering became apparent in business and in science as early as the beginning of the twentieth century. Dr. Hollerith left the Bureau in 1903 and formed

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[3]An introduction to IBM Punch Card Data Processing, Data Processing Division, (White Plains, N. Y., 1960), p. 1.

[4]*Ibid*.

the Tabulating Machinery Company which became the International Business Machine Corporation (IBM) in 1912.[5]

Although a demand for data processing was growing, the improvements made in the fifty years following 1890 were not of great significance. The machines were quite sophisticated; however, mechanically geared machines were expensive, subject to frequent breakdowns, and limited as to their internal speed. During World War II, the scientists who were working on the atomic bomb and on other military projects were hindered greatly by the inability of the best mechanical data processing machines of the day to perform the calculations quickly enough. Dr. John W. Mauchly and J. Presper Echer of the Moore School of Engineering of the University of Pennsylvania designed a computer which used electronic impulses to transfer information, rather than a moving mechanical gear.[6] The two men submitted these plans to Army Ordnance which gave the University of Pennsylvania a contract to begin development of an electronic computer. After two years of work, the Electric Numerical Integrator and Calculator (ENIAC), the first all-electronic, high-speed, large-scale computer in the work was completed in 1945.[7] The outstanding feature of this

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[5]Richard N. Schmidt and William E. Meyers, <u>Electronic Business Data Processing</u>, (New York, N. Y.: Holt, Rinehart, &Winston Co., 1963), p. 12.

[6]<u>Ibid</u>., p. 14.

[7]<u>Ibid</u>., p. 15.

computer was its speed; it could do in ten seconds what a desk calculator took twenty hours to do.

The ENIAC which transmitted data internally at very high rates of speed allowed processing time to be cut substantially. The machine instructions for the ENIAC were initially programmed on interchangeable control panels. The computer processed data according to the instructions contained in these preset devices, and could only depart from the fixed sequence in a limited way. Scientists proposed that the computer store its program in a high-speed internal memory device to give the computer greater latitude in working problems without operator assistance. In 1948, a computer that incorporated this feature was completed; thus the computer was now able to make comparisons and decisions.[8] The stored program greatly increases the internal operation when it is contained in a storage medium that can supply the instructions as rapidly as they are called for. The first storage medium that truly had this ability was the magnetic core which was developed in the early 1950's.[9] The items in a core storage can be located in a few millionths of a second.[10] Since 1950 other storage media have been developed that can be used as internal storage. There were also some important developments made

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[8] Introduction to IBM Data Processing Systems, (White Plains, N. Y., 1963), p. 8.

[9] Ibid., p. 9.

[10] Ibid., p. 29.

in storage devices that could store vast quantities of data with relatively small access times. Two of these media were the magnetic drum and the magnetic disks. These developments in storage devices coupled with improvements in electrical circuitry increased computer applications considerably.

The first commercial computer was completed and delivered to the Bureau of the Census in 1951. This computer presented many problems in design, in programming, and in maintenance; however, the mechanical data processing machines laid the groundwork by demonstrating the economics of using automatic data processing equipment.

Since 1951, the developments in computer technology and in computer design grew at such a fantastic rate that some refinements seem difficult to believe. The computer industry developed rapidly into a present-day five billion dollar world-wide industry. Jacque G. Mainsonrouge, Vice-president for European operations of International Business Machines World Trade Corporation in Paris, stated that the computer industry will be the next great international industry--after the oil industry and after the automobile industry.[11] Computer sales, in industrial nations, were shown to be increasing at the rate of twenty to twenty-two percent a year, while automobile sales, the next booming world-wide industry, were shown to be increasing at the rate of seven percent a

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[11] *Ibid.*, p. 113.

year. Figure 1 shows the projected growth of computers in 1970. The implications of this projected growth will be discussed in Part 5 of this study.

	1966		&	1970	
	Number of Computers	$ Value (Millions)	Growth Rate	Number of Computers	$ Value (Millions)
United States	27,000	7,500	10-13	45,000	12,500
Western Europe	6,000	2,200	20-22	18,000	5,500
Japan	1,900	300	20	4,575	900
Canada	900	150	23-25	3,000	750
Australia	280	40	35	1,000	250
Latin America	200	25	7	440	115

Figure 1[12]

Recent and Projected Increase in Use of Computers in the United States and in Foreign Countries

[12] *Ibid.*, p. 113.

II. BACKGROUND OF AUTOMATIC DATA PROCESSING

Two Basic Types of Computers: The Analog and the Digital

There are two basic types of computers, the analog and the digital. An analogy exists between the type of input data the computer will accept and the form of output it provides. The analog computer utilizes input in the form of a physical quantity, such as a voltage, or current, or the angular rotation of a shaft. The analog computer transforms these input quantities into output quantities in accordance with the program of the computer. The early computers used for scientific purposes were very often of the analog type. For example: The computer was programmed to simulate a mathematical problem which in turn described a physical system, such as the launching of a rocket. The analog computer is used for control devices in rockets because the output directly provides the necessary control. All analog devices have the same characteristics in that the numbers in the problems handled are represented by corresponding physical or electrical quantities.

The other basic computer is the digital type. This type operates by counting, and the input data must be in the form of numbers. The input information is processed in accordance with the rules of arithmetic. It utilizes special input and output devices to translate the input data into a form usable by the computer and then to convert the output into a form usable for control and information purposes.

The analog computer is superior to the digital computer in calculating time and initial set-up time but, because of the form of input that the analog computer requires, it seems to be of little use outside scientific applications.

The Two Automatic Data Processing Systems: The Punch Card (Tabulating and Electronic)

The applications of automatic data processing systems are divided into two separate systems: conventional tabulating machine procedure and the complete electronic system. Any number of combinations of systems that fall between the tabulating and the electronic system are possible.

The equipment in the punch card system can be segregated into two groups depending upon what phase of the operation it performs. The equipment that prepares the input data, checks it for accuracy, duplicates data in punch card form, and arranges it in the proper format so it can be processed by machines, is in one group, e.g. Key Punch, Verifier, Reproducer, and Collator. (See Appendix A, Pages 1A-4A , for a definition of punch card equipment.) This phase of a punch card system may be compared to that of an operator putting data into a desk calculator in the proper positions so that the machine can operate on it. The second group includes equipment that actually performs operations such as multiplying, dividing, adding and subtracting, e.g. The Calculator and the Tabulator (Accounting Machine). See Appendix A. This phase of the operation can be compared to that of the internal operation of the desk calculator after the start button has been pushed.

The number of jobs a punch card system can perform is dependent upon the flexibility of the calculator and the tabulator. This equipment is so designed that a detachable wire control panel is used to give the equipment instructions on how to manipulate the data, i.e. add numbers in columns 11-22 to numbers in column 44-55 or subtract these numbers. If a punch card system is used to process different data such as payrolls and credit sales, it is usually more convenient to wire a permanent control panel for each operation, so that a change in operations can be accomplished quickly by merely changing control panels.

The electronic system differs from the punch card system in many ways, but the most important differences are that the electronic system has the ability to store its program internally and modify it by comparing data (numbers) and then following different paths depending upon the result of the comparison. Figure 2 on page 10 illustrates how a computer might be programmed to make a comparison of the numbers A and B. The electronic system also eliminates several of the separate processes that are necessary in tabulating procedures. To understand how the computer integrates the processing it might be helpful to think of the computer as consisting of six component parts:[13] 1. Input, 2. Internal

[13]Schmidt and Meyers, *op. cit.*, p. 83.

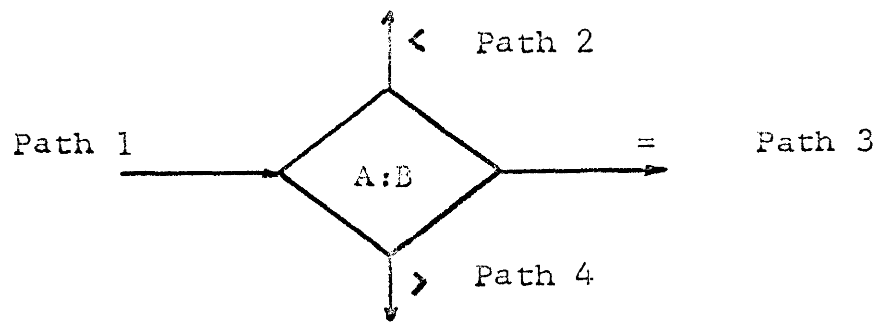


Figure 2

Possible Outcomes of a Comparison of Two Numbers

Storage, 3. Arithmetic Unit, 4. Comparison or Logic Unit, 5. Control, 6. Output.

1. Input	The input is the data in machine readable format such as the punch card.
. Internal Storage	The computer uses storage devices that store information in the form of electric impulses. This storage or memory unit "...is designed to receive and hold procedural steps (program) required in processing data, to receive input data, to permit the procedural steps to operate upon the data in memory..."[14]
. Arithmetic Unit	The unit that performs the four mathematical operations.
. Logic or Comparison	Every computer has a logic unit that can make comparisons such as the one shown in Figure 2.
. Control Unit	The unit is sometime called the electronic clock. It has two functions: to select the instructions from the program and to execute the instructions.
. Output Unit	The processed data that is printed or punched on the cards.

[14] Ibid., p. 85.

The computer actually has access to two storage media--internal and auxiliary storage. The internal storage (mentioned above) is a storage unit which permits the retrieval of the data with no delay, that is the computer knows exactly where the particular data are and can address it directly. Core storage and Mercury Delay Lines are two forms of internal storage and are very desirable because of this feature, however, they are also very expensive. Magnetic Drums and Magnetic Disks are media that have been developed that can store very large quantities of data, but they do have positive access time (time required to retrieve data from storage) so they are generally used as auxiliary storage. These forms of storage are very desirable when large amounts of raw data are being processed or when there is a delay between the time input data is put into the system and is processed.

An analysis of the two systems, in handling the billing for a utility company of 100,000 customers permits some insight into the advantages of the electronic system over the tabulating procedure. See flow charts of both systems, Figures 3 and 4, on pages 14 and 15.

The mark sense card that is issued to the meter reader contains the following historic information: Customer number, customer address, rate, old meter reading, and other desired historic information. An explanation of how the card is prepared by the meter reader can be found on page 26. The following steps are correlated to the steps on the flow chart in figure number 4.

CONVENTIONAL PUNCHED CARD MACHINE PROCEDURE:

1. The meter reader mark senses the meter reading.

2. A reproducer punches all the pre-coded historic information and mark-sense readings into a punch card.

3. The cards are then processed by a calculator which subtracts the old meter reading from the new reading and punches the result on the card.

4. The cards are then sorted by rate on a sorter. The customers that have the same rate are placed in separate groups by this process.

5. The cards are again processed by a calculator which multiplies the rate times the usage and punches the amount of the bill on the card.

6. The sorter then arranges the cards in order by customer number.

7. A reproducer is used to prepare the mark sense cards for the next meter reading.

8. The current billing cards are then merged with the current balance in the accounts receivable on the collator.

9. The current billing cards and the accounts receivable (collator) cards are then merged with the name and address card for the permanent file. This provides a check to see that all customers are being billed; if no mark sense card was turned in for a customer, the unmatched name and address card for this customer is separated and investigated.

10. The three cards, the current billing card, name, and address card, and accounts receivable card are then sent through an accounting machine which prints the bill.

11. The name and address cards are then separated on the sorter from the other two cards and refiled until they are to be used again.

12. The current billing cards and the accounts receivable cards are processed by a calculator which produces a

new account receivable card. These cards are used to prepare the accounts receivable subsidiary record.

ELECTRONIC SYSTEM:

The procedure followed in an electronic system is essentially the same as that in the punch card system. The difference is the internal storage capabilities of the computer and its ability to control the input and process the data with no human handling of the data. The following may help explain the operation of the electronic system depicted in figure 4.

1. Meter reading cards are prepared by the meter readers.

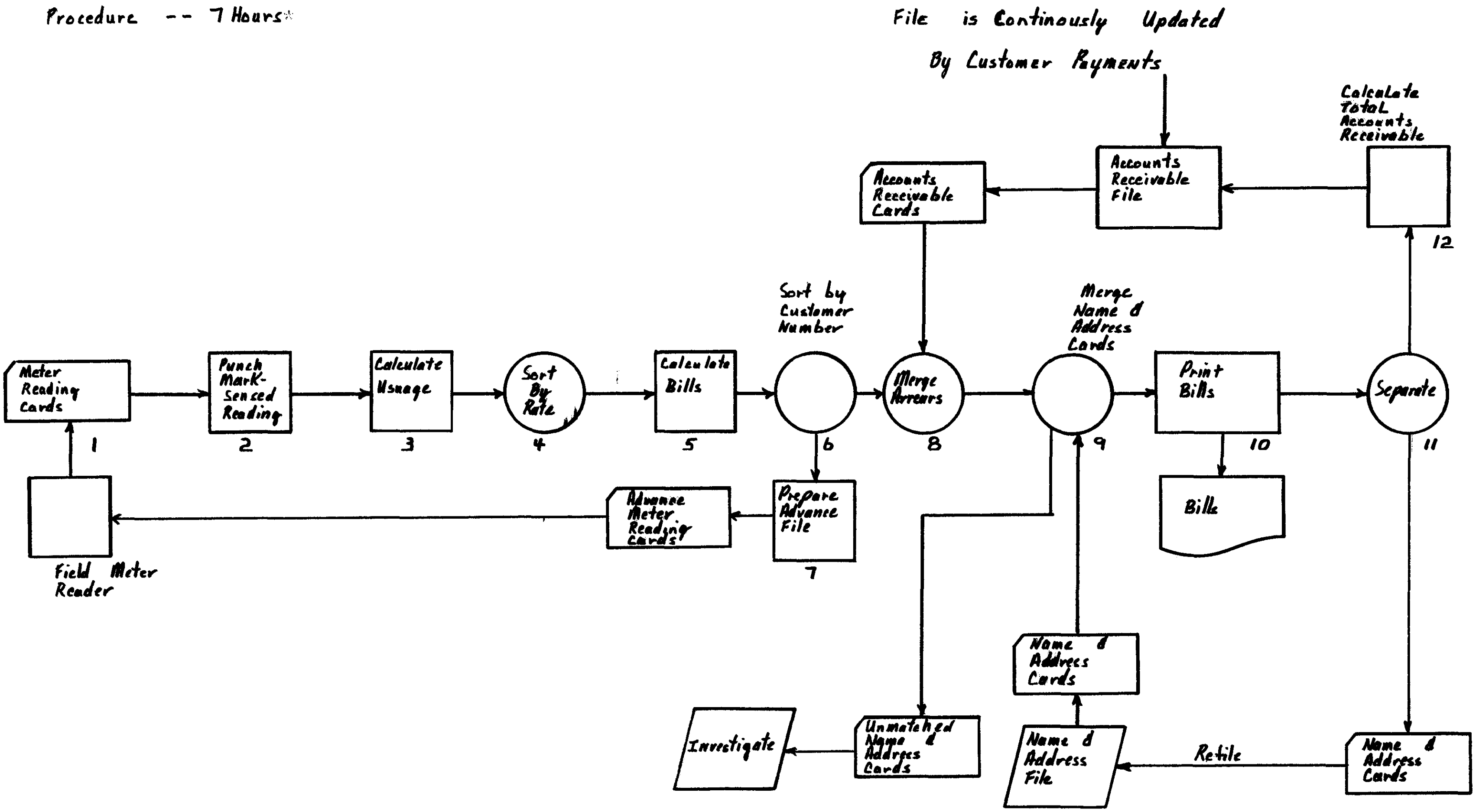
2. Information on the mark-sense cards is converted to punch cards.

3. The remainder of the steps are similar to that of the punch card system, however, the processes such as sorting and collating are unnecessary because the internal storage capacity of the computer allow them to be integrated into one process. The computer transmits the data in the form of electric impulses, materially cutting down the computer's processing time. The computer might handle the remaining steps as follows.

    a. The electronic clock takes the information as it is read in and places it in temporary storage, instructs the arithmetic unit to calculate usage, rate, and determine current amounts due from the customer by checking the accounts receivable file. The logic unit then compares current billing information with the name and address file to make sure all customers are billed and adds new names to the file if new cards are denoted. (The computer will print out all unmatched names and addresses after all the accounts have been processed.) The bills can be printed directly by a printer controlled by the computer, punched on cards for later printing, or placed in auxiliary storage for later use.

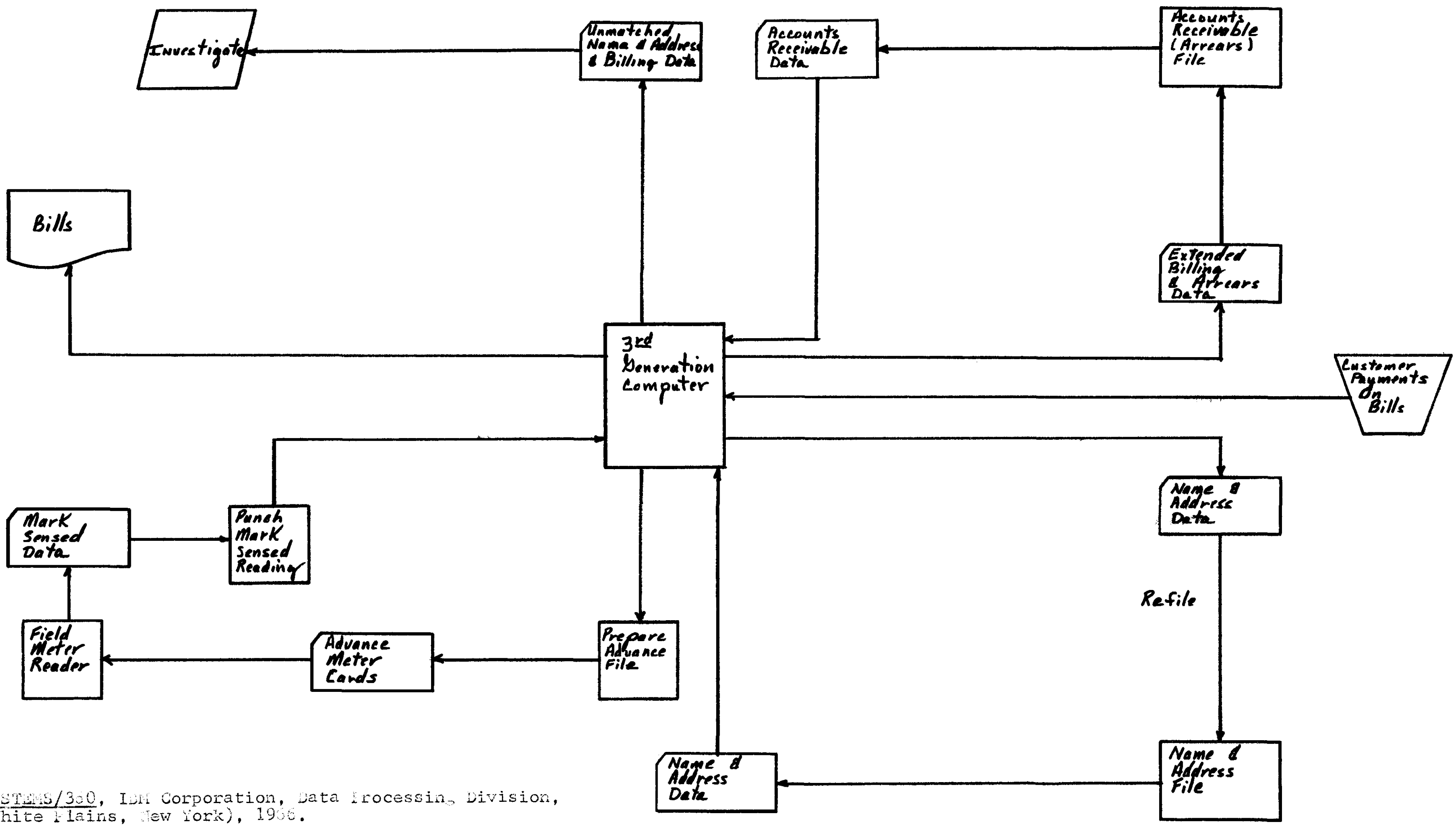
The punch-card system reduced the clerical work consider-

Conventional Punch Card Machine
Procedure -- 7 Hours*



*IBM SYSTEMS/360, IBM Corporation, Data Processing Division, (White Plains, New York), 1966.

IBM System / 3rd Generation Computer: 5000 Accounts 2.5 Hours*



*IBM SYSTEMS/360, IBM Corporation, Data Processing Division, (White Plains, New York), 1966.

ably when compared to manual methods. However, the following drawbacks led to the development of an electronic system.

1. The problem was solved in separate phases, not in one continuous process; hence, time was lost.

2. The amount of information processed at one time was limited due to storage.

3. Cards were more subject to manipulation or error because they must be carried by humans to the different machines for processing.

4. The punch card system did not have the ability to make logical decisions.

Although the tabulating procedure is being discarded in favor of the more sophisticated electronic system, it always will be an important tool in explaining electronic systems. Punch-card procedure is so fundamental to automatic processing of data that a complete understanding of its operation is usually desirable before exploring the capabilities of integrated electronic systems.

Also, the simplicity of the punch-card system was instrumental in gaining acceptance of automatic data processing and in laying the groundwork for the complex machines of today.

Developmental Stages of Computers

Technologically, electronic computers were developed in three separate stages which are frequently referred to as first, second, and third generation computers. The Electronic Numerical Integrator and Calculator (ENICA) was developed to replace the mechanical relay switches with vacuum tubes. The vacuum tubes were used to record and to transmit information in the form of electronic impulses. These impulses allowed the computer to perform calculations thousands of times faster than comparable machines using mechanical relay switches. Computers which made use of vacuum tubes were classified as first generation computers. As a direct result of the use of vacuum tubes the amount of time required by the computer to locate file data was decreased and storage capacity was increased by the development of direct control tape storage, magnetic disks, and magnetic drum storage equipment.

Electronic impulses are capable of traveling at the speed of light (186,000 mi./sec.); however, the vacuum tube, although a significant improvement, did not begin to take advantage of this potential speed. In an attempt to take advantage of the potential increase in speed, computers were built larger than they had been; however, limits soon were reached in the size that the computer could be built.

The Korean War, as well as the space race, placed a great demand on research and on development of electronic circuitry. In 1951, Dr. William Shockly of the Bell Telephone Laboratory, discovered the transistor which became the characteristic of the second generation computer. The transistor, a small semi-conductor diode, performed the same operations that the vacuum tube did; however, it was smaller, demanded less power, and was more reliable than the vacuum tube. During the 1950's, the transistor almost completely replaced the vacuum tube.

In 1961, the third generation computer was born with the development of integrated circuits. A Computers and Automation, "Market Report" stated:[15]

> Integrated circuits are essentially the combination of active electronic devices with passive elements, i.e., combinations of transistors and diodes with resistors and capacitors, into one unit.

A practical example of its usage was demonstrated when the internal guidance computer of the Minuteman Missile was reduced from 14,711 to 5510 components by utilizing the integrated circuits.[16] Figure 5 compares the critical factors

INTEGRATED CIRCUITS EFFECT ON COMPUTER PERFORMANCE

	Speed	Size	Cost	Reliability
1st. Generation	1	1	\$0.50-\$5.00/unit	1
2nd. Generation	10	.01	\$0.30-\$1.00/unit	75-100
3rd. Generation	25* to	.001	\$2.50-\$7.00/unit	100-650

*Average of presently available Integrated Circuits.

**Potential

Figure 5

Comparison of the Critical Factors Determining the Value of the Three Generations of Computers.[17]

[15] "Market Report", Computers and Automation, Vol. 14, (July, 1965), p. 9.

[16] Ibid.

[17] Ibid.

which determine the value of the three generations of computers.

The most important effects of integrated circuit (IC) technology on the computer industry were:[18]

1.	Speed	Computation speeds will eventually be increased 10-fold. New large computers using ICs can execute over 10,000,000 operations a second.
2.	Size	Information processing equipment size can eventually be reduced 100-fold and ultimately will be limited only by the size of peripheral input/output and mass-random-access memory devices.
3.	Reliability	Maintenance cost will become significantly less as reliability increases and replacement parts are incorporated into the equipment during manufacture.
4.	Cost	Cost will be modestly reduced for central processors but will not change for most peripheral equipment.

Another important factor in third generation computers is the "compatible family" approach. John E. Varsour contended:

> In this approach, which all major manufacturers are using, the product line consists of a series of central processors spanning the range from the very small machines to the very large. "The advantage of the "compatible family" concept is that programs written for any model in the family can be run on any larger model with full advantage of the higher speed."[19]

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[18] *Ibid*.

[19] John E. Varsour, "The Third Generation of Computers-New Tools for Management", *Management Accounting*, Vol. 47, (Oct., 1965), p. 4.

This approach means that a business or a service center, starting with a data processing system geared to the initial volume requirements, can convert to a large system as the workload increases. There is no need to reprogram the work that had been performed on the small system.

The internal speed of the third generation computer is so fast that the computer can process simultaneously many different and unrelated programs. The computer actually does not perform two calculations or operations on two programs at exactly the same time; however, it operates so rapidly (10,000,000 operations a second) that, for practical purposes, it might be said that the computer operates on the different programs simultaneously.[20]

Hardware and Software

In every automatic data processing system, two separate phases are denoted: the "hardware" phase and the "software" phase. The physical configuration of equipment is denoted the "hardware" phase. Configuration refers to the computer plus auxiliary units, such as input, output, and memory storage devices. Combinations can be altered for different tasks, each combination constitutes a new configuration. In the last twenty years almost all important technological developments in ADP were made in the "hardware" phase of computer systems, and advancements in such parts as vacuum tubes, transistors,

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[20] Computers and Automation, op. cit., p. 9.

ICs, and storage units.

The second phase, the "software" phase, is denoted by the non-equipment aspect of ADP such as punch cards, systems concepts and designs, machine language, and programs. The challenge for improvement in automatic data processing systems shifted to the "software" phase because the developments in "hardware" were so far ahead of the "software" that additional internal computer speed added little to performance. Otto Stitz, the manager of Univac in West Germany, stated in a recent Business Week article:

> Anyone can make a computer. The trick is in putting it in the user's hands, equipped and ready to solve his problems. The quality of the "software" and the service determines whether the computer itself will sell in sufficient quantities to be profitable.[21]

A significant improvement in "software" was the development of the Semi-Automatic Ground Environment (SAGE) program written for the United States Air Force. This program was developed to protect the United States from air attack. The program instructs an On-Line-Real-Time computer system receiving input from all radar networks to analyze and to compare the results with flight patterns filed by the commercial airlines, government flights, and private aircraft. The SAGE program required the equivalent of eighteen hundred man years to write and cost 1.6 million dollars. The program was the first important multiple program capable of utilizing fully

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[21]Business Week, op. cit., (Feb. 19, 1966), p. 114.

the third generation computers on a large scale. The knowledge gained allowed private airline companies to develop a program for running a OLRT passenger reservations system at about 1.5% of the cost incurred by the Air Force.[22]

Common Methods of Data Input

Before a digital computer can process data, the information must be converted to a form which the machine can interpret. The following forms of data input are cited as the common methods in use today:

1. Punch Card
2. Paper Tape
3. Magnetic Sensing Cards
4. Magnetic Ink Characters
5. Optical Scanning Characters
6. Magnetic Tape

Punch Card

The punch card is the most common input form in use today. The data is recorded as holes in specific locations on a punch card as shown on the IBM punch card, figure 6. Rectangular holes are used to record data on IBM cards and round holes are used to denote the information on the Univac punch cards. The IBM card contains twelve rows in each of the 80 columns. The combinations of punches that will provide the

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[22]Gilbert Burck, "On-Line in Real-Time", Fortune, Vol. 69, (April, 1964), p. 144.

numbers 0-9, and the letters of the alphabet are illustrated on figure 6.

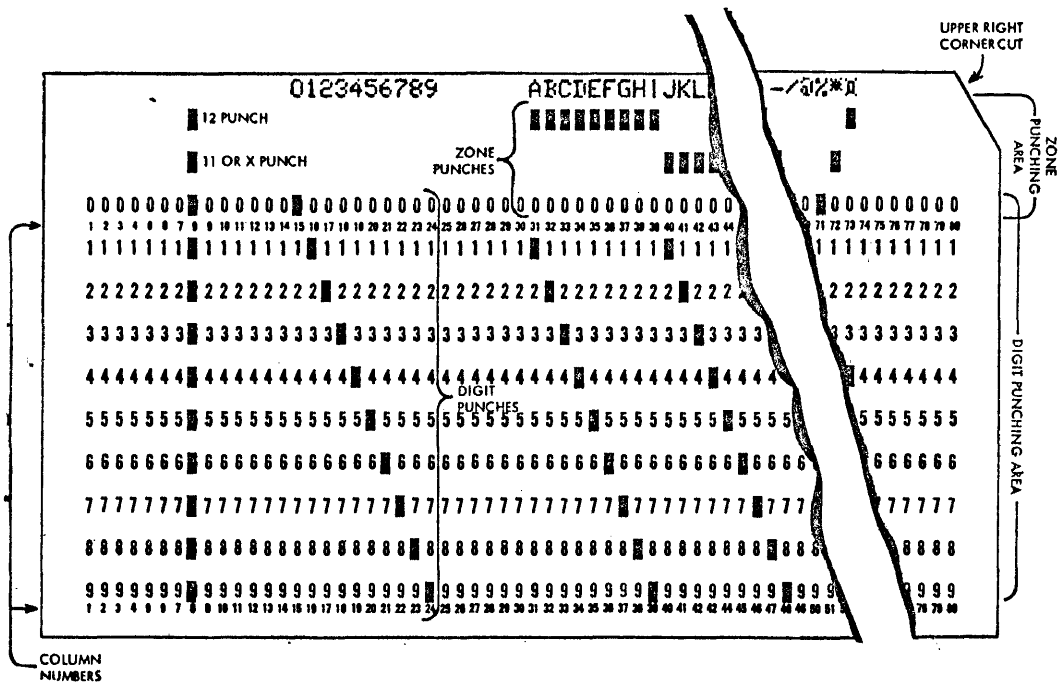


Figure 6

The information on the card must be arranged in a specific sequence so that the card reading machine can identify different information. This identification is accomplished by dividing the cards into segments called fields. Figure 7 shows an IBM punch card that has fields for customer number columns (26-31), invoice number columns (32-43), and invoice amount columns (39-43). The field may be as large as needed and may extend to another punch card. The cards are generally prepared on a key punch (Appendix A) from the source of information.

Advantages of the punch card.

1. The information contained on the punch card can be printed at the top of the card allowing the data to

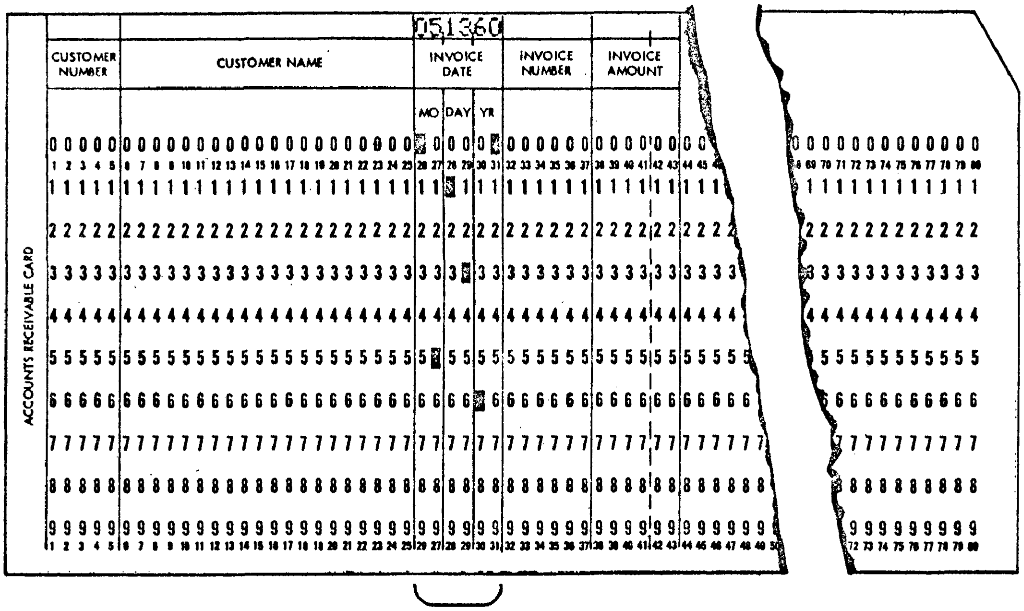


Figure 7
A Typical Data Field

be identified by human inspection.

2. The punch card can be an economical method of putting input data into ADP systems.

3. The punch card can be used by almost all automatic data processing systems.

Disadvantages of the punch card.

1. The cards can be identified by inspection, thus are more subject to manipulation.

2. Cards are rather a slow method of putting data into the computer, comparing it with other methods to be discussed.

3. Limited storage capacity.

Paper Tape

The paper tape is similar to punch cards because the data are recorded by combinations of punches along the length of a paper tape. Figure 9 illustrates the combinations of punches required to produce the various letters, numbers, and symbols. The paper tapes are becoming more popular because they can often be produced as a by-product of adding machine operations or other office equipment.

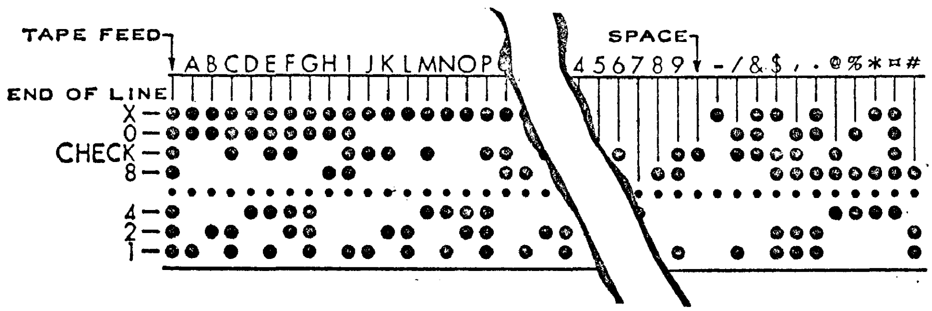


Figure 8
A Typical Punched Paper Tape

Advantages of the paper tapes.

1. It allows continuous processing with no human handling.

2. It is generally regarded as the most economical form of input media.

3. It is very often produced as a by-product of adding machine operations or other office equipment.

Disadvantages of the paper tape.

1. Paper tape is not especially good for permanent storage because it is not durable.

2. It is a relatively slow method of data input.

Magnetic Sensing Cards

Magnetic sensing cards are similar to punch cards; the only difference is that the information is recorded by manually shading oblong spaces on the card with a special pencil rather than punching holes in it. Figure 9 shows a magnetic sensing card that might be used by the meter reader for a utility using one of the two systems of ADP discussed on pages 10-16. The meter reader would mark a number 1-7 in the space for service in the upper right hand corner of the card depending upon what meter he was reading; gas, water, electricity, etc. The card contains a legend which the meter reader follows. The meter is read and the reading is then transferred to the card by shading the correct spaces in the respective month. The card in Figure 9 is a water reading of 3445 for the month of May.

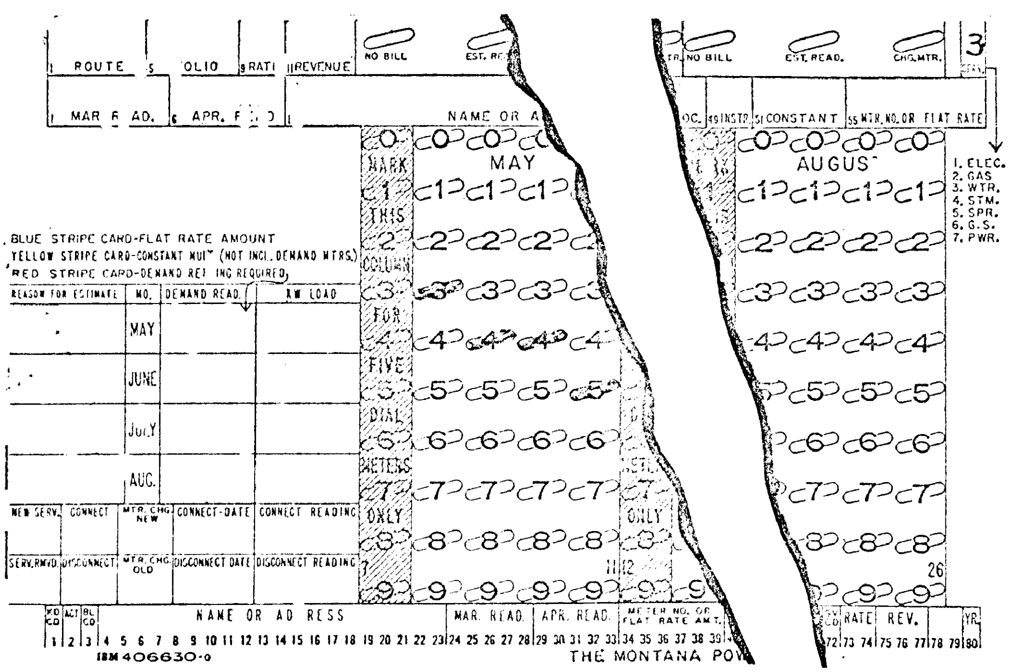


Figure 9
Magnetic Sensing Card For A Utility

Magnetic Ink Characters

The magnetic ink character is a special form of input developed by the American Banking Association and computer manufacturers. The number of characters used in this input medium has this far been limited to 0-9 and four symbols. The document containing the magnetic ink characters is sent past a reading head and ten data channels send signals to an electronic storage device called a character matrix. There are seventy character segments in each matrix location. When a character passes under the reader it denotes which areas in the matrix have been blacked out by magnetic ink. Figure 10 shows the magnetic characters and how each are placed in a 70 square matrix.

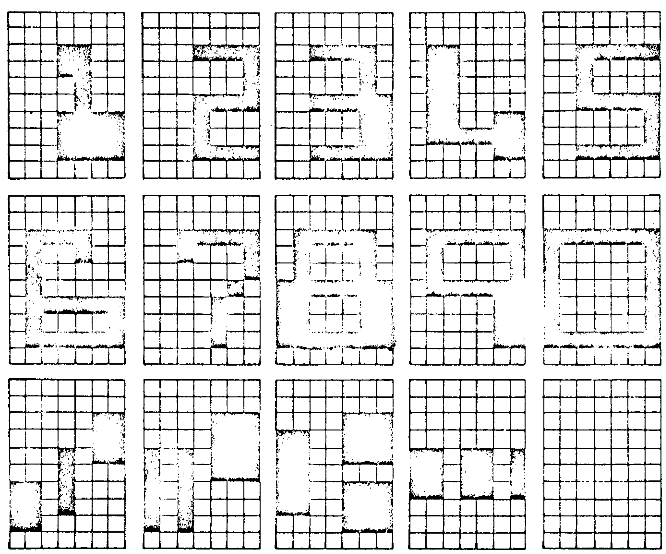


Figure 10
Magnetic Ink Characters

The advantages of the magnetic ink characters.

1. Bank checks containing the characters can be printed in mass quantities very economically, thus this input is very economical when a large amount of the source data can be precoded. See Figure 11.

2. The characters can be interpreted by humans; thus, there is no need for extensive verification.

3. The document containing the characters can be of various sizes.

The disadvantage of the magnetic ink characters.

1. The present application is limited to special situations, i.e. the characters must be printed by special equipment. Normally it is easier to use punch cards unless a large amount of the data can be precoded onto source documents. The large amount of data on the punch card can be verified by machine economically, but Magnetic Ink Characters cannot.

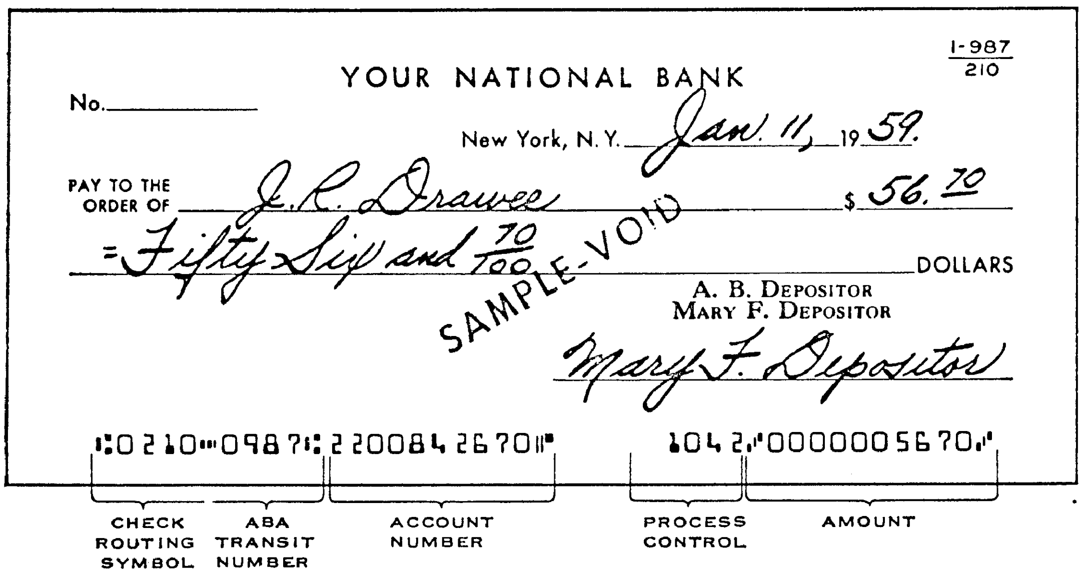
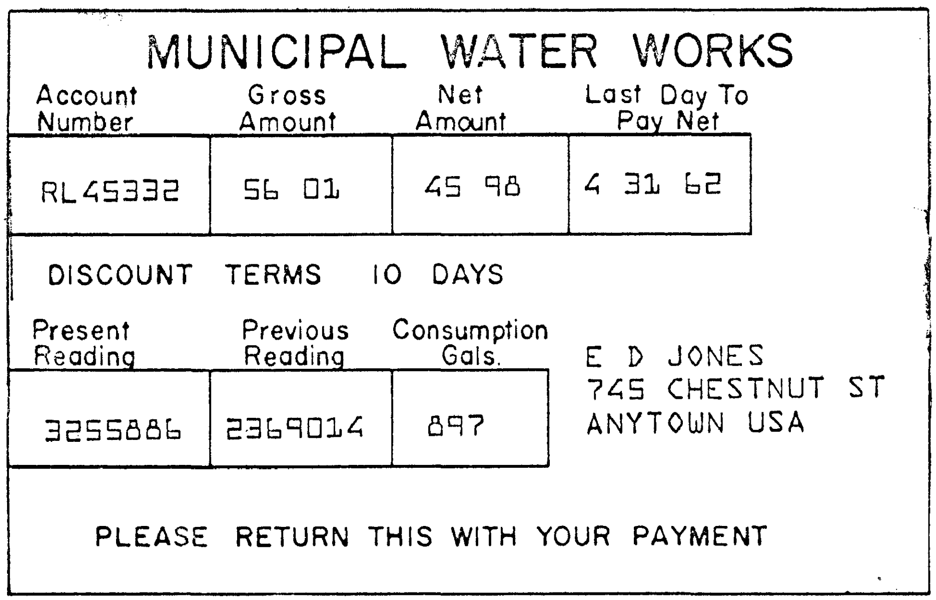


Figure 11
Magnetic Ink Characters on a Bank Check

Optical Scanning Input

The most recent development in the input medium is optical character reading. This is a significant development because it allows the computer to accept as input all uppercase letters, numbers, and certain special characters directly from the source documents. The characters are transmitted into electrical impulses (internal storage media of the computer) by sending the source document to an optical scanning station. The scanner interprets the characters by using a powerful light source and a lens system that detects the black and white patterns of reflected light; the patterns are then read as a number of small dots and converted into electric impulses. Figure 12 shows a water bill utilizing optical scanner characters. This form of input is more desirable than the magnetic characters when a large amount of data cannot be pre-coded, because this form of input requires only a typewriter equipped with the proper type.



MUNICIPAL WATER WORKS

Account Number	Gross Amount	Net Amount	Last Day To Pay Net
RL45332	56 01	45 98	4 31 62

DISCOUNT TERMS 10 DAYS

Present Reading	Previous Reading	Consumption Gals.
3255886	2369014	897

E D JONES
745 CHESTNUT ST
ANYTOWN USA

PLEASE RETURN THIS WITH YOUR PAYMENT

Figure 12
Optical Scanning Characters on a Water Bill

Advantages of optical scanning input.

1. The source document can be used directly as input, i.e., the intermediate step of preparing punch cards is eliminated.

2. The data can be entered on the document at different times very easily.

Disadvantage of optical scanning input.

- Optical scanning input does not allow continuous processing and cannot be controlled by the computer.

Magnetic Tape

The magnetic tape is a powerful medium for recording data for machine processing, see Figure 13. Data are recorded on the tape in the form of magnetized spots. The lower four rows on the tape are used for coding the numbers 0-9. This is accomplished by using a binary coded decimal system, which is capable of expressing numbers in the form of zero or one. The next two rows denoted as the zone, are used to allow enough different combinations of bits to permit the coding of the alphabet and eleven symbols. The check row on the upper edge of the tape is used automatically by the computer to verify the accuracy of the data.

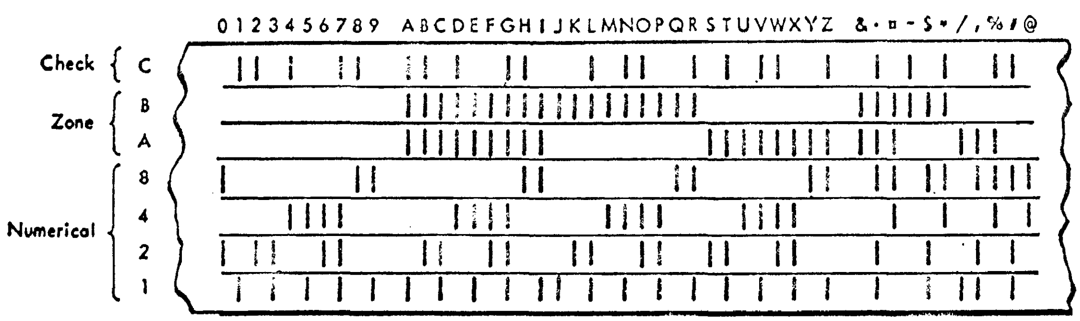


Figure 13
Magnetic Tape

The magnetic tape is often used as input-output recording media for computer systems because data can be transmitted to and from tape at a speed of 340,000 numeric characters a second, and can be controlled by the computer. The tape is produced in reels up to 2400 feet and can store 1511 characters per inch, thus a 2400 foot tape can store 86,000,000 characters.[23]

Advantage of the magnetic tape.

1. The magnetic tape allows continuous processing and can be controlled directly by the computer, i.e. auxiliary storage.

2. The tape can be used more than once.

3. Large amounts of information can be stored without occupying much space.

Disadvantage of the magnetic tape.

1. The magnetic tape requires more sophisticated equipment and a large minimum before it is economical.

Common Methods of Data Transmission and Output

After the data are converted into one of the preceding input media, they can be entered directly into most modern computing systems. If the data input is prepared in a location not near the processing system, it can be mailed to the data center, can be transmitted over private cables, or can be transmitted over any telephone line connected with the A. T. & T. nationwide telephone system. The method of transmission depends largely upon time, cost, volume, and the type of central processor. Data transmitted over telephone lines can be reproduced in the same form, i.e., cards to cards and in addition, the data can be reproduced in different input media such as paper tape or magnetic tape. Telephone com-

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[23] Introduction To IBM Data Processing Systems, op. cit., p. 26.

panies are encouraging the use of their lines for "tele-processing"; and as an added inducement, offer free technical assistance in such areas as tele-data transmission systems design. Long distance telephone rates are based upon the same rates offered for voice calls. As a result, companies are offered economical methods of data transmission. Considering the volume of data that can be transmitted by the machines in short periods of time, the cost of tele-data transmission is economical.

Tele-data type of input is also desirable because it decreases the idle time of central processing units and as a result, the cost of processing can be borne by additional users. This type of system is known as an on-line system because the data is fed into the computer as soon as it is available. When the data is processed completely, it is sent into storage devices which can be instructed to print out the information at any given time. If the information is desired immediately, it can be transferred to a buffer (a temporary storage device controlled directly by the computer) which transmits the output back over telephone lines. It is reproduced from the telephone lines on such agents as visual display terminals, punch cards, paper tape, or magnetic tape. This type of operation is called an "on-line-real-time" (OLRT) system.

When the OLRT system is in use, another input medium can be used -- the typewriter. Computers employed in these systems are programmed to respond to questions typed on a typewriter connected to the computer. Typing data is a slow method of data input, and it is only practical to use it when asking the computer to reproduce data already stored in the system. For example:

Question:	What is the status of Account Number 987689?
Computer response:	$190.00 debit balance, credit rating AAA, address, telephone number, dollar volume of business this year.

Output media in these cases are extremely flexible when the volume of output is small. All forms of input discussed on pages 22-31 can be used as well as the typewriter, visual display terminals, and audio-response units. Since audio-response media were developed in the last few years, the media is presently programmed with a limited vocabulary.

Future Methods of Input and of Transmission

Most computer manufacturers are working to increase the number of input media available. Some experimental computers, which can receive data via the human voice, are in existence. However, the newness of this medium seems to indicate that it will be some time before such devices are available on the commercial market.

The most desirable method of input media would be one in which the computer could accept source documents directly. The advantage will be the elimination of the intermediate step of preparing punch cards and or paper tape from the source documents. Manufacturers hope to develop computers capable of source document input in commercial production by 1970.

With reference to the future transmission of data, "Party-Line Computer," an article in Time, reported:[23]

> Micro-Wave Transmission: The IBM Company has taken advantage of a seldom used property of radio waves. Radio waves diffract (Bend) around obstructions. The IBM people have tested this microwave system and found that they could send a signal from a 15-watt transmitter 45 miles south of San Jose, California, on the other side of Loma Prieta, a 3798 foot peak in the San Cruz Mountains.

Furthermore, the article pointed out:

> IBM feels sure that a micro-wave system using bare and costless ridges of land instead of expensive repeater stations could carry computer chatter all over the country. It would probably be too noisy to carry human conversation, but unlike their creators, computers are not bothered by noise on the phone lines.

Another possibility of future transmission is the use of satellites similar to those used to relay television signals.

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[23]"Party-Line Computers", Time, Vol. 79, (April 13, 1962), p. 51.

III. OWNERSHIP OF DATA CENTERS

Data centers, often referred to as ADP service centers, are owned and operated by many different entities; however, almost all of the entities can be placed in one of the following categories:

1. Commercial banks and other financial institutions.
2. Colleges and universities.
3. Independently owned service centers.
4. Manufacturers of equipment such as IBM, RCA, and Sperry Rand.
5. Certified Public Accounting Firms.

There are numerous reasons why most data centers are operated by the above-listed groups; a discussion of these reasons should provide some insight into the future of data centers.

Commercial Banks and other Financial Institutions

Commercial banks and other financial institutions were among the first entities that had the volume of business transactions to warrant the use of Automatic Data Processing (ADP) equipment and could afford to procure such equipment. Most commercial banks providing checking services found that by using preinscribed magnetic ink characters, as shown on page 28, they could cover all operating costs out of the revenue received from customers' checking accounts. The modern ADP machines used to process checks are able to read fifteen hundred characters a second or 90,000 documents an hour.[24] These increases in input and the superior third generation computers left many banks with idle computer time. The American Bankers Association stated that there are more than seven hundred United States Banks with computer systems today; about forty percent of these banks were selling some sort of computer service in order to use their idle computer-time efficiently.[25]

Richard E. Sprague, director of advanced business systems for Touche, Ross, Bailey, and Smart, Certified Public Accountants, felt that in the future, banks may be the most numerous owners and operators of data centers. Sprague declared:

> The reasons have to do with the possible expansion of services to include financial responsibilities and money handling services. The commercial bank, because it is the logical organization to handle and store money, will find an increasingly important set of relationships between its own information handling problems and the information-credit-money services it may offer its subscribers.

In addition, Sprague stated:

> Part of this interest stems from the thought that new accounts from consumers, merchants and other businesses, will be acquired as a result of offering the new information utility services which are self-supporting in themselves. Another part of the interest will come from the possibility of reducing check handling and other paperwork costs through electronic

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[24] Gilbert, Burck, "The Boundless Age of the Computer", Fortune, Vol. 69, (March, 1964), p. 107.

[25] "Is There A Computer In Your Future?", Merchandising Week, Vol. 97, (Feb. 1, 1965), p. 15.

transfers of funds among accounts.[26]

Another advantage that commercial banks enjoy is their reputation for being an honest business entity. Banks and other financial institutions, in gaining valuable experience and in training qualified staff personnel in ADP, will be in an excellent position to sell machine data processing.

Colleges and Universities

Many colleges and universities have installed automatic data processing equipment to acquaint students with its applications in science, in basic research, and in business. The centers established at the schools that choose to provide commercially have some decisive advantages.

1. Generally, students run the machines for little or no compensation in order to gain valuable experience.

2. The center is not under pressure to be run at a profit; thus, services could be offered at a reasonable rate.

3. Students who work in the center can gain valuable contacts for possible job opportunities upon graduation.

4. Most centers are under the control of the mathematics department of the school, thus giving the centers a source of highly qualified and experienced technical personnel.

Centers operated by schools are interested particularly in programming, in mathematical models, and in basic research applications. Most repetitious accounting work such as pay-

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[26]R. E. Sprague, "Information Utilities", "Financial Executive," Vol. 33, (Oct., 1965), p. 59.

rolls, accounts receivables, and other standard routines, affords the center little opportunity to write new programs, and gain a variety of experience; consequently, most data centers in schools and universities probably will be used for solving one-time problems and program "debugging."

Independently Owned Service Centers

Service centers independently owned, that are established for the sole purpose of selling computer time, currently do the largest volume of dollar business of any processing center. These centers range from the special-purpose to the general-purpose type of center. Special-purpose centers may only offer limited services such as payroll or receivables billing. This type of center is able to offer low rates due to their specialization. General-purpose centers can accept almost all work that is capable of being run on ADP equipment.

These independent centers work closely with computer manufacturers in the development of new equipment. The manufacturers often provide technical and financial support to these centers because they are important customers and the data centers expose the ADP equipment to many potential users who some day may be interested in installing their own equipment.

These centers also hire full-time qualified personnel who can increase the amount and the quality of services they provide. Unlike some other owners of data centers, the independent service centers engage in large scale advertising and perform feasibility studies for computer applications.

The Association of Data Processing Service Organization (ADPSO), organized by these service centers, promotes the exchange of ideas by centers and gives their members current information on computer applications. These service centers are also accumulating a large store of knowledge in the "software" phase of ADP which will probably insure them a place in the future as data centers.

Manufacturers of Equipment

The manufacturers of ADP equipment also operate a number of data centers. Most manufacturer objectives for operating these centers are characterized by the response to the following question which the writer asked J. H. Bivins, Manager of Data Center Division of the IBM Corporation.

1. Why do computer manufacturers operate data centers and who uses these services?

> The IBM Data Centers are run primarily as testing facilities for IBM customers. For example, when a person or corporation orders a computer, they are entitled to a pre-determined number of hours on a similar computer to check out their programs at no charge.

The following statement was made by the manufacturer of Univac computers regarding its policy in connection with the operation of their data centers.

> For business, government, and industry, Univac Data Processing Centers offer a complete and extensive roster of data processing services. Economical and speedy solutions to data processing problems at the Univac Data Processing Centers are insured by expert, personal

attention.[27]

The manufacturers that choose to operate data centers on a commercial basis have the benefit of more capital resources than most data centers, extensive "software" facilities, use of the sophisticated third generation equipment, and a direct outlet for its products. Figure 14 shows the Univac centers located in the United States. The two master centers are located in Phoenix, Arizona, and Mineola, New York.[28] These two centers contain the most sophisticated

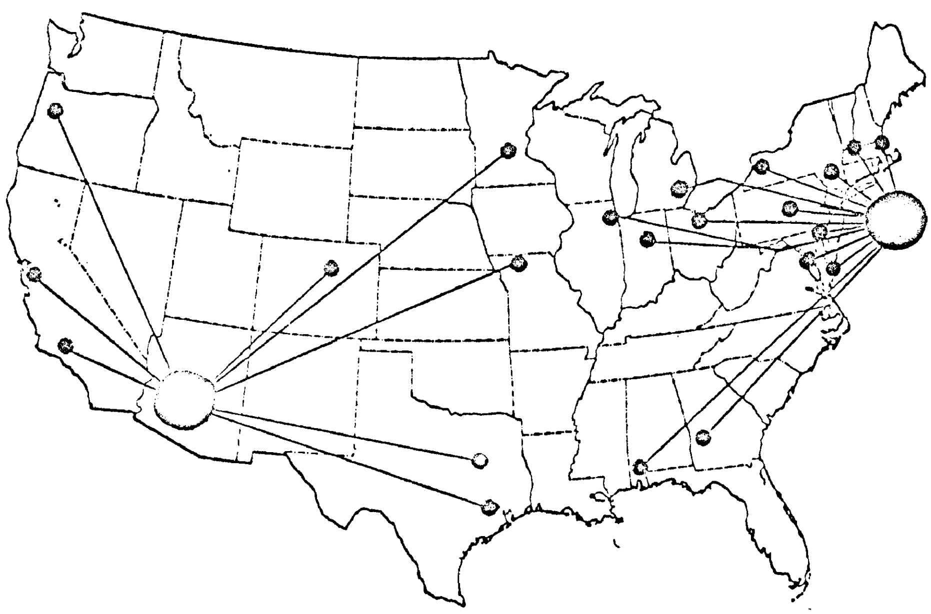

Figure 14. Univac Centers in the United States[29]

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[27] Univac Data Processing Centers: Programmed for Problem Solving, (New York: Sperry Rand Corporation).

[28] Ibid.

[29] Ibid.

third generation computers that Univac has and are connected to the small centers via tele-data lines.

Certified Public Accounting Firms

Another logical operator of data centers are Certified Public Accounting (CPA) firms. These firms have several advantages not shared by any other data center operator.

1. They are familiar with the flow of accounting data, therefore, the changeover from hand methods to machine operations can be accomplished with less errors, in a shorter time, and at a saving to the company.
2. Businesses requiring the services of CPA firms for audit, for tax returns, and for write-up work, in addition to service center processing, may be able to reduce their total bill by obtaining this service from a CPA firm that also operates a data center.

The Committee on Data Processing Centers of the American Institute of Certified Public Accountants made a survey to determine the effect of data centers upon individual and small firms of CPA's. The report stated that these small firms, on the average, derived thirty-three percent of their revenue from providing write-up work for their clients.[30] The firms

[30] Ralph F. Lewis, "Data Processing Centers and the CPA", Journal of Accountancy, Vol. 112, (July, 1961), p. 45.

that participated in this survey also stated that their clients are being solicited by service centers offering write-up service at lower prices. For these reasons, it seems likely that CPA firms will be forced into the operation of data centers.

In a recent article in the Journal of Accountancy, John E. Lennox, partner in a small CPA firm, reported some benefits his firm gained when they established a data center for their clients.[31]

1. Gross volume increased forty percent with only a nineteen percent increase in the staff.

2. The reports offered by the center were tailored to customers' needs because the staff had a greater insight into the needs of the companies.

Lennox declared: "It has been a real boon to our firm, both in improving the efficiency of our operations and as a source of additional business."

Lennox made the following comments on problems regarding the CPA's code of ethics which does not permit solicitation of business, and requires rigid maintenance of professional independence.[32]

> . . . we have not found that our service bureau operations have posed any threat to our professional independence. As the American Institute and many of the state societies have already ruled, when a CPA firm performing data processing services for its own or

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[31]John E. Lennox, "The Accounting Service Bureau: One CPA Firm's Experience," Journal of Accountancy, Vol. 118, (Nov. 1964), p. 50.

[32]<u>Ibid</u>. p. 53.

other firms' clients follows the established rules of professional conduct, there can be no conflict. The use of mechanical equipment to expedite the gathering or presentation of data does not in itself have any effect on the CPA's independence.

Another possible problem that has failed to materialize is that of getting enough business to keep the equipment busy. Even though we are in a sense competing with commercial service bureaus which can advertise, we have had no trouble whatever in adding names to our list of clients.

Most clients are recruited by word of mouth or by referral from other CPAs who have used or observed our ADP installation in action. Some referrals have been made by ADP manufacturers. Thus, our system has proved to be self-generating; that is, the work it produces creates the demand for additional work. Our regular clients are continually asking for additional services, and most of our outside clients have come back with more work for us after completion of the initial assignment.

Our advertising campaign consists solely of the services we render, and our only public relations man is the computer. So far they have done well by us.

IV. PROBLEMS OF DATA CENTERS

All operators of data processing centers are faced with many common problems that have to be overcome before data centers are accepted completely by the business community.

Resistance to the Computer

Man's ability to survive evolved from his ability to utilize tools rather than his physical strength. Automatic Data Processing often carries connotations of magic to people, because they regard it as a replacement for man's brain rather than a tool to be used by man. All computer experts realize that a computer cannot replace the human mind because it has the ability only to manipulate data within the limits of its program, i.e., the instructions devised by man. The machines are programmed to make decisions by comparing alternatives, however, even such comparisons are possible only within the limits of the computer's program. In recent years, educational institutions, data centers, and computer manufacturers have made attempts to educate interested parties in computer applications. However, much more education is needed before there will be complete understanding and acceptance of what a computer is--a machine capable of manipulating data at fantastic speeds by following human instructions contained in the program.

Much resistance to the computer comes from the rank of middle management. The fear of middle management is justified when the middle manager's job is one of making routine decisions. In order to use an ADP system effectively it is often necessary to include a number of routine decisions in the program so that the machine can automatically choose among alternatives. This resistance was evident in a study of three hundred ADP installations in twenty-seven major manufacturing companies. The study revealed that eighteen companies were not earning enough on their computers to warrant their use.[33] In all eighteen of these companies, it was found that top management had not begun to utilize the potential of the computer. In many of these same cases, it was further learned that middle management had been given control of the computer, and evidence of resistance by this group was apparent. Middle management is not necessarily the only occupation that suffers as a result of the adoption of machine processing equipment, but it appears to be the only group that is in a position to resist it actively.

Problems of Scheduling

The objective underlying the successful operation of data centers is to eliminate idle computer time so that the high fixed cost may be absorbed by as many users as possible. Scheduling the work for the center in order that the machines are always operating, often presents difficult problems, especially in punch card systems that lose time due to the human

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[33]Fortune, op. cit., (March, 1964), p. 108.

handling of the cards and the non-continuous processing. Center operators find that most clients want reports near the first of each month. To eliminate some scheduling problems, centers offer cheaper rates to clients who will allow their statements to be processed during the month. After a client has used the center, he might be persuaded to order supplementary reports such as sales and labor analysis prepared during the month. Another solution available to small centers is to have working agreements with larger centers so that data can be sent via tele-data for processing at peak load times.

The third generation computers eliminate many scheduling problems because of their ability to process different programs simultaneously. Most third generation computers that are of the on-line-real-time (OLRT) type and utilize time sharing have the following characteristics:

1. Simultaneous. A number of people use the computer at the same time.

2. Instantaneous. All users can receive responses from their inquiries within seconds, or fractions of a second, of the completed computation.

3. Independent. Different programs, services, and devices can be in use separately or in combination during any given period of time.

. General Purpose. No restriction is placed on the kind of program or the application under the time-sharing system.[34]

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[34]Jules I. Schwartz, Introduction to the Time-Sharing System, Systems Development Corporations, Santa Monica, Calif., (Sept. 14, 1964), p. 2.

Lack of Skilled Workers

The rapid growth of the computer industry has created a large demand for personnel skilled in many phases of computer applications such as: programmers, systems design, and machine operators. The shortage of skilled workers is handicapping data centers which are attempting to expand their volume of business. The answer again is the expansion of educational facilities to teach the required skills.

Computer manufacturers have established numerous schools to train programmers and machine operators. Generally an individual with a high school education can qualify for either of these jobs with one to four months training. The shortage of system designers is greater because this position usually requires a college level education. Some colleges are meeting this challenge by requiring that business students take courses in data processing as a prerequisite to graduation. Other schools, such as Carnegie Institute of Technology, have changed their curriculum to meet the challenge. Time said about the "new look" at Carnegie Tech.:

> The new stress is on the Big Picture...one of the leaders in this area is Carnegie Tech's Graduate School of Industrial Administration in Pittsburg... . It is the first graduate school to stress behavioral sciences, higher mathematics, electronic data processing and managerial careers.[35]

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[35]"Man and Machine at Carnegie Tech.", Time, Vol. 83, (April 3, 1964), p. 52.

Need for Security

Competing companies might use the same center, therefore it is essential that the data and the reports be kept confidential. In data centers where stored information is kept on punch cards and off-line tapes, they should be locked up when not in use. Several procedures are feasible; procedures that will prevent misuse of records. One solution is the establishment of a storage area with a person responsible for all data; no data to be released except by written authority. If information is stored in a format readable only by the machines, a division of labor would permit careful control over these data, because the persons in charge of these data would not have access to machines that can print it in standard readable format. In such systems, the best control is accomplished by having dependable and trustworthy employees, and by having carefully developed internal control procedures.

A different type of security problem is posed when an on-line-real-time system is in operation; an operation in which a number of programs are in process simultaneously. Data are sent into the system and are extracted from the system by users connected directly to the computer. The center must take precautions to see that only the authorized parties are allowed access to the filed data. This is usually accomplished by programming the computer to respond only after a special identification number has been received.

Loss of Information

Most modern computers store information in the form of electric impulses. This form of storage is very desirable because it allows the computer to recall, operate on, and refile data in fractions of a second. Procedures to prevent the loss of data in such systems are mandatory because a minor error in a program could cause the data to be released or to be manipulated into a useless form. To prevent such a loss, centers usually retain all data in other forms--punch card, paper tape, or magnetic tape--until new programs are completely tested. This is not a common problem but one that might cause irreparable damage if safeguards are not provided.

Loss of Customers

The initial cost of setting-up the records of a company for a machine processing system is dependent upon the type of accounting system that the business is using. Generally, a chart of accounts is set up, numbers assigned systematically to the different accounts, input forms developed, along with other modifications, as preliminary steps in organizing the records for machine processing. Data centers often assume this expense to entice the customer to subscribe to the service.

To cover this expense, the center normally charges a higher service rate than usual. Mr. Art Ayers, owner of Montana Data Processing, Helena, Montana, stated that the loss of customers whose records have been set up for a data processing system was one major problem of small centers. This is true because businesses find that other centers will provide the service at a lower rate once the records of a company have been prepared for machine processing.

'. ADVANTAGES OF DATA CENTERS

There are numerous reasons why companies use the services that data centers provide. The reasons for the use of data centers and some of the services which they provide are discussed in the following section.

Production of Reports During Business Peak

Many companies find that their sales fluctuate due to seasonal demands, fads, or changes in economic conditions. These companies are often forced to hire more office workers to handle the increased paper work during periods of increased business activity. In many cases the cost of hiring and training temporary employees is quite expensive. A partial solution to the paper work problem during peaks in business activity is the use of service centers to prepare some of the more time-consuming and repetitious reports such as payrolls and receivables billing.

If a service center is called upon to prepare only a few reports during periods of peak workload, the input data is generally precoded into machine readable format at the data center because it usually does not pay a company to rent or buy conversion equipment for such a small volume. (The latter assumes that neither optical nor magnetic characters are used, nor other media that can be interpreted directly by an ADP system.) The processing of payrolls would be another service that a data center could provide. After a payroll program has been placed into storage along with the historic (or constant) information such as wage rate, employee number, etc., the amount of input needed to prepare the payroll for each pay period will be limited to the number of hours worked and jobs worked on. Centers preparing payrolls often prepare the tax reports for the government, the payroll checks, reports allocating labor burden, and other related reports, because once the information is in the system it can be processed very economically. Even companies which have their own ADP equipment often use data centers when their own machines are being fully utilized to prepare other reports at peak load times.

Preparation of Most Financial Reports

Many companies employ some form of machine data processing to prepare their financial reports. Although new or small businesses often have a need for ADP, they normally do not have the volume, personnel, floor space, nor the funds to warrant the installation of expensive equipment either by leasing or buying it. These companies are the primary customers of data centers, and data centers often prepare the entire accounting records for these clients. Figure 15 illustrates a number of ways that data and reports can be transmitted when data centers handle the complete accounting operation of a company, depending upon (1) type of equipment owned by the center and (2) type of equipment used by the client.

CUSTOMER		DATA CENTER
Key punch, paper tape as by-product of adding machine →	Data mailed in batches every week. →	Punch card system
Report ←	Reports mailed weekly unless requested in advance. ←	
Key punch, paper tape →	Data sent in as soon as prepared in machine format via tele-data →	Complete Electronic System (ON-LINE) Data accepted from source and processed as soon as possible.
Report ←	Data sent back when processed delay depends on computer load ←	
*Key punch, paper tape →	Data sent in via tele-data →	OLRT-time sharing system
Report ←	Reports returned seconds after requested ←	

*Clients using this type of service may be able to put data into the system at all times, but may be limited to certain periods of time when they can request a feed back. This service allows more users to participate on a time-sharing OLRT system. Cost to the users is also reduced.

Figure 15. Different Methods of Data Transmission when the Data Center is Handling the Complete Accounting Operation

When data centers prepare the entire accounting records for companies, they are often able to prepare special reports economically because all information needed is already in the ADP system.

Production of Special Reports

Certain reports can be valuable to business managers--profit contribution by each salesman, inventory turnover by specific item, sales and profits by customer, and profit by product. If these reports are prepared by manual methods, the cost to produce them might outweigh their advantages.

Area sales analysis. If a company selling a large number of low-priced products were to attempt to determine the best markets for products by analyzing all their invoices and by preparing summary schedules by hand, the cost would probably be prohibitive. The same reports can be prepared by an ADP system using the following procedure. Each salesman is issued mark-sensed cards which have spaces for marking in the following information: product sold, dollar sales, quantity, area, and the date. The salesmen complete the cards for each order and send them in with the orders to the home office. The total sales on the cards can be compared with the total of the purchase orders received from the salesmen to establish accuracy and control. This type of input can then be sent directly to the data center and a report on sales by area as well as sales by individual salesmen can be prepared accurately within a short period of time, and for a fraction of the cost that would be required for manual preparation. With the advent of new input media such as optical scanning, companies will find that the data centers can prepare many reports even when volume is low, and at a very economical rate.

Solutions to Business Problems

Operations research is concerned with the mathematical aspects of company management such as -- efficient planning, and inventory control -- and has led to the development of a number of new methods of decision making. In most cases, the mathematics involved in operations research is complex or detailed enough so that a computer is the only practical means of arriving at a solution. A discussion of two common operations research methods should serve as illustrations: linear programming and critical path analysis.

Linear Programming. A complete discussion and explanation of Operations Research (OR) linear programming is beyond the scope of this paper, however, an illustration of a simplified problem permits an example of the usefulness of linear programming to business managers.

Facts: A manufacturer produces two products, X and Y; X can be sold at a profit of $20.00 a unit, and Y can be sold at a profit of $30.00 a unit. The production equipment of the manufacturer limits the production of product X to 7 per day and product Y to 5 per day. Another limitation is introduced because of the manpower needed to produce products X and Y.

The manufacturer has 12 production men. One man day is required to produce product X and two man days are required to produce product Y. An assumption is made that all products manufactured can be sold.

Problem: By staying within the limits given, what combination of product production will yield the highest profit?

Solution: (Graphical) When dealing with two variables, the solution can be gained by two methods--graphically (the graphical solution does not always yield the exact solution; it is dependent upon the accuracy of the graph), and mathematically. The graphical solution is impractical to use when there are more than two variables. The graphical method is illustrated here because of its simplicity. The mathematical solution would be the method the computer would be programmed to solve. Equipment limitation on production are indicated by the red lines on the graph, Figure 16.

$$X \leq 7$$

$$Y \leq 5$$

Manpower limitations on production are indicated by the black lines on the graph.

$$X + 2Y = 12$$

Some possible combinations of production are presented below:

$X = 12,$	$Y = 0$	$(12 + 2\ (0) = 12);$	M_1
$X = 10,$	$Y = 1$	$(10 + 2\ (1) = 12);$	M_2
$X = 8,$	$Y = 2$	$(8 + 2\ (2) = 12);$	M_3
$X = 6,$	$Y = 3$	$(6 + 2\ (3) = 12);$	M_4
$X = 4,$	$Y = 4$	$(4 + 2\ (4) = 12);$	M_5
$X = 2,$	$Y = 5$	$(2 + 2\ (5) = 12);$	M_6
$X = 0,$	$Y = 6$	$(0 + 2\ (6) = 12);$	M_7

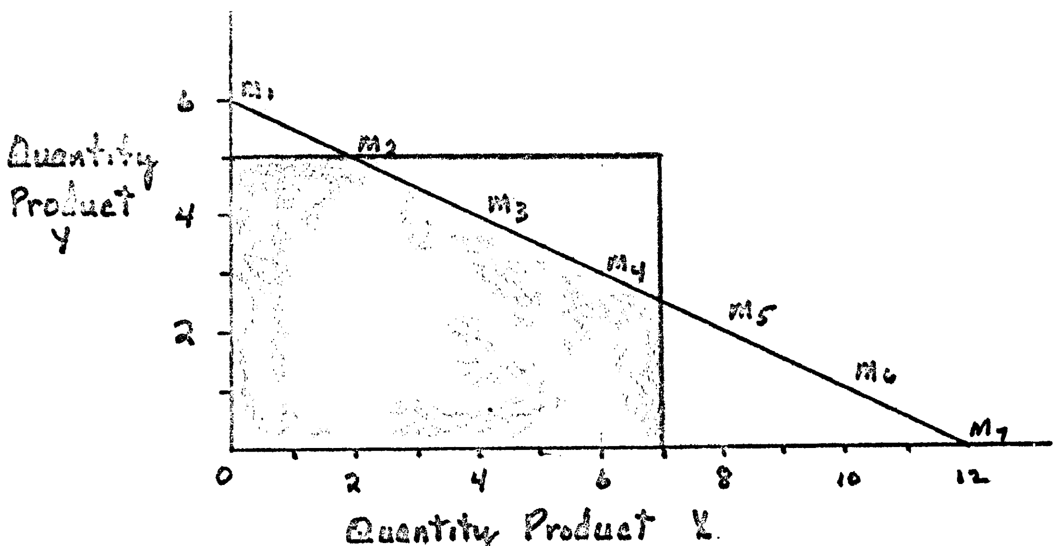

Figure 16. Limits on Production[36]

The limitations on equipment and manpower on the graph show that the pentagon indicated by the shaded portion of the

[36]Henri Theil, John C. G. Boot, Teun Kloek, Operations Research and Quantitative Economics, (New York, N. Y., McGraw-Hill Book Company, 1965), p. 8.

graph, Figure 16, is the only area in which it is possible to produce the various combinations of X and Y. The next step in the graphical solution is the arbitrary selection of several possible profit figures and then to determine the production mixes which will produce the profits selected.

Profit:	\$60.00
	(X = 3, Y = 0)
	(X = 0, Y = 2)
Profit:	\$120.00
	(X = 6, Y = 0)
	(X = 0, Y = 4)

By graphing the production which results in profits of \$60.00 and \$120.00, as shown in Figure 17, it is noted that the lines P-60 and P-120 are parallel. The parallelism is observed because the profit ratio is constant 3::2. The next step is to extend a line parallel to lines P-60 and P-120, as far from

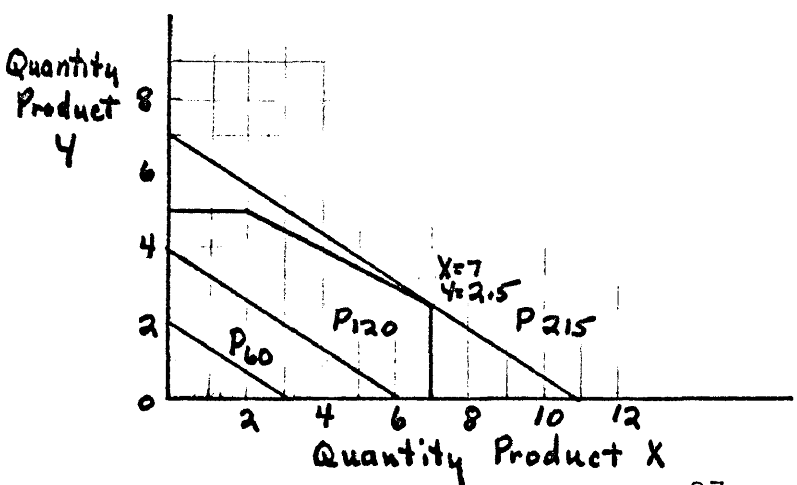

Figure 17[37]

[37]Ibid., p. 9.

the origin of the graph as possible, yet staying within the production limits. Extending the line, as shown in Figure 17, to intersect at coordinates X = 7, Y = 2.5, illustrates the highest possible profit for the defined problem.

X = 7	Products each day	\$140.00
Y = 2.5	Products each day	75.00
		\$215.00

The linear programming problem is simplified, however, some practical problems involving several variables can be solved on the computer in a few hours whereas a mathematician would need several months to arrive at a solution.

Solution: (Mathematical) The mathematical solution to this problem shown below is the method the computer would be programmed to solve. A wide range of linear programming programs for computers have been prepared by hardware manufacturers and are made available to the purchasers of their equipment. (Service centers can also obtain these programs for their clients.) In most situations more than two variables are present, thus the mathematical method calculated by the computer is the only practical means of arriving at a solution. The mathematical method employs the simplex technique which introduces another variable called a slack variable. By using a slack variable, the equations can be expressed as equalities rather than inequalities, e.g.

Constraints $X + 2Y \leq 12$
$X \leq 7$
$Y \leq 5$

Slack variables R, S, and T.

$$X + 2Y + R = 12$$
$$X + S = 7$$
$$Y + T = 5$$

The simplex technique is characterized by the following two properties:

. Initially, one must find a non-negative solution with the (decision) variables equal to zero. This is usually the solution in which all decision variables are equal to zero and all slack variables are positive. In the example X = Y = 0, R = 7, S = 5, T = 12. In other words, one begins at the origin, where no products are being produced.

2. One continues by switching variables which are zero (X, Y) and variables which are positive (R, S, T). In each step one positive variable is exchanged for one zero variable, in such a way that the non-zero variables do not become negative and in such a way that the value of the objective function increases (at least does not decrease). If this last condition cannot be fulfilled--if all possible switches decrease the value of the objective function--the solution has been found.

These are the basic principles of the simplex technique. Usually there are from m to 2m (m = number of variables in problem) switches before the solution is reached. Proceeding according to the simplex rules, one finds consecutively (with p = profit = 20X + 30Y).

(1) X = 0, R = 7, S = 5, T = 12, Y = 0
(The origin O, P = 0)

(2) X = 0, Y = 5, R = 7, S = 0, T = 2
(The point D, P = 150)

(3) X = 2, Y = 5, R = 5, S = 0, T = 0
(The point C, P = 190)

(4) X = 7, Y = 2.5, R = 0, S = 2.5, T = 0
(The point B, P = 215)

Thus the maximum value has been found after four steps. Using the simplex technique, one moves from one corner point to an adjacent corner point in such a way that the value of the objective function increases, as illustrated in Figure 18.[38]

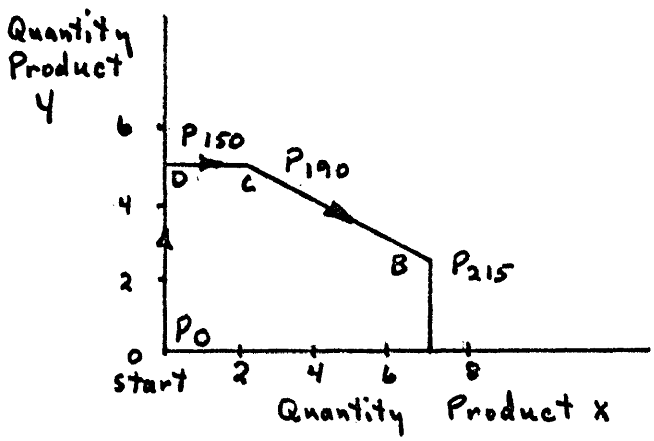

Figure 18. Simplex Solution[39]

Critical Path: The critical path method (CPM) is used to determine the best way to produce a product when there are a number of steps involved. It has been most useful in the construction of homes, ships and industrial plants. It was estimated that CPM allowed the Polaris submarine to be completed two years ahead of schedule. A simple illustration or a problem and how CPM can be applied to solve it is pre-

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[38] Ibid., p. 16.

[39] Ibid., p. 17.

sented below.[40]

Facts: The manufacturer produces wigits and the production consists of nine different processes. Some of the processes must be completed before others can be started. The net work diagram in figure 19 shows the time required for the different processes and the order in which they must be performed.

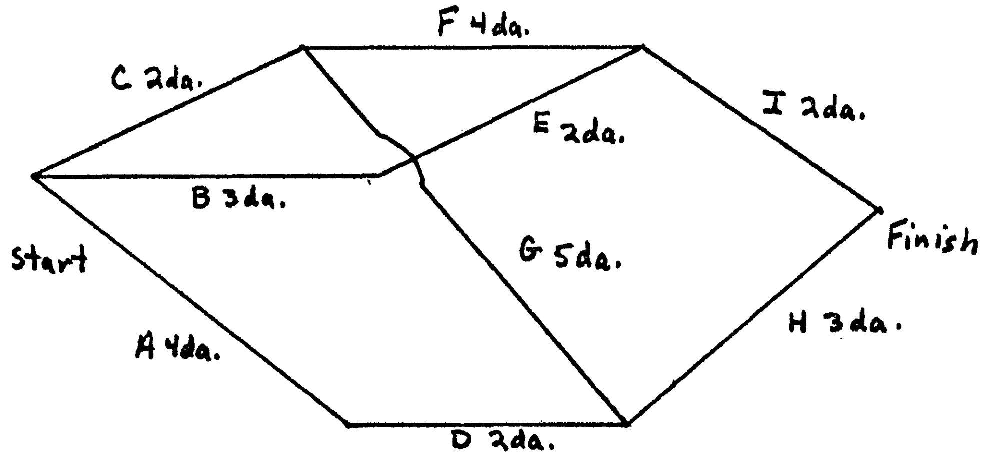

Figure 19. Network Diagram[41]

Problem: Determine in what order the processes should be run to permit completion in the shortest time period.

Solution: ... The first step consists of analyzing the various subtasks and determining their respective performance times. These data are then used for the construction of a net work, (Figure 19), the nodes of which are formed by the completed subtasks. Connected nodes are formed by subtasks which necessarily have to be completed in a certain order; other subtasks can be tackled simultaneously.

This network shows that completion of

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[40] Ibid., p. 48.

[41] Ibid., p. 48.

A takes 4 days, and of H, 3 days. It also follows that C must be finished before starting F or G, however, the tasks F and G can proceed simultaneously, as in the cases of A, B, and C. Before starting on H, both D and G must be completed, etc.

The critical path of this network must then be determined. The critical path is defined as a series of tasks so arranged that when a delay occurs in the performance of one of them, the completion of the whole project is delayed. On the other hand, if one of the subtasks on the critical path is finished more quickly than expected, the whole project is completed sooner. The critical path in such a network is the longest path (measured here in days) from start to finish. For example, it is evident from the network that one needs at least 7 days before starting on task H. This is true because the road CG requires 7 days and because one cannot start H before G is completed. The road to H via AD requires only 6 days which means that tasks A and D are not critical. Some delay in their completion is possible without influencing the total time required to complete the project. C and G, however, are critical tasks. The critical path is indicated in Figure 20 by dashed lines, and the non-critical tasks are shown as solid lines. In this simple case the critical path has been determined by observation. In complicated cases the path can be determined--indeed, very simply and quickly--only with an electronic computer.

The most obvious use of the critical-path method is to employ more men and or machines for those subtasks which are on the critical path. The resulting economy more than compensates for the extra cost.[42]

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[42] *Ibid.*, p. 48.

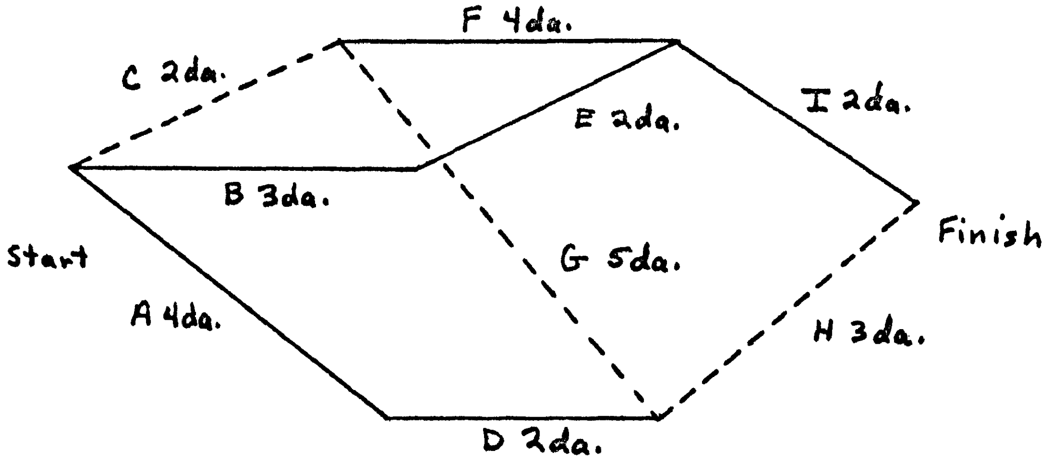

Figure 20. Network Diagram Indicating Critical Path[43]

The DuPont Engineers and the Univac Data Centers processed a critical path network for the construction of a ten million dollar plant on a Univac 1107 computer. It was estimated that the reduction in the time it took to build the plant saved DuPont one million dollars. Univac Data Centers are designed to handle critical path networks containing a maximum of 2000 tasks, and the Univac people believe that their computer application of the critical path system provides management with the capabilities to:[44]

1. Report progrss against original plans and objectives.

2. Forecast potential bottlenecks.

3. Replan and update projects.

4. Coordinate multiple projects.

5. Pinpoint responsibilities of project participants.

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[43]Ibid., p. 49.

[44]Univac Data Processing Centers: Programmed For Problem Solving, op. cit.

6. Determine inter-relationships between jobs.

7. Indicate feasibility of project implementation based on resource requirement and availability.

8. Indicate optional schedules for expediting a project.

9. Compute probability of meeting schedules.

10. Evaluate alternate strategies.

11. Produce bar charts for graphic display of schedules and job progress.

Other Uses of Data Centers

Business games. Simulation is defined as the construction and operation of a physical, mathematical, or symbolic model that has the characteristics of the actual situation. Most simulation is accomplished by using mathematical models which are a series of equations that represent all the definable internal and external factors affecting any event. Models of this type were developed that could simulate the operation of two or more companies that are competing against each other. These types of models are known as management or business games. The business departments of many colleges and universitites are using the games as aids in helping students to understand the effects of price changes, plant investment, advertising expenditures, research and development expenditures, etc., on the operation of a company. Such games (models) are also used by many companies to supplement on-the-job training for new employees.

Most models and all the complex ones are programmed into the computer and the solutions calculated by computers. Some games can be operated manually, however, the number of variables in the model is restricted. Figure 21 illustrates the decision sheet used in the Marksim business games.[45]

Marksim developed by Professors Paul S. Greenlaw and Fred W. Kniffin, of the School of Business Administration, Pennsylvania State University, is a widely used business game. This game can be used to simulate the operation of three companies for three months on an IBM 1620 in nineteen minutes; the 1620 prepares a balance sheet and an income statement for each company. The computer can simulate and prepare reports for each additional industry of three firms in five minutes. The manual operation of this model would take approximately five hundred man hours.

Dr. Hunt, a professor at the University of Montana, who has used business games as a teaching aid, believes that the main benefit of business games is that:

> ... they simulate the challenges and problems that today's executive faces, thus providing a realistic setting in which the player can develop and sharpen his decision-making skill, ... They provide for a better evaluation of the abilities and potentialities of those involved.[46]

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[45]Greenlaw, Paul S. and Kniffin, Fred W., Marksim, (Scranton, Penn.: International Textbook Co., 1964), p. 34.

[46]Lawrence J. Hunt and Walter L. Brown, Jr., "Business Simulation, A Technique for Updating Management", Montana Business Quarterly, Vol. 3, (Fall, 1965), p. 22.

MARKSIM
DECISION FORM B
IBM 1620

___ ___ Period	___ Firm	___ ___ Industry
9 10	20	29 30

OPERATING DECISIONS	
___ ___ ___ ___ 34 35 36 37	National Advertising ($ Thousands)
___ ___ ___ ___ 44 45 46 47	Debt Payment ($ Thousands)

MARKETING RESEARCH INFORMATION	
	(1 = Purchased; 0 = Not Purchased)
___ 51	Industry National Advertising
___ 52	Industry Advertising Allowances to Retailers
___ 53	Company Potential Sales for This Period
___ 54	Market Potentials for Next Period
___ 55	Own Share of Market

OPERATING DECISIONS	
___ ___ ___ 8 9 10	Quality ($)
___ ___ ___ 18 19 20	Price ($)
___ ___ ___ 25 26 27	Production (Thousands)
___ ___ ___ 35 36 37	Shipments to Distribution Centers (Thousands)
___ ___ ___ ___ 44 45 46 47	Advertising Allowances to Retailers ($ Thousands)

Figure 21

Miscellaneous Uses. Companies that are investigating the possibility of installing their own equipment often purchase service center time to experiment and to evaluate the potential value of an ADP system for their firm. Some firms utilize a data center to set up their accounts and to familiarize their staff with machine processing as a step in the plan for a future installation.

Production of Tax Returns.

The Computer Science Corporation of El Segundo, California, developed a program that enables a computer to prepare tax returns. The Computer Science Corporation believes that the advantages of computer prepared tax returns warranted setting up a separate corporation, Computax Corporation, to operate a service center specializing in this operation. The services are offered to professional tax men only. Mr. Stern, the project manager, lists the areas in which Computax can materially assist the professional tax man.

1. Performing all calculations for:
   A. FICA tax over-withheld.
   B. Dividends received exclusion.
   C. Retirement income credit.
   D. Foreign tax credit.
   E. Lowest tax, including alternative tax method for capital gains.
   F. Investment tax credit.
   G. Tax reduction due to income averaging.

2. Checking returns for missing information such as name, address, social security number, occupation--and for any unanswered questions regarding travel reinbursement, previously filed returns, etc.

3. Checking for inconsistency of information. The computer will immediately catch such inconsistencies as a single taxpayer's return showing a social security number of a wife, or a rent schedule filed with no depreciation schedule, etc.

4. Revealing areas for potential tax reduction, such as medical deductions for taxpayers over sixty-five years of age, retirement income eligibility, the comparative advantage of filing separate or joint returns.

5. Relieving the accountant of many clerical procedures involved in preparing returns.[47]

Computax Corporation supplies its clients with special forms that allow the tax man to interview his client and to fill out the forms at the same time. These forms are then sent to the data center, key punched and the return is completed. The main advantage to a professional tax man is the saving in time as indicated by Figure 22. Centers of this type could become an integral part of the business community because of the additional savings realized through specialization.

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[47]Alan A. Stern, "Tax Returns-By Computer", Journal of Accountancy, Vol. 119, (Feb. 1965), p. 23.

	Time Spent, in Hours Accountant	Clerk
1. Gathering and assembling all data on work sheets, excluding the actual preparation of the return itself.	1.7	.1
2. Preparing return from all information available.	1.1	
3. Reviewing for theory.		
4. Reviewing calculations.		
5. Preparing, reproducing and collating final returns.	.7	1.1
	4.3	1.5

Figure 22[48]

Time Saved Through Use of Computer by Professional Tax Person

[48] *Ibid.*, p. 24.

VI. FACTORS INVOLVED IN ACQUIRING ADP SERVICE

The advantages offered by automatic data processing are different for nearly every company. The decision to convert a manual record-keeping system to a machine system should be made only after a careful study of the particular needs of a firm. The study often is referred to as an ADP feasibility study. The ADP feasibility study should determine the following factors: The value of ADP to the company considering current and future needs and the cost of acquiring and using ADP.

The following criteria are the steps that a feasibility study probably would follow to determine whether a firm can use ADP efficiently.[49]

1. Study the costs of clerical help, floor space, present equipment, and personnel problems such as turnover and training. Costs of personnel may not make any difference now, but five years from now they might. Computer costs are going down while salaries are going up.

2. Weigh the importance of timeliness and accuracy for the reports received. Generally reports can be prepared more frequently and accurately if ADP equipment is used, however, the value of these reports must be considered in terms of their costs.

3. Determine what information is needed. Can machine processing give better information than is already being supplied? Some important information such as the number of markdowns, markdown cancellations, markups, etc., can only be prepared economically by machine processing.

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[49] *Merchandising Week*, *op. cit.*, p. 14.

Another factor to remember is that once the original information is obtained, a multiple of reports can be prepared from the original data; reports impossible to achieve with manual methods except at prohibitive cost.

4. Define in detail the present record-keeping operations of the firm and decide whether such operations are adequate to serve the firm in reference to anticipated growth.

5. Determine the accuracy of source data before a decision is made to switch to ADP. If the source data is unreliable and if internal accounting controls are poor, a data processing service will become nothing more than a high-speed error producer. The information received is only as good as the information transmitted. Computer technicians say: GI - GO (Garbage-in Garbage-out).

6. Evaluate present procedures in a methodical and accurate fashion. Mistaken cost estimates can be costly. The following steps should allow a firm to prepare cost estimations:[50]

   Prepare procedures showing processing steps required for each operation.

   a. Record actual volume for each operation.

   b. Record equipment time required to perform each operation (billing, typing) and clerical time required for each step.

   c. Total the equipment time for each application.

   d. Total the clerical hours spent on each application.

   e. Compute actual cost for each application.

   f. Project expected future volume and required time for each processing step.

   . Compute expected equipment and personnel costs by application, and compare to actual costs.

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[50] *Ibid.*, p. 14.

. Factors affecting conversion costs:[51]

a. Is the present accounting method manual, machine, punched card, or some other type of system?

b. Are accounts numbered? Are products numbered or coded? Are salesmen or branches numbered; how many? How many products and accounts? How many open accounts? How many inactive accounts? Is customer name and address information current? Are invoices numbered?

The preceding criteria do not include all the factors that a feasibility study might contain, but does present a good idea of the problems involved.

Many variables affect the cost of ADP and some variables are almost impossible to measure in terms of dollars. In many cases, the final decisions have to be based upon intangible factors, and involves a risk, however, the element of risk might very well be justified on the basis of expected increase in efficiency, accuracy, control, and eventually in profits. The risk factor is usually decreased considerably by using the services of data centers. This decrease occurs because if ADP proves to be unwise, the investment in expensive equipment or equipment lease contracts is not lost.

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[51]*Ibid.*, p. 14.

VII. FACTORS INVOLVED IN CHOOSING A PARTICULAR DATA CENTER

Once the decision to purchase ADP services from a data center is reached, a firm is faced with deciding which center can provide the best possible service. The following criteria can be helpful in rating a particular service center.[52]

1. Decide what is expected from a service bureau in terms of finished reports, responsibility, and integration into the activities of the company. This decision is necessary to determine the relative merits of different service bureaus and the value of their services.

2. Obtain competitive bids. In terms of personnel, experience, and prices, service bureaus are all different. Securing competitive bids aids in obtaining the right bureau for specific needs.

3. Organize a committee within the company to evaluate the service bureau proposals. The committee should represent the managers of the accounting, production, and marketing departments as well as the top management of the company. The proposals should be reviewed for technical competence, price and schedule, legal commitments, and completeness.

4. Investigate the bidders. Their references should be checked, and their technical reputation considered. To protect the firm it is worthwhile to assemble a file containing such information.

5. Compare the services offered. Will the service bureau supply the entire project itself, or will part of it be subcontracted? Is this desirable? What other auxiliary or additional services are wanted? Will this service bureau be able to provide them? When ready for extensions or changes, will this service bureau be able to assist? Is a competent sales representative assigned to

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[52]Arnold P. Smith, "Choosing A Service Bureau", *Computers and Automation*, Vol. 13, (Dec., 1964), p. 23.

your account? Will he be responsive to the needs and requests of your firm?

6. Consider the responsibilities of the project. The service bureau will require the cooperation of your personnel and access to your source information. The firm and the service bureau should agree on all such points.

7. Be certain that agreements on what is expected of the service bureau--context and format of reports, rates, schedules, methods to be used, personnel commitment, and lines of responsibility are supplied the contracting firm. This information should be detailed in the contract.

8. A careful reading of the terms and conditions of the service bureau contract is necessary. A legal department should inspect contracts and should know what the clauses mean.

9. Examine the types of contracts available. The three most common are fixed price, time and material, and cost plus fixed fee or percentage. Specify allowable and non-allowable cost (sales, travel, telephone, supplies, and administrative expenses). In most cases, the best business contract for both parties is the fixed price type. Everything is known in advance, and only mutually agreed upon changes or additions can alter the initial agreement. If the problem is not defined fully or is of extreme magnitude, however, the fixed price contract is probably not feasible at first. Nevertheless, a fixed price contract usually can be developed during the course of the project.

10. Interview the service bureau personnel who will be working on the project. Do they show knowledge of the problem? Do they have good computing and application experience? How do they handle projects? What are their lines of responsibility? What reporting do they have? What billing information will be received?

11. The lowest bidder or the service bureau with the most attractive proposal is not necessarily the best choice. Various technical, administrative, and procedural considerations are just as important as price and appearance. Is the service bureau responsive to demands and does it offer real service? Does it have the necessary exper-

> ience, personnel, and operating procedures to handle the project?

The Research Institute of American recommended that a firm:

> . . . use the same approach and standards in dealing with a Data Center as you do with any other vendor or service firm. Don't expect the glow of good personal relations to make up for inconvenience and errors. And don't let the aura of electronic wonderment blind you to hard-headed dollar considerations. There's only one test of the service center: Is it doing the job more efficiently or at lower costs than would be possible in your own office?[53]

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[53]"How to Choose and Use an Outside EDP Center", The Research Institute of America, Inc., New York 17, N. Y. (Sept. 4, 1963), p. 1.

VIII. SUMMARY AND CONCLUSIONS

Summary.

The first commercial electronic computer, the Univac I, was put into use seventeen years ago. Since 1957, the number of computers in operation increased from less than one hundred to approximately twenty-three thousand.[54] Most experts believe that this increase is only the beginning and that computer technology in the near future will make obsolete modern computers just as the modern ones did their predecessors. Changes in computer technology, that are in sight, can be cited: decreased cost to users due to more flexible computers, decreased physical size, improved direct access storage units, increased methods of input such as human voice and standard source documents. Many innovations that appeared to be unrealistic a few years ago have since been placed on the commercial market.

The biggest challenge is in the development of the "software" phase of computer systems. The ability to write programs and to set up systems which permit the current updating of valuable business information so that it is available in critical decision-making times, still has to be solved. These challenges are being met by not only the American computer manufacturers but also by many other manufacturers in indus-

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[54] Hunt and Brown, op. cit., p. 14.

trial nations of the world. The estimated number of computers in use are approximated at around twenty-three thousand, however, the number of users is higher because of data centers.

Data centers appear to be becoming an integral part of the business community because of the type of service that they are providing. For example:

> A small retailer bought from hundreds of suppliers. Dollar volume was low, but item volume high. He gave the job of aging, discounting, and preparing checks for his accounts payable to a service center. He not only saved the time of figuring and writing hundreds of checks a month, but also picked up an additional $1,500 a year in discounts he normally would have missed.[55]

In 1962, the Small Business Administration reported that fourteen thousand small businesses failed and that a material factor in a large number of these failures was the poor control over inventory.[56] The inventory problem is one area in which ADP systems can be of great benefit to companies because the system provides a company with current inventory information: turnover, high and low quantities, etc. A St. Louis automobile dealer believed that his inventory investment was too high and asked a data center to automate his inventory control. After the data center organized an inventory control system the auto dealer cut the average number of

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[55]"A New Look at Data Processing Service Centers", Modern Office Procedures, Vol. 8., (Dec., 1963), p. 19.

[56]"Small Businesses, Big Pitfalls", Administrative Management, Vol. 24, (Aug., 1963), p. 66.

parts in the inventory by seven hundred units and decreased the dollar value of the inventory by $12,000; at the same time, monthly sales jumped $21,000. The average monthly service charge of the data center was $290.[57]

Computers are also making inroads in business management as shown by a recent survey by the American Management Association. Figure 23 shows where the computer information is used in managing.

ADP has provided many companies with accurate, timely, and special reports; services which manual operations cannot provide. The cost and value of ADP should be determined before the adoption of ADP service, although data centers have permitted more companies to procure the use of ADP because of lower cost and less risk.

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[57] The Research Institute of America, Inc., op. cit., p. 1.

(Percentage of firms using computers in each area*)

	(1)	(2)	(3)	(4)	(5)
PLANNING					
Forecasting	68	55	42	35	36
Evaluating Progress	62	51	61	32	34
Setting Objectives	55	40	42	32	28
Allocating Resources	26	35	32	23	28
Seeking New Products, Companies, Markets	47	16	14	10	8
CONTROLLING					
Measuring Performance	62	63	64	40	60
Setting Standards	36	46	42	30	38
ADMINISTERING					
Decision Making	54	58	54	46	39
Co-ordinating	32	33	31	22	26
Directing	42	43	39	23	33
Communicating	42	35	37	25	25
Delegating	14	14	16	12	12

(1) Sales and Customers
(2) Goods Produced
(3) Finances
(4) Materials Purchased
(5) Man-power

*Figures apply to 103 firms in durable good manufacture.

Figure 23[58]
Where Computer Information Is Used In Managing

[58] Norman Ream, "Computers: Doing Better Than Expected", Steel, (March 8, 1965), p. 26.

<u>Conclusions</u>.

Richard Sprague, Director of Computer Systems, Touche, Ross, Bailey and Smart, CPAs, stated that: "By 1970, all electronic data processing systems will be of the on-line-real-time variety."[59] Most computer experts agree with Sprague's opinion on the trend toward the increased use of OLRT systems.

The benefits that accrue to a company that has been able to integrate an OLRT computer system so that it coordinates the discipline functions of management, marketing, budgeting, and production has been clearly demonstrated by Westinghouse Electric Corporation's OLRT installation; the benefits are listed below.[60]

1. Prior to the adoption of the system it took an average of five days to fill an order, now orders are filled in fifteen minutes regardless of origin.

2. Due to the lag in feedback of sales and inventory information, Westinghouse found itself out of stock on a quarter of the orders received; now Westinghouse is out of stock only on one out of twenty orders.

3. "The Treasurer's office has been made happy by all kinds of savings. Cash flow has been speeded up by five days . . ."[61]

. The computer also does all the bookkeeping; this reduced operating costs by more than $200,000 a

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[59]Richard E. Sprague, <u>Electronic Business Systems</u>, (Ronald Press Co., New York), 1962, p. IV.

[60]Carl Rieser, "The Short-Order Economy", <u>Fortune</u>, Vol. 66, (Aug., 1962), p. 90.

[61]<u>Ibid</u>., p. 92.

year in one factory alone.

5. "Westinghouse, like any large industrial company, has a melange of normal trade discount structures for its thousands of products. It is also changing prices constantly. In pre-computer days, there was always a lag between the time a price change was announced and the time the news got to all the 100-odd Westinghouse sales branches. Now the computer gets the news immediately and applies the new price at once. As a result, Westinghouse realizes an average of about one-half of one percent more on the price of each item.[62]

6. Better inventory control ". . . has cut over-all inventories by twenty-five percent, and has leveled out seasonal peaks and valleys on the production lines."[63]

Companies that cannot afford to lease or buy ADP equipment with OLRT processing capabilities will usually be able to procure this service at data centers. Data centers that have third generation computers can offer OLRT processing to a large number of users because these sophisticated systems have the following characteristics:

1. Simultaneity--A number of people use the computer at essentially the same time.

2. Independence--Work carried on at a user station is not a function of work at any other station.

3. Immediacy--To all requests for a computer response, the response comes within seconds (or less) of the completion of the computation required for the response.

4. General-Purpose Access--No restriction on the type of application or resource exists. Essentially anything that is "programmable" on the computer

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[62] *Ibid.*, p. 92.

[63] *Ibid.*, p. 93.

can be made available through time-sharing.[64]

Figure 24 shows how a data center can provide this service to its clients.

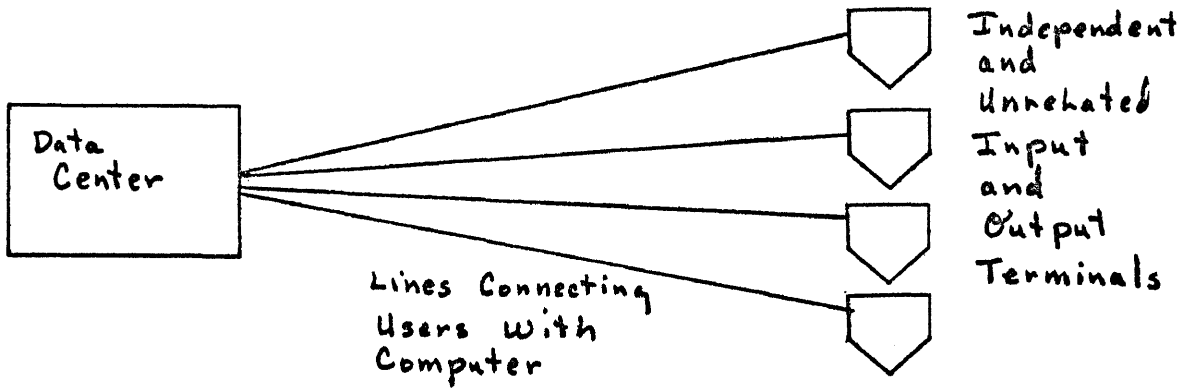

Figure 24
Data Centers OLRT Service To Its Clients

A professional paper prepared by the Systems Development Corporation, a pioneer in developing time-sharing systems had the following comments in regard to the time-shared computers.

> . . . Time-sharing provides the economical means for mass on-line use of a computer. In the trivial case, one person can use a computer on-line without time-sharing; but, unless the computer were extremely inexpensive, its use in this way would be uneconomical. Yet computers that are inexpensive enough to warrant one-at-a-time-on-line usuage normally do not have sufficient capacity to provide all the power desired in a sophisticated on-line system. Thus, users need to "share" a powerful computer, so that they can benefit from the existence of a strong executive system, large storage areas, and the presence of a large number of services and routines. This computer then per-

[64]Jules I. Schwartz, Edward G. Coffman, and Clark Weisman, Potentials of a Large-Scale Time-Sharing System, (System Development Corp., Santa Monica, California), (July, 1964), p. 2.

> mits the existence of a "large-scale" time-sharing system, where "large-scale" implies a large number of users having access to considerable amounts of computing power.[65]

The increases in flexibility, speed, and applications afforded by OLRT systems will provide its user (large or small) with competitive advantages that can only be challenged by another comparable computer system. Service centers will probably be an important supplier of ADP (OLRT) for many smaller companies that require the use of ADP to remain competitive.

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[65] *Ibid.*, p. 25.

APPENDIX A

ADP HARDWARE

Key Punch[66]	The key punch is a recording device. It serves to record data by entering them upon cards in the form of representative punched holes. It may be described as a key-driven punch die.
Interpreter[67]	Visual interpretation of the holes in a punched card is difficult. In some situations--usually for purposes of reference--it is convenient to have a means of ascertaining, at a glance, the code contents of all or part of a card. The interpreter meets this need. The interpreter consists of a sensing device and a printing mechanism, linked together by a control panel or fixed wiring. The machine reads data recorded in the form of holes in the card and prints the data on the card.
Verifier[68]	Cards, as previously punched, are placed in the feeding hopper. Working from the source document, the operator depresses the keys on the verifier. If the key strokes, denoting the codes, fall into the same positions as did those in the original punching, the verifier causes a small nick to be cut along a vertical edge of the card. If the positions of the holes indicated by the two operations do not coincide, the verifier looks temporarily and causes a small nick to be cut along a horizontal edge of the card. Subsequent visual inspection reveals the incorrect cards.
Reproducer[69]	The reproducer is a recording mechanism.

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[66]<u>Introduction To Data Processing</u>, (New York, N. Y.: Haskins and Sells, 1957), p. 31.

[67]<u>Ibid</u>., p. 31.

[68]<u>Ibid</u>., p. 32.

[69]<u>Ibid</u>., p. 32.

It is used to duplicate, on a new card, in the same or different positions, all or part of the data contained on an existing card, or to place constant data upon either a new or an old card.

Magnetic Drum[70]

The magnetic drum is a constant speed, rotating cylinder with an outer surface that is coated with a magnetic material. If an area of this magnetic material is placed in a magnetic field, the area will become magnetized. After the magnetic field is removed, the magnetized spot will remain on the surface of the drum indefinitely. Data recorded on the drum surface may be read from the drum repetitively. Each time new data are recorded upon, and retrieved from, the rotating drum by read-write heads that are suspended a very slight distance from the periphery of the drum.

Each drum has a specific number of storage locations, each of which is addressable by the computer. The capacity of each storage location depends upon the design of the drum and the data representation code used. Because reading or writing can occur only when a specified location is passing under the distance to be traveled by the addressed location to the head.

Magnetic Disk[71]

The magnetic disk is a thin metal disk coated on both sides with magnetic recording material. Usually twenty-five disks are mounted on a vertical shaft; they are slightly separated from each other to provide space for the movement of read-write assemblies. The shaft revolves, spinning the disks.

Data are stored as magnetized spots in concentric tracks on each surface of the

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[70] _Introduction to IBM Data Processing Systems_, _op. cit._, P. 33.

[71] _Ibid._, p. 33.

disk. Some units have 250 tracks on each surface for storing data. The tracks are accessible for reading and writing by positioning the read-write heads between the spinning disks.

The magnetic disk data surface can be used repetitively. Each time new information is stored on a track, the old is erased as the new information is recorded. The recorded data may be read as often as desired; data remains recorded in the tracks of a disk until written over.

Removable. IBM 1311 Disk Storage is similar in operating principle to the 1301 except that the 1311 uses interchangeable disks packs. Six disks are mounted as a disk pack and can be readily removed from the 1311 Disk Drive and stored in a library of disk packs in much the same manner as reels of magnetic tape may be stored. The packs are 14 inches in diameter and weigh less than ten pounds. Each of the ten recording surfaces contains 100 data recording tracks. The disks turn at 1,500 revolutions per minute. Nearly 3,000,000 characters of information can be stored on each disk pack.

Fixed. IBM 1301 Disk Storage contains one or two modules of disk assemblies. Each module consists of 25 magnetically coated disks, two feet in diameter, and an access mechanism with 24 access arms. Each disk surface has 250 tracks. The disks are mounted ½ inch apart on the rotating vertical shaft.

Printer[80]

IBM printing devices provide a permanent visual record of data from the computer system. Speeds of printing vary from 10 to 2,000 characters per second.

As an output unit, the printer receives data, symbolized in electronic form, from the computer system. These electronic symbols enter appropriate circuitry and

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[80]*Ibid.*, p. 53.

cause printing elements to be actuated. All printing devices have a paper transport that automatically moves the paper as printing progresses.

BIBLIOGRAPHY

Periodicals

"A New Look at Data Processing Service Centers", Modern Office Procedures, Vol. 8, (Dec. 1963).

Burck, Gilbert, "On-Line In Real-Time", Fortune, Vol. 69, (April, 1964).

Burck, Gilbert, "The Boundless Age of the Computer", Fortune, Vol. 69, (March, 1964).

"Don't Be Afraid To Use A Computer", Administrative Management, Vol. 24, (January, 1963).

"How to Choose and Use an Outside EDP Center", The Research Institute of America, Inc., New York 17, N. Y. (Sept. 4, 1963).

Hunt, Lawrence J., and Brown, Walter L., Jr., "Business Simulation--a Technique for Updating Management", Montana Business Quarterly, (Fall 1965).

"Is There A Computer In Your Future?", Merchandising Week, Vol. 97, (Feb. 1, 1965).

Lennox, J. E., "Accounting Service Bureau; One CPA Firm's Experience", Journal of Accountancy, Vol. 118, (Nov., 1964).

Lewis, Ralph F., "Data Processing Centers and The CPA", Journal of Accountancy, Vol. 112, (July, 1961).

"New Tool, New World", Business Week, (Feb. 29, 1964).

"Man and Machine At Carnegie Tech", Time, Vol. 83, (April 3, 1964).

"Market Report", Computers and Automation, Vol. 14, (July, 1965).

"Party Line Computer", Time, Vol. 79, (April 13, 1962).

Ream, Norman, "Computers: Doing Better Than Expected", Steel, (March 8, 1965).

"Small Businesses, Big Pitfalls", Administrative Management, Vol. 24, (August, 1963).

Smith, Arnold P., "Choosing A Service Bureau:, Computers and Automation, Vol. 13, (Dec. 1964).

Sprague, R. C., "Information Utilities", _Financial Executive_, Vol. 33, (Oct., 1965).

Stern, Alan A., "Tax Returns-By Computer", _Journal of Accountancy_, Vol. 119, (Feb., 1965).

"The $5-Billion World Market For Computers", _Business Week_, (Feb. 19, 1966).

Vassaur, John E., "The Third Generation of Computers-New Tools For Management", _Management Accounting_, Vol. 47, (Oct., 1965).

Reports

An Introduction To IBM Punch Card Data Processing, Data Processing Division, (White Plains, New York: 1960), p. 1.

IBM Systems/360, IBM Corporation, Data Processing Division, (White Plains, New York: 1966).

Introduction To IBM Data Processing Systems, (White Plains, New York: 1963).

Schwartz, Jules I., _Introduction To The Time-Sharing System_, (Santa Monica, California: Systems Development Corporation, Sept. 14, 1964).

Schwartz, Jules I., Coffman, Edward G., and Weissman, Clark, _Potentials Of A Large-Scale Time-Sharing System_, (Santa Monica, California: Systems Development Corporation, July 28, 1964).

Univac Data Processing Centers: Programmed For Problem Solving, (New York: Sperry Rand Corp.).

Books

Introduction To Data Processing, (New York: Haskins & Sells, 1957).

Schmidt, Richard N., and Meyers, William E., _Electronic Business Data Processing_, (New York: Holt, Rinehart, & Winston Co., 1963).

Theil, Henri, Boot, John C. G., and Kloek, Teun, _Operations Research And Quantitative Economics_, (New York: McGraw-Hill Book Company, 1965).

Sprague, Richard E., _Electronic Business Systems_, (New York: Ronald Press Co., 1962).

Greenlaw, Paul S., and Kniffin, Fred W., _Marksim_, (Scranton, Pennsylvania: International Textbook Co., 1964).

Other Sources

Personal interview with Art Ayers, Owner, Montana Data Processing, Helena, Montana, November 30, 1965.

Direct Correspondence with J. H. Bivins, Manager, Data Processing Division, Datacenter, IBM, March 17, 1966.