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Administrative Aspects of the Digital Computer

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B O S T O N U N I V E R S I T Y
College of Business Administration

THESIS

Administrative Aspects of the Digital Computer

by

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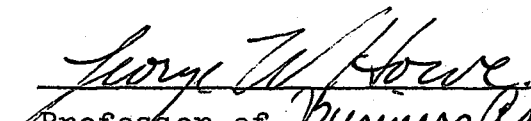
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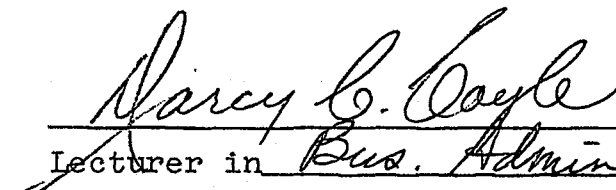
1960

This thesis was prepared under my supervision
and approval is hereby indicated.



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INTRODUCTION

Since the first large, all electronic digital computer went into operation in 1945, management has made increasing use of them in three areas.¹ The first is in the reduction of existing clerical costs. The second is in the production of faster and better management control information than is practical by alternative methods. The third is in the application of mathematical techniques to the solution of business problems. This application has become widely known as operations research. In addition to these three areas, there is extensive use of digital computers in such fields as science, engineering, and education.

Remington Rand, division of Sperry Rand, and International Business Machines Corporation were among the first to manufacture large scale digital computers. Burroughs Corporation, The Radio Corporation of America, and the Datamatic Division of Minneapolis-Honeywell have also manufactured and successfully installed digital computers. Some of these are considered large-scale machines. However, the majority can be classified as medium-scale machines.

Remington Rand entered the field of computer manufacturing when it acquired the Ackert-Mauchly Computer Corporation whose founders designed both the ENIAC and the UNIVAC. The ENIAC is used to calculate ballistic tables and work on complex equations in science and engineering.

The UNIVAC is used for both scientific and business data-processing applications. Remington Rand also absorbed the company that manufactured the ERA computer - Engineering Research Associates, Incorporated, a small firm which since 1944 has built more than twenty computer systems for the government. Remington Rand's 1954 production schedule was planned for six UNIVACS and six ERA 1103's.²

By 1953 IBM had developed its 701 computer. It is a large binary-digit machine designed chiefly for scientific and engineering work. In January of 1954, IBM was just completing production on eighteen of its 701's, the first large computer to reach anything like mass production.³

Because of speed, input/output capabilities, and the characteristics of their command structure, some computers are ideal for business data-processing applications; others are better for scientific applications. Consequently, management must recognize the needs of its organization and find the computer for the job, not the job for the computer. A business data-processing application generally involves large amounts of input and output with a small percentage of calculating. A scientific application usually involves a large percentage of calculating with a small amount of input and output. The basic difference between computers is in the machine language used to perform arithmetic operations, transfers, and decisions.

Management must be aware of the difficulties involved in adapting existing accounting systems to a digital computer. In many cases the entire accounting procedure will have to be changed to meet the exacting demands of the computer.⁴

Organizations contemplating the purchase or lease of a digital computer spend a great deal of time and money arriving at the answers to the following questions. The first is: Shall we obtain a digital computer? A "yes" answer usually depends upon sufficient economic justification. This justification can be made up in part or in total by such things as potential to improve the organization's future profit picture and/or operating efficiency.

Today's digital-computer industry has been in existence for approximately fifteen years. During that time, the dollar value of the industry's output has increased significantly each year; therefore, management has at its disposal a means for evaluating computer performance.

The second question is: Which digital computer shall we obtain? This is answered by an analysis of the input, processing, and output capabilities of various computers with respect to the individual organization's requirements. The requirements are generally defined as the result of a feasibility study which precedes any equipment selection.

Management must consider the effect of computer obsolescence since the computing speeds and input/output capabilities of computers are increasing rapidly while the cost of purchasing or leasing this equipment is increasing slowly.

The third question is: How can we insure the successful application of a digital computer? Part of the answer is based upon correct management decisions during the pre-installation period and installation period.

Thousands of employees are applying the programmers' problem-solving technique of: process charting, flow charting, coding, debugging, and documentation. However, management is concerned with the staffing problems involved in this area.

The purpose of this study is to investigate and present the material which management has considered of value in arriving at informed answers to the preceding questions. It assists in providing assurance that, when these questions have been answered, and if the decision to purchase or lease has been made, the people directly responsible can be reasonably certain that they have obtained the computer which best fits their requirements. The selection should produce the finest possible end product at the greatest possible economic advantage to the organization.

THE DIGITAL COMPUTER

The Remington Rand UNIVAC was the first large computer to be used for extensive business data-processing applications.⁵ The machine's fast magnetic tape input/output proved itself an excellent storage media for many records. The magnetic tape input/output devices are buffered. In other words, the machine can be reading records from magnetic tape, writing records on magnetic tape, and calculating simultaneously.

The first large integrated data-processing system was the UNIVAC installed at General Electric's Appliance Park Development in Louisville Kentucky.⁶ The thought behind Appliance Park is to centralize all of General Electric's electrical appliance manufacturing units in one place, with savings in overhead, freight, and other costs. Five separate departments operate at Louisville with a sixth nearby.

In 1953 when Appliance Park was developed, a need was seen for a new type of centralized control. There appeared a good possibility of installing a large computer before large clerical staffs were established and awkward accounting systems had been adopted. Therefore, General Electric leased a UNIVAC from Remington Rand for two years, with an option to purchase. The first application for the

computer was the payroll which had been done on smaller electronic computers for some time. The employees' master record is stored on magnetic tape. The updating of this record is done at normal pay intervals: for example, weekly, bi-monthly, and monthly. The machine calculates each worker's pay, prepares the paychecks, and compiles various payroll accounts such as the deduction register. The preparation of this payroll requires four hours of computer time.

The second group of tasks to be given the machine were certain routine clerical jobs such as compiling cost distribution records and handling materials scheduling and inventory control.

The third group of tasks to be given the machine were the compilation of sales records and the preparation of bills.

In 1955 the computer was programmed to handle the organizations complete cost accounting and general accounting. The programming section has set as a goal something entirely new: rapid sales analysis, fast enough to detect regional shifts in sales of various appliances and to modify production upwards or downwards as required.

Although computers are complex - both in construction and operation - the difficulties of understanding them

are similar to those encountered when one approaches any unfamiliar subject. Much of their complexity can be reduced to a combination of simple principles.

Any problem to be economically handled by a computer must be highly repetitive. We can classify these problems into one of four groups. One involves a large amount of processing and a small amount of data. This is a characteristic of many mathematical and scientific applications. Another involves a small amount of processing and a large amount of data. This is a characteristic of business data-processing applications such as inventory control. The next involves considerable processing and data, and the last involves little processing and data.

Management has taken three approaches to integrated data processing. The first is to take the application as a whole and develop it so that profits will not be realized from any piece of the applications until such time as the entire system is completely integrated and working.

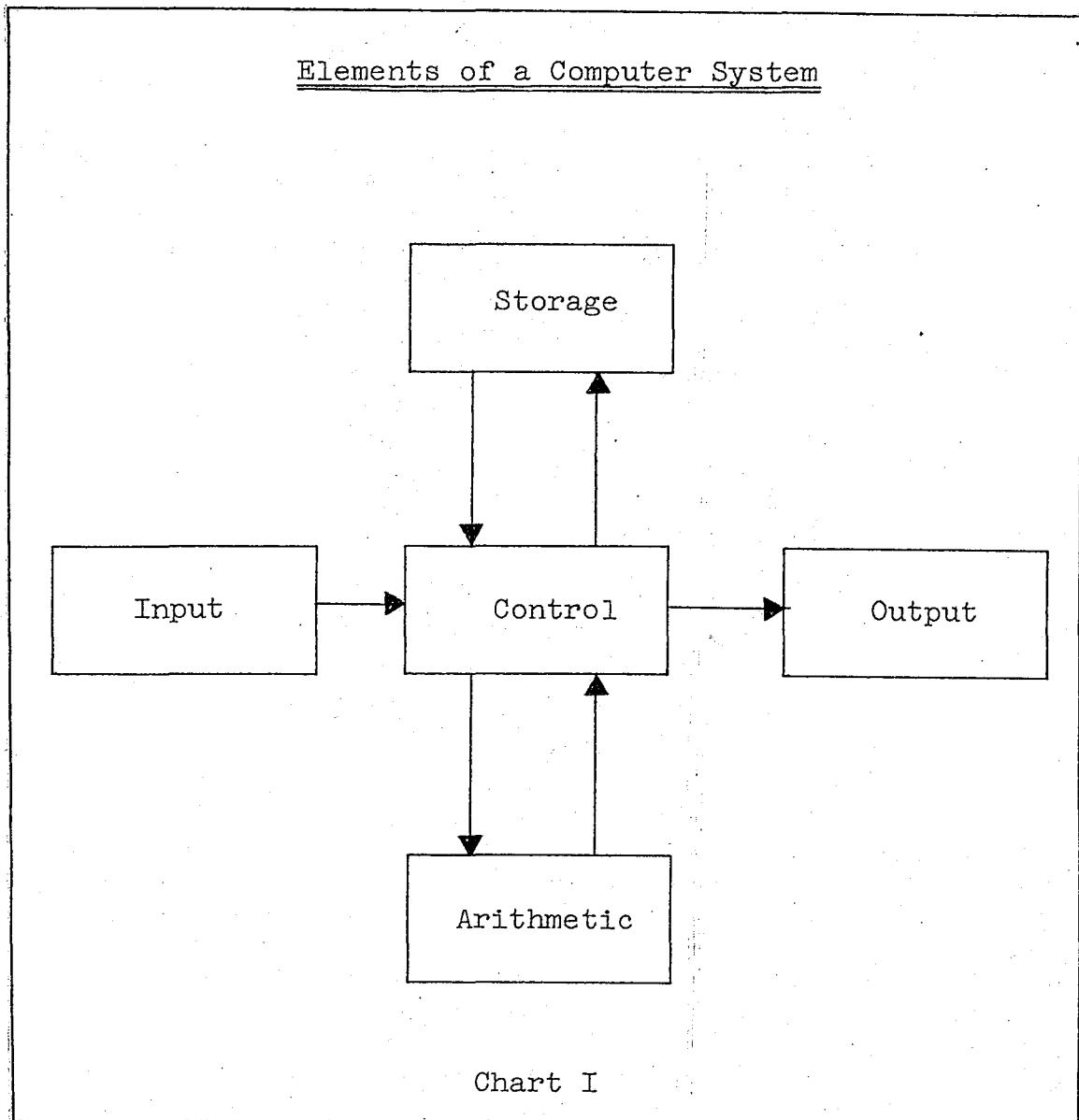
The second is to develop the application piece by piece and to realize profits from each piece as it is completed.

An improvement over these methods of devising systems for computers in the recent past is the current

method of considering the problem as a total concept from the start, then taking pieces of the concept and developing them one by one into working and paying jobs. Using this method, the over-all concept is continually analyzed so that the pieces will eventually fit together smoothly.

Definition

The five basic elements of a computer are: input, storage, arithmetic, control, and output. Let us take a closer look at each of these from the standpoint of their place in a computing system.



The input element transmits information from the outside to the computer. Any of several input devices can be used to read specially prepared information into the computer.*

The storage element provides a means by which information received from the outside can be held available to the computer. There are two types of storage: internal and auxiliary. Internal storage is used to store information necessary for immediate processing. An internal storage unit must provide rapid access to the information it contains, and it should have a large capacity. Because there are technical and economic limits to the size of high-speed internal storage units, information not currently needed is often stored in larger but slower auxiliary devices. Auxiliary storage is almost always included in a large data-processing system.

The arithmetic element is the computing portion of the system. The operations of addition, subtraction, multiplication, and division are performed by this unit. It also provides a means for comparing one number to another to determine whether they are equal or which is the greater. The result of such a comparison allows the computer to make decisions.

*See Integration Into Existing Systems for further explanation. pp. 22-27.

The control element controls the operation of the computer during the complete process of problem solution. This element directs the sequence of operation, interprets the operations to be performed, initiates the action which performs the operations, and activates the input and output devices.

The output element transmits processed results from the computer to the outside. Output devices accept information from the computer storage and reproduce it in a convenient form for normal use.*

Computers perform three different groups of operations. These operations are: first, arithmetic operations; second, transfer operations; and, last, decisional operations.

The arithmetic operations are designed for various types of addition, subtraction, multiplication, and division.

The transfer operations are used to transfer information from an input unit into the computer, from one place to another within the computer, and from the computer to an output unit. Transfers are also used for changing program control to specific computer instructions (operations).

*See Integration Into Existing Systems for further explanation. pp. 22-27.

The decisional operations are conditional transfers based upon the results of a comparison. Typical results of a comparison would be: equal, not equal, greater than, or less than.

The internal storage of a computer generally consists of digits, words, and memory.

A digit is frequently represented in binary arithmetic.⁷ E.g., if we have four street lights and they are assigned numeric values of 1, 2, 4, and 8, we can use combinations of these numeric values to represent any digit from 0 through 9. If all the lights are off, the number represented is zero. If the light with a value of 1 is on, the number represented is 1. If the lights with values of 1 and 2 are on, the number represented is 3 and so forth. Computers represent digits in this manner. However, positive or negative electrical charges representing binary bits are substituted for the street lights.

A word is frequently a combination of decimal digits. The number of decimal digits in a computer word can be either fixed or variable. For example, the IBM 650 electronic digital computer has a fixed word length of ten decimal digits. This ten-decimal digit word has a sign which can be either positive or negative. For identification purposes, the digits within the words are numbered from right to left beginning with 1. The word can contain data, an instruction, or a constant.

Numeric characters are frequently represented by one decimal digit. If a word contains all numerics, it is said to be numeric. Alphabetic characters are frequently represented by two decimal digits. Therefore, an alphabetic may occupy twice as much word space as a numeric. If a word contains all alphabets, it is said to be alpha. If a word contains some alphabets and some numerics, it is said to be alpha-numeric.

Binary bits are combined to make decimal digits. Decimal digits are combined to make computer words. The computer memory is comprised of computer words. Now, the question arises of how to keep track of individual words in memory. Each word which enters a computer is stored in memory in a specific location identified by a unique number called an address. For example, the Burroughs 220 electronic digital computer has a basic memory size of two-thousand words; the words are numbered sequentially from 0000 through 1999.

A 110-digit inventory master record can be represented in the following manner in a computer's memory:*

Word 0000 contains a ten-digit stock number.

Word 0001 contains a signed ten-digit number which represents the balance on hand.

*See Chart II p. 19.

Master Inventory Record

<u>Word #</u>	<u>Record Description</u>
0000	† - STOCK NUMBER
0001	† - BALANCE
0002	† - UNIT OF ISSUE
0003	† - UNIT PRICE
0004	† - REORDER POINT
0005	† - REORDER QUANTITY
0006	† - REQUISITION #1
0007	† - REQUISITION QUANTITY #1
0008	† - REQUISITION #2
0009	† - REQUISITION QUANTITY #2

Chart II

Word 0002 contains a five-digit field called the unit of issue.

Word 0003 contains a ten-digit unit price with the decimal point two places from the right.

Word 0004 contains a signed ten-digit number which indicates the point at which the replenishment program must initiate a purchase requisition.

Word 0005 contains a predetermined order quantity for the preparation of a purchase requisition by the replenishment program.

Word 0006 contains the number of outstanding purchase requisition #1.

Word 0007 contains the quantity on order by outstanding purchase requisition #1.

Words 0008 and 0009 are analogous to Words 0006 and 0007.

The basic memory of a computer is high-speed internal storage. It has not yet proved technically or economically feasible to build a high-speed internal storage with the capacity for the large volume of data and instructions necessary for all applications which one computer might handle.⁸ For example, all the data required for an inventory file of thousands of automobile parts need not be readily available at all times. Nor is it necessary to have the program for several applications in memory at the

same time. In fact, an application may require a program so long that only a portion of it will be stored in memory at any given time.

In each of these situations, there is a need for some type of auxiliary storage for large volumes of information. Such auxiliary storage need not provide the high speed access required of the more expensive internal storage element and thus can store large volumes of information economically. A common auxiliary storage media is magnetic tape.^{9*}

In computers there are certain locations separate from the memory which provide temporary storage for words while they are being used by the control element and arithmetic element. These temporary storage locations are often called registers. One of these is used to store the result of all arithmetic operations such as addition or subtraction.

Most computers have a vocabulary of from twenty to seventy instructions (operations). Putting the problem to be solved into words the computer can understand is called coding.

Coding a computer application of some length is not a simple matter. Consider, for example, trying to

*See Integration Into Existing Systems for further explanation. pp. 22-27.

translate an extensive work, such as the Bible, into a language with a vocabulary of only 800 words. It might take several paragraphs to explain one word not included in the vocabulary. A computer vocabulary does not include such phrases as, "calculate net pay." Therefore, a coder must build such an operation using only the words - called instructions - that have meaning for the computer.

To solve a particular problem, the various instructions are combined into what is called a program. This program is stored in the computer memory along with data which it processes.

A general-purpose computer can obey a number of basic instructions but is not mechanized to perform them in any particular sequence. The coder sets up a sequence of instructions for the computer; and, in this way, he equips it for a specific problem. When it is finished, the computer can be set up for an entirely different problem simply by changing the program.

Integration Into Existing Systems

Present accounting systems were not designed for digital computers. Therefore, when installing an electronic data-processing system, management should question the need for existing inputs and outputs. Some of the questions that might be asked follow: What documents are needed?

How fast is the information needed after it becomes known? How often is the information needed? What are the volumes of source documents or of output documents? What is the method of gathering the source information? What is the method of distributing the output documents?

The answers to these questions will assist management in making the following decisions: Which jobs should be converted to electronic data processing? What is the best method of information gathering? What is the best method of output distribution? What should the pre-installation schedule be? What should the schedule for the installation of the computer be?

Management's analysis of the company's input and output requirements may indicate that it is possible to change present job procedures and still satisfy the company's requirements. The change or changes may involve the combination of several jobs into an integrated application with savings created by the elimination of intermediate results and the combining of master files.

From 1945 until 1955, computers were used for many mathematical and scientific applications but for few business data-processing applications.¹⁰ The input/output devices had to be improved to rates of speed commensurate with the computer's internal microsecond arithmetic. The circuitry had to be placed in easily manufactured sub-

assemblies which could be put together rapidly and swiftly replaced. Internal checking features were built in to flash a warning light when any marginal tubes deteriorated. All of these techniques have brought the computer's reliability up to about 98 percent. This reliability is as good or better than that of punched-card systems, teletypes, and other long-established equipment.

A scientific problem usually involves a great deal of computation on small amounts of data. However, most business problems are characterized by masses of data and little computation. Early attempts to translate business problems into large computer programs have generally used paper tape, punched cards, and magnetic tape as input media.¹¹ This is not to say that others such as keyboard entry and visible records are not used.

With such machines as the Friden Flexowriter, a typist can prepare paper tapes simultaneously with source documents. For the Datatron 220 data-processing system,¹² numeric words are punched on paper tape in binary code exactly as they appear in the computer's memory. Each word contains up to eleven digits. Alphabetic and alpha-numeric words are distinguished both on paper tape and in the computer memory by a 2 in the sign position. The word as it is punched on paper tape is defined to be the information bounded by two end-of-word characters.

The normal paper-tape input device is the photo-electric reader which may read paper tape at a rate of one-thousand characters per second from one of ten readers. The normal paper-tape output device is a high-speed mechanical punch which may be used interchangeably with a character-at-a-time printer. In order to examine the contents of a paper tape, it is merely necessary to list it off line on a character-at-a-time printer.¹³

Many companies which have a computer today had punched-card installations long before they obtained it. This is one situation where a computer is compatible with existing accounting systems. Using multiple card input/output units and what is called a buffer between them and the computer, it is possible to achieve a high input/output speed. The computer communicates only with the buffer, and the card-handling mechanisms communicate only with the buffer.

Each card-handling machine can communicate with the buffer to which it is attached independent of computer control. Hence, several card-handling machines may be operating simultaneously. The information-transfer rate of the IBM 089 input device is 320 alpha-numeric characters per second. The information-transfer rate of one buffer when it is communicating with the computer is approximately 22,000 alpha-numeric characters per second.¹⁴

One of the most impressive characteristics of digital computers is their operating speed. In discussing computer speeds, it is necessary to use words for divisions of a second: millisecond, for a thousandth of a second, and microsecond, for a millionth of a second.

It happens that if a machine can work faster, its time is more valuable. In the case of computers which can work so very fast, time is valued right down to the last microsecond. It would be wasteful to make a large expensive computer spend seconds waiting for many operator functions or even for slow mechanical input and output devices. For this and other reasons, most large computers make extensive use of high speed magnetic tape input and output. Numerous off-line converters have been developed which will convert from other input media to magnetic tape and from magnetic tape to other output media. For example, the Remington Rand UNIVAC II computer has an off-line converter for recording punched-card data on magnetic tape independent of computer operation. The data can then be read into the computer by fast magnetic tape, rather than by a mechanical card reader.

Magnetic tape provides the computer with auxiliary storage. For example, the magnetic tape used in a Datatron 220 system has provision for recording two lanes of information parallel to one another along the length of

each tape. In each lane, the recording density is approximately 208 decimal digits per linear inch of tape. Tape is transported at a rate of 120 inches per second. The computer can, therefore, read information from magnetic tape at the rate of 25,000 decimal digits per second. The Beginning and end of tape are marked by reflective strips. The reflective strip is a piece of pressure-sensitive tape which is affixed manually near each end of the tape. It is not possible to read or write past these reflective strips.

Information is stored on the above tape in blocks. A block is defined as the information which is recorded between two inter-block gaps. The minimum block size is ten words; the maximum block size is one-hundred words. It is possible to read or write from one to ten blocks with one magnetic tape read or write instruction. The Datatron 220 computer can read or write 150, ten-word blocks in one second.¹⁵

John Plain And Company

With improved input and output equipment, the business possibilities are well illustrated by a computer called "Distributor" which was built for the Chicago mail-order house of John Plain and Company by ERA, Engineering Research Associates, a Division of Remington Rand, Incor-

porated.¹⁶ This computer belongs to a class of moderately fast magnetic-drum machines which are offered by a number of manufacturers.

While this machine is by no means a large computer, it was the first major application of its kind and involved a simple approach to the larger type of problem. The problem was this: John Plain sell some eight thousand gift and houseware items by catalogue through about one thousand retail merchants, mostly rural. Its business is highly seasonal ranging from less than two thousand orders per day in the off season to more than fifteen thousand per day in the Christmas season. The company must follow its inventories closely in order to determine whether or not an item is available for shipment.

Originally they employed a battery of clerks for this purpose. Since the work was tedious and seasonal, it did not attract a high grade of workers. During the rush season, the inventory status reports fell a week or two behind, and there were many errors.

In 1953, the company replaced the sixty clerks with the "Distributor" machine and ten operators. The machine can handle ninety thousand transactions per day. Each night the machine is set to run off a complete stock-status report on all eight thousand catalogue items. To

compile such a daily stock-status report by the old method would have required some one hundred fifty clerks. Moreover, the compilation of this report is far more accurate when done by a computer. With modifications in size and input/output devices, the same machine could handle many other inventory-control and material-scheduling problems.

WHO USES DIGITAL COMPUTERS?

Like all advances in automation, electronic data processing depends upon two characteristics which management developed in factory automation seventy-five years ago. These characteristics are those of complete definition and of repetition.¹⁷ The problem must be defined completely and unambiguously before a computer can be successfully programmed. Whether an economical program will actually be written depends upon the repetitive nature of the problem. Many organizations feel they can meet these requirements, and, therefore, may use computer time. They can be classified on two bases: first, by type, and second, by size.

Type of Users

There are six types of computer users: the government which includes all federal, state, local, and international government agencies.

Second, are commercial organizations which include utilities, trade, finance, transportation, and service organizations.

Third, are scientific groups that are engaged in research, development, and testing on a commercial basis.

Fourth, are educational institutions which include all levels of formal and technical schools as well as commercial and trade schools.

Fifth, are insurance companies which include insurance carriers, agents, brokers, and insurance service organizations.

Sixth, are industrial organizations which include all agricultural, extractive, construction, and manufacturing concerns.

Size of Users

Many large organizations can afford to purchase or rent a computer and carry its operation along until it begins to pay. However, a number of smaller firms cannot afford computers of their own even though they can make good use of what computers offer. Management of these firms may not have the trained staff to develop applications or enough work to economically justify a computer. Management does not want its company to be left out of the competitive race. These companies represent a sizeable market, and many are willing to purchase computer time on an as-required basis. In order to meet the needs of this market, many computer service centers have been formed. Basically, a service center is a fully staffed computer installation in which a number of different companies can buy time. Its services may extend to feasibility studies, operations research, programming, and training of a client's personnel. The smaller companies can rent these services

for special one-time problems or use them regularly on a part-time basis.

There are at least five types of computer service centers available for the management of a small firm to decide upon. Companies that rent time on their computers usually do this reluctantly. Most concerns prefer to be the exclusive user of their own machine. Management is concerned about the continuity of such relationships and may hesitate to process company documents through another company's machine and office. Second, many mechanical punched-card centers have expanded into computer service centers. Third, many consulting firms have established their own computing centers to handle engineering problems and business applications for themselves as well as their customers. Fourth, service centers are operated by computer manufacturers. Fifth, many colleges and universities operate service and research centers. For example, Boston University, at the present time, has an IBM 650 electronic digital computer installed in its computation center. The machine is used for a variety of educational, business, and scientific purposes.

By using these various services, management of the small company can achieve many of the advantages of a computer. The smallness that handicaps some concerns in buying computers can at times become an advantage. For

instance, in larger companies adjustments such as the complete conversion of cost accounting to computer systems can take months or even years. However, the flexibility of small concerns enables them to convert much faster.

Blaw Knox Company

When an organization does not have a computer of its own, it may obtain the use of a computer from service bureaus, punched-card centers, consulting firms, other companies, or educational institutions. If a company does not have an experienced programming staff and there is an immediate need to solve a specific problem by means of an electronic computer, it may hire a computer expert or the services of one of the five previously mentioned organizations. The following example illustrates the approach which the management of one manufacturing concern took in such a situation:

In 1954, the management of the Blaw-Knox Company's Power Piping Division in Pittsburgh noticed that the calculation of pipe stress problems was one of the heaviest engineering loads for Blaw-Knox and other power-pipe designers.¹⁸ These problems are highly repetitive and each required hundreds of engineering man hours in order to make the necessary calculations. Faced with mounting engineering costs and increasing work loads, management

decided to hire the consulting firm of Arthur D. Little, Incorporated.

In its simplest form, the task is to predict what will happen when a length of pipe is heated. Knowing the expansion rate of the material, simple computations will indicate how much a piece of straight pipe will grow if it is heated to 1000° Fahrenheit. However, the problem is complicated if both ends of the pipe are anchored, for, if the pipe is heated in this situation, it will either bow, bend, twist, break, or distort one of the anchoring structures. The problem is further complicated when the piping is twisted and has five or six branches each of which is anchored to a structure that moves on its own when heated.

Management selected one of their senior research and development engineers to work with the Arthur D. Little consultants. This engineer knew very little about electronic computers. However, he did understand the problem of pipe-stress analysis. Management had, therefore, built a team consisting of computer experts and an expert on the problem to be solved. Together this team developed a program for the UNIVAC computer. It was the first such program in the field of pipe-stress engineering calculations.

A relatively inexperienced operator can now code the problem directly from a single drawing of the pipe system. A typical problem requires one half hour of computer time. Although the application involved a significant amount of computer time, it was not enough to justify the purchase or lease of a large machine. However, management recognized that Blaw-Knox required a minimum amount of computer time; and, therefore, made arrangements to purchase a fixed amount of time from a UNIVAC Service Center in New York. Additional time is available to Blaw-Knox on an as-required basis.

When the problem was completed, management had achieved its goal of reduced costs and reduced time in the calculation of pipe-stress problems without acquiring a computer or hiring a programming staff.

HOW DO THEY USE THEM?

The applications for electronic digital computers can be classified into two groups if the evaluation is based upon computer characteristics. These are scientific and business data processing. However, if the evaluation is based upon the application rather than the computer, the number of groups can be expanded to five. These are general accounting, engineering, marketing, research, and operational controls.

The application of computers to scientific problems has not stressed the need for larger and faster input and output devices. Most of the actual work is done inside the machine and input/output time may be sacrificed for faster internal computing time or a more comprehensive command structure. Scientific computers are generally less expensive than business machines because they require less peripheral equipment which may cost as much as the central computer itself.

The application of electronic data-processing systems to commercial data-handling problems has been based upon certain fundamental objectives established by management for the handling of inquiries, file maintenance, and input/output. These are: first, to consolidate multiple files into single files; secondly, to minimize the number

of processing steps or passes required for any particular file; third, to process several classes of information against the same file simultaneously; and, last, to eliminate intermediate results wherever possible. Despite these objectives, computers used for electronic data processing in business require a large number of peripheral devices.

There are five more specific classes of computer applications. These are: general accounting, engineering, marketing, research, and operational controls. General accounting includes accounts receivable, cost accounting, billing, and payroll. Engineering includes the development or design of a product or process. Marketing includes all applications related to the sale and transfer of goods and services from producer to consumer such as forecasting and market research. Research includes basic and applied research in science. Operational controls include any application which involves a system of control such as inventory control, production control, budget control, or quality control.

The following example will indicate the scope of existing electronic data-processing applications. Although it is an insurance data-processing problem, the objectives as established by management and the advantages

attained from the system are not confined to insurance applications.¹⁹

In 1875, this insurance company's data processing was done by one clerk who kept all the records and prepared all the policy statements. Quick reference to one file folder enabled the company to prepare a premium notice, approve a change in the contract, and accomplish almost any other data-processing task required.

Within nine years, however, the file had grown to 340,000 folders, and there were over two-million dollars in company assets to keep track of. By this time, management realized that the accounting system would no longer meet the company's requirements. It became more and more efficient to subdivide the clerical functions and split existing files.

When punched-card accounting machines became available, management was quick to take advantage of what they offered. The basic data about each policy was recorded in several different files.

In 1956, management decided to investigate the possibility of electronic data processing. The first major data-processing area studied was the ordinary policy operation. This was all ready highly mechanized through conventional punched-card procedures. The operations are centered around eight major files.

The policy master file is the basic file for all premium-paying policies. The billing file consists of one punched card for every premium billed and unpaid. The commission file contains a record for all premium-paying policies on which a commission is paid to a company agent. The ordinary dividend file contains the name and address records for all paid-up policies. The loan files contain loan information. The ordinary register file contains a policy history and is the basic random-access file.

Management established the usual electronic data-processing objectives. First, consolidate multiple files into single magnetic-tape files, Second, minimize the number of passes required for the file. Third, process several classes of information simultaneously. Fourth, eliminate intermediate results wherever possible.

After setting the prime objective as consolidating, it was found that all files except the ordinary register file could be combined into one magnetic-tape file. The effect of this consolidation of files is three-fold - simplification, speed, and a higher degree of accuracy.

Simplification is attained by the elimination of duplication of processing brought about by the consolidation. The policyholders also benefit directly. A consolidated and simplified notice replaces separate statements for premiums due, dividend, and loan interest. Several

hundred punched-card machine steps are reduced to approximately twelve under the electronic data-processing system.

Because of high-speed processing, the time required for file maintenance is reduced. For example, the machine will process a policy in less than one half of a second.

Accuracy is increased because record maintenance is performed on one file in place of several files.

To summarize the preceding example, management established the principal electronic data-processing goal as consolidation of multiple files. This was accomplished by means of an electronic data-processing system with the following advantages resulting: simplification, speed, and accuracy.

THE DIGITAL COMPUTER IN A MANUFACTURING ORGANIZATION

The success of a manufacturing concern depends upon the ability of its management to be consistently correct in its decisions. Management may provide the solutions or approve the recommendations of assistants. In either case, the viewpoint in seeking the solution to a business problem is invariably profit. Improved profits can be the result of greater sales, increased operating efficiency, or a sound financial policy. Both sales and production are geared to the profit motive. Sales is the means through which profits are obtained; production is the means with which profits are obtained.

Sales

Selling in a manufacturing organization requires: the creation of demand, the finding of a buyer, negotiation of the price and terms of sale, and finally, the transfer of title.

The number and locations of potential buyers and the data pertaining to them requires careful study. Department stores may effectively contact their customers through newspapers, and manufacturers of industrial goods may contact their market through technical journals. Both can make use of statistical market research to deter-

mine the most successful method of reaching potential customers. The discovery of new and better methods of marketing, more economical means of distribution, new markets, and better means of selling can often be attributed to such research.²⁰

All statistical market research has one thing in common, and that is its dependence upon the analysis of numerical data. The statistical relationship of actual to potential volumes involves the compilation of actual sales data and the estimation of potential volumes by numerical methods. Testing the response to new products, checking advertising efficiency, and studying consumer attitudes are all based upon the analysis of numerical relationships between such factors as sales and advertising volume.

Cost studies are based largely on statistical analysis since the relationships between cost, production, and other factors are usually determined by statistical formulas.

An electronic data-processing system can assist sales management in reaching the proper market. For example, it can do this through the solution of statistical market research problems which were previously not practical because of their length and complexity. It can also assist

sales management in completing transactions by performing faster and more accurate invoicing, billing, and inventory control.

Production

Management is concerned with eliminating or reducing to a minimum inefficiencies in manufacturing. For example, they may be the result of performing work on an incorrect machine or at the wrong time. Production control, inventory control, and payroll calculation offer the opportunity of indirectly reducing cost if their efficiency can be improved.

Production control regulates the flow of materials through the plant from raw materials to the finished products. The goals of management in production control are to produce the right product, of the right quality, in the right quantity, at the right time, and by the most efficient and less costly method.

Effective inventory control requires that an adequate, but not excessive, amount of material be on hand at all times. Under ideal conditions, there is no necessity to maintain an inventory; when a material is required, it would be leaving the receiving room for production. However, seldom, if ever, is this possible and the storage of materials is necessary to permit production flexibility

and the advantage of quantity discounts. Certain materials represent a considerable investment and their storage ties up capital which management could use for other purposes.

The repetitive nature and volumes of some production payrolls are high. In these situations, a computer may offer an attractive alternative to the existing preparation and recording operation.

The following case cannot be called an example of a production payroll in a manufacturing organization. However, some of the reasons for adapting any payroll operation to a computer, and the problems involved, are illustrated.

The continued growth and complexity of a large payroll application is indicated by the history of the City of Detroit's payroll system.²¹ In 1937, the payroll for the entire city was prepared on typewriters. In those days, the payroll consisted of: employee name, title, rate of pay, time worked, gross pay, and a check number.

In 1938, the first payroll deduction was added; namely, a five-percent retirement deduction. At this time, a punched-card system was installed. During the years that followed, the city took advantage of the latest punched-card equipment. The need for better systems and equipment was due primarily to the continually changing

payroll picture. During the war, the Withholding tax, Victory tax, and War Savings Bonds created problems that were met by punched-card equipment. In the following years, deductions such as Insurance, Hospitalization, and Torch Fund, created problems. However, all of these demands were met utilizing only one punched card per employee.

In 1955 union dues and credit-union loan payments, by means of a payroll deduction, were approved. At this time, the system was expanded to two cards per employee: a pay card and a deduction card. Before this system was installed, it became obsolete by the addition of social security coverage for city employees. At this time, it was decided to place an order for an IBM 650. By 1957, all of the city's payroll was being computed on the IBM 650.

At the present time, the computer processes one-hundred twenty-five departmental payrolls involving 38,000 employees who are paid as follows: 18,000 salaried employees are paid bi-monthly; 10,000 hourly employees are paid every Friday; 10,000 pensioners are paid monthly. Employees are paid five, six, or seven-day work week rates, elected official rates, overtime, premium pay for Sundays and holidays, annual longevity pay, sick-leave pay, periodic step increases, and retroactive pay for promotions.

The preceding paragraph has indicated some of the types of payment to city employees. These are only a few of the conditions which must be handled by the computer. Many more can be listed if the various payroll deductions are considered.

Three typical problems faced the people responsible for the installation of the electronic data-processing system. First, there was a lack of procedural data on the payroll system as it existed. An entire month was spent in resolving problems, exceptions, and stating objectives in order to arrive at the over-all problem definition. This was accomplished in part by conferences of key employees in the Controller's Office.

Second, there were twelve different payroll sequences in use. The efficient utilization of the computer required that only one sequence be used. The question of: operating departments accepting a change in the operating sequence to which they were accustomed - became apparent. The solution to this problem actually set the pattern for the others to follow. This was to explain the problem and proposed solutions to the departments; thereby, selling the idea rather than forcing a final solution upon them at that time.

Third, input and output forms had to be designed. The existing punched-card payroll system was somewhat compatible with what could be considered an acceptable computer payroll system. Therefore, it was decided to continue using input and output forms similar to those already in use.

The characteristics of the City of Detroit's payroll are not unique in themselves. The reasons for their using a computer and the problems encountered are the same as those which face any other governmental unit or private industry comparable in size.

An electronic data-processing system can make possible the integration of production control, inventory control, and payroll calculation with other operations of the company. The result of such a system might very well be: less work in process, smaller inventories, more rapid inventory turnover, and reduced clerical expenses. These in turn could result in less capital invested in materials, lower overhead, and reduced unit cost of products.

Finance

When a manufacturer thinks of finance, he usually thinks of three things: How to acquire funds, how to use them, and how the profits of the business are to be distributed.

Finance is intimately related to other functions of business: namely, sales and production. The present and future sales statistics must be analyzed by management in order to determine if it is profitable to spend additional funds on a given product. When production is inefficient, funds will be wasted.

Promotion is one of the important duties of financial management. It involves the discovery of business opportunities and the subsequent organization of men, materials, and equipment for the purpose of capitalizing upon the opportunities. It requires sound financial management and often includes an operations research solution in order to determine the expected value of an investment. This is a problem of comparing the risks involved with the advantages possible.

If a business opportunity involves a difficult production problem, the investigation may be carried out by engineering methods. If its success depends upon demand, the analysis of marketing statistics may be necessary. Possibly, the company will have to conduct a marketing survey; in which case, statistical sampling and an analysis of these samples may be necessary.

Every company must have a certain amount of working capital in order to carry on its daily operations.

There is no generally accepted definition of working capital.²² However, some businessmen consider it the excess of current assets over current liabilities, and that is its use in this paper.

No business can afford to operate without a margin of cash over immediate needs. A certain amount of capital may be invested in inventory. The reduction of these inventories may permit a more flexible financial operation with room for new product investigation. Many products are of a seasonal nature, and their material inventories can be reduced to a minimum during slow months.

The maintenance of a sound financial structure can provide many advantages. Employee morale is not the least of these. The ability to take advantage of discounts and maintain a high credit rating are others.

Electronic data processing can make financial management easier through more accurate and timely information. For example, the availability of engineering and statistical programs can assist management in determining the success or failure potentials of a new product. Tighter inventory control is possible and can release additional capital for the needs of the organization.

The pre-requisites for the success of electronic data processing in a manufacturing concern are character-

istics of the application. First, it must be thoroughly defined; and, secondly, it must be highly repetitive. These are requirements for the economical use of such a system in any organization.

THE DECISION TO OBTAIN A COMPUTER

Management must ask itself the following two questions in order to establish goals for future electronic data-processing plans. Does management intend to do something new? - For example, scientific scheduling or increased control through more complete and timely information. Secondly, does management intend to improve existing systems? - For example, by reducing clerical cost and time, improving production efficiency, reducing inventory costs, and more comprehensive and faster reporting. Prior to authorizing a costly feasibility study based upon these goals, management must be fairly certain that the company's data-processing requirements do not preclude the use of a computer from the start.

Economic Justification

The economic justification for an electronic data-processing system established by management usually consists of two things - the potential to improve the company's future profit picture and the improvement of the company's operating efficiency. For example, the Navy requires the following justification for the installation of a computer: a reduction in present costs and/or increased management effectiveness sufficient to offset the cost of the computer.²³ It is expected that a large computer

application will result in reduced clerical costs, increased reliability, and improved systems and procedures.

Since 1920, manufacturing productivity has increased more than 100 percent while the number of factory workers has risen only about 55 percent. However, paper work productivity has not kept pace with productivity in manufacturing. E.g., in 1950, it took one clerk to process the data for \$47,000 worth of business. In 1957, without electronic data processing it still required one clerk to process the paper work for \$47,000 worth of business.²⁴

The reduction of this cost is management's major economic justification for an electronic data-processing system. A significant part of the cost reduction may come from the elimination of human participation in the over-all task. An example of this would be the elimination of the need for preparing and transferring records from one desk to another or the conveying of punched-card records from one machine to another. In many cases, multiple files that had been maintained separately can now be combined into a single file. Rate tables which were not easily stored in smaller machines are easily introduced into electronic data-processing systems using large auxiliary storage devices.

The reliability computers have achieved is far better than that of previous equipment which management is

more familiar with. For example, in reading and writing data on magnetic tape, we may find that a transcription error will occur once every three hours.²⁵ Since 10,000 to 20,000 characters per second are characteristic of magnetic-tape transcription rates, this can be translated into the statement that an error occurs about once in every one-hundred million characters. A similar performance for a card machine running at one-hundred cards per minute would mean that there would be only one character in error during an entire week of operation in which the machine operated twenty-four hours a day for seven days. Furthermore, in instances when the computer does make such an error, it can be automatically detected.

In applications where punched-card systems have been used, the care with which procedures must be analyzed and specified is already well known. However, electronic data-processing equipment can, because of its flexibility, handle many applications that have never been performed on punched-card equipment. In attempting to apply the electronic data-processing equipment to these broader applications, the necessary systems and procedures analyses will probably disclose weaknesses in the old procedures which, when corrected, lead to appreciable savings and increased efficiency. Much of the saving effected by the actual use of a computer may well be attributed to the careful and

logical methods developed to satisfy the exacting demands of the computer. The greatest savings have resulted from computer applications which were too large for mechanical punched-card equipment.

The Feasibility Study

Once the company's goals have been established and if management decides to go ahead with an electronic data-processing study, the next step will probably be to organize a feasibility study committee. It is not a study of the feasibility of computers but a study of the feasibility of achieving management's improvement goals. A computer system may be involved in the achieving of these goals or it may not. If the feasibility study is well oriented, it can do two important things. First, it can take an objective look at the needs of the organization. Secondly, it can pay for itself in operating improvements even if no equipment is ordered.

At this point, management must find the answers to two questions - Who should establish the goals for the feasibility study? Who should be on the feasibility study committee? These questions are best answered by referring to the current method of designing systems for digital computers; i.e., to take the problem as a total concept from the start and then to develop it piece by piece into working

and paying jobs. Using this method, the over-all concept is continually analyzed so that the pieces will eventually fit together smoothly.

Based upon this method of devising systems, no one lower than top management is qualified to establish the goals. Top management is in a position to understand the needs of the entire organization. It should not take much time to establish goals, and it does not require specialized knowledge. If they are established by the restricted viewpoint of middle management, the effort and expense which follow may be misdirected toward a piecemeal approach rather than toward the over-all concept.

Next, is the question of who should be on the feasibility study committee. Management must organize it based upon three qualities: first, a knowledge of the company; second, technological know-how; and third, strong leadership. An electronic data-processing feasibility study is expected to cut across functional lines; therefore, the group should include responsible representatives of all segments of the organization. They need not be the top men, but they should be high enough to have a broad knowledge of how the organization functions. If the organization has a systems specialist familiar with the various machines available, he should be included on the committee.

However, in those cases when it does not have an expert on such matters, management usually has hired the services of an expert to assist the committee. Finally, the group should be led by an executive whose authority is sufficient to make decisions as the study proceeds. Management's goals will have to be modified and, in some cases, discarded. The committee leader should have the authority to do this.

At the time a feasibility study is initiated, there is no guarantee that the final recommendation of this study will be the purchase or lease of an electronic data-processing system. It is merely a study of the feasibility of attaining management's improvement goals. These goals may be in the areas of improved existing systems and/or new applications. The length of time required for a feasibility study is variable. However, the study may lead to definite plans which can then be given a completion date. Generalizations as to the length of time required have been made. For example, the Navy management manual indicates that only the most complex activity should require a feasibility study of more than two or three months.

Management usually assigns the task of a feasibility study to a feasibility study committee which has

representation from all segments of the organization as well as a technical expert on the machines which are currently available. Here the question of how a feasibility study is to be conducted arises. It is conducted by a three-step, output-processing-input analysis. First, any system will have to produce certain outputs in order to achieve management's goals. These outputs should be listed and defined along with the frequency with which they will be required. Next, certain processing is necessary in order to produce the desired outputs from the available inputs. Finally, certain inputs will be needed to produce the desired outputs.

Using this three-step, output-processing-input technique, a major question arises: Can the required inputs be made available in the required time at a reasonable cost?²⁷ If not, the original goal must be modified or dropped. If the answer is affirmative, the following question must then be asked: Can the processing necessary to convert the inputs to the outputs be done fast and at a reasonable cost on existing equipment? To answer these questions, the feasibility study committee must gather four types of data: first, the nature and volume of transactions, records, and reports; second, the cost of preparing these data; third, samples of all the forms; last, special data-processing and management problems.

When developing systems based upon this data, the group should consider four objectives of integrated data processing. These are - consolidating multiple files into single files, minimizing the number of processing passes required for any file, processing several classes of information against the same file simultaneously, and eliminating intermediate results wherever possible.

The feasibility study committee analyzes the four types of data, and, based upon the objectives of integrated data processing, it prepared detailed input, processing, and output reports for management. The result of each report is in effect a statement which says, "The following goal can be achieved by certain methods in a certain time and at a certain cost." Management can evaluate the reports and decide whether to conduct a further investigation of the system or not.

Systems and Forms Analysis

Existing accounting systems and practices were not designed for digital computers. Consequently, one of management's most difficult tasks in adapting business applications to computers has been in the area of input/output definition. One of the duties of the systems analyst is to define these various inputs and outputs.

When developing input records, the systems analyst must ask the following four questions: What must be prepared? How must it be prepared? When must it be prepared? By whom must it be prepared? There are many input media to choose from including paper tape, punched cards, magnetic tape, keyboard entry, and visible records. The exact format of a record must be developed based upon the capabilities of the input media which the analyst has selected.

Paper tapes and source documents can be prepared simultaneously and later transcribed on magnetic tape by means of a paper-tape to magnetic-tape converter.

Punched cards are easily prepared and the profitable application of punched-card equipment overlaps that of computers. Card machines are excellent for small sorting, merging, and tabulating operations which cannot be economically justified on a large computer.

Magnetic tape is a fast input media and offers the possibility of large time savings. E.g., an insurance company may have a file of one-million customers with at least one-hundred digits per account. This file must be brought up to date periodically even though not every account will be changed in the process. Between fifty and one-hundred magnetic tapes may be required to

store the information, and recently announced computers can scan all one-million accounts in less than three hours.

Keyboard entry is a common input media for variables which may change once during the running of a computer program. There also special-purpose computers available which will read magnetized characters from such documents as bank checks.

When developing output records, the analyst must ask the following six questions: Why is it necessary? What is its purpose? When should it be done? Where should it be done? Who is best qualified to do it? How should it be done? There are a variety of computer output media available including paper tape, punched cards, magnetic tape, and printed documents. For example, the Burroughs 220 high-speed printer will print numeric information at a rate of 1500 lines per minute. Each line can contain up to one-hundred twenty characters. However, if alphabetic information is to be printed, the speed is reduced to 1250 lines per minute.²⁸

It is the job of the systems analyst to select from among the various input and output media those which best fit the particular application.

Once the inputs and outputs have been defined, a process chart must be constructed. A process chart is

designed to give an over-all picture of how the electronic data-processing system as a whole will handle a particular application. It identifies the inputs to the system, the various computer programs involved, and the final outputs of the system.

The process chart is a master plan showing the breakdown of the application into its several parts and indicating the sequence of events from beginning to end.* There are three process-charting rules: First, the analyst must choose fixed starting and ending points. Second, the principal direction of flow must be drawn from left to right. Third, use logical symbols that will be adaptable to any electronic data-processing system rather than tied to a specific piece of equipment.

*See Appendix A for typical Process Chart Symbols, pp. 99-101.

SELECTING A COMPUTER

The selection of a computer should not be difficult if management precedes this selection with a strong preliminary study. There are approximately eighteen companies engaged in manufacturing electronic digital computers today. Ten of these are large organizations. The others are modestly capitalized, and lack of capital is their principal problem.²⁹ This number can be further reduced if management considers the two classes of digital computers available - computers for solving scientific problems and computers for solving business data-processing problems. By eliminating those machines which obviously are not suitable, management can select one of the remaining on the basis of cost and an evaluation of the manufacturer and his product.

Preparing Specifications For The Manufacturers

Manufacturers of electronic data-processing systems spend a great deal of time with potential customers to gather necessary facts about their data-processing requirements. If the manufacturer is satisfied that his machine can handle the application based upon these facts, he may submit what is called a proposal. Proposals usually recommend the manufacturer's product,

describe his solution to the organization's electronic data-processing requirements, and state characteristics of the equipment.

If an organization is interested in a particular computer and the manufacturer is unwilling or unable to prepare a proposal, management may still consider this machine. For example, Navy directives indicate that management should have such a proposal prepared by government employees for subsequent evaluation.³⁰

Computers proposed by manufacturers may be in the drawing-board or prototype stage, while others are in full production use. The newer machines will have better specifications. However, management cannot be certain that they will be reliable or productive enough to do the job. For the older product, they can determine reliability and productivity by a representative sample of present users.

If three or more computers are being considered, management may assign a group similar to the feasibility study committee to work with the manufacturers on a full-time basis. This group is frequently called an application study committee. They are familiar with the detailed electronic data-processing plans of the organization and are qualified to answer most of the manufacturer's questions. The manufacturer's representatives who are

probably experienced data-processing specialists may contribute significantly to this committee's progress.

The manufacturer may ask management to have the application-study committee present them with five types of information relevant to the input/output and processing requirements of the organization. First, the general applications must be explained. Second, a description of all input and output forms including volumes and suggested input/output media are required. Third, the amount of processing necessary to produce the desired output from the available input must be explained. Fourth, there are many restrictions which have been placed upon price. For instance, the cost of the over-all system may not exceed ten thousand dollars per month, or the cost per record processed may not exceed .01 cents per day. Fifth, are the features which an organization may demand of any electronic data-processing system which it will consider. These are too numerous to present at this time. However, the following list will indicate some of the more common electronic data-processing system capabilities:

Magnetic tape input and output

Punched card input and output

Paper tape input and output

Printer output

- Input/output buffering
- Large memory size
- Comprehensive command structure
- Fast memory access time
- High computing speed
- Large and fast random-access storage
- Inquiry possibilities
- Punched-card to magnetic-tape capabilities
- Magnetic-tape to punched-card capabilities
- Magnetic-tape to printer capabilities

The application-study committee may request the following information from each manufacturer in order to assist in evaluating all on a common basis. First, the method the manufacturer has used to solve the company's data-processing requirements. Second, the amount of computer time which his machine will require to complete the processing. Third, the cost the organization will be required to pay in order to acquire the system recommended by the manufacturer. Fourth, the educational and programming assistance which the manufacturer will give the organization. Fifth, the delivery and installation date.

After evaluating all manufacturers on this common basis, the application-study committee may then present its

evaluation of each manufacturer and its recommended course of action to management.

Preparing Cost Estimates

Once the need for electronic data processing has been determined, one of the first questions management should consider is that of cost. Arriving at the right cost is likely to be difficult and require a careful analysis of several factors.

These factors would be: Is the equipment intended for improvement or expansion? What is the installed cost of such equipment? Will its installation create problems of plant layout? What are the maintenance and repair costs? Are future additions and modifications to the system required; and, if so, what will their cost be? What will the operating costs be - including men, materials, and overhead? If purchased, at what rate is the machine to be depreciated? What financing costs are involved? If the equipment is for improvement, what is the present cost of producing the output? It is difficult to secure reasonably accurate cost data of this nature, and the proper analysis of them requires good judgment on the part of management.

Aeroquip Corporation justified a computer to maintain inventory records for all four of its divisions.³¹

The computer determines if an order can be shipped from the division receiving it. If not, it informs the materials control planner of the existing alternatives. The management of Aeroquip believed that the job of inventory control was one of becoming aware of exceptional conditions at the right time. The materials control planner now has the means for isolating unusual situations which can subsequently be remedied.

Typical electronic data-processing center costs have been placed in three categories for illustration:

Category One - Men

Supervision

Systems Analysts

Programmers

Coders

Operators

Maintenance Engineers

Internal Auditors

Other Operating Personnel

Category Two - Materials

The Electronic Data Processing System

Peripheral Equipment Including

supply cabinets, desks, etc.

All Supplies Required including

magnetic tape, forms, etc.

Repair and Replacement Parts for
the Electronic Data Pro-
cessing System

Category Three - Other

Floor Space

Site Preparation

Air conditioning

Insurance

Computer Transportation

Parallel Operations

Power

Taxes

Overhead

The government presently considers many electronic data-processing systems as a class of capital equipment which may be depreciated by the declining-balance method over a period of five years. However, the depreciation cannot be below a nominal salvage value of approximately 10 percent. Using this method, the electronic data-processing system cost is divided by five and the result is multiplied by two. This is the maximum amount which may be depreciated in the first year.³² For example, in the first year, a system which cost \$300,000 may be depreciated \$120,000 for income-tax purposes. The

availability of such accelerated depreciation formulas has made the purchase of electronic data-processing systems more attractive to management.

The attention of management should also be directed to the legal questions that arise in connection with the purchase or lease of an electronic data-processing system, although no attempt will be made to discuss them here. The extent of liability for accidents to employees is one such problem. Another is the contract or purchase agreement which is often long and involved, offering many opportunities for legal controversy. Many forms of insurance coverage are used and are often subject to varying interpretations. Any machine must comply with the safety regulations of the state in which it is to be operated; these safety regulations vary greatly in different states. These and many other situations exist which call for careful interpretation by qualified legal counsel. The importance of this phase should not be overlooked.

Evaluating The Manufacturer And His Product

Before an organization purchases or leases a computer, management must evaluate the manufacturer and his product. Established manufacturers will supply management with a partial list of their customers. This is not only to indicate the popularity of their machines but also to

provide the potential user with a means for evaluating the record and integrity of the manufacturer.

Management must also study the field services branch of the computer manufacturers. This usually consists of six elements: the sales representative section, the sales technical representative section, the educational services section, the consulting section, and engineering liason section, and the field engineering section.

Sales Representatives have the responsibility of assuring all customers in their area of satisfactory services from all departments of the manufacturer. Their broad experience qualifies them to assist management in electronic data-processing activities and in the co-ordination of all customer-manufacturer relationships.

Sales Technical Representatives are primarily concerned with assisting management on the technical aspects of data processing. These people are usually experienced electronic data-processing specialists and computer experts who will work right with the customer to solve problems of technique.

The educational services section co-ordinates and sets the educational standards for field training. They have the responsibility of providing customers with the necessary training courses whether at the customer's

installation or at the manufacturer's. An electronic data-processing installation has continuing as well as preliminary training requirements which are also the responsibility of the educational services group.

The consulting section is usually concerned with assisting customers at the request of the Sales Representatives. They are qualified for work of a highly technical nature and prepare subroutines and service routines which may be useful to all customers.

The engineering liason section is responsible for co-ordinating all engineering changes and improvements on installed computers. They insure that each machine has included in it the latest techniques compatable with the logic of the machine.

The field engineering section is respnsible for installing and maintaining all computers. They consult with management on problems of floor space, air conditioning, and power requirements to assure the prompt and proper performance of the system when installed.

It would be impossible at this time to elaborate upon all of the factors for evaluating the capabilities of an electronic digital computer. However, a number of the more significant factors are speed, accuracy, reliability, down time, and ease of programming.

The three common denominators for evaluating the speed of a machine are: the access time, and add time, and the input/output rate. The accuracy depends to a great extent upon the built-in error checking features. An example would be the read/write check of the UNIVAC II magnetic-tape system. The reliability of existing computers is generally 98 percent or better. This compares favorably with other machines such as punched-card readers. The down time of the machine includes both scheduled and unscheduled down time. Restart and rerun time due to an equipment failure is unscheduled down time. The difference of programming various machines in machine language is not great. Basically, their command structures are the same. However, there is a significant difference in the quality of automatic-programming aids which are offered by the various manufacturers.

Why are automatic programming aids necessary and what are they? When the management of an organization decides to acquire a computer, they usually have certain goals in mind such as improving something or doing something new. For example, in a scientific installation, an objective may be to reduce the time and cost of solving complex equations. Another objective might be the solution of a problem of such length that it could not be undertaken without a computer. A business application may

be designed to speed up the handling of paper work or to prepare reports which were not otherwise feasible. In either situation, the computing system must be supported by a large amount of coding especially in the early stages of installation. To reduce the time required for this coding, automatic programming aids are offered by the computer manufacturers.

Machine language coding is the basic language for communicating with a computer. However, there are ways to simplify the job of coding. These methods make use of the computer itself to help in preparing programs. The programs that can be used to manufacture other programs have their own names, but, in general, they are all referred to as automatic coding. There are four classes of automatic coding: assemblers, interpreters, generators, and compilers.

The first of these major programs is the assembler. An assembler can eliminate many coding difficulties. For example, the inserting or deleting of instructions in a program can be made easier. While a programmer is working on the fiftieth instruction of his program, he may realize that a command must be inserted between the third and fourth instructions. Without an assembler, the memory addresses of forty-six commands may have to be changed as well as the instruction inserted. However, with an assem-

bler, the instruction merely has to be inserted. The first advantage of an assembler is the elimination of the necessity for assigning an address to each instruction. The second advantage of an assembler is that the programmer can code the problem alphabetically rather than numerically. For instance, a machine-language instruction for an addition is 10, but the assembler instruction is ADD.

The second major group of automatic coding routines is the interpreter. It is used to convert programs from one language to another and to execute the new program as it is produced. The coding which interpreters recognize may be artificial or it may be the machine language of another computer. For example, it is possible to make up a vocabulary of instructions for a non-existent computer that would be very simple to program. Then, an interpreter could execute the instructions written in this code. Unlike the assembler, an interpreter executes the final program as it is prepared. Each time the program is to be run, the complete interpretation must be repeated. Interpreters require much more computer time than machine-language programs; therefore, the price paid for ease of coding is substantially reduced speed of operation.

The generator is the third major group of automatic coding. It is a program which produces coding for a specific purpose. Generators may be included in an

assembler. However, they are frequently written as separate programs. The programs produced by a generator may be used immediately or they may be stored for future use.

The compiler is the fourth and most comprehensive type of automatic coding. In the brief history of computer installations, most of the coding has been done by specialists, not by the engineers, scientists, or businessmen who originated the problems. The people who originated the problems frequently did not have the time and knowledge of computer techniques essential for efficient coding. Therefore, they had to explain to coders or programmers exactly what their requirements were. Compilers have been developed to eliminate this difficulty, and permit the problem to be stated in problem-oriented language.³⁴ Standard English words are used such as PRINT or STOP as well as the conventional algebraic expressions. The compiler language allows these symbols to be grouped into arithmetic and logical statements which the computer will use to produce the final machine-language program. The program produced by a compiler may be used immediately or stored for future use.

Purchasing vs. Leasing

One of the primary missions of management is to deploy capital into productive and profitable channels.

Even for larger corporations, the installation of electronic data-processing equipment constitutes a major capital outlay.

For many years, management has been conditioned to the idea that leasing is a standard and desirable business practice. This is particularly true in the office-equipment industry, where certain machines have either been unavailable for purchase or else overpriced in contrast to rental. Furthermore, advancing computer technology has introduced the danger of obsolescence; consequently, many companies pay out hundreds of thousands of dollars in equipment rentals yearly.

In the computer field, however, more and more firms are giving serious thought to the possibility of buying data-processing systems outright. Their cost analysis has shown profitable advantages in purchase which could not be ignored.

Following are the factors which may favor leasing rather than purchasing of data-processing equipment:

Lease agreements generally require the lessor to maintain equipment in satisfactory working condition and to replace all worn parts. Management thereby avoids serious responsibility for system maintenance.

Leasing requires a lower cash outlay than purchasing at the time of equipment installation.

Leasing minimizes the possibility that future technological advances or changes in requirements may make the customer's investment obsolete.

By avoiding the investment of cash in fixed assets, leasing results in an apparently better balance sheet and financial picture.

Against these benefits, the following significant advantages of purchasing must be weighed:

Under many circumstances, purchasing as compared with leasing will yield substantial savings, representing attractive rates of return on the computer investment.

Unlike the lessee, a computer owner is not limited with respect to how, when, or where he operates his data-processing system.

The purchase price of the computer is a one-time payment, whereas rental rates and terms are legally open to change by the lessor at the end of each lease period.

Although past arguments have been made that lease effects a tax savings, the current availability of accelerated depreciation formulas has favored purchasing.

A significant fact emerges from these comparisons. I.e., the lease-purchase question is basically a matter of matching the risks involved in each situation

with the advantages due to the party assuming these risks. When a buyer purchases assets of any kind, he assumes certain risks which under lease are borne by the manufacturer. Before any action is taken, management must answer these questions to their satisfaction: How great are the risks under the circumstances? Can we profitably assume them? What penalty must we pay through higher rental if the manufacturer bears the risk burden?

Leasing offers a form of insurance against obsolescence. However, it does not omit the obsolescence risk but merely shifts it to the manufacturer. He will naturally insure himself by adjusting his rental structure. An important question is - How great a threat is obsolescence in electronic data processing? Physical deterioration of equipment is not a factor; a properly maintained computer will perform as well after ten years of operation as it did on the day of installation. However, within the life span of one computer, a new one may appear whose improved design makes possible large reductions in cost and increases in speed and efficiency. Management may feel that the greater output of such a computer might force the organization to dispose of its original equipment before it has been fully depreciated.

The large capital outlay necessary at installation is often cited by management as a purchasing dis-

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advantage. This can be reduced through an installment purchase plan. Only a fraction of the full sales price is invested as a down payment, and the average investment throughout the period of equipment life may raise the rate of return.

Equipment maintenance is another risk, or inconvenience, of which rental relieves management. Under certain circumstances, this may be counted as a benefit. However, most manufacturers offer a service agreement for those purchasers who prefer not to handle maintenance themselves. This plan makes available necessary labor and parts to assure the same standard of maintenance obtainable under a lease contract.

Finally, leasing as opposed to purchasing may give the appearance of greater liquidity on the balance sheet by omitting a large capital asset. However, financial analysts and creditors do not overlook the obligations of leases.³⁵ They further recognize that, while computer leases generally run for only one or two years, a user would hardly dispose of leased equipment so soon after a large investment in programming, systems, revision, and possibly new plant facilities.

The advantages and disadvantages of both leasing and purchasing should be identified and judged by management. The risks of ownership may be no different in kind

or size from other business risks. Management must determine whether ownership can provide dollar advantages to justify these risks. The equipment manufacturer can supply cost information helpful to the user; but only management can decide what is an acceptable rate of return in the situation. It is possible that an analysis will show purchasing to offer an attractive investment opportunity.

THE PRE-INSTALLATION PERIOD

Considerable planning must precede the installation of an electronic data-processing system. This is principally directed toward getting the machine installed and in a productive status as soon as possible. However, management should also consider the future and the efficiency of the programming staff.

Physical Facilities Of The Computer Room

The manufacturer's engineering representatives are available to assist management in planning for a successful installation. They understand the exact requirements of their system and the tolerances which are permissible.

For example, management may have a problem of fluctuating power levels during the morning and evening rush hours. Some computers allow for a variation of from 15 to 40 percent in power levels. Exceeding this tolerance may cause the computer's power supply regulator to automatically turn the computer off.

Management must consider the future as well as the present when planning the physical facilities of an electronic data-processing center. There should be room for two types of expansion - first, increased volume on

initial applications, and second, additional applications to meet the continuing needs of management.

Expansion caused by greater volumes on initial applications may require more equipment as well as additional computer time. Information files can be of two types: open end or closed end. Open-end files can have an infinite storage capacity and additions to them are relatively simple. An example would be the policy file of a major insurance company; adding new policies or deleting old ones would cause the file to expand or contract periodically. If all new policies are added to the end of the existing file, the result may be the addition of a few magnetic tapes, and, consequently, no management problems arise.

This is not the case with a closed-end file or random-access storage device. These reduce the amount of computer time required to locate and update a particular record.³⁶ They usually have a fixed capacity and no problems arise until their capacity is exceeded. However, in times of increasing business prosperity, this may occur; and it is then necessary to purchase or lease an additional random-access device. This equipment will occupy computer room floor space and increase air-conditioning requirements as well as power requirements.

Expansion caused by new applications will require computer time and possibly additional equipment. If the application is designed for the existing equipment, configuration, then the only major requirement, will be computer time. However, if the new application is designed for a system with greater capabilities than the existing one, it becomes necessary to acquire additional equipment. This results in increased floor space, air-conditioning, and power requirements.

The Electronic Data Processing Department

When the decision to obtain a computer has been made, the organization must then realize the objectives established during the feasibility study. Of major management importance at this time are gaining acceptance for electronic data processing, and staffing the Electronic Data Processing Department.

Gaining acceptance is sometimes difficult.³⁷ Within any organization utilizing electronic data processing, there are individuals who prepare input to the computer, define the details of processing, and utilize output from the computer. Communication becomes increasingly important when dealing with such individuals, for their assistance is valuable in further defining computer applications. Their willingness to co-operate may

speed things up or slow them down depending upon the situation. For example, one public utility application was delayed because branch-office personnel felt their responsibilities were reduced by the electronic data-processing system.

A program to communicate the place of electronic data processing should start during the feasibility study and continue until the system is accepted as a normal part of the firm's operation. A form letter prepared and signed by a top executive is one method of communication. Such a letter should define the computer's purpose and the effect it will have upon employees.

The greatest staffing problem management faces in the area of electronic data processing is that of obtaining good programmers. In terms of man years and problems, the process of programming will cause the most difficulty during installation. Management might obtain, by hiring or consultation, at least one expert programmer. He should have three or more years' experience in data processing. This may seem expensive at first, but it will pay off well in problems that will not have to be solved.

Much has been written about what qualities an individual should have in order to become a proficient programmer. Two of these stand out above all others -

first, an understanding of the application, and secondly, a facility for solving mathematical and logical type problems. Management must decide upon the weight to be given each based upon the requirements of the organization. For example, if the application involves complex linear programming of oil refinery problems, management may select experts in this field and have them trained as programmers.

The duties of a programmer are best illustrated by the programmer's problem-solving technique. This is a five-step process which involves the following elements: process charting, flow charting, coding, debugging, and documentation.

Process charting, often associated with the job of systems analysis, involves a study of the various outputs required and the inputs available.* From this study, the programmer must decide the number of separate programs the application requires and what their sequence will be. For example, a large insurance actuarial application may involve one program to validity check the input data, another program to update the master policy file, and a third program to print the output documents.

The programmer's flow chart is a graphic presentation of a program for an electronic data-processing system.** The formulation of such a chart precedes the

*See Appendix A for typical Process Chart Symbols, pp. 99-101.

**See Appendix B for typical Flow Chart Symbols, pp. 102-105.

actual coding necessary to complete the program. It represents a logical analysis and should be universal in that coding for any comparable equipment could be accomplished from the same flow chart.

Coding involves the actual conversion of the programmer's logical analysis into the language of the computer.

Debugging is the process of correcting any errors which exist in a computer program. These errors are of two types - first, coding errors, and second, logical errors. The first are mistakes which the programmer himself has made. Logical errors may be the result of a misinterpretation by the programmer or improperly defined input/output requirements.

Documentation of computer programs involves the preparation of process charts, flow charts, coding, input/output diagrams and operating instructions. These should insure the smooth transfer of programs from one person to another.

There are many good reasons which can be given for proper documentation. One is the avoidance of serious management repercussions which might occur if a programmer is lost.

THE INSTALLATION PERIOD

Many users of electronic data-processing systems have years of experience in the successful and unsuccessful application of that equipment. Management and labor of these and other companies expect something from electronic data processing. It is not always the same, nor is it easy for either management or labor to attain the goals which they have established in this area.

Management is faced with many problems such as effective control of approved applications. Labor and management are faced with changes in the size of certain labor forces and changes in the rate of pay for the individuals affected.

The successful control of approved applications is in one way or another dependent upon a project control system which must co-ordinate the needs of the systems analyst, programmer, and operator. Project scheduling, progress reporting, and the establishment of a project file for future reference are major areas of responsibility.

Each project leader may be responsible for preparing a project schedule upon receipt of an assignment. At prescribed intervals the actual progress should be compared to the project schedule. This may indicate that schedule revisions are necessary. Since changes in sched-

uling may upset inter-related planning, manpower adjustments may be required.

When a project has been either completed or abandoned, the project leader should review the project file to insure that it contains all the information required if the project is to be revised. At the same time, any papers whose usefulness expired with the closing of the project should be removed and destroyed.

The purpose of a project file is to keep all information related to a single project in one place and to provide background information for future revision or extension of the project.³⁸ The project file is a master record of a programmed job and must contain information collected during the development stage. The development stage consists of the systems analysis stage (problem definition), the programming stage (problem solution), and the operational stage (production).

It would be impossible at this time to list and describe all of the material which should or should not be included in a project file. The requirements of different organizations are not the same. What may be an excellent project file from the viewpoint of an insurance company may not be acceptable to manufacturing organizations. However, for illustrative purposes, the contents of a typical electronic data-processing project file are listed:

Management approval documents
Historical information
Project description
Process charts
Input/output layouts and volumes
File descriptions
Flow charts
Description of accuracy control techniques
Description of subroutines used
An input/output test package
Documented program listing
Computer operating instructions
Record of program operation

Management expects three results from electronic data processing. These are: economy, accuracy, and promptness.³⁹ They are similar to what is expected of any department within a manufacturing organization. As far as management problems are concerned, the difference between an ordinary production department and an electronic data-processing department is not great. The justification for producing something which has to be sold on the competitive market may be that production costs are within the limits which permit the product to be sold at a profit. To justify the use of electronic data processing, there should

be benefits either directly in the form of lower costs on specific operations or indirectly in performing other operations which result in better over-all control of the organization.

Management problems may occur in the following areas: work scheduling, work planning, system usage, peripheral equipment usage, operating techniques, equipment maintenance, internal auditing, employee relations, and customer relations. For example, the establishment of an hourly rate for each piece of equipment and a record of the idle time for such equipment may indicate that there is a substantial financial loss due to improper planning or scheduling.

Reducing the number of man hours by increasing the productivity of the operator is the principal justification for using almost any machine. If the total cost of the machine exceeds the value of the operator's increased productivity, the investment may be economically unsound. As the productivity of the operator increases, many feel that wages should also be increased. If the total cost of the machine plus the cost of an associated wage increase is greater than the value of the operator's increased productivity, this may also be considered economically unsound.

The problems which arise because of the creation, loss, upgrading, or downgrading of existing jobs warrant the close attention of management. Good management requires that employees be fairly paid for their efforts. Although the foregoing statement may be readily accepted by managers of all sizes and types of organizations, there is less agreement about the method of accomplishing such a goal.

If management wishes to provide employees with a fair day's pay, it must consider and act upon the following six problems: First, is the problem of wage and salary levels within the community and industry. Second, is the problem of wage and salary structures within the company. Third, is the problem of individual wage payment for specific jobs. Fourth, is the problem of wage payment methods. Fifth, is the problem of fringe benefits. Sixth, is the problem of controlling wages and salaries in the future.

When jobs are lost or downgraded by the installation of an electronic data-processing system, overpaid employees present a problem. Various solutions are possible; namely, pay reductions, transfers, promotions, retirements, increased duties, and responsibilities for specific jobs, and the elimination of future rate increases. Although all of these are possibilities, it has been general practice to avoid reducing the pay rate of employees

in such circumstances. This overpayment is generally not the fault of the employee. Unions have insisted that the pay rates of present employees not be reduced in such cases. It is common practice, however, to keep track of these situations and correct them at every opportunity to the mutual satisfaction of management and labor.⁴⁰

CONCLUSIONS

Computers are complex both in construction and application. However, the complexity of applying computers to scientific and business data-processing problems has been reduced to a few simple principles. Management should be familiar with these principles for they indicate the capabilities and limitations of existing machines. Based upon this information, management can determine whether or not the requirements of the company preclude the use of a computer from the start.

Any problem to be economically handled by a computer must be highly repetitive. This requirement is a cost consideration based upon the cost of programming and computer time as compared to the value of the output. For small volume applications, it may be more economical to use conventional calculating or accounting equipment. However, manufacturers have reduced the cost of programming by the introduction of automatic programming aids which enable a program to be written in problem-oriented language. Therefore, restrictions which have previously been placed upon the repetitive nature of a problem are being lowered.

Management can learn much from the experience of others in the field of electronic data processing.

The future should be considered as well as the present when designing a computer application. For example, an improvement over old methods of devising systems for computers is to consider the problem as a total concept from the start; then, develop the system piece by piece into working and paying jobs. Using this method, the over-all concept is continually analyzed so that the pieces will eventually fit together into an integrated data-processing system.

The small company which is unable to purchase or lease a computer can take advantage of what computers offer. These firms may not have the trained programming staff or the work to economically justify full-time use of a system. However, some are anxious to use computers on a part-time or as-required basis. To meet the needs of this market, many service centers have been established and will rent time on an hourly basis. Most of these are fully staffed and offer not only computer time but also programming, educational, and systems analysis services.

Large electronic data-processing systems offer management the advantages of consolidating existing files and eliminating intermediate results by parallel rather than serial processing. Management has the opportunity to use scientific scheduling and to increase control by more current information. Existing systems can be improved by: reducing clerical costs, improving production efficiency,

reducing inventory costs, and more comprehensive and faster reporting.

Once the electronic data-processing goal of management has been established, a feasibility study should follow. This is a study of the feasibility of achieving the goals established by management, not a study of the feasibility of computers. A computer may be involved in the achieving of these goals or not. The feasibility study should take an objective look at the needs of the organization and pay for itself in operating improvements whether a computer is acquired or not.

Top management is in a position to understand the needs of the entire organization. Based upon the current method of designing systems for a computer, no one lower than top management is qualified to establish goals for the electronic data-processing needs of the organization. If they are established by the restricted viewpoint of middle management, the effort and expense which follows may be misdirected toward a piecemeal solution rather than toward the over-all concept.

The economic justification of management for a computer consists of: the potential to improve the company's future profit picture and the improvement of the company's operating efficiency. It is expected that a large electronic data-processing system will result in

reduced clerical costs, as well as increased reliability and improved systems and procedures.

Existing accounting systems and practices were not designed for an electronic data-processing system. When adapting accounting systems to a computer, the necessity for existing information can and should be questioned.

Computers proposed by manufacturers may be in the drawing-board or prototype stage, while others are in full production use. The newer machines will have better specifications. However, management cannot be sure of their reliability or productivity, for the older machines, a representative sample of present users will indicate this.

The selection of a computer will not be difficult if management precedes this selection with a strong preliminary study. By eliminating those machines which are obviously not suitable, management can select one of the remaining on the basis of cost and evaluation of the manufacturer and his product.

For many years, management has been conditioned to the idea that leasing is a standard and desirable business practice. This is particularly true in the office-equipment industry where certain machines have been unavailable for purchase. However, more and more firms are giving serious consideration to the possibility of buying

electronic data-processing systems. Cost analysis shows profitable advantages in purchasing as opposed to leasing.

Management must consider the future as well as the present when installing an electronic data-processing system. There should be space for expanding volumes and new applications. If air-conditioning requirements and floor plans are prepared from this point of view, it will minimize future expansion problems in these areas. Master files should allow for unlimited expansion within reasonable limits established by management.

Gaining acceptance for an electronic data-processing system depends upon the success of management in communicating with people who must: prepare input data, utilize output data, and define problems. A program to communicate the place of electronic data processing should start during the feasibility study and continue until the system is accepted as a normal part of the firm's operation.

The greatest staffing problem which management faces in the area of electronic data processing is that of obtaining good programmers. Much has been written about the qualities an individual should have in order to become a proficient programmer. An understanding of the application and a facility for solving mathematical and logical type problems are two of the most important qualities.

Management's control of approved applications is dependent upon a project control system which must coordinate the needs of the systems analyst, programmer, and operator. Project scheduling, progress reporting, and the establishment of a project file for future reference are major areas of responsibility.

When jobs are lost or downgraded by the installation of an electronic data-processing system, overpaid employees present a problem. Various solutions are possible: namely, pay reductions, transfers, promotions, retirements, increased duties, and responsibilities for specific jobs, and the elimination of future rate increases. Although all of these are possibilities, it has been general practice to avoid reducing the pay rate of employees in such circumstances.

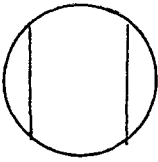
An electronic data-processing system, properly applied, is a valuable asset for the reduction of costs and the improving of operating efficiency. It can supply management with data upon which to base some business decisions. However, regardless of how simple or how complicated it may be to obtain this data, one fact cannot be overlooked - namely, that human judgment must always be called upon for the final answer.

APPENDIX A⁴¹

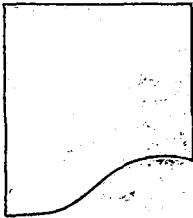
Process Chart Symbols*



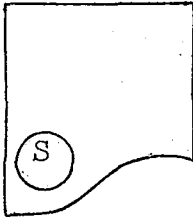
Card input or output



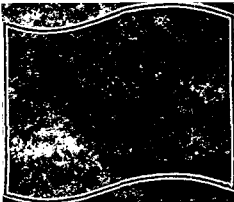
Magnetic tape input or output



Printer output



Supervisory control printer output



Paper tape input or output



*From Laieto, pp. 2-7.

APPENDIX A (Continued)



Keyboard input



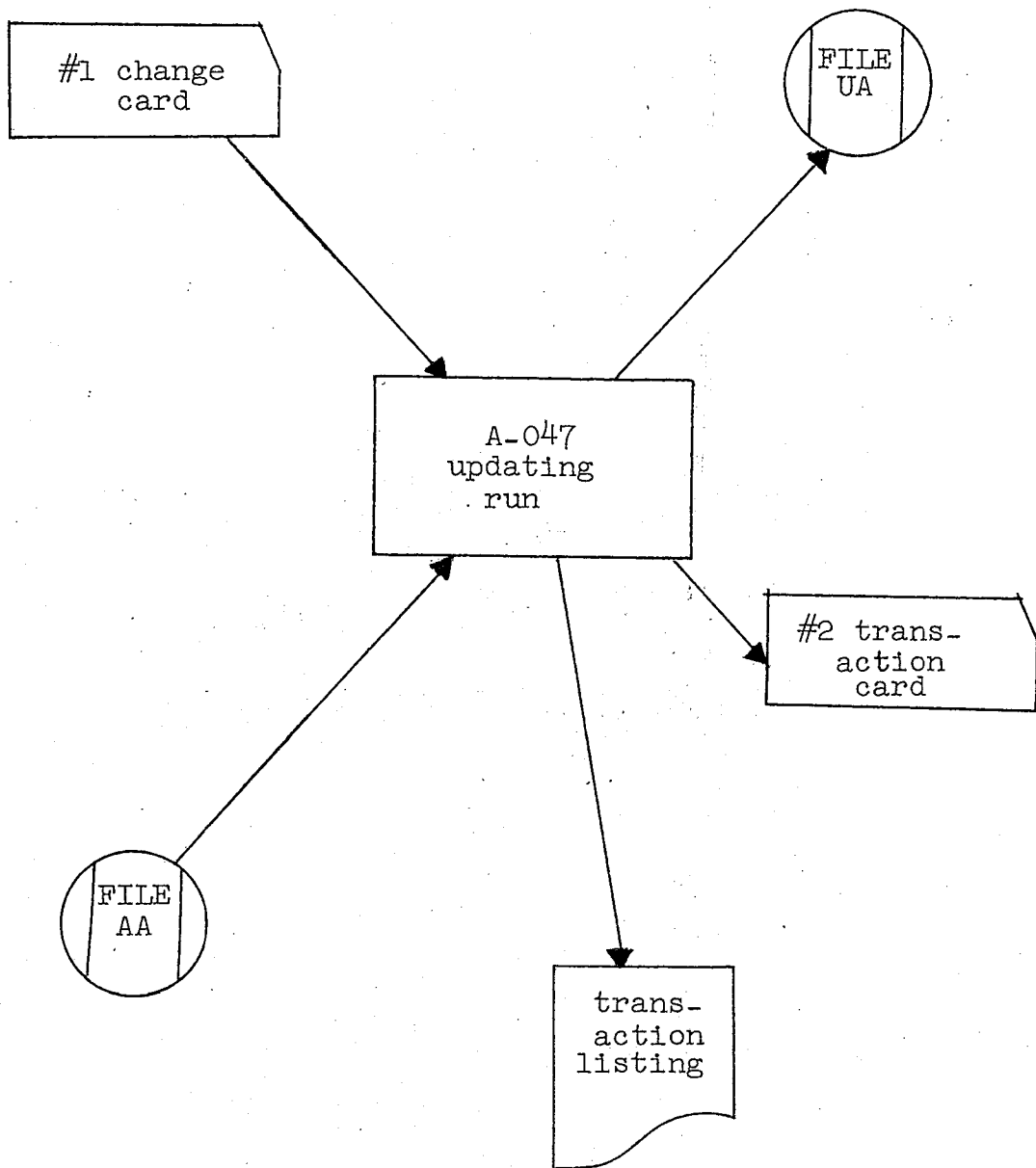
Program description

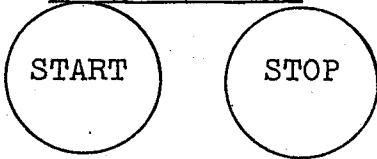


An off-line operation, such as the sorting or collating of punched cards, etc.

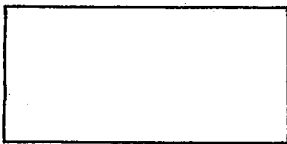
APPENDIX A (Continued)

Process Chart Example

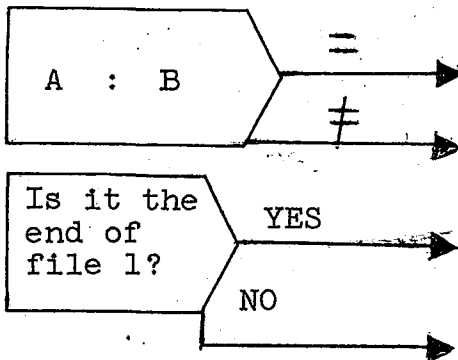


APPENDIX B⁴²Flow Chart Symbols*1. Start or Stop

This symbol indicates the start of a program or an unconditional program stop.

2. Operation

This is a one-entry, one-exit symbol which is used to describe a non-decisional type operation.

3. Decision

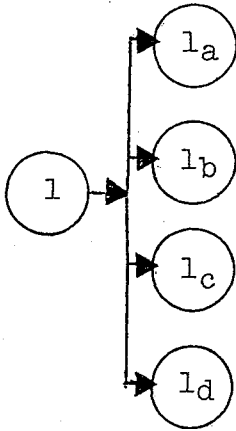
This is a one-entry, two-exit symbol which is used to indicate that one of two branches is possible. The branch depends upon the result of the comparison.

4. Fixed Connector

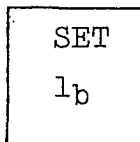
This symbol is used if control must be transferred to another location on the flow chart. Common practice calls for sequential numbering of fixed connectors beginning with 100.

*From Laieto, pp. 2-7.

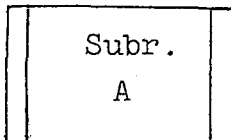
APPENDIX B (Continued)

5. Variable Connector

This symbol is used the same as a fixed connector, except, transfer to one of a number of flow-chart locations is possible depending upon the connector setting. Common practice calls for sequential numbering of variable connectors beginning with the numeral one, and an initial setting (?A) for all variable connectors.

6. Setting a Variable Connector

This symbol is used to set a particular path of a variable connector.

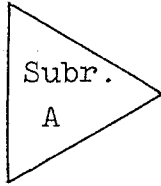
7. Subroutine

This symbol is used to indicate: enter Subroutine A, execute Subroutine A, and return to the flow chart symbol following this symbol.

APPENDIX B (Continued)

8. Subroutine Entrance,

Exit



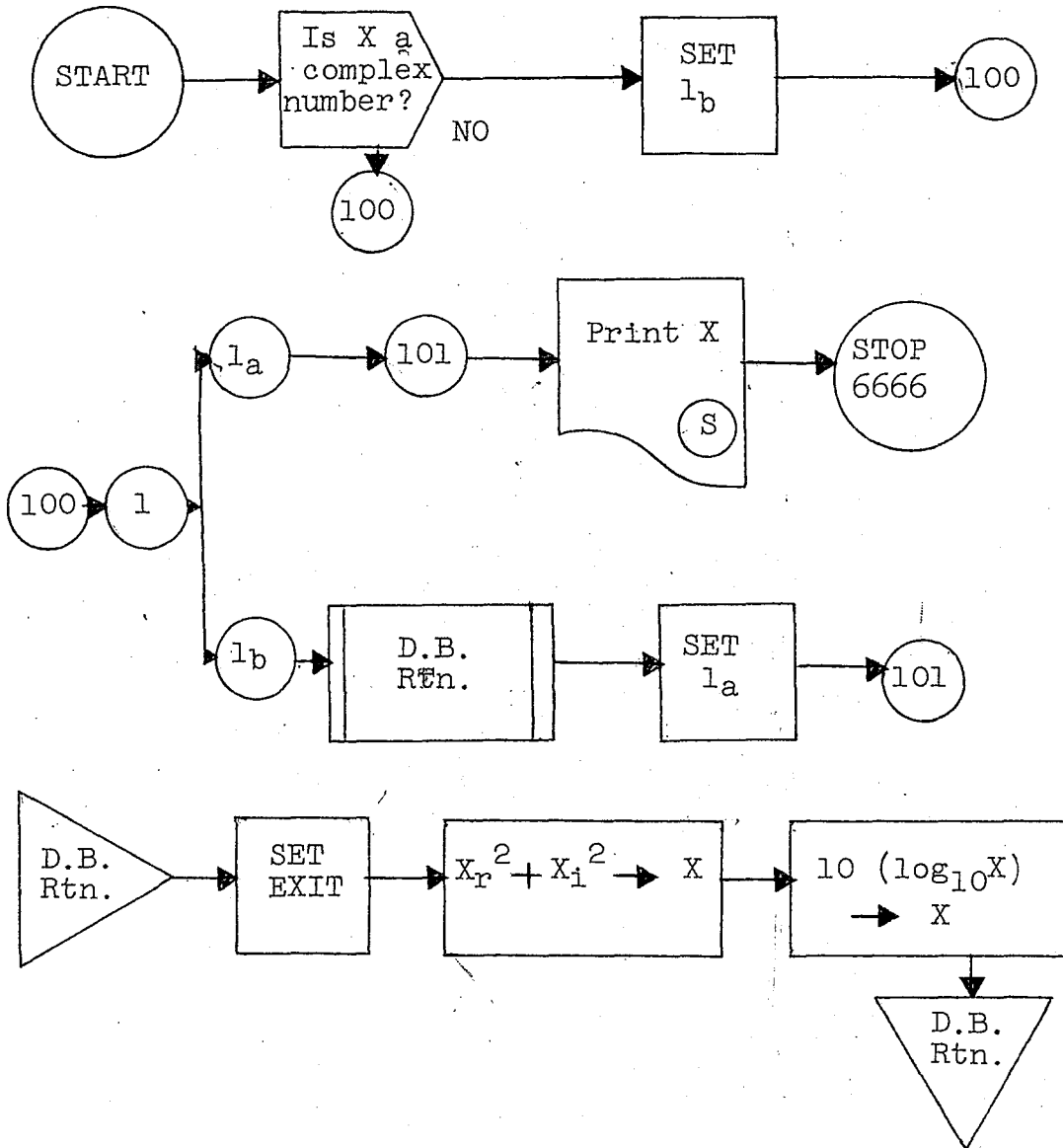
This is the first and last symbol of a subroutine and is somewhat analogous to the start and stop program symbols.

9. Flow chart input/output symbols are the same as the process chart input/output symbols.

APPENDIX B (Continued)

Flow Chart Example

YES



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