Computer-Oriented Business Systems

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To all my students,
who provided the stimulus
to write this book.

Preface

The difficulty with most books in the field of business data processing stems from the fact that they are essentially descriptive in nature. In this book we attempt to relate the work which has been done in the area of systems theory to the business firm. The actual implementation of the systems design is left to people in business and industry who are intimately acquainted with the environment within which the computer system must function. The plethora of implementation techniques greatly increases the actual number of alternatives which could be described in depth. Were we to describe them all here, however, there would be considerable danger of overwhelming the serious reader with descriptive material and detail. Hopefully we have avoided this danger by describing a minimum of these detailed techniques.

The reader should view this book as problem-oriented rather than as a data bank of information relating to business-oriented computer systems. The book is divided into four sections. Chapters 1 and 2 deal with those computer hardware concepts which are required for an understanding of computer systems. (A secondary benefit of these chapters is that the reader will become familiar with the "jargon" of the computer world. This is of vital importance to the business manager who must communicate with the professional when discussing hardware and the design of the computer system.) Chapters 3 through 6 deal with various aspects of computer software, including programming languages and some theoretical propositions relating to systems design. (It should be noted that a separate workbook is available which includes a section on the elements of the COBOL language and incorporates problem material suitable for classroom use.) Chapters 7 through 11 present the stages of development of the computer-oriented business systems in operation today. (It is inevitable that these chapters include descriptive material, but implications for systems theory are discussed where they are deemed appropriate.) The last chapter, Chapter 12, was perhaps the most difficult to write and the one which is most open to question. No one can really comment on what will happen in the next fifteen or twenty years without reservations; but an author feels a certain obligation to state his expectations of the future, since some notion of future developments is inherent in all that he has written.

This book can be used for a one-semester course, or in a two-quarter sequence course in business information systems if the workbook is used. There is no problem material in the text. Selected references at the end of each chapter indicate sources which can be explored if the reader wishes to delve more deeply into specific problems. I hope this book will furnish a workable introduction to the subject of computers for the student of business information systems—how computers relate to present business information systems and, hopefully, how these relationships are likely to change in the foreseeable future.

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chapter 1

The Dawn of the Computer Age

In terms of the earth's life span, man as a social animal has had a relatively brief tenure on this planet. During this period, when he was not struggling for existence, he has been concerned with his relationship to the universe. His initial exploratory efforts were largely an examination of the nature of his environment. Another, more dynamic, investigation—the domain of the social sciences—involves the relationship of man with his fellow men. Philosophers and historians have attempted to state this relationship in a variety of meaningful forms; only recently have mathematicians, physical scientists, and engineers entered this debate. Their purpose before had been to understand the relationship of man to his environment rather than to understand relationships between men. The problem we are concerned with here involves the contributions of quantitative disciplines to problems of the social scientists.

Communication can at times be extremely frustrating. Indeed, it would be delightful if each word had but one meaning; there would be less confusion in the political arena, platform issues would be clearer, and statements by politicians could be compared word for word. This problem of communication is especially acute in all academic disciplines concerned with the social sciences. Since the early 1940s, there has been an increasing emphasis in these sciences on the use of quantitative techniques to clarify meanings. The verbalists and the quantitative theorists continue to debate where the line should be drawn in determining what procedures, what directions, what conclusions can be expressed quantitatively without destroying their original meanings. The problem became especially acute with the advent of the stored-program digital computer in the latter part of the 1940s.

The idea of quantifying data is not limited to the past 20 or 30 years, but has existed since men first attempted to express business-type transactions and to preserve the record of them for posterity. The history of accounting techniques, culminating in the double-entry system set forth by Fra Paciolo in his *Summa de Arithmetica* in 1494, is a most eloquent testimonial to man's struggle for clarity of expression; yet accounting still has problems presenting financial information to interested outside parties because of an inability to quantify certain types of data. At present we can quantify some of what we know about the interaction of man, but a great deal of what we know in this realm remains outside the ken of quantification. Many business firms engaging in feasibility studies for the acquisition of mechanical equipment tend to consider only the part of a firm's business information system that is readily quantifiable. The result has been to de-emphasize the integrative aspects of a computer system and to emphasize instead a segmented, *ad hoc* approach in computerizing certain manual operations, and to rely on increased speed and accuracy as economic justification for acquisition of the equipment. We should instead investigate the logical design of computers as a background for study of the problem of systems design. We should also investigate some of the tools available to a systems designer. Some of these, such as systems flow charts and programs flow charts, are descriptive tools; others, such as decision tables and computer languages, are analytical.

We can compare the system-hardware relationship to the chicken-egg analogy. In one sense it is true that the idea of a system independent of hardware was developed at an earlier stage; recent studies, however, reveal that because of the computer's logical structure hardware has generally dictated the configuration of the system. Therefore, we should consider computer hardware before considering a system's theoretical aspects, although, in fact, a better approach would be to establish a system concept before considering the hardware.

THE DESIGN OF A COMPUTER

The logical structure of a computer consists of three basic parts: the input device, the processing mechanism, and the output device. The input device is a means of communicating to the computer the data to be used or processed. In the early days of computer technology, data were supplied to the computer by means of switch settings, dials, or electronic pulses created by holes punched in paper tape or cards. More recent input devices employ optical scanners, light pens, character-recognition equipment, and magnetic tape, and experimental work is now being done to use the human voice as computer input.

We can break down the processing section of computer hardware into three subcomponents: the arithmetic-logical section, the storage section, and the control section. The key to the processing unit or central processing unit (CPU) is the control unit, the traffic director for data. Data are introduced into the memory section and converted into usable information in the arithmetic-logical section of the CPU. When the information is to be printed or read out of the computer, the control unit directs the flow from memory to the outside environment. The computer diagrammed in Fig. 1–1 shows the input, processing, and output areas, and the major components of the processing area: the control unit, the arithmetic-logical unit, and the computer memory section.

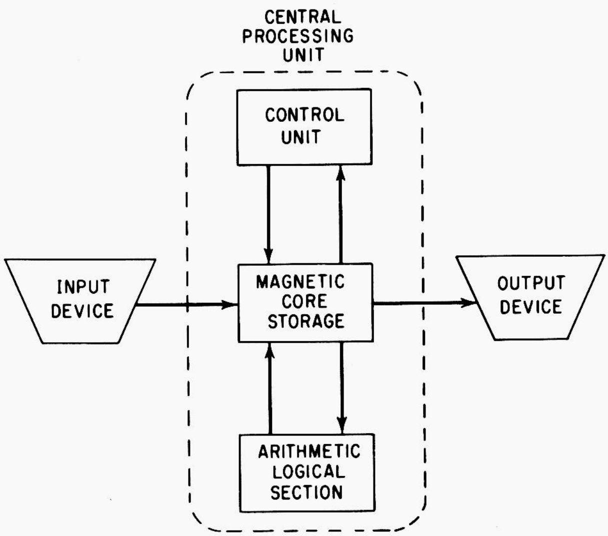

FIGURE 1–1. Logical Design of a Digital Computer

FORERUNNERS OF THE COMPUTER

The early history of data quantification perhaps has more mathematical overtones than computer-related facts. The use of the decimal system of counting—a natural result of the availability of ten fingers to most individuals—continues today in the communication of data. Computer designers were aware that input data and output information must necessarily be communicated to and from the computer via the decimal system; thus computer hardware design was oriented to the manipulation of decimal symbols. This concept led to several difficulties in the development of the earliest of the stored-program digital computers which was completed in 1944.

The earliest device of assistance to computer designers was the abacus (see Fig. 1–2), developed sometime around 3,000 B.C. It was one of the first devices utilizing the idea of *positional notation:* If a bead was against the bar it had one meaning; if it was away from the bar it had another meaning. It is interesting to note that when the computation had been

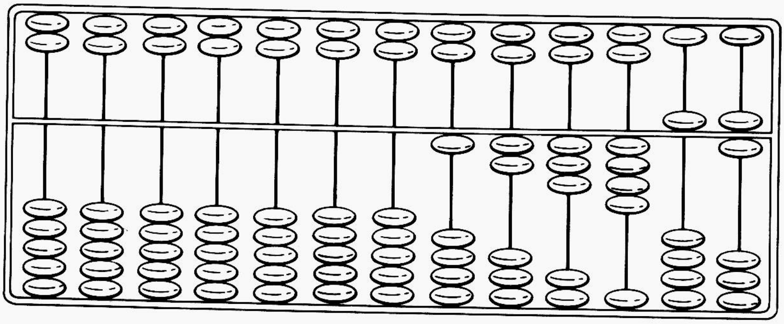

FIGURE 1–2. Sketch of an Abacus (Note: the beads below the bar represent ones, while the beads above the bar represent fives. The number "stored" in the abacus in the sketch is 123,456.)

completed, the manipulation or division total remained fixed until the operator changed the positions of the beads. The idea of *data storage* is one of the basic concepts applied in the modern computer. In the abacus fixed storage was limited to one number, but this was better than no storage at all. Other early developments of aid to computer designers were Napier's bones in 1617, Pascal's adding machine in 1642, and Leibnitz's multiplication machine in 1671. Table 1–1 gives a chronological listing of some of the early devices that led to the concept of the computer first formalized by Charles Babbage early in the nineteenth century. Babbage's "Difference Engine," as the early version was called, was never completed because of lack of funds and because of the absence of an adequate technology. The portion of the machine that was completed is now on display in the Science Museum of London.

TABLE 1–1

SIGNIFICANT DEVELOPMENTS LEADING TO THE INTRODUCTION OF THE BUSINESS-ORIENTED COMPUTER

Year	*Inventor*	*Designation*	*Description*
3000 B.C.	—	Abacus	Calculating device
30 B.C.	Greek	Digital machine	Device for astronomical calculations
1617	Napier	Napier's bones	Multiplication device
1642	Pascal	Calculating machine	First calculating machine
1842	Babbage	Difference engine	Machine for calculating tables by means of difference
1850	Babbage	Analytical engine	Theoretical design for a stored program digital computer
1890	Hollerith	Punched-card sorter	Development of EAM equipment for processing census data *
1944	Aiken	Mark I	First general purpose computer
1946	Eckert, Mauchly	ENIAC	First use of electronic circuitry
1952	Eckert, Mauchly, von Neumann	EDVAC	First use of binary mode and acoustic delay line memory
1951–52	Remington-Rand	UNIVAC I	First commercially available computer
1953	MIT	Whirlwind I	First use of magnetic core memory

* Dr. Herman Hollerith, the father of punched-card equipment, formed the Tabulating Machine Company to manufacture and lease these machines to the government and other organizations interested in processing data. Through a succession of mergers, his company became the International Business Machines Corporation (IBM). In 1911 James Powers formed a company to compete with Dr. Hollerith's company. The company formed by Powers later became a part of Remington Rand, Inc., now known as Sperry-Rand Corporation.

Babbage also designed a machine that he referred to as the "Analytical Engine." He combined the ideas of analytical formulas with the Jacquard Loom Principle (whereby a loom is capable of weaving any design by inserting a set of pasteboard cards with punched holes into the machine to guide the pattern of weaving).

Babbage conceived of the analytical engine as follows:

> The analytical engine consists of two parts; first the store in which all the variables to be operated upon as well as all those quantities which have arisen from the results of other operations are placed; two, the mill into which the quantities about to be operated upon are always brought.
>
> . . . there are two sets of cards—the first to direct the nature of the operations to be performed, these are called operation cards; the other to direct the particular variables on which those cards are required to operate. These latter are called variable cards.[1]

Babbage's Analytical Engine is very similar to the modern concept of a computer. It involves feeding a program and data into the computer and operating on them. The Analytical Engine was never built because of an unsympathetic English government and because the Difference Engine was not a success. The designs of the Analytical Engine are preserved in the papers of Charles Babbage (see the bibliography at the end of this chapter).

Toward the end of the nineteenth century another interesting development occurred that had a significant impact on the future design and implementation of computers. Herman Hollerith, an employee in the U.S. Census Bureau, concerned himself with the processing of data collected by census takers for the 1890 census. Optimistic estimators indicated that it would take ten years to assimilate and make available this data, by which time the information would be out of date and the next census already in progress. Hollerith, in attempting to analyze and solve this problem, also took his cue from the Jacquard Loom Principle. Because much of the census data could be evaluated in terms of "yes" or "no" answers, he determined that results could be tabulated by means of a two-state binary process, with one hole to represent "no" answers and another to represent "yes" answers. Hollerith's contribution was development of a machine that could sort these data, count the items, and retain a record of the count.[2] This machine, called the sorter, is the key to the success of today's unit-record equipment.

It is interesting to note that the development of punched card equipment excludes one of the most important principles introduced by Babbage. Although the punched card equipment processes data, there is no way to control the processing other than by external programming. As Babbage indicated in his description of the Analytical Engine, one can

[1] Charles Babbage, *Passages from the Life of a Philosopher* (London: Longmans, Green & Company, Ltd., 1864), pp. 118–119.

[2] The 1890 census data were introduced into cards by means of a hand punch. The cards were positioned over cups filled with mercury. Telescoping pins were located above the cards, and when a hole was encountered the pin dropped through the hole into the mercury completing an electrical circuit.

control the processing by first inserting program cards, then inserting data cards. The punched card equipment, or unit-record equipment as it is sometimes called, does not make use of program cards. Programming is done externally, through manipulation of switches, dial settings, or plug board wiring.

Further developments in business data processing involved the refinement and improvement of Hollerith's idea. Up to World War II, however, there were no significant inventions in the area of business data processing.

THE COMPUTER IS BORN

By World War II the need for increased calculations and more sophisticated information was apparent. There were needs for calculating ballistic trajectories and probable areas of damage, as well as other military problems requiring either deterministic or probabilistic solutions. Although during World War II a great deal of military personnel information was kept on unit-record equipment, engineers and scientists were exploring the possibility of developing a more flexible device to expedite the calculations so vitally needed to obtain personnel information for military commanders. The idea of the computer as we know it today was conceived by Dr. Howard Aiken of Harvard University in 1937. The rapid developments in international affairs tended to make other people interested in this project, and with the support and encouragement of the government, the first stored-program digital computer was born.

This first stored-program digital computer was developed to expedite problems that were too time-consuming and tedious for men to perform accurately. As Dr. Aiken stated in a discussion with George C. Chase on April 22, 1937, certain branches of science had reached a barrier that could not be passed until means could be found to solve mathematical problems too large for available mechanical devices.

It may be useful to consider here the physical configuration and logical structure of the first computer—the Mark I. Figure 1–3 indicates the essential elements, the general configuration, and the logical layout of the Mark I. Because the decimal system is used in America, it was only natural that the designers of the first American computer system would attempt to incorporate the decimal system into the logical circuitry. This involved some very real engineering problems. It was necessary to design a ten-position switch (*C*) and a ten-position relay (*D*) to represent the ten allowable integers of the decimal system. The Mark I also had two-position switches (*A*), two-position relays (*B*), buttons such as the "start" button (*E*), and various cam contacts (*F*). Because of the combination of electromechanical devices, the mass of internal wiring, the tremendous heat generation, and other engineering problems, it took almost seven

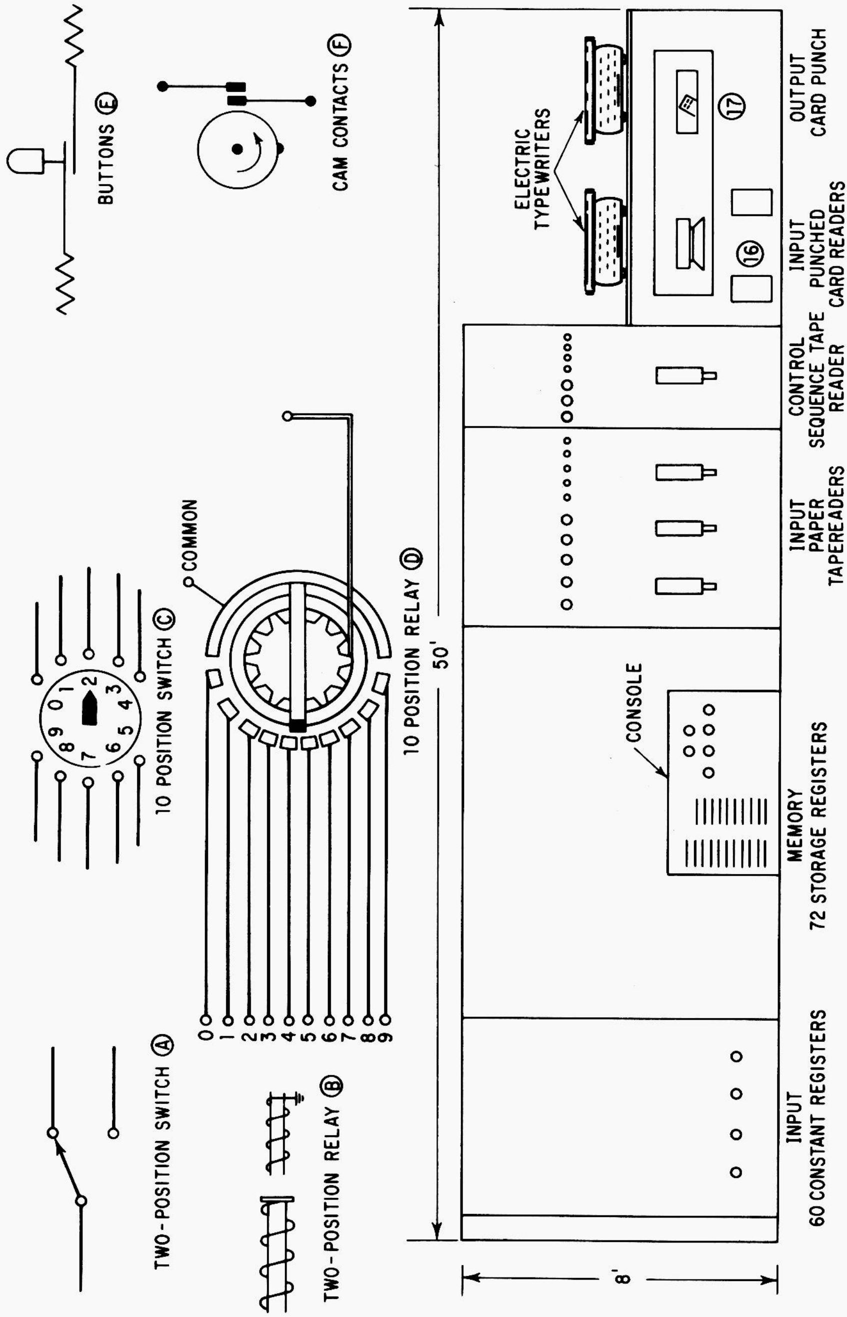

FIGURE 1–3. The Mark I (Sketch adapted from E. C. Berkeley, *Giant Brains* [New York: John Wiley & Sons, Inc., p. 90].)