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DATA PROCESSING

BY ELECTRONICS



HASKINS & SELLS

DATA PROCESSING BY ELECTRONICS

A Basic Guide for the Understanding and Use of a New Technique

HASKINS & SELLS

By the development of electronic dataprocessing systems, a new and valuable tool has been fashioned to aid business management in the manifold problems of administration and research. Without doubt, these systems have wide potentialities.

Available literature upon the subject is useful and impressive. Both the complex technical features and the broad implications of these systems have been well expounded.

The aim, in this study, is to find the middle ground — to convey, to the interested reader who is not a specialist in the subject, a basic understanding of the operation and use of electronic data-processing systems.

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Foreword

ACCOUNTING has been described as the universal language of business. Order in the conduct of business affairs depends heavily upon accounting. Record keeping, the utilitarian link between business transactions and their expression in accounting terms, is a task of formidable proportions in modern business. That efficient record keeping and good accounting are well worth their cost has long been recognized. Nevertheless, the cost warrants cognizance. There are strong evidences that record-keeping costs have been increasing relatively more than the costs of other business functions.

The problem has not grown unwatched. The demands of business and Government for more information and for earlier availability of information are ever-increasing. Yet much has been done to improve efficiencies in record keeping and to slow the trend of rising costs. In this, mechanization has provided a major contribution. But the application of mechanization, until now, has been hampered by substantial limitations.

In vigorous attack upon this obstacle, new techniques are now being focused upon the problem. Adapted from earlier applications in the physical and mathematical sciences, electronic devices have been turned to the task of providing the solution. The implications are startling. Illustrating the progress that has been made is the development of devices that will read or transfer 56,000 characters a second, multiply two 5-digit numbers 1,250 times a second, and print 2,000 characters a second. Advances such as these stir the imagination, suggesting vast possibilities. Dramatic effects upon the cost factor and great acceleration in availability of information are among the major benefits that may be realized. Certainly the new developments hold great promise. Even more intriguing than improvements in record keeping is the prospect of marked enhancement in the effectiveness of management controls. The way to new methods of control may be opened. Noteworthy progress in business planning may be achieved: stimulated by the possibilities in the electronic system, methods may be found to better evaluate future trends and conditions and to better appraise the probable effects of contemplated actions.

What is electronics? The scientists tell us that electronics treats of the emission, behavior, and effects of the electron, especially in vacuum tubes, photoelectric cells, cathode ray tubes, and the like. For our purposes here, however, the significant principle is that the flow of electrons, acting as signals in the circuitry of electronic equipment, is susceptible to direction and control. In the type of electronic system with which we are concerned, there is linked with this principle a mathematical convention or code in which numbers and alphabetic or other characters are symbolized by electronic pulses or other electrical manifestations. The controlled movement, or flow, of these symbolic signals is the basic framework of the electronic data-processing system.

Speed, of course, is the crux of the matter. The speed of the mechanical system is tied to the movement of mechanical parts, straining against friction and inertia. Electronic speed, the flow of information through electronic devices, is many thousands of times faster.

This study is not a technical treatise upon data processing by electronics. It seeks only to portray broadly the nature and implications of the new techniques available in the electronic system and the task to be met in learning to use them effectively.

HASKINS & SELLS

May 1955.

PART I

A COMPARISON OF METHODS

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THE SCOPE OF ELECTRONIC DATA PROCESSING

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FUNDAMENTALS OF PROGRAMMING

• •

PREPARING FOR THE ELECTRONIC SYSTEM

A COMPARISON OF METHODS

Electronic data-processing systems are versatile. They will operate upon various types of data for many purposes. Prominent among these purposes are the functions of record keeping.

The uses of records obviously are not limited to accounting. Records are necessary in practically all forms of business activity. The importance of statistics and studies as guides to management in production, marketing, and research, as well as in financial control, is well known. The development of these statistics and studies usually involves extensive use of records. Current information is collected, recorded, and assembled. Related data previously recorded, bearing upon past performances or conditions, are also utilized. Although sometimes informal in structure, these records serve the purpose of receiving and preserving basic data. The records themselves, together with the procedures and devices which are used in introducing data into the records and operating upon them, constitute the record-keeping system for the purpose to be served.

Although interspersed to some extent with references to record keeping for accounting purposes, the discussion which follows is applicable to any activity where records are necessary.

Basic Functions

All record-keeping systems, whether maintained manually, or with the aid of key-driven machines, punched-card equipment, or electronic data-processing devices, serve to perform these seven basic functions:

- (1) Preparation of source documents.
- (2) Introduction (or input) of data from these documents into the record-keeping system.
- (3) Data manipulation, comprising assembly, sorting, and classification of data; reference to and extraction of related data, previously stored; and computation.

- (4) Storage of data, including temporary filing of intermediate results and other data in process and the maintenance of files of carry-forward data.
- (5) Withdrawal (or output) of results from processing.
- (6) Summarization of results.
- (7) Supervisory control.

Manual Operation

In the manual system, the preparation of source documents by hand, classification of transactions by columnar arrangements, posting of ledgers, computation of account balances, construction of trial balances and statements, and other familiar procedures can readily be identified with the basic functions. Obviously, supervisory control is also exercised entirely by human agency.

Key-Driven Operations

With the aid of key-driven equipment, certain of the basic functions can be handled mechanically. Source documents may be prepared by typewriters. Adding machines, desk calculators, and bookkeeping machines assist in the various phases of the manipulation function. Although the storage function is effected in large part by manual filing, intermediate results of arithmetic computations are stored in counter wheels of mechanical equipment. Supervisory control, although principally human, is also exercised by control bars and other mechanical devices.

Punched-Card System

In the punched-card system, still more of the basic functions may be performed mechanically. Source documents in this system usually are prepared manually or by typewriter. In many applications, however, the punched card itself serves as the source document. Input is effected through punched cards which are prepared either by mark sensing or a direct punch process. In the mark-sensing method, marks upon cards are automatically converted into punched holes.

Similarly, the various phases of the manipulation function become more mechanical. Card-sorting and collating machines

are used to assemble, sort, match, merge, and classify data; and a variety of machines, including electronic calculators, perform the various arithmetic computations. To a great extent, manual filing of bulky records gives way to mechanical maintenance of card files. Output, in the medium of punched cards, and summarization of results, through punched-card tabulating printers, assume increasing mechanization. Supervisory control also becomes more nearly automatic, through devices such as wiring panels, although human intervention is still required at various stages.

Much as the punched-card system has contributed to the easier handling of clerical loads, two characteristics have tended to limit the extension of its use. One is the inability to handle exceptions within the normal machine routines, thus necessitating manual processing in that area, and the other is the very limited capacity of the system to make decisions in the course of the processing operations. The practical effect is that complex problems must be solved in pieces, not in one continuous process. These limitations are overcome in the electronic data-processing system.

Electronic Data-Processing System

In this system, many of the basic functions in record keeping are handled at electronic speed. The preparation of source documents is performed generally by the same means as those employed in the punched-card system. Both this step and the transfer of data from the source documents to a medium acceptable for electronic processing are accomplished by input preparation equipment. This equipment transcribes source data onto tapes or cards by the direct punch or mark-sensing method, aided by an intervening mechanism which converts the data into a binary code, the language of the electronic system. The medium may be magnetic tape, paper tape, or punched cards. Magnetic tape is by far the fastest — it can be read into the central processing unit of the system at speeds as high as 56,000 characters a second whereas the maximum for paper tape is about 1,000, and for punched cards around 325 characters a second.

In the manipulation function of record keeping all the

assembly, sorting, classification, reference, and arithmetic operations are performed automatically within the components of the system, directed by a series of stored instructions, called a program. It is mainly the performance of the manipulation function that sets apart the electronic system as unique and it is there that the electronic system gains its greatest advantages over others. Storage capacities of the system make possible the retention of data from master files, carry-forward balances, intermediate results, and the like, thus obviating the need for temporary filing, separate cross references, and other manual handling. Access to stored information, intercommunication within the system, computation, and the making of decisions – all required in the manipulation function – occur at electronic speed.

Results from electronic data processing are withdrawn from the central processing unit, written upon magnetic tape, paper tape, or punched cards, and fed into automatic printers. Alternatively, output data may be produced by direct connection between the processing unit and the printing device, eliminating tapes or cards.

Beyond the preparation of the program and input data, human participation plays only a minor part in supervisory control in the electronics system. Substantially all required supervision is provided for in the program.

In addition to the handling of the conventional record-keeping functions, electronic equipment has a far greater potential in alternative uses than is found in other systems. Possessed of the immense advantages of superior capacities and speeds, electronic equipment brings within reach of attainment a higher level of effectiveness in production control, sales analysis and forecasting, inventory control, and other tasks of business management. Superior capacities and speeds not only permit the present job to be done faster; they also make possible the accomplishment of tasks never heretofore attempted because of the impracticability, under other systems, of completing them in time for the results to be effectively utilized.

THE SCOPE OF ELECTRONIC DATA PROCESSING

The Electronic System and Its Functions

The heart of the electronic data-processing system is the central processing unit, often called the computer. The processing unit receives data and instructions, stores them in and calls them out of its "memory" as needed in the processing routine, performs the arithmetic operations of addition, subtraction, multiplication, and division, and has the further ability, found only in very limited degree in mechanical systems, to make comparisons between numbers or other characters and to take the action called for by the result. It also directs the processing operations within itself and controls the flow of inbound and outbound information. All these operations are performed at electronic speed. The electronic pulses and other electrical manifestations, acting as signals in the functional operation of the unit, are symbolic representations of numbers and other characters.

Since the equipment will do only what it is directed to do, the data-processing plan must be of human creation. This plan is a series of instructions, called a program.

The processing unit consists of a control unit, a storage device, and an arithmetic unit. The control unit interprets the instructions and directs the various data-processing operations. The storage device, or "memory," receives the instructions and data from the input device, stores intermediate results, and releases information, all as directed by the control unit. The arithmetic unit performs the arithmetic and comparison operations upon data and instructions routed from the storage device, again as directed by the control unit.

Directly linked electrically to the processing unit are devices which "read" information into it and "write" information out of it. These devices are collectively characterized as input equipment and output equipment. Like the processing unit, they are electronic in principle. The function of the input devices is to translate, from the input medium (a tape or card), the data of the problem and the instructions necessary to its solution and to move them into the processing unit. The function of the output devices is to receive the information emitted from the processing unit and to dispose of it as directed by the control unit.

Inbound information fed into the "reading" device must be expressed in, or converted into, the symbolism of the processing unit and conversely, outbound information, emitted from the processing unit through the "writing" device, in the same symbolism, must be converted to plain language and transcribed upon the end-use document. To do these things necessitates the use of input preparation equipment and output printing equipment. For reasons which will appear presently, the input preparation equipment is technically not considered to be a part of the electronic *system*. In other words, the electronic *system* begins, or takes over in the data-processing routine as a whole, at the point where the information is "read" into the central processing unit.

Other Functions in Data Processing

Some of the input preparation equipment may be electronic in principle but at least a part of it always is not; the combination of equipment used for this purpose depends upon many factors not of uniform importance in all cases. Now, the significance of excluding all of this equipment from the concept of the system is more than a matter of mere semantics. The real significance is that the fact of the exclusion itself appears to be not as yet commonly understood. There is a tendency to visualize the electronic system as one that handles all steps in the data-processing routine. This is a misconception — one with practical implications.

These become apparent by considering the operations performed by the input preparation equipment. A data-processing routine, as a whole, begins at the source documents which constitute the record of the transactions. In the chain of processing between the source documents and the operation of "reading" information into the processing unit, input preparation equipment handles a broad range of operations. The purpose of these steps is to transcribe information from the source documents onto a medium acceptable to the processing unit. The practical significance of this is two-fold: first, to perform these input preparation operations may require the services of many people, operating a large battery of the same types of equipment, such as card and tape punches, as are used in mechanical systems; and second, the speed of performing the operations is still bound by human and mechanical limitations.

Data processing in its entirety therefore is not wholly electronic in concept at the present time. Nevertheless, the electronic phases of processing encompass a vast area. Moreover, the challenge to overcome the limitations of input preparation equipment has met a strong response, and encouraging progress is being made.

FUNDAMENTALS OF PROGRAMMING

Wondrous in performance though they may be, electronic systems do not think for themselves; they can do only what they are instructed to do. Human beings not only must give the system its instructions; more importantly still as a practical matter, they must do a prodigious amount of work to know what the instructions should be. The preparation of the instructions is known as programming. Programming consists essentially of analyzing the source data and determining what is to be done with them to produce the required end result.

Programming has three aspects: the material, the equipment, and the technique. The material is the raw data and the end-use document or report, the equipment is the system itself, and the technique is the procedure employed in formulating the instructions to the equipment. For example, if the routine to be programmed is the processing of sales transactions, the raw data may be sales orders and shipping records and the end-use documents may be sales invoices and sales distribution reports. Among other items of information, the sales order and shipping record may show the customer's name and address, the terms of sale, date and route of shipment, description, number, and price per unit of items sold, and transportation or other additional charges. The sales distribution report may show sales by departments, by individual products or lines of products, by salesmen or sales territories, or by geographical units such as states, counties, or cities.

The first step in processing would be the transcription of data from the sales orders and shipping records upon a medium (a tape or card) acceptable to the system. In this connection, it would be necessary to consider the capacities and order of use of input preparation equipment. Also, as a part of the over-all plan of manipulation, the arrangement and sequence of the data upon the medium would be precisely determined.

Reading In and Manipulating

The next step would be to read the raw data into the central processing unit of the system. Beginning at this point and con-

tinuing to the end of the routine, each step must be translated into instructions to the system. In connection with the reading-in operation, the instructions must specify the order in which the data are to be read. For example, the sales order data may have been transcribed upon one tape and data from the shipping record upon another. For the purpose of preparing the invoice, these data must be brought together. The instructions therefore must direct the equipment to read segments of each tape in a manner that will cause all data pertaining to the individual order or customer to fall into correct sequence.

Also, in connection with the reading-in operation, it is necessary to decide where the information is to go and to direct the equipment to send it there. All information read into the system is first routed to the storage unit. Obviously, in the plan of manipulation it is necessary to know at all times where to find information as needed in the successive stages of processing. Accordingly, the instructions must assign each item of information to a specific location in the storage unit and must direct the equipment to read the item into that location. This involves not only the allocation of space in a logical manner but also the consideration of available storage space.

Having read the data into the system in required sequence and having filed them in known locations in the storage unit, the next stage in processing is manipulation. In this connection, the instructions must direct the equipment to perform the operations of classification, computation, and assembly required to accomplish the end result. In framing these instructions, as well as all others, provision must be made for all possible exceptions to the normal pattern of the routine.

Manipulation having been completed, once again it is necessary to decide where the information, now representing the results of manipulation, is to go and to direct the equipment to send it there. Results of processing are returned to the storage unit. The instructions must specify the spaces in the storage unit where the results are to be filed and must direct the equipment to route them to the assigned locations. Here again, this involves the consideration of storage space as well as the allocation of space in a logical manner. Space is needed simultaneously for data undergoing manipulation, for data representing the results of manipulation, and for the instructions themselves.

Writing Out

The final stage in processing is writing out the results. Output devices write out the results from the storage unit and convert them to end-use form. The instructions must tell the equipment where to get the results, where to write them, and how to write them.

The place where the results are to be found, as previously indicated, is determined by reference to the storage spaces previously assigned at the conclusion of manipulation. The questions as to where and how to write the results involve the purpose of the end use. Sometimes the results of processing are used as input information in subsequent processing, in which event these intermediate results will be written in coded form upon a tape or other medium for later use. Where the end use is a report document, the results will be written, in report format, upon the document.

To compose the results in report format involves the phase of programming known as editing. Information as emitted from the central processing unit is like very crude copy. It emerges as a stream of numbers and other characters, without placement of decimal points, designation of capitals, punctuation, and the insertion of dollar signs or other symbols. The equipment must be instructed to make the required changes and insertions.

In summary, programming is planning. It involves a complete analysis of the data-processing routine, beginning at the source data and ending at the final report.

In the programming of a data-processing routine, it is well to pause at the outset to make certain that the problem has been clearly defined and that the over-all plan provides for all conceivable eventualities. Programming is a lengthy process, involving long study and the preparation of instructions, in minute detail, to direct the equipment. While adjustments to a program sometimes may be made without undue difficulty, extensive revision or the complete rewriting of a program involves considerable delay and expense.

PREPARING FOR THE ELECTRONIC SYSTEM

Will there be a net advantage in using an electronic dataprocessing system in our business? That question is being heard with increasing frequency. In some instances the answer is fairly obvious; in others, it is not clear. In the areas of uncertainty, no easy answers, no tests of ready reference, have yet been devised. The decision can be reached only by analysis, the degree of analysis appropriate to the individual case. Even then, the decision will not always come easily; it must sometimes rest upon relative values — a matter of judgment.

Business wants from the electronic system a process that will do the job of its present systems; that will do it certainly at least as well, and preferably better, at lower cost. But the matter is not always so neatly simple. Higher costs sometimes must be weighed against the value of added benefits, or lower costs must be appraised in the light of disadvantages.

In the broad sense, planning an electronics program comprehends all the activities from the investigation stage to the installation of the system.

Organization for Planning

It must be recognized, at the outset, that adequate planning may encompass a wide range of activities and that protracted investigation may be necessary to formulate conclusions. The conversion of present systems, or even parts of them, to electronic data-processing systems, together with the attendant planning, usually is a big undertaking requiring a great deal of time and special study.

Personnel of the business should be heavily represented in the planning group. Others may well make important contributions to planning, but ultimately it is the personnel of the business itself that must operate the system.

It is important also to recognize that the long-run potential may be even greater in areas outside the immediate applications to conventional record keeping, extending, as mentioned earlier, into such functions as production control, sales and market analysis and forecasting, and inventory management. The fields of usefulness may well tend to cut across the organizational lines in the business and for that reason it may be advisable to include in the planning group a cross section of all interested personnel. Representation in the group and agreement upon initial emphasis therefore are matters requiring decision at the outset.

Training

At least some of those among the planning group must have a comprehensive training in electronic data processing. The scope and duration of training necessarily depend upon the individual. The objective is a practical understanding of the functions and potentialities of the equipment and of the techniques employed in the solution of data-processing problems. Excellent courses of instruction are offered by various manufacturers and by a few universities, some having computer facilities. Formal training naturally should be supplemented by investigations of equipment offered by the various manufacturers.

There is a fast-growing body of literature dealing with various phases of electronic data processing. Little of it, however, is found in textbooks. A comprehensive compilation of the literature has been prepared and published by Controllership Foundation, Inc. under the title "Business Applications of Electronic Machines: An Annotated Bibliography" (July 1954). The Foundation plans to issue revised compilations from time to time.

In this comparatively new field, changes in equipment and methods are taking place more or less constantly. There should be a plan for keeping abreast of these developments.

In due course, those who will operate the system will require training for their specific assignments. Lengthy training of personnel required for maintenance will be necessary if the equipment is purchased.

Analysis

The advisability of change-over can be determined only upon analysis of the routines to be converted. Where to start? Generally, the order of approach should be progressively from the areas of greatest promise to the marginal routines. In this approach, a logical starting area is that in which there are found, in combination, the highest cost and the greatest number of detailed processing operations in the present system. Areas such as inventories, billings to customers, payrolls, and cost accounting at once come to mind. Occasionally, however, there may be a preference to first analyze routines known to be inefficient or otherwise presently unsatisfactory.

Analysis is essentially nothing more than ascertaining, step by step, how something is now done, followed by determining, also step by step, how it may otherwise be done. The question of need enters also into the matter. Analysis may reveal that data for which need no longer exists continue to be compiled or, conversely, that data which might be highly significant have never been developed. Flow charts, data on work loads and time schedules, and manuals or memoranda of procedures are among the useful aids of analysis.

To determine the total time involved in any data-processing operation as a whole is not alone a matter of considering speeds of reading data and instructions in and out of the central processing unit and of manipulation within the unit. The time that counts is the interval between the beginning of work upon the raw data and the completion of the results of processing, in report or other required form. In the input preparation phase, the time required for transcription of current-transactions data is still tied generally to the speeds of key-driven devices used in punched-card systems. In addition, there must be included the time necessary to prepare the instructions, or program, and this must be reckoned in the order of several man-years for complex routines. Obviously, however, programming time is largely non-recurring in repetitive problems and in that respect stands as an amortizable investment.

As a by-product, analysis almost invariably will reveal collateral benefits. Even though electronic data processing be found to be inapplicable, methods analysis will serve to challenge existing routines and may well point the way to improvements and savings. A companion effect, as these advantages are uncovered, is that the performance standards, against which the electronic system is to be measured, are raised.

Equipment

In choosing equipment, the objective obviously is to select the system that will best serve the purposes of the business. Electronic data-processing systems at present on the market, even at this comparatively early stage of development, have a wide range of capacities. There are special-purpose and generalpurpose systems, "large" and "small" systems, and a number of types of storage mechanisms and of input and output devices usable in various combinations.

In the light of the job to be done, including not only immediate applications but potential applications of major significance as well, the factor that should govern the selection of equipment is economic balance. The combination of equipment within the system should be designed to produce the maximum economic benefit within the limits of the choices available. The ideal combination, of course, would be the smallest number of units of each component, all operating with a minimum of interruption. But here, as in other phases of business operations, the ideal will seldom be attained. The problem is essentially one of leveling out variations in work loads, in so far as planning and the characteristics of the equipment will permit. If purchase, rather than rental, of equipment is contemplated, the factor of possible obsolescence should be taken into consideration.

Special-purpose systems, designed to handle one data-processing routine, will be the best selection where it is known that the application will be correspondingly limited. As a practical matter, however, this is seldom the case since potential applications usually enter into the choice. General-purpose systems are basically flexible. Moreover, flexibility may be augmented by assembling the several components in numerous combinations, as required.

As to the matter of "large" and "small" systems, no unit of common measurement for rating the over-all capacity of electronic systems has yet been devised. Although also affected by other factors, capacity is largely dependent upon speed of access to information in storage.

This, in turn, depends upon two factors: first, the inherent speed of response of the storage medium and second, whether the

storage medium is designed to release information in parallel fashion, or serially. Ranked in the order of inherent speed, the media used for primary storage are magnetic cores, cathode ray tubes, vacuum tubes, acoustic delay lines, and magnetic drums. Inherent speed is enhanced where access to the several parts of a unit of information in the medium is simultaneous, or parallel, rather than piece by piece, or serial.

To supplement the volume capacity of the primary storage device, it is sometimes necessary to use other media as secondary storage. Magnetic tape, the slowest of all media in respect to access time, is most commonly used as the secondary storage device. In some systems, magnetic drums are used to supplement other primary storage media.

The size of the system required will depend in part upon the extent to which record keeping is to be centralized. In the larger concerns, there will be reasonable freedom of choice. Both large and small systems may be employed, depending upon the degree of centralization in record keeping that is desired. Freedom of choice will tend to become narrowed, or to vanish altogether, as the size of the business becomes smaller.

Integrated Data Processing

In recent years, a variety of new devices, some of them not electronic in principle, have been developed to increase the speed of data production and transmission. Attachments to adding machines, desk calculators, bookkeeping machines, cash registers, and typewriters make possible not only the preparation of original documents but also the simultaneous production of perforated tapes or cards for use in automatic processing. Advanced techniques speed up the transmission of data over long distances.

Output from these devices, unaltered or after easy conversion, is acceptable to the electronic system. Thus, these conventional machines may be employed not only for their primary function of document preparation but also to produce a medium compatible with the electronic system. The effect is an integration of functions, a fusing of operational steps, which eliminates those transitional operations that otherwise would be required in converting source data to the language of the electronic system. This concept of integration, now in the early stage of development, is known as "integrated data processing." This is a broad subject in itself, one upon which much could be said. For present purposes, however, mention will be made concerning its significance only in relation to the electronic data-processing system. Reference has been made earlier to the batteries of equipment and the large number of people frequently required in the input preparation operations. Future developments in the further integration of this phase of the input function may overshadow all other future advances in data processing. When and if input preparation equipment becomes fully electronic in concept, automation in data processing will have been achieved.

Dependence Upon the System

Electronic systems are revolutionary not only in their potential contribution to mechanization but also in creating a degree of dependence upon equipment heretofore unknown in record keeping. As dependence increases, so must the risk of equipment failure be correspondingly controlled.

Control against error must be attained within acceptable tolerances, either in the design of the equipment or by the inclusion of checking procedures in the program. At the present stage, there is a need for further development of experience data in this phase of control.

Control against functional failure involves the consideration of various contingencies. Maintenance requires the services of electronic engineers. Responsibility for maintenance is assumed by the manufacturer when the equipment is rented, but maintenance becomes the responsibility of the owner if the equipment is purchased. To provide in part against functional failure, input data may be retained temporarily and programs may be duplicated at nominal cost.

Even though the input data and programs for all unfinished processing have been preserved, there remains the possibility that the components of the system may become inoperative for a critical period. In that event, the only recourse will be to available facilities of other users or those provided by manufacturers through service bureaus. As electronic systems come into use on a broader scale and as equipment becomes more readily available, this risk will tend to be minimized.

In fairness, it should be said that electronic equipment has shown a very high degree of reliability in the limited applications to data processing to the present time.

Implicit in the operation of the electronic system is the fact that the direction of the system is concentrated in a limited number of people, a situation that imposes a heavy dependence not only upon the equipment but also upon a very small group of key personnel.

Inflexibilities

While flexibility predominates, there are certain elements of rigidity in the electronic system. Although magnetic tape provides high input speed, to lift information from the tape for any special need may require extensive scanning and if this interrupts scheduled routines, it may present operating and cost problems.

Similarly, the planning of an elaborate routine requires comprehensive analysis and the preparation of thousands of programmed instructions, all inter-related in precise pattern to produce one planned result, and no other. To amend the program may involve considerable time and cost - and time, in many situations, may be the more important factor. Nevertheless, in some cases, amendment may be mandatory.

For like reasons, the complete programming of a one-time job may be impractical. The preparation cost may be excessive or the preparation time may preclude availability of the results when required.

Assuming analysis and programming costs to be justified, it may be advantageous to place on the system certain jobs which are performed intermittently. To the extent that these jobs absorb idle time of the system, such a plan is clearly advantageous. On the other hand, a problem of scheduling may develop. Eventually, departments or groups within the business may be competing for system time.

In general, under other systems the current operating costs are variable or controllable in fair degree as the volume of the work load expands or contracts. Given the system, with its preplanned capacities, the current operating costs of electronic data processing do not vary appreciably with fluctuations in current requirements and therefore are largely fixed.

Operating Personnel

An item of cost by no means to be passed over lightly is the cost of personnel to handle the complete data-processing routine. In the input preparation phase, machine operators will still be required, much as in other systems, for the punches and key-driven or other equipment used in converting raw data to the language of the processing unit. Beyond this stage, the personnel previously required in data processing will become available for other tasks. Personnel required to operate the electronic system will consist of analysts, programmers, and coders to organize the data-processing problem and to formulate and check the instructions for processing the data, supervisory personnel and clerks to perform various operating functions, and engineers to handle the servicing of the equipment. The number of persons required in these respective capacities depends upon the size of the system, the volume of the data to be processed, and the complexity of the processing problem.

Installing the System

Before the stage of actual installation is reached, much planning and other work will have been done. In the earlier phases, various applications probably will have been investigated, routines will have been roughed out, various combinations of equipment will have been considered, personnel training will have been initiated, and the economics of the matter will have been brought into perspective. But when the point of decision is reached, all becomes precision. Forms, procedures, and reports must be brought into careful alignment. All affected groups within the business must be schooled in their participation in the system and in the planned performance. The data-processing routines must be minutely analyzed and reduced to detailed programs. Transcribing the backlog of carry-forward data into the system will be a major task in itself. Problems of audit must be resolved. Necessary arrangements must be made for physical installation, including required power circuits and air conditioning or cooling equipment.

The changeover to the system will be gradual, as successive applications are planned and programmed. All manufacturers maintain facilities for making experimental runs of programmed routines. Prior to installation, these facilities will be utilized to make required corrections until operating readiness is achieved. In order to obtain earlier use of the equipment, it is usually preferable to limit the number of applications to be placed under the system at the outset.

The successful installation of an electronic system is fundamentally like the installation of any other new process or procedure – it requires thorough indoctrination, training, and practice.

Costs

Spectacular performance alone, however fascinating, will not persuade business to accept the electronic system. When all else has been resolved, the choice eventually comes down to a matter of cost. Here, everything is familiar in principle. Like all cost comparisons, the decision depends upon relative values. Present costs, under present methods, are known. Future costs, either with present methods unchanged or with present methods altered where analysis shows that better performance can be obtained from the present system, can be reliably estimated. All these incurred costs or projections can be reduced to a cost per unit of work — per document processed, per dollar of payrolls, per machine hour of the equipment used, or whatever other measure is most meaningful.

In estimating future costs under the electronic system, the same degree of refinement is not to be expected — at least not yet. In many situations, it is fairly easy to show a clear-cut saving from the system's immediate application alone. Assuming the magnitude of the saving to be satisfactory, a change to the electronic system is readily justified. Difficulty crops up, however, when this is not the case and justification must rest upon further refinement of cost estimates. It is here that the cost per unit of work becomes elusive. Not only must the immediate application be studied more closely but it may also be necessary to approximate the effects of future applications.

In the latter event, many additional problems must be considered. For example, what are the future applications to be, what will be the add-on costs of investigating and programming them, and when will they come into operation? Above all, perhaps, how much is it worth to get the results of processing faster than present methods will produce them? Or to have available the additional information the present system practicably cannot produce but the electronic system can? This, the factor of availability of information, may mean little or may be the most important consideration of all — but rarely, if ever, can it be precisely evaluated. These are some of the questions that may arise in seeking to refine the estimates of cost under the electronic system.

Impressive savings have been estimated in the comparatively few large-scale installations that have been made to the present time. Experience in these cases, as well as anticipated results in many other installations now in prospect, point to a bright future for electronic systems. What one company can do, others similarly positioned probably can also do in approximately like degree. However, this is still only a probability, not something to be assumed. In each case, analysis must be pursued until the proof is clear.

PART II

BASIC CONCEPTS

COMPONENTS

AN ILLUSTRATION OF PROGRAMMING

AN ACCOUNTING APPLICATION

BASIC CONCEPTS

Electronic Equivalents of Units of Information

To control the behavior of electrons for the purpose of data processing, it is necessary that numbers and alphabetic or other characters be symbolized in some form of electronic equivalents. To do this, recourse is taken to the field of mathematics. In the binary system, all numbers are represented by one or more of two symbols only, which may be "0" and "1." Letters and other characters may also be represented by combinations of these two symbols. Applying this principle to electronic behavior, the two symbols of the binary system, "0" and "1," become the absence of a pulse ("no pulse") and "pulse," or other analogous state or action in the electronic system, such as "charge" and "no charge" and "on" and "off," thus enabling the system to receive and manipulate data. The process is essentially one of translating the language of one system into that of another, roughly similar, for example, to a telegraphic code in which numbers and letters are represented by dots and dashes, or the familiar punched card in which the representation is by combinations of holes, or absence of holes, in a card.

In binary notation, the decimal digits 0 to 9 are expressed as follows:

Decimal	Binary
digit	notation
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001

[31]

It will be observed that the digit 1 in binary notation doubles its value each time it moves one place further to the left. This system of notation requires a maximum of four binary digits to represent each decimal digit and is known as the binary coded decimal system. In this system, the number 1955 would appear as follows:

	Thousands	Hundreds	Tens	Units
Binary coded decimal	0001	1001	0101	0101
Decimal digit	1	9	5	5

The system of coding data in binary may be extended to alphabetic and other information. For example, adding two binary digits to the binary coded decimal makes possible the representation of alphabetic characters, punctuation marks, and other symbols, as well as decimal digits. Such a group of six binary digits makes available 64 combinations. To represent the 10 decimal digits and the 26 alphabetic characters requires 36 of the combinations, leaving 28 for the representation of other characters. One adaptation of the use of six binary digits to represent these various characters may be illustrated as follows:

	Binary
Character	notation
1	00 0001
2	00 0010
9	00 1001
Α	01 0001
В	01 0010
С	01 0011
D	01 0100
E	01 0101
\$	11 1011
%	11 1100

The smallest unit of information in which binary code is expressed in the electronic system is known as a "bit." For example, in the designation of the letter A, "01 0001" in the preceding illustration, each of the four zeros (no pulses) as well as each of the two code symbols "1" (pulses) is a bit. Remembering that one group or series of bits collectively symbolizes only one decimal digit or alphabetic or other character, to symbolize one or more digits or characters as a unit of information – for example, the expression "May 1955" – the groups or series of bits representing these digits and characters are combined into what is known as a "word." The word is formed in accordance with the order in which the groups or series of bits are introduced into or manipulated within the system and the determination of the order is entirely a matter of human planning in programming.

Word length of course is measured by the number of digits or characters comprising the word. In some electronic systems, word length is fixed, and in others, variable almost without limitation. To symbolize data having digits or other characters in excess of the fixed word length, two or more words are used.

To control the handling of "words" within the system, they must be directed to specific locations known as "addresses." In systems using fixed word length, the address designates the complete word. Where variable word length is used, an address is assigned to each character, but the complete word (regardless of the number of characters) is designated by addressing the position of one character within the word.

Since the same system of representation is used to designate both data and instructions, in the functioning of the equipment there must be a means of separating one from the other. A number or other character, comprising a group of bits, may have one meaning as data and a different significance as an instruction. Separation is accomplished through programming procedure. Only the control unit will interpret an instruction and direct the action intended. In programming procedure, instructions are therefore routed to the control unit only, except when routed, under the direction of the control unit, into the arithmetic unit for amendment. In at least one system, separation is aided further by variations between the basic structures of "words" used as instructions and as data.

Manipulation

Given a symbolism for the representation of data and instruc-

tions, the accomplishment of data processing in the electronic system becomes reduced to a process of manipulation, of direction and control of numbers and other characters as represented by electronic equivalents. Essentially, manipulation is accomplished by equipment design, utilizing the characteristics and capacities of various devices to move the data and instructions through the system.

By means of equipment design, devices are provided which will bring the data and instructions to the central processing unit, manipulate them there, and take out the results. Without troubling at the moment to understand how, it is sufficient to know that the devices within the central processing unit can add, subtract, multiply, and divide, and make comparisons between numbers and alphabetic or other characters, and that they have the power of memory; they can retain data and instructions and introduce them into the manipulation routine as needed. They can even amend basic instructions as required in the course of processing. Further, the central processing unit does all these things at electronic speed.

Given now the symbolism and the range of abilities of the equipment, manipulation becomes finally reduced to a process of direction and control of instruction symbolism upon data symbolism, working always, of course, within the abilities of the equipment. How this is done, in terms of the methods used in directing the system to make the manipulations, is important as a basic concept. These methods may be illustrated by an elementary analogy.

Assume a group of consecutively numbered boxes, as in a post office. Each box contains a single piece of paper upon which is written an instruction or other item of information. To bring into the analogy the capabilities of electronic equipment, it is necessary to assume also that the capabilities of the office clerk are limited to carrying out simple instructions, adding, subtracting, multiplying, and dividing, and making elementary decisions based solely on comparisons of the size of numbers.

The clerk is directed to take his first instruction from a certain box and to take each succeeding instruction from the next box in order, unless he receives instructions to the contrary. A series of three instructions might then be prepared for the clerk, in the following manner:

Instruction address

Instruction

- Box 1. Copy on a piece of paper the number contained in box 100.
- Box 2. Copy on the same piece of paper the number contained in box 101. Add the two numbers and write the sum on the piece of paper.
- Box 3. Copy the sum on another piece of paper, place this new piece of paper in box 102, and destroy the piece of paper previously contained in that box.

Many clerical routines can be analyzed into steps as simple as these. For example, in inventory accounting the quantity of an item purchased is added to the previous balance to obtain the total inventory to be accounted for. Thus, the foregoing series of three instructions to the clerk might be applied in the handling of four inventory items as follows:

Instruction address

Instruction

- Box 1. Copy on a piece of paper the number contained in box 25 (previous balance of part A).
- Box 2. Copy on the same piece of paper the number contained in box 50 (quantity of part A purchased). Add the two numbers and write the sum on the piece of paper.
- Box 3. Copy the sum (new balance for part A) on a new piece of paper and place in box 25. Destrov the piece of paper in that box showing the previous balance.
- Box 4. Copy on a piece of paper the number contained in box 26 (previous balance of part B).
- Box 5. Copy on the same piece of paper the number contained in box 51 (quantity of part B purchased). Add the

two numbers and write the sum on the piece of paper.

- Box 6. Copy the sum (new balance for part B) on a new piece of paper and place in box 26. Destroy the piece of paper in that box showing the previous balance.
- Box 7. Copy on a piece of paper the number contained in box 27 (previous balance of part C).
- Box 8. Copy on the same piece of paper the number contained in box 52 (quantity of part C purchased). Add the two numbers and write the sum on the piece of paper.
- Box 9. Copy the sum (new balance for part C) on a new piece of paper and place in box 27. Destroy the piece of paper in the box showing the previous balance.
- Box 10. Copy on a piece of paper the number contained in box 28 (previous balance of part D).
- Box 11. Copy on the same piece of paper the number contained in box 53 (quantity of part D purchased). Add the two numbers and write the sum on the piece of paper.
- Box 12. Copy the sum (new balance for part D) on a new piece of paper and place in box 28. Destroy the piece of paper in that box showing the previous balance.

From these tedious repetitions of detailed steps, it is obvious that such a manual method of inventory accounting would be extremely cumbersome. Essentially, however, direction and control in electronic data processing must be symbolically expressed in degree of detail analogous to the elementary steps described in the illustration. The difference, of course, is that hundreds of operations such as those described can be performed each second in the electronic system.

To capitalize fully upon the advantage of speed of the sys-

tem, direction and control must provide for varying the order of instructions as conditions require. Returning to the last illustration, it would not be necessary to perform any operations in any case where there were no purchases of a part. Therefore, the first instruction (lodged in a box preceding box 1) to the clerk would be: "Look at the piece of paper in box 50. If the quantity is (equal to) zero, look in box 4 for your next instruction, otherwise take the next instruction in order (box 1)." This would provide for skipping over all the instructions for part A if no purchases were made. Comparable instructions would be included as to each remaining part. Because the electronic system has the ability to make decisions based upon comparison, it is possible similarly to amend the instructions in electronic data processing. By making use of this same ability, the equipment may be instructed to select one of several alternative methods of processing.

Direction and control will also afford better utilization of the equipment by amending the content of the instructions. For example, storage space required for the instructions may be reduced. Continuing the analogy, the only difference between the instructions in boxes 1, 4, 7, and 10 is the number of the box from which the previous balance is to be obtained. Similarly, only the box number distinguishes the instruction in box 2 from those in boxes 5, 8, and 11 and the instruction in box 3 from those in boxes 6, 9, and 12. Under these conditions, box space will be saved by the elimination of reiterated instructions through the revision of the basic instructions as follows:

Instruction

address

Instruction

Box 1. Copy on a piece of paper the number contained in box 25. (This instruction is later amended, by the instructions in boxes 4 and 5, to direct the clerk to copy the number contained in boxes 26, 27, 28, etc., in turn.)

Box 2. Copy on the same piece of paper the number contained in box 50. Add the two numbers and write the sum on the piece of paper. (This instruction is later
amended by the instructions in boxes 6 and 7, to direct the clerk to copy the numbers contained in boxes 51, 52, 53, etc., in turn.)

- Box 3. Copy the sum on a new piece of paper and place in box 25. Destroy the piece of paper in that box showing the previous balance. (Here again, the instruction is later amended, by the instructions in boxes 8 and 9, to direct the clerk to copy the sum on new pieces of paper and place them in boxes 26, 27, 28, etc., in turn.)
- Box 4. Copy on a piece of paper the box number in the instruction contained in box 1 and add one to it.
- Box 5. Erase the previous box number in the instruction in box 1 and insert the number resulting from the preceding instruction as the new box number.
- Box 6. Copy on a piece of paper the box number in the instruction contained in box 2 and add one to it.
- Box 7. Erase the previous box number in the instruction in box 2 and insert the number resulting from the preceding instruction as the new box number.
- Box 8. Copy on a piece of paper the box number in the instruction contained in box 3 and add one to it.
- Box 9. Erase the previous box number in the instruction in box 3 and insert the number resulting from the preceding instruction as the new box number.

Box 10. Return to box 1 for next instruction.

Thus, by the method illustrated, the number of boxes required for instructions has been reduced from 12 to 10. If the number of parts to be handled had been 4,000, instead of 4 as in the illustration, 11,990 boxes would have been saved since 12,-000 boxes would have been required under the pattern of instructions originally followed whereas, under the conditions assumed, the number of boxes needed in the revised instructions would remain fixed at 10. By the inclusion of analogous steps in the program of instructions in the electronic system, a limited number of basic instructions may be successively amended at electronic speed.

Conversely, it is sometimes necessary to increase the number of instructions in order to reduce the volume of data required to be processed at any one time, all for the purpose of adjusting the total volume of instructions and data to the capacities of the equipment.

Returning again to the analogy, one box has been provided for each item in the inventory and another box for each transaction. If the aggregate number of inventory items and transactions exceeds the number of available boxes, it will obviously be necessary to reduce the number of boxes required at any given time. This can be accomplished by processing the inventory items in groups. A further series of instructions would be inserted in additional boxes, generally as follows:

- Gather up the pieces of paper from boxes 25, 26, 27 ... 49 (showing the new inventory balances) and set them aside until tomorrow.
- Gather up the pieces of paper from boxes 50, 51, 52...74 (showing the purchases which have now been processed) and destroy them.
- Place in boxes 25, 26, 27 ... 49 pieces of paper on which are recorded the old balances of the next twenty-five parts.
- Place in boxes 50, 51, 52... 74 pieces of paper on which are recorded the purchases of the next twenty-five parts.

In the electronic system, the processing of data in groups may likewise be employed to effectively use available storage capacity.

Many other illustrations of methods of directing manipulation might be given. All, however, would serve only to emphasize the basic principle, already stated, that manipulation is the controlled direction of instructional symbolism upon data symbolism.

COMPONENTS

Proceeding from the basic concepts of the electronic dataprocessing system, it is next appropriate to examine further the basic components of the system which have been generally described earlier as consisting of input devices, the central processing unit, and output devices. The processing unit consists of a control unit, a storage device, and an arithmetic unit. Most equipment is designed to permit the use of more than one type of input, output, or storage device.

Although not technically a part of the electronic system, input preparation equipment also is discussed in connection with system components so as to bring out the full scope of the input function in the data-processing routine as a whole.

What things are done by the various components and how are they accomplished? Similarly as elsewhere herein, no attempt is made to answer these questions in terms of the scientific principles of electronics. To delve into the uses of diodes, triodes, transistors, gates, and the many other devices and circuits fulfilling electronic functions is therefore outside the scope of exploration here. Components are explained primarily from the viewpoint of their operating functions and characteristics, and the data and instruction symbolism in which they work.

Input Devices and Input Preparation Equipment

In the complete data-processing routine, the input function comprehends all steps from the preparation of media from source documents to the reading of data and instructions into the central processing unit. Media are prepared from source documents by the direct punch or mark-sensing method.

Where the medium is a punched card, the method of representing data by means of one or more holes in various positions in the vertical columns of the card is familiar. The same principle is used in respect to paper tape. The coding of a character takes the form of holes or inked dots across the width of the tape, in channels running the length of the tape. Paper tape is approximately one inch in width. Various codes are used, having from five to eight channels or positions. The coding of characters on magnetic tape takes the form of magnetic spots placed laterally on the tape by means of pulses from small electromagnets. Magnetic tapes vary from $\frac{1}{4}$ inch to 3 inches in width. They are either metallic or plastic and contain a magnetizable material. Characters may be compactly stored upon magnetic tape – up to 200, or more, to each linear inch.

Following these operations by the input preparation equipment, the input medium passes to the input reading devices, the first link in the chain of true electronic processing. These devices function under the direction of the control unit of the system, in accordance with the program of instructions. Reading occurs as the medium physically moves through the reading device, which translates the data and instructions expressed upon the medium in binary code into their electronic equivalents in the processing unit. The reading rate depends upon the type of medium used.

Reading devices consist of punched-card readers, paper-tape readers, and magnetic-tape readers. Punched cards may be read at speeds up to 250 cards a minute, or a maximum of about 325 characters a second. Paper tapes may be read at speeds of 10 to 1,000 characters a second and magnetic tapes may be read at speeds of 360 to 56,000 characters a second.

The input medium may be introduced directly into the reading device. However, in some situations the original medium is converted into another, either to provide greater reading speed or to bring the medium into compatability with the system. Conversion is effected by special devices.

Input data are of two types: carry-forward data and currenttransactions data. In most systems, carry-forward data are stored upon magnetic tapes available from prior processing and therefore need not be reproduced anew from source documents. Where the carry-forward data are the more voluminous, it may be advantageous to use cards or paper tapes for current-transactions data without reducing the over-all speed of processing.

In addition to all the previously mentioned devices that may be employed in the input cycle, it is necessary in all electronic systems to have a device that will provide access to the system for two purposes: first, to give the system its first instruction to start the processing routine and second, to permit intervention, in unusual circumstances, by direct insertion of correctional data or instructions. This device is a keyboard, known as a console, and is operated manually.

Control and Arithmetic Units

As stated earlier, the control unit interprets the instructions of the problem and directs the processing operations. Instructions in pre-planned sequence are routed into the control unit. By means of circuitry and tubes or other electronic devices, this unit interprets and transmits the instructions to the system as directions for the processing of data.

The arithmetic unit performs the operations of addition, subtraction, multiplication, and division and reaches decisions by comparisons. These abilities are attained by coupling with the binary concept of numbers the property of an electronic circuit, known as a "flip-flop," to change from one state or condition to another by the application of an electrical pulse.

A flip-flop circuit has two physical states, which may be designated as "on" and "off." Further, if a pulse is applied to a flip-flop circuit, the physical state of the circuit is changed. When a pulse is applied to a circuit in the "off" state, the circuit is changed to the "on" state. When a pulse is applied to a circuit in the "on" state, the circuit is changed to the "off" state and a pulse is emitted from the circuit. This pulse passes to the next adjoining circuit, creating a corresponding effect there, in accordance with the state of that circuit.

A group of flip-flops may be arranged to serve various purposes — for example, a group may be interconnected to function as a counter in order to symbolize a series of numbers. Four flip-flops can be arranged to symbolize, in binary notation, the decimal digits 0 to 9. Using O to designate a circuit in the "off" state and \blacksquare to represent a circuit in the "on" state, the effects of the application of pulses, one by one, to produce the states of the circuits to represent these digits may be illustrated as follows:

[42]

To designate the decimal digit 0, the series of four circuits might be in this state

- If a pulse is applied to the circuit at the right of the series, the circuit is changed from the "off" state to the "on" state, and the series of circuits becomes
- If a second pulse is applied at the same point, it will pass through the right hand circuit (since it is in the "on" state) into the adjoining circuit and at the same time, will change the states of the two circuits, thus **O**
- The application of a third pulse merely changes the last circuit at the right from the "off" state to the "on" state. The circuits now appear
- A fourth pulse will pass through the two right-hand circuits (since both are now in the "on" state) into the adjoining circuit and at the same time will change the states of the three circuits, as follows

The application of additional pulses would produce similar effects, until the range of the ten decimal digits was covered. Thus the states of the circuits and the corresponding equivalents in decimal digits and in binary notation would be as follows:

State of	Binary	Decimal
circuits	notation	digit
00000	0	0
00000	1	1
00000	10	2
000	11	3
0000	100	4
0-0-0-0	101	5
0	110	6
	111	7
0000	1000	8
••••••	1001	9

O





This illustration merely shows the effect of single pulses when successively applied to a series of circuits, all in the "off" state at the beginning of the applications. It serves to demonstrate that the application of nine pulses to such a series of circuits will produce a pattern of states of the circuits to represent the ten decimal digits in binary notation.

In the actual operation of the system, however, single pulses are not applied to the circuits in the manner described in the illustration. Instead, groups of pulses, representing the electronic equivalents of data and instructions, are applied simultaneously to groups of circuits in various states. The effects of these applications will now be explained in connection with the operation of addition.

An instruction to add causes the control unit to direct the arithmetic unit to set up the circuitry to accomplish the operation of addition. To illustrate, assume the binary number 101 (decimal number 5) is to be added to the binary number 11 (decimal number 3). One way in which this may be done within the equipment is to cause the pulses and no pulses representing one of the numbers to be first transferred to a group of interconnected flip-flops, known as a register, in the arithmetic unit. Thus, if the pulses and no pulses representing the decimal number 3 be so transferred, the register would appear as follows:

00000

Next, the pulses and no pulses representing the second number are moved into the register, causing the circuits to change from one state to another and thus to record the results of the operation of addition. In this example, the pulses (\square) and no pulses (\square) moved into the register, representing the decimal number 5, are as follows:

The effect of the simultaneous action of a group of pulses and no pulses upon the circuits is the same, in all electronic systems, as though each pulse and no pulse were moved into the circuits separately. Thus, for example, if it be assumed that the pulses and no pulses are applied successively from right to left, the effects would be as follows:

[44]



Accordingly, the state of the register ($\bullet \bullet \bullet$) upon completion of the operation of addition in this example symbolizes the binary number 1000, or the decimal number 8. Further study of the example will show that the result is the same, regardless of the order in which the pulses and no pulses are assumed to have been moved into the register.

If the magnitude of the numbers to be operated upon, or the result, is greater than 9, the size of the register obviously must be greater than the four circuits assumed in the example. Arithmetic operations upon these higher numbers involves a process of carry-over into successive banks of circuits, in addition to the operations illustrated in the example.

Subtraction, multiplication, and division are accomplished

by making use of the familiar principle that all arithmetic operations may be performed as variations of the process of addition. In the arithmetic unit of the system, subtraction may be effected by the addition of complements, multiplication is accomplished by successive addition, and division by successive subtraction. Comparison of numbers or other characters may be made by subtracting one from another and determining whether the result is zero (in which event they are equal) or not.

From an operating viewpoint, the capacity of the system is affected in some degree, but not materially, by such factors as the method used in the control unit to designate addresses, and the size and number of the registers used in the arithmetic unit.

Storage Devices

Storage devices provide a place to which data and instructions may be directed in the first instance and there held for introduction into the processing routine as required. In the processing which takes place within the central processing unit, everything — all data and instructions — goes first to the storage medium. All data and instructions must be assigned to specific locations (addresses) within the system at all times; otherwise, the system would be in chaos.

Speed of processing is affected by the time required to find data and instructions as needed in the sequence of processing operations. Since all, and not merely part, of the data and instructions flow in and out of storage in the course of processing, it is obvious that storage volume and speed of access to storage are very important factors in determining the capabilities of the system.

As mentioned earlier, the principal types of storage devices are vacuum tubes, cathode ray tubes, magnetic cores, acoustic delay lines, magnetic drums, and magnetic tapes. Storage devices are sometimes referred to as the memory unit of the system.

Vacuum Tubes

The first type of storage used in electronic computers was the flip-flop tube circuit. One of these circuits can store only one bit of information. This being the case, it is obvious that the expression of a great many numbers would require a very large number of circuits, or tubes. To express one decimal digit requires four tubes. Thus, for example, one ten-digit number requires at least 40 tubes and 1,000 such numbers require at least 40,000 tubes. Since smaller and better devices are now available, vacuum tubes are no longer generally used as a storage medium.

Cathode Ray Tubes

The cathode ray tube used for storage has a much smaller face-diameter but otherwise is the same in external appearance as that in a television receiver. The face of the tube is coated with a material which will hold a charge for a short period of time. An electronic beam directed from the base of the tube toward the face can be sent to any one of a fixed number of spots — usually about 1,000 — on the face which then becomes individually charged. Each charged spot represents one bit of information. The charge must be regenerated many times a second or it would be dissipated. The face of the tube is read by directing the electronic beam at the spots.

Magnetic Cores

Magnetic cores are doughnut-shaped ferro-electric rings, usually about 1/16 inch in diameter. Bits of information are read into the cores by sending current through wires passing through the centers of the cores. Each core stores only one bit of information at a time, hence storage volume depends upon the number of cores used. Bits are read from the cores by sending current through the wires passing through the centers of the cores and transferring the resulting pulses to probe wires linked to the main circuitry of the equipment. Because regeneration of the stored information is unnecessary and access speed is faster, one of the present trends in equipment design is a more extensive use of magnetic cores.

Acoustic Delay Lines

In acoustic delay lines, the stored bits of information are represented by pulses traveling continuously through a device which first converts the pulses into sound waves. After passing through an acoustic medium, such as a tube of mercury, these waves are converted back into electrical pulses. Since the speed of sound is much slower than that of electricity, this device affords a practical means of storage. Access to the bits is not immediate since it is gained by picking them off at a fixed point in the circuit.

Magnetic Drums

The magnetic drum used in storage is a rotating cylinder with a magnetizable substance on its surface. The drums vary in size, usually within the ranges of about 4 to 12 inches in diameter and 14 to 20 inches in length. The speeds of rotation vary also, but generally the operating speed at the surface of the drum is about 100 miles an hour. Adjacent to the drum surface are reading-writing heads, which convert incoming pulses into magnetized spots on the drum surface as they pass the heads. Each spot represents one bit. The arrival of the bits at the heads is timed so as to synchronize with the rotation of the drum, in order to place the spots at their designated addresses. In some systems, flexibility in capacity may be accomplished by varying the number of drums used. Access to the stored bits is effected by the reading-writing heads. Access occurs only as the fixed location (address) on the drum surface passes the heads.

Magnetic Tapes

Magnetic tapes are used extensively as secondary storage, as well as input and output media. Their use in the storage function is necessarily secondary because manipulation in the central processing unit cannot be accomplished without utilizing, at least to some extent, the primary storage devices such as those heretofore described. When used as secondary storage, bits upon magnetic tapes are read into primary storage and bits in primary storage are read out and written upon magnetic tape by the same reading-writing devices used in the input and output functions. Access to bits upon magnetic tape occurs as the tape moves mechanically past the reading heads and therefore the rate of access is relatively slow.

Accessibility to Storage

The over-all speed of the central processing unit in the electronic system is largely dependent upon the speed of access to data and instructions in storage. Information stored in magnetic cores, cathode ray tubes, and vacuum tubes remains in a static state. Access to the bits of information is direct and hence inherent speed of access is greatest. Information in acoustic delay lines and magnetic drums moves or circulates within the storage device. Inherent speed of access is slower since access is gained by picking off the information at a fixed point in the cycle of movement.

Speed of access is enhanced if the storage device is designed to give up simultaneously the several bits of information comprising a digit or other character, rather than singly. In the former case, access is said to be parallel and in the latter, serial. Some storage devices are better adapted to parallel operation than others.

Where the stored information remains in a static state, access is immediate. There are only slight variations in inherent access speed between the respective media which store information in this manner. Where the stored information moves or circulates within the devices, there are variations in inherent access speed of the respective devices which store information in this way, because of differences in the speeds at which the bits of information move past the reading points. This speed in turn is determined, in the case of acoustic delay lines, by the speed of sound traveling through the acoustic medium and the length of the delay line and in the case of magnetic drums, by the mechanical speed of rotation of the drum. The speed of access to storage in magnetic drums is much slower than that in acoustic delay lines.

Speed of access in magnetic drum storage may be accelerated, however, by modifications of the storage device itself. The principal modification is to increase the number of reading-writing heads. One reading-writing head is required for each channel on the surface area of the drum. One set of heads consists of a row of heads at fixed positions lengthwise of the drum. If the number of sets of heads (positioned at equal distances from each other around the circumference of the drum) is increased, average access time is increased proportionally.

Speed of access to storage in both magnetic drums and acoustic delay lines may be increased by a procedure known as optimum programming. In this procedure, the order in which bits are placed in the storage device is synchronized with the speed of rotation of the drum or the speed of sound traveling through the acoustic medium. The objective is to bring the bits under the reading-writing heads at the precise instant required in the processing routine. In this way, access time is minimized. In more precise technical terms, this technique is known as minimal latency coding.

As stated earlier, because of mechanical limitations, access speed in magnetic tape storage is slow; unless overcome, this may reduce the over-all speed of processing. To search completely a tape 2,400 feet in length from one end to the other may require five or six minutes. However, searching time may be shortened by binary searching, bloc searching, or tape indexing, each of which has the effect of reducing the area of the tape required to be inspected. Another way of avoiding, or minimizing, the reduction in processing speed is to use special tape-searching equipment which operates simultaneously with the other dataprocessing devices.

Output Devices

Output data are emitted from the central processing unit in binary code form. The output function is essentially one of conversion, which may be direct or indirect. Direct conversion occurs when the output data are transferred to a medium which carries or incorporates the data in end-use form. This medium will be magnetic or paper tape, or punched cards, if the end use is the storage of the output data for use as input in subsequent processing. If the end use is the production of report data, the medium will be the final report document.

Indirect conversion occurs when it is desirable, in connection with the preparation of the final report document, to hold all or part of the output data in intermediate storage, on magnetic or paper tape or punched cards, in order to avoid reducing the over-all speed of processing. The central processing unit emits information in the form of pulses and these must be translated into their electronic or other equivalents in the end-use medium. Even though the code of the end-use medium may still be in binary form, it is necessary to effect translation into the code scheme of the medium, that is, from pulses to magnetic spots in the case of magnetic tape and from pulses to holes or inked dots in the case of cards or paper tape. If the code of the end-use medium is not in binary form, which is the case in the final report document, the pulses must be translated into final report language.

Various conversion devices are interposed to make these translations. Where the translation of the pulses is made upon magnetic tape, a tape reading-writing device is used — one identical with that employed for reading in connection with the input function. Where the translation is made upon paper tapes or cards, the device used is a punching or writing unit which is actuated by the pulses and internal circuitry to produce inked dots or holes. Where the translation is made upon the final report document, the device is a printing unit, again actuated by pulses and internal circuitry, to print characters in report language. To effect translation from intermediate storage to report documents, the device is the same printing unit, actuated in this case, however, by circuitry and by the pulses created by the spots, dots, or holes upon the tapes or cards to print characters in the language of the report.

The speeds at which data may be transferred from the processing unit vary considerably. Illustrative are the following:

Transferred from	Characters		
processing unit to:	a second		
Typewriters or Flexowriters.	8 to	10	
Punched paper tapes	10 to	60	
Punched cards	67 to	225	
Line printers	200 to	2,000	
Magnetic tapes	360 to :	56,000	

To accelerate speed of output, or to provide compatability either within or without the system, one output medium may be converted to another, as is also done in the input function. For example, magnetic tape may be converted to cards or paper tapes.

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Buffer Storage Devices

Electronic data processing is built around the basic functions of input, manipulation in the central processing unit, and output. Separate components, each comprising one or more devices, carry out these respective functions. The over-all speed of processing is affected by three factors: first, the operating speeds of the respective components, which are not uniform; second, variations in the extent of processing as between the components; and third, the circumstance that, in the chain of processing each component normally must wait, before beginning its operations, until the preceding operations performed by other units in the chain have been finished.

Buffer storage devices serve to modify the limitations imposed by the third factor. By enabling all the components to operate simultaneously, these devices reduce the waiting times. In this way, the over-all speed of processing is increased.

The application of buffer storage may be illustrated by an example. If it requires 20 milliseconds to read 100 characters into the processing unit and 20 milliseconds to manipulate them within the unit, it will require 40 milliseconds to complete the two operations. Also, it will be observed that, after reading the first segment of 100 characters into the processing unit, the reading unit must wait during the next 20 milliseconds while this first segment is being manipulated. By interposing buffer storage between the reading and processing units, in this intervening 20 milliseconds the reading unit may read the second segment into buffer storage, thus keeping both the reading and processing units operating simultaneously during this interval. In the next 20 milliseconds, the second segment will be manipulated in the processing unit (access to buffer storage being immediate) while at the same time the third segment will be read into buffer storage, again keeping both the reading and processing units in simultaneous operation during this interval. In this way, all waiting time in the reading or processing units is eliminated so that in each 40 milliseconds of elapsed time, two segments, instead of one, may be read and manipulated, thus reducing the average time required to complete the two operations to 20 milliseconds, or one-half the time otherwise required.

If the times to read and to manipulate were different, rather than the same as in the preceding illustration, by the use of buffer storage the average elapsed time required to complete both operations would be reduced to the larger of the two times, rather than one-half of the aggregate time, for the reason that it is impossible for both units to operate simultaneously during all of the elapsed time.

In some systems, buffer storage is built into the processing unit and thus is available to all tape reading and writing units. Other systems have separate buffer storage units.

While buffer storage will always increase the over-all speed of data processing, it does not necessarily follow that its use will always be advantageous. As in all other choices of equipment, the selection of faster equipment will be advantageous only if its cost is less than its benefits are believed to be worth.

AN ILLUSTRATION OF PROGRAMMING

Programming is the planning of data-processing operations. It is comprehensive in scope, extending into each step of the routine. The results of the various studies required in the shaping of the plan of processing are ultimately reduced to the form of operational flow charts. The final step in programming is the translation of the flow charts into a series of instructions which can be introduced into and interpreted by the equipment.

To illustrate everything that is done in carrying out the programming function is impracticable. Even the flow charts and list of instructions which finally emerge as the condensed results of the programming process are exceedingly detailed in content. However, to illustrate a very small segment of programming procedure is feasible. Accordingly, there are described below the operational flow chart and the instructions covering the manipulative steps in the processing unit which would be required, in connection with a payroll procedure, to apply certain deductions against "net pay" and to arrive at "final net pay." It is assumed that gross pay, less taxes, has been previously computed, and that the steps to be covered therefore consist only of those required to apply the deductions other than taxes, if any, against this net amount and to arrive at final net pay. It is assumed also that neither the whole nor any part of any deduction which would reduce the final net pay below \$15 is to be applied; however, such deductions must be listed along with final net pay.

One type of flow chart which would express this segment of the programming problem symbolically is as follows:



The chart shows first that a test $(D_i:Z)$ is made to determine whether or not the last deduction has been processed. In the routine, an "end of deductions" sentinel (Z) will be placed immediately following the last deduction. If the test indicates the last deduction has been reached, that is, the deduction being processed is equal to (=) the symbol Z, final net pay is printed on a typewriter (P-SCP). The last deduction having been processed and net pay printed out, the routine is completed and operations stop.

If the test indicates the last deduction has not been reached, that is, the deduction is not the same as (\neq) the end-of-deductions sentinel, the deduction being processed is applied to the net pay $(P - D_i)$. Thereafter, a second test is made to determine whether or not the \$15 limitation has been reached ($(P-D_i:15)$). If this second test indicates the \$15 limitation has been reached, that is, the remaining net pay is less than (<) \$15, the deduction is printed on a typewriter ($(D_i - SCP)$) and the processing routine skips to the point designated (). Here, the next deduction ((i+1-i)) is selected and the processing routine skips back to the point at the beginning designated ().

If the second test indicates the \$15 limitation has not been reached, that is, the remaining net pay is equal to or larger than (\geq) \$15, the deduction being processed is applied to the remaining net pay ($P-D_i \rightarrow P$). Here again, the next deduction ([i+1-i]) is selected and the processing routine skips back to the point at the beginning designated (1).

Following construction of the flow chart, the next step in the programming procedure is the translation of the chart into a series of instructions, or codes. The term "codes" as used at this point means the representation of the basic operations (add, transfer, compare, etc.) that can be performed by the equipment. This representation is expressed in a more or less arbitrary scheme of designation known as a "code" which is devised by the manufacturer for use in all applications on the system and hence, of course, built into the circuitry of the equipment. The application of this scheme of designation in connection with programming is often referred to as coding.

The basic operations are not performed in the same manner in all types of systems and therefore the codes to designate operations are more complex in some systems than in others. Complexity, however, does not necessarily imply unwieldiness. Facility in use, to achieve a desired result, may be equal to or even greater than that of simpler codes.

Under one system, the series of coded instructions, which will be explained later, to translate the flow chart in the illustration would be as follows:

		Instr	uctions		
		6	ınd		
Address		con	stants		Coding notes
000	В	100			$D_i \rightarrow rA$
			L	009	Sentinel $\rightarrow rL$
001	Н	098			$D_i \rightarrow Memory$
			Q	008	Transfer control
					$if D_i = Z$
002	В	099			$P \rightarrow rA$
			S	098	$P - D_i$
003	L	010			$14.99 \rightarrow rL$
			Т	007	Transfer control
					$\text{if } P-D_i \geq \$15$
004	50	098			Print Di
			00	000	Skip
005	В	000			$i \rightarrow rA$
			Α	011	i+1→i
006	H	000			$i \rightarrow Memory$
			U	000	Transfer control to
					beginning
007	H	099			$P - D_i \rightarrow P$
			U	005	Transfer control to
					step 005
008	50	099			Print P
			90	000	Stop
009	ZZZ	ZZZ		{	End of deductions
			ZZZ	ZZZŞ	sentinel
010	000	000			
			001	499	Constants
011	000	001	000	000	-Olistants
			000	0005	

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Through a conversion device, the coded instructions would be automatically translated to a binary code form upon an input medium and introduced into the system. The instructions and constants would be recorded in storage memory locations (addresses) 000 to 011. It is assumed that payroll data have been read into the system with net pay (gross pay less taxes) stored in memory locations 099 and the deductions stored in memory locations starting with 100, the last deduction being followed by the end-of-deductions sentinel. Manipulation of the data would begin upon depression of the start key, whereupon the control unit would look for its first instruction in memory cell 000.

Expressed in plain language, the program would be interpreted by the system as follows:

Program

step	Address	Instructions and descriptions
1	000	B100 – Place into register A the deduction from memory cell 100. (This instruction is amended subsequently to place in register A the deduction in memory cell 101,102, etc.)
2		L009 – Place into register L the test sen- tinel from memory cell 009.
3	001	H098 – Store the deduction in memory cell 098. (In this operation, the deduction also remains in register A.)
4		Q008 – Compare amount in register A with sentinel in register L and transfer control to program step 16 in memory cell 008 if the deduction in register A matches the sentinel indicating the last deduction has been processed. Otherwise program step 5 is followed in sequence.
5	002	B099 – Replace contents of register A with the remaining net pay from memory cell 099 (if last deduction has not been made).
6		S098 – Subtract the deduction from net pay and hold remainder in register A.

Program		
step	Address	Instructions and descriptions
7	003	L010 – Replace contents of register L with the constant \$14.99 from memory cell 010.
8		T007 – Compare amount in register A with amount in register L and transfer control to program step 14 in memory cell 007 if the remainder, net pay, is \$15 or over. Otherwise program step 9 is followed in sequence.
9	004	50098 – Print on the typewriter the deduc- tion stored in memory cell 098 (when the application of the deduction reduces net pay below \$15).
10	005	B000 – Replace contents of register A with the instruction from memory cell 000.
11		A011 - Add one to the instruction so that it will now indicate the address of the next deduction.
12	006	H000 – Store the revised instruction back in its original location, memory cell 000.
13		U000 – Transfer control back to the first program step and start processing the next deduction.
14	007	H099 – Store remainder, net pay, in memory cell 099 (when it is \$15 or over).
15		U005 – Transfer control to the program step in memory cell 005, which is the routine for amending instructions to select the next deduction.
16	008	50099 – Print the final net pay from mem- ory cell 099 on the typewriter (when the last deduction has been processed).

Program step	Address	Instructions and descriptions
17		90000 – Stop the system.
Constant	5	
1	009	Z's have been used as a means of indicating that no further deduction items appear on the input medium. This constant is stored in the memory for use in making comparisons.
2	010	This constant is used in program step 7 in connection with the test to determine whether or not remaining net pay is less than \$15.
3	011	This constant is used in program step 11 as a means of increasing by one the address of each successive deduction.

This illustration has been adapted from an elementary problem used by a manufacturer for instruction purposes. In planning a complete payroll routine, a great many additional operations, both preceding and following those of the type here illustrated, would require similar analysis and coding. For example, very extensive editing instructions are required merely to arrange the results of processing in final report form. Also, as a general objective, the instructional pattern should be designed so as to provide a workable sequence of usage of the various input and output devices.

To program completely a payroll having few complicating features might require a thousand or more instructions. A payroll involving special features, such as incentive plans, alternative deductions, and complex account distributions, would require a substantially greater number of instructions.

The complete programming of a payroll routine is a lengthy operation. Once completed, however, the program can be used successively until a change occurs in payroll procedures; usually, changes can be worked into the routine without extensive alterations in the program.

AN ACCOUNTING APPLICATION

Selecting again for purposes of illustration the field which is most generally familiar, a typical example of an accounting application is the combination and use of the components of an electronic data-processing system to process a weekly payroll. Assume that the system consists of a processing unit, several units for both reading and writing tapes, a high-speed line printer, and, as input preparation equipment, key-driven paper tape punches and a paper-to-magnetic tape converter.

Assume also that master personnel files containing carryforward payroll and personnel data are available on magnetic tapes. Assume further that the payroll procedures have been completely analyzed and that the routine required to compute gross pay and deductions and to distribute payroll charges has been programmed and coded into instructions. Finally, assume that the instructions have been key-punched on magnetic tape.

The payroll application, under these assumed conditions, is represented in the diagram on the opposite page which denotes by number references the following successive steps in the processing routine:

- 1. At the end of each payroll period, key-punch operators punch from the clock cards a paper tape showing employee number and total hours worked for each employee.
- 2. Key-punch operators also punch from job tickets a paper tape showing employee number, work order number, and time spent during the week on each job.
- 3. The paper tapes prepared in steps 1 and 2 are converted to magnetic tape on paper-to-magnetic tape converters.
- 4. A sorting operation is next performed. As the first step, the following reels are placed on the tape read-write units:
 - (a) The reel containing the coded instructions for sorting data from the clock cards into employee number sequence.
 - (b) The reel containing the clock-card data on the tapes prepared in steps 1 and 3.



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- (c) The reel to receive the clock-card data sorted in employee number sequence.
- (d) Two or more reels to store partially sorted data temporarily.
- To start processing, the coded instructions from reel (a) are read into storage and the clock-card data from reel (b) are read into storage and processed in accordance with the coded instructions. Following this, the clockcard data, now sorted in employee number sequence, are written out on the magnetic tape, reel (c).

Sorting having been completed, the reel containing the sorted clock-card data is removed and held for processing in step 6. The reel containing the sorting instructions is removed and held for use in connection with next week's payroll and the reel containing the unsorted clock-card data is removed and held temporarily for reference.

- 5. A similar sorting operation is performed upon the jobtickets data placed on magnetic tape in steps 2 and 3, to arrange the data in employee number sequence.
- 6. The following reels are placed on the read-write units:
 - (a) The reel containing the coded instructions for processing the payroll checks, payroll register, and labor distribution.
 - (b) The reel containing the master personnel files.
 - (c) The reel containing clock-card data in employee number sequence, prepared in step 4.
 - (d) The reel containing the work-order data from job tickets, in employee number sequence, prepared in step 5.
 - (e) Reels of tape to receive the payroll-check data, the payroll-register data, and work-order data.
 - The tapes upon all reels (a) to (d), in the programmed time and order sequences, are read into the processing unit and after data processing there, the following tapes are prepared on the read-write tape units:

A tape containing all data required to prepare payroll checks.

- A tape containing all data required to prepare the payroll register.
- A tape containing work-order data (in employee number sequence) to be used in processing the labor distribution record. At this point the work-order data have been balanced with the hours from the clock cards and have been extended in dollars, using the employees' wage rates.
- Following this, all the reels are removed from the readwrite units. The reels containing the coded instructions and the master personnel files are held for use in connection with next week's payroll. The reels containing the data required to prepare paychecks, the payroll register, and the labor distribution are held for processing in steps 7, 8, and 9, respectively. The reels containing the clock-card data in employee number sequence and the work-order data in similar order are held temporarily for reference.
- 7. The reel containing the data required to prepare the payroll checks is connected to the printer and the payroll checks are prepared automatically.
- 8. The reel containing the payroll-register data is connected to the printer and a payroll register is prepared, again automatically.
- 9. The reel containing the work-order data in employee number sequence is next processed to produce the data required for the labor distribution report. To avoid repetition in the explanation and also to illustrate a difference in processing methods, it is assumed that the number of job orders involved is limited and therefore it is unnecessary to perform a sorting operation to produce the required data. The following reels are placed in the read-write units:

The reel containing the coded instructions for processing the labor distribution.

- The reel containing the work-order data (prepared in step 6).
- A reel to receive the processed data.

- The tapes upon the first two reels, in the programmed time and order sequence, are read into the processing unit and after the data are processed there, a tape containing the total labor charged to each job, in job order sequence, is prepared on the read-write tape units. In this case, arrangement in sequence was accomplished in processing by assigning addresses in sequence to the respective job orders.
- The reels are then removed. The instruction tape is held for use in processing next week's labor distribution records. The reel containing the work-order data in employee number sequence is held temporarily for reference. The reel containing the work-order data in job order sequence is used in step 10.
- 10. The reel containing the work-order data in job order sequence is connected to the printer and a labor distribution report is prepared.

This illustration merely outlines in a general way the required procedures. Omitted, of course, are innumerable details such as the content and explanations of programs.

APPENDIX

APPENDIX

This appendix contains summaries of the principal functional characteristics and the costs of purchase or rental of certain electronic data-processing systems, including, in some instances, certain items of input preparation equipment. No attempt has been made to cover special-purpose equipment or electronic computers designed primarily for scientific purposes. No attempt has been made to evaluate the equipment. The summaries have been compiled from information furnished by the manufacturers; the information is current as of the dates shown at the close of each summary.

It will bear repetition to emphasize again that each system should be studied in relation to its proposed application. Operating speeds and capacities, although important, should not be considered alone. A 4,000-word magnetic drum is not to be preferred if a 1,000-word drum is adequate. High internal operating speeds are wasted if the system's internal capacity lies unused because of input or output limitations. Large capacity and high speed mean little if the equipment is to be used only a fraction of the workday. In summary, all functional characteristics must be weighed in relation to the operations which the system may be called upon to perform.

Manufacturer	System Page
Datamatic Corporation	Raycom 68
ElectroData Corporation	Datatron 71
International Business Machines	
Corporation	Type 650 75
International Business Machines	
Corporation	Types 702 and 705 . 79
Marchant Calculators, Inc.	Miniac
Monroe Calculating Machine	
Company	Monrobot MU 88
National Cash Register Company	CRC 102D and
	NCR 303 90
Radio Corporation of America	Bizmac
Remington Rand, Inc.	Univac (including
-	Univac II) 99
Remington Rand, Inc.	Univac File-Computer 105
Underwood Corporation	Elecom 125 110

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RAYCOM

Manufacturer

Datamatic Corporation, Waltham 54, Massachusetts.

General Characteristics

- The Raycom is a high-speed, general-purpose electronic dataprocessing system. Data in punched cards are transcribed to magnetic tape by an independent card-to-tape converter. Magnetic tape serves as the data-processing and file storage medium.
- Data on output tape are prepared, by a separate converter, in a form suitable for printing on standard tabulating printers, or for other types of printing, card punching, or tape punching.
- Tape searching may be accomplished as an independent operation by scanning up to 10 magnetic tapes simultaneously. Searching is performed under control of standard built-in orders. The availability of buffer storage makes possible the performance of searching while other operations are in process.

Monthly Rental – Selling Price

The cost of a complete system will be comparable with the cost of other existing large-scale electronic data-processing systems. Since the size of the Raycom system will depend upon the dataprocessing problem, specific lease or purchase data are available only after analysis to determine the equipment required.

Operating Characteristics

- Circuitry parallel reading and writing of 31 words on magnetic tape with serial handling of bits comprising each character and word. Access to high-speed memory is parallel. Arithmetic operations are serial.
- Internal operating code decimal digits in binary coded decimal, alphabetic characters in 6-bit code. Every word (alphabetic or numeric) contains a proof digit.
- Word length number words comprise 11 decimal digits and sign. Alphanumeric words comprise 8 alphanumeric characters.

Block length -31 words.

Facilities for handling alphabetic information – unlimited.

Program code – three address, either programmed or automatic sequencing.

Conditions governing transfer of control – equal or unequal and other special conditions such as overflow, etc.

Magnetic Tape

- Description plastic, 3 inches in width; reel length, 2,800 feet. Magnetizable material is sandwiched between layers of plastic to protect recorded information and increase tape life. The tape comprises 31 channels, each channel consisting of one word arranged serially on the tape.
- Effective recording density -156 bits to each inch. Through the use of 31 channels on the tape, a one inch length of tape contains space for the equivalent of 1,209 decimal digits.
- Average storage capacity for each reel 34,000,000 decimal digits or 24,800,000 alphanumeric characters (equivalent of 425,000 and 300,000 punched cards, respectively).
- Read-write speed rates of 56,000 decimal digits a second or 37,000 alphanumeric characters a second.

Tape moving speed -100 inches a second.

Rewind speed -100 inches a second.

Maximum number of tape units -100.

Card-to-Tape Converter

Function – conversion of data in 80-column punched cards to magnetic tape. A detachable plugboard is used to rearrange fields as well as control various modes of conversion. Speed – 900 cards a minute.

Magnetic Core Memory

Capacity – 2,000 words (22,000 decimal digits).

Access time – approximately .010 millisecond. Since access to memory is parallel, access time for reading a word from any memory address or delivering any word to any memory address is also approximately .010 millisecond.

Buffer Storage

Input buffer storage comprises two 31-word sections operating in parallel. Output buffer storage comprises two 31-word sections operating in serial.

Internal Storage Registers

Contains 7 word-length registers, some of which store results of

arithmetic operations; the remainder are used for various control functions.

Output Converter

Function – Editing of data received from tape for printing in IBM Type 407, or other printer, or for card or tape punching. Rearranges fields and controls various modes of conversion.

Physical Characteristics (assuming a very large installation to include 5 card-to-tape converters, 18 magnetic tape handling mechanisms, and 2 printers).

Recommended floor space -40 by 100 feet.

Voltage requirements – 208 volts, 3 phase, 60 cycle.

Cooling required – air cooling with a total of 75 gpm of cooling water required.

General Information

First installation to be made in summer of 1956.

May 9, 1955.

DATATRON

Manufacturer

ElectroData Corporation, An affiliate of Consolidated Engineering Corporation, 717 North Lake Avenue, Pasadena 6, California.

General Characteristics

- The Datatron is a moderately priced, magnetic drum electronic data-processing system. Data may be introduced into the system directly by punched-card readers. Also, data can be transcribed by one or more Flexowriters into punched paper tape which then can be read photoelectrically into the system. Magnetic tape serves as the principal file storage medium, and may be reintroduced into the system for processing.
- Output consists of punched paper tape, Flexowriter copy, punched cards, or printed copy prepared directly on tabulators (line printers). Punched-card readers are the most-used input devices; line printers are the most-used output devices.
- Block searching of magnetic tapes is performed independently of other operations.

Selling Price — Monthly Rental

	Selling price	Monthly rental
Basic processing unit	\$119,200	\$3,715
Console, with photoelectric reader		
and tape perforator unit	13,271	423
Typewriter control unit	4,560	137
Modified Flexowriter	3,135	95
Punched card converter unit	18,625	567
Magnetic tape control unit	18,560	586
Magnetic tape storage unit:		
First unit	14,675	444
Each additional unit	12,875	390
Tape preparation system with verifier	3,791	133

Monthly rentals stated are for one-shift operation under lease contracts for a period of one year, then cancellable on 3-months notice. If option to purchase is exercised, 40% of rentals paid may be applied toward selling price, up to a maximum of 60% of such price.

Operating Characteristics

Circuitry – serial by decimal digits, parallel by bits.

Internal operating code – binary coded decimal.

Word length – 10 digits plus sign.

Block length -20 words.

- Alphabetic facilities alphabetic and special characters require two decimal positions for internal processing.
- Program code single address, automatic (non-programmed) sequencing.

Transfer conditions - zero, minus, and overflow.

Magnetic Tape

Description – oxide coated plastic, ¾ inch in width; reel length, 2,500 feet.

Recording density -100 digits an inch.

Capacity – 400,000 words to each reel.

Maximum number of tape units -10.

Tape moving speed – 60 inches a second.

Record gap $-\frac{1}{2}$ inch.

Rewind speed -2,500 feet in three minutes.

Tape searching – each tape unit may be programmed to search for addressed blocks, independently of other operations.

Punched Paper Tape

Code – 4-channel binary coded decimal. Recording density – 10 characters an inch. Reading speed: Flexowriter – 9 digits a second. Photoelectric reader – 540 digits a second. Punching speed – 20 digits a second.

Punched Cards

Card read and punch units – IBM types 513, 514, 517, 523, or 528.

Read speed - 100 or 200 cards a minute, depending upon unit type.

Punching speed -100 cards a minute.

Line Printers

Equipment – IBM types 402, 403, 407, and 416. Printing speed – 100 or 150 lines a minute, depending on unit type.

Magnetic Drum

Capacity:

Main storage -4,000 words.

Fast access storage – 80 words.

Access time (average):

Main storage – 8.5 milliseconds.

Fast access storage – .85 milliseconds.

Description – 12 inches in diameter, 15 inches in length; 3,600 rpm.

Storage Registers

Accumulator — two registers, total of 20 digits plus sign. Distributor — 10 digits plus sign.

Buffer storage:

Magnetic tape input-output - 20 words.

Paper tape input-output -1 word.

Punched card input-output – 8 words.

Speed of Basic Arithmetic Operations (time to procure command and operand and to execute operation):

Addition or subtraction -2.0 milliseconds each.

Multiplication (10 digits \times 10 digits) - 8.5 milliseconds each. Division (20 digits \div 10 digits) - 12.0 milliseconds each.

Physical Characteristics

Dimensions:

Computing unit $-78\frac{1}{2}$ inches high, $143\frac{1}{2}$ inches wide, 28 inches deep.

Control console – 44 inches high, 60 inches wide, 31 inches deep.

Weight:

Computing unit -2,700 pounds.

Control console $-427\frac{1}{2}$ pounds.

Voltage requirements – 208-230 volts, 3 phase, 60 cycle.

Cooling – approximately 5 tons of room air conditioning recommended.

General Information

Selling price includes training of customer personnel in programming, operation, and maintenance.

Service contracts for maintenance by manufacturer's personnel are available.

Delivery schedule -5 to 7 months after acceptance of order.

May 6, 1955.
IBM TYPE 650

Manufacturer

International Business Machines Corporation, 590 Madison Avenue, New York 22, New York.

General Characteristics

The Type 650 is an electronic data-processing system designed for use with punched cards and magnetic tape. The principal storage device is a magnetic drum. It is a numerical, decimal system which can handle alphabetic and special characters through the use of additional devices.

Wiring panels provide flexibility in card reading and punching.

Monthly Rental Rates

Basic system with 1,000 word magnetic drum				\$3,250
Basic system with 2,000 word magnetic drum				3,750
Alphabetic device for basic system				325
Magnetic tape units (maximum of four), each				550
Magnetic tape control unit (one only)				1,200
High-speed core storage (10 words)	•			1,800
Punched-card accounting machine				
(Type 407 printer with input-output device))			1,300
Alphabetic device for Type 407 printer			•	325
Special character device for printer or punch .				100

Rentals stated are for single shift operation.

Operating Characteristics

Computing circuits – serial by digit, parallel by bits.

Card reading and punching – parallel by digit.

Tape reading and writing – serial by digit, parallel by bits. Codes:

Card read and punch buffers, and arithmetic and control circuits -7 bit biquinary.

Tape – 7 bit decimal coded binary, alphabetic zone plus check bit.

Drum -5 bit (0, 1, 2, 3, and 6).

Word length -10 decimal digits plus sign.

Block length -10 words.

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Program code – double address, programmed sequencing.

- Conditions governing transfer of control zero, minus, overflow, or presence of certain digits in distributor.
- Words containing alphabetic characters require two decimal digit positions inside the system. Numeric characters may be intermingled with alphabetic characters.
- Alphabetic capacity six words of 5 characters each, or 30 characters in total on each card read or punch cycle.

Magnetic Tape

- Description oxide coated plastic tape, $\frac{1}{2}$ inch in width; reels are $10\frac{1}{2}$ inches in diameter and 2,400 feet in length.
- Recording density 200 characters an inch with ³/₄ inch interrecord gap; fixed record length of 100 characters subdivided into 10 words of 10 digits, each with its own sign.
- Average storage capacity for each reel over 22,000 records, each with 100 characters plus ten signs.
- Read-write speed maximum rate of 75 inches a second or 15,-000 characters. Equivalent to .067 milliseconds for each character plus 10.0 milliseconds start-stop time.
- Rewind speed average of 500 inches a second.

High-Speed Core Storage (Type 653)

Functions:

- Required as an integral part of the tape system to provide temporary storage for either input data from tapes or output data to tapes.
- The device can be used as a high-speed storage for 10 individually addressable words of data and instructions when not used as a temporary storage device for the tape system, or when used without the tape system.
- Capacity 10 words, each with 10 digits plus sign.

Read Punch Unit (Type 533)

Card read speed -200 a minute.

Card punch speed -100 a minute.

Wiring panel – provides for flexibility in reading and punching (selection of three types of cards, rearrangement of fields for reading and punching, etc.).

Punched-Card Accounting Machine (Type 407)

- Function serves as output printer to the basic 650 system. Also, it can be used to read information into the system for processing, the results being stored or printed, or both. Many functions normally associated with the standard Type 407 accounting machine, such as comparison, program control, print control, and summary punching, can be performed even though the Type 407 is attached to the basic system. Output from the 650 system can be rearranged by control panel wiring.
- Speed dependent upon the complexity of the operation performed; maximum speed – 150 cards or lines a minute.

Arithmetic and Control Unit

Accumulator - 20 digits plus sign, divided into two sections of 10 digits which may be used independently for certain operations.
Distributor - 10 digits plus sign (may be used for interim storage).
Program register - 10 digits plus sign.

Magnetic Drum

Capacity – 1,000 or 2,000 words.

Access time – average 2.40 milliseconds a word.

Size – 4 inches in diameter, 16 inches long.

Speed – 12,500 rpm.

Buffer storage – 10 word capacity for card read and card punch (each).

Speed of Basic Arithmetic Operations

- Addition or subtraction 5.52 milliseconds average with regular programming; .72 milliseconds with optimum programming.
- Multiplication (any 10 digits by 555555555) 16.9 milliseconds.

Division (any 20 digits by 555555555 - 20.7 milliseconds.

Physical Characteristics

- Console unit $-76\frac{1}{2}$ inches over-all length, 30 5/16 inches deep and 71 inches high.
- Power unit $62\frac{1}{8}$ inches long, 30 5/16 inches wide and 71 inches high.
- Read-punch unit 49¹/₈ inches high, 59 7/16 inches long, 25³/₈ inches wide.

Weight -5,360 lbs. for the three units combined.

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Power and Air Conditioning Requirements

Power requirements for basic system – 230 or 208 volts, single phase, 60 cycles, 100 ampere; 16.8 kva.

Air conditioning – certain requirements of conditioned air, dust, and humidity control must be met. The temperature and humidity requirements are similar to the IBM Types 702 and 705.

General Information

Courses provided by manufacturer for training of programmers and operators.

May 11, 1955.

Manufacturer

International Business Machines Corporation, 590 Madison Avenue, New York 22, New York.

TYPE 702

The Type 702 has been superseded by Type 705. Details of the Type 702 are not submitted since only a limited quantity of this system will be delivered to customers.

Type 702 and 705 are similar in many respects. However, the following changes incorporated in the Type 705 have improved substantially the operating performance of the newer system:

- Increased internal storage capacity and substitution of magnetic cores for cathode ray tubes (electrostatic storage) as principal storage medium.
- Increased speed through (1) increased speed of basic character cycle, (2) parallel interpretation of instruction characters, (3) parallel transmission, in groups of five characters, of data from one memory location to another, and (4) simultaneous reading and writing of tapes.

Greater flexibility and simplified programming through use of fifteen auxiliary accumulator storage registers.

Control panel added to the card reader for rearrangement or elimination of fields and the emitting of constant data.

TYPE 705

General Characteristics

- The Type 705 is a high-speed, general-purpose, electronic dataprocessing system. Magnetic tape is the principal file storage and processing medium. Data on punched cards normally are transcribed to magnetic tape by an independent card-to-tape conversion operation. Punched cards may also be introduced directly into the system in conjunction with magnetic tape.
- Internal storage consists of magnetic core memory and, if desired, one or more magnetic drums.

Output consists of magnetic tape, punched cards, or printed copy.

- A large number of tape units, card readers, card punches, and line printers may be operated under control of the Type 705. Conversion of data from punched cards to magnetic tape, from magnetic tape to punched cards, and from magnetic tape to printed copy may also be performed as independent operations, reserving the central processing unit for other operations.
- Alphabetic, numeric, and symbolic characters are accommodated in any combination in reading, writing, and processing operations.
- The Type 705 employs variable word and record lengths in all operations.

Monthly Rental

705 Central processing unit and operator's console	\$14,000
714-759 Card reader and control unit	2,400
717-757 Printer and control unit	1,800
722-759 Card punch and control unit	1,050
728 Magnetic tape unit	550
754 Tape control unit	2,000
733 Magnetic drum storage unit	2,800
775 Record storage unit	2,400
Rentals stated are for one-shift operation. Premium re	ntals are
arranged for more extensive use of the equipment.	

Operating Characteristics

- Circuitry chiefly serial; however, parallel circuits are provided for simultaneous interpretation of the five characters of an instruction and for high speed transmission of data (in groups of five characters each) from one memory position to another.
- Internal operating code -7 bits (4 straight binary numeric bits, 2 zone bits, and 1 check bit).

Word, block, or record length – variable.

- Facilities for handling alphabetic data complete flexibility (nonnumeric characters require only one storage position).
- Program code single address, automatic (non-programmed) sequencing.
- Conditions governing transfer of control:
 - Quantitative comparisons accumulator equal to memory, accumulator greater than memory.
 - Algebraic conditions accumulator positive, accumulator zero, accumulator containing zero to extreme left.

Presence of certain signal indicators.

Magnetic Tape

Description – oxide coated plastic tape, $\frac{1}{2}$ inch in width; reels are $10\frac{1}{2}$ inches in diameter and 2,400 feet in length.

- Recording density 200 characters an inch with 34 inch interrecord gap.
- Average storage capacity for each reel equivalent to 25,000 punched cards with 80 columns each (ungrouped records) or over 50,000 grouped records of 100 characters each.

Maximum number of tape units -100.

Read-write speed — maximum rate of 75 inches a second or 15,000 characters. Equivalent to .067 milliseconds for each character plus 10.0 milliseconds start-stop time. Simultaneous reading of input tape and writing on output tape may be performed through programming.

Rewind speed -500 inches a second (average).

Record Storage Unit (Type 775)

- Function buffer storage register which allows central processing to continue while other data are read from or recorded on magnetic tape.
- Capacity for each unit -1,000 characters.
- Read-write speed (buffer to central processing unit) .0231 milliseconds a character.

Card Reader (Type 714)

Speed – .068 milliseconds plus .0335 milliseconds a character (for each card); maximum speed, 250 cards a minute for each card reader.

Maximum number of card readers -100.

- Buffer storage capacity (provides for simultaneous operation of central processing unit while card is being read) -92 characters.
- Control panel provides for rearrangement of card fields, deletion of unnecessary fields, emitting of constant data, and other editing functions including the grouping of up to 46 characters from each of two cards in one tape record.

Card Punch (Type 722)

Speed - .068 milliseconds plus .0335 milliseconds a character (for each card); maximum speed, 100 cards a minute for each card punch.

Maximum number of card punches – 100.

Buffer storage capacity (provides for simultaneous operation of central processing unit while card is punched) – 80 characters.

Printer (Type 717)

Speed – .068 milliseconds plus .0335 milliseconds a character (for each line); maximum speed for each printer – 150 lines a minute, 120 characters a line.

Maximum number of printers -100.

Buffer storage capacity (provides for simultaneous operation of central processing unit while record is printed) -120 characters.

High-Speed Line Printer

A public announcement has been made of the development of two high-speed line printers with speeds of 500 lines a minute, 120 characters to each line, and 1,000 a minute, 60 characters to each line. Specifications are not available.

Typewriter (for output only)

Speed -10 characters a second.

Buffer storage – none; typewriter prints directly from memory, all other operations being suspended during use of typewriter.

Magnetic Core Memory

Capacity – 20,000 characters.

Speed (movement of data between memory and accumulator storage register, etc.) – .034 milliseconds to interpret instructions plus .017 milliseconds for each character.

Magnetic Drum (Type 733)

Capacity – 60,000 characters on each drum.

Maximum number of drums -30.

Access time (average) - 8.000 milliseconds.

- Read-write speed .040 milliseconds a character (25,000 characters a second).
- Physical characteristics length 12.5 inches; diameter 10.7 inches; 3,730 rpm.

Accumulator and Auxiliary Storage Units

Function — interim storage of data, constants, and results, comparison of data, rearrangement of fields, etc. Multiple units facilitate programming. Capacity:

One 256-position accumulator. Fourteen 16-position auxiliary storage units. One 32-position auxiliary storage unit.

Independent Operations (performed independently of central processing unit by connecting any magnetic tape unit to a card reader, card punch, or printer).

Card-to-tape - 250 cards a minute.

Tape-to-card – 100 cards a minute.

Tape-controlled printer -150 lines a minute.

Speed of Basic Arithmetic Operations

Addition or subtraction (10 digit result) – .204 milliseconds each. Multiplication (two 5 digit operands) – .799 milliseconds each. Division (5 digit divisor, 10 digit dividend, and 5 digit quotient) - 4.820 milliseconds each.

Comparison (two 10 digit operands) – .204 milleseconds each.

Physical Characteristics

Recommended floor space for a typical installation - 2,400 square feet.

Recommended floor strength – 200 lbs. for each square foot. Power – 63 kw; 208 volts; 60 cycle, 3 phase; 296 amp.

Refrigeration – approximately 22 tons of room air conditioning required; room temperature 65° to 80°; relative humidity, 40% to 60%.

General Information

Free courses are provided by the manufacturer for training of customer's operators and programmers.

May 10, 1955.

MINIAC

Manufacturer

Marchant Calculators, Inc., Oakland 8, California.

General Characteristics

The Marchant Miniac is a compact, moderately priced, medium speed, electronic data-processing system. Data may be entered directly by means of a Flexowriter or by punched paper tape prepared by Flexowriters and read either mechanically or photoelectrically into the system. Data may also be entered into the system by magnetic tape, which can be prepared in convenient magazines, or capsules, by means of a magnetic-tape typewriter. The magnetic-tape capsules can be mounted directly into the system and can be used as a secondary storage device.

Output is by typed copy prepared directly by a Flexowriter, by perforated tape or magnetic-tape capsules, or by high-speed line printer.

Sequencing and collating of data on magnetic tape is accomplished by a Tape Information Processor.

Selling Price

Basic Miniac computer	\$85,000
Flexowriter, including mechanical tape punch	
and reader, and equipped for direct connec-	
tion to the Miniac	2,950
Optical tape reader (photoelectric)	4,000
Fast access memory modification	15,000
Command modification and tally register	10,000
Complete operating console	15,000
Tape Information Processor	30,000
Tape capsule	100
Magnetic-tape typewriter	4,000
Magnetic-tape transport	2,000
High-speed line printer	75,000

Operating Characteristics

Circuitry – completely serial, including handling of binary components of decimal digits.

Internal operating code – 4 bit, binary coded decimal (or hexa-

decimal) digits in basic processing unit; 6 bit alphanumeric in Tape Information Processor.

- Word length in the basic Miniac computer, 10 digits and sign; in the Tape Information Processor, 100 alphanumeric characters.
- Facility for handling alphabetic data in the basic Miniac computer, 6 bits are used to identify a character as a number or a letter, reducing the word length for alphabetic data to six characters. Input and output instructions and commands for comparison, matching, and extracting are provided for handling such data. The contents of internal registers, however, cannot be identified as characters or digits. Facility for handling alphabetic data is also provided through the use of the Tape Information Processor.
- Program code single address, automatic (non-programmed) sequencing.
- Conditions governing transfer of control programmed overflow, tally register equal to zero, and accumulator register equal to or greater than zero.

Punched Paper Tape

Description – 6-channel tape, 7/8 inch in width.

Recording density -10 characters an inch.

Tape moving speed:

Mechanical reading and punching -1 inch a second.

Photoelectric reading – 100 inches a second.

Read-write speed:

Mechanical reading and punching -10 characters a second. Photoelectric reading -1,000 characters a second.

Magnetic Tape

Description – oxide coated Mylar, ¹/₄ inch in width; reel length, 550 feet.

Recording density – 32 characters an inch.

Storage capacity of each reel (maximum) -211,000 characters.

Dimensions of magnetic tape capsule $-1\frac{1}{2} \times 5\frac{1}{2} \times 7$ inches.

Maximum number of tape units – unlimited.

Tape search – available, using Tape Information Processor.

Read-write speed -1,250 characters a second.

Rewind speed -200 to 400 inches a second.

Buffer storage – Tape Information Processor.

Magnetic Drum

Capacity – 4,096 words, including (optional) fast access storage of 256 words.

Access time (average):

Main storage – 5 milliseconds.

Fast access storage – 1.25 milliseconds.

Description $-6\frac{1}{2}$ inches in diameter, 10 inches in length, 6,000 rpm on vertical axis.

Internal Registers

Arithmetic registers:

Accumulator – 10 decimal (or hexadecimal) digits and sign. Other – two registers of 10 decimal (or hexadecimal) digits for factors used in multiplication and division; one register, 1 decimal digit, for overflow indication.

Other:

Command register.

Command modification and tally register. Sequencing register.

Speed of Basic Arithmetic Operations (Average in milliseconds):

	Main memor	Fast access y memory	Fast access with Tape Information Processor
Addition, subtraction, or			
comparison	. 10.5	3.4	2.3
Multiplication	. 23.4	16.3	12.1
Division	. 24.6	17.5	13.2

Printed Output

Flexowriter, controlled by the Miniac.

Flexowriter, controlled by punched paper tape.

Tape-typewriter, controlled by magnetic tape.

High-speed line printers, operated from magnetic tape -10 lines of up to 100 characters a line each second.

Physical Characteristics

Dimensions of Miniac cabinet -4 feet x 4 feet x 4 feet; console requires approximately the same space.

Weight - 1,800 lbs.

Power – 4kw, 208-230 volts, 60 cycle, single phase.

Cooling – water (city or re-circulated) at 4 gallons a minute; no air conditioning required.

General Information

Purchase price includes initial training of customer's programmers, operators, and maintenance men.

Service contract available for maintenance by manufacturer's engineers. The first 90 days are covered by factory warranty, and a one year service contract is available at 5% of purchase price.

Delivery schedule -6 months from receipt of order.

May 5, 1955.

MONROBOT MU

Manufacturer

Monroe Calculating Machine Company, Monrobot Laboratory, Morris Plains, New Jersey.

General Characteristics

- The Monrobot MU is a medium scale electronic data-processing system. Input and output is accomplished by the use of the following standard commercially available devices: teletype units; Flexowriters; punched-card readers, punches, and tabulators; photoelectric paper tape readers; magnetic tape units; and line printers. Internal storage is provided by one or more magnetic drums.
- Special buffer facilities will provide fast access and will permit the simultaneous operation of the central processing unit with a given input or output device.
- Two complete and independent arithmetic and control units are employed.
- The MAID (Monrobot Automatic Internal Diagnosis) simplifies maintenance and provides internal verification of certain processing operations.

Operating Characteristics

Circuitry – chiefly serial.

Internal operating code – binary coded decimal.

Word length – 24 decimal digits plus sign.

- Alphabetic facilities alphabetic and special characters require two decimal positions for internal processing.
- Program code modified single address, automatic (non-programmed) sequencing.

Transfer conditions – greater than, less than, or equal to.

Speed of Basic Arithmetic Operations

Addition, subtraction, or comparison – 8 milliseconds. Multiplication – 68 milliseconds. Division – 77 milliseconds.

General Information

Few of the physical characteristics of the system are presented because the multiple-unit concept of the system permits the use of a wide variety of standard commercially available components. Also, many of the components would be made to conform to the requirements of any specific system. Obviously under these conditions, costs are not quoted.

Drum capacities will range from a few thousand to tens of thousands of words, depending upon the requirements of the system. Likewise, access time will vary.

May 2, 1955.

CRC 102D and NCR 303

Manufacturer

The National Cash Register Company, Dayton 9, Ohio.

CRC 102D

General Characteristics

- The CRC 102D is a moderately priced, magnetic drum electronic data-processing system. Raw data are transcribed to punched paper tape by one or more Flexowriters, or by various "Point of Origin" data originating devices equipped with tape punches. Input consists of punched paper tape and punched cards. Magnetic tape, prepared internally from such media, is the principal file storage and data-processing medium.
- Output consists of punched paper tape, punched cards, and copy from a console typewriter. Final copy is also obtained from multiple tape-operated typewriters or from standard punchedcard tabulators.
- Tape searching for a particular block of data on magnetic tape may be performed independently of other operations.

Selling Price

Computer unit, control console, and one Flexowriter	\$99,500
Magnetic tape units, each	19,500
High-speed paper tape reader, each	9,500
High-speed paper tape punch, each	5,000
Additional Flexowriters, each	2,900
Equipment may be obtained on a lease basis with option	n to pur-
chase.	•

Operating Characteristics

Circuitry - serial.

Code – binary coded decimal.

Word length – 9 decimal digits plus sign.

Block length -17 words.

Alphabetic facilities – 6 alphabetic and special characters can be stored in one word; mixed alphanumeric data handled by inputoutput editing. Program code – three address, automatic (non-programmed) sequencing.

Transfer conditions – greater than and equal to comparisons, overflow, algebraic condition, and interrogation of console switches and tape searching indicators.

Magnetic Tape

Description – oxide coated plastic, 1 inch in width; reel length, 1,200 feet or 2,400 feet.

Recording density -134 digits an inch.

Capacity – approximately 115,000 words for 1,200 feet of tape. Maximum number of tape units – 7.

- Read-write speed 60 words a second (600 decimal digits or 360 alphabetic characters a second).
- Block search average random access time to any one of 115,000 words in 57 seconds. Effective time is materially less, since tape searching of as many as 7 reels may be conducted independently while computer unit is performing other operations. Search speed is 90 inches or 7,200 characters a second.

Punched Paper Tape

Codes – 6-channel Flexowriter code, and 7-channel NCR code (the latter for use with "Point of Origin" recorders).

Reading speed:

Typewriter tape reader -10 characters a second.

High-speed reader -200 characters a second.

Punching speed:

Typewriter tape punch -10 characters a second.

High-speed tape punch -60 characters a second.

Punched Cards

- IBM punched cards are read or punched on a modified IBM Type 523 or equivalent gang summary punch.
- 40 columns may be read or punched at a rate of 100 cards a minute; 80 columns may be read at a rate of 50 cards a minute.

Magnetic Drum

Capacity:

Main storage – 1,024 words. Fast access buffer storage – 8 words. Access time (average):

Main storage -12.5 milliseconds.

Fast access buffer storage -1.5 milliseconds.

Description – 12 inches in diameter, 6 inches in length; 2,400 rpm.

Storage Registers

4 operating registers are employed for accumulating, storing, etc. Each register contains 42 bits.

Speed of Basic Arithmetic Operations (execution of complete three address command, making reasonable use of buffer register -9 digit operands):

Addition or subtraction – 9.8 milliseconds (maximum).

Multiplication or division -17.2 to 45.2 milliseconds.

Physical Characteristics

Dimensions:

Processing unit - 73 inches high, 59 inches wide, 30 inches deep.

Control console – 30 inches high, 46 inches wide, 33 inches deep.

Magnetic tape unit – 48 inches high, 18 inches wide, 30 inches deep.

Weight:

Processing unit -1,700 lbs.

Control console – 200 lbs.

Magnetic tape unit – 400 lbs.

Power – 230 volts \pm 5%, single phase, 60 cycle; 7.7 kva; 59 amp.

Cooling - external cooling system not required.

General Information

Training of customer personnel (included in selling price):

Programming – 4 weeks.

Advanced laboratory course – 6 weeks.

Maintenance contracts, for periods of 6 months or more, are available at \$695 a month, exclusive of parts.

Delivery schedule – approximately 16 months after acceptance of order.

General Characteristics

- The NCR 303 is similar to the CRC 102D, except for the following basic differences:
 - The NCR 303 is designed principally to process punched paper tape created by various "Point of Origin" recorders developed by the company.
 - Punched card input-output has been eliminated. Punched cards can be handled only by conversion to punched tape.
 - The NCR 303 features more efficient sorting and collating techniques, facilities for rearrangement of data from punched tape as it is read into the system, and automatic editing during printing.

Selling Price

Computer unit, control console, and	on	ne	Fl	ex	ow	rit	er	\$140,000
Magnetic tape units, each						•	•	25,000
High-speed paper tape reader, each								9,500
High-speed paper tape punch, each								5,000
Additional Flexowriters, each								2,900
The selling price of the NCR 303 incl	ud	es	in	sta	lla	tic	n	and main-
tenance for one year.								

Equipment may be obtained on a lease basis with option to purchase.

The following specific changes have been made in the NCR 303:

Operating speeds have been increased by providing:

- (1) sort and merge commands,
- (2) programmed access to operating registers,
- (3) automatic editing (zero suppression, decimal point insertion, and tab insertion),
- (4) magnetic tape read-write speed of 900 decimal digits a second, and

(5) automatic sum-checking command.

The number of magnetic tape units has been increased to 8 and with modifications may be extended to 64.

Magnetic tapes may be searched automatically by blocks having certain common characteristics.

Data in storage registers are addressable through programming.

April 27, 1955.

BIZMAC

Manufacturer

Radio Corporation of America, Engineering Products Division, Camden 2, New Jersey.

General Characteristics

- The Bizmac is a high-speed, general-purpose electronic dataprocessing system. Magnetic tape is the basic file storage and processing medium. The system includes equipment to convert data to magnetic tape from the following sources: documents, coded manually or by the system; punched cards; Bizmaccoded paper tape, prepared manually by keyboard; and standard teletype perforated paper tape.
- Output consists of magnetic tape, which is converted to printed copy by a high-speed line printer or by an electronic page printer. Facilities are provided to convert magnetic tape to Bizmac-coded paper tape and from such paper tape to standard teletype paper tape.
- Manual handling of tape reels may be minimized through use of a switching unit for interconnection of selected tape stations with various other components of the system.
- High-speed memory consists of magnetic cores, supplemented by a small magnetic drum. The drum is used primarily for intermediate storage of instructions and constant data.
- A separate sorting unit, with built-in programs, permits sorting, merging, and extracting operations to be performed independently of other processing.
- An interrogation unit accepts inquiries entered by keyboard and prints out messages recorded on tapes selected by the unit.

Selling Price

- The price of a Bizmac system is dependent upon the complement of equipment and complexity of interconnecting cabling. Prices for the various components have not been announced. However, a typical installation, selling for approximately \$1,-200,000, might comprise:
 - 1 Processing unit with 2,048 character high-speed memory, 16,368 character drum memory, 4 input trunks, and 8 output trunks.
 - 15 Tape stations and control units.

10 Tapewriters and tapewriter-verifiers.

- 1 Paper tape transcriber.
- 1 Interrogation unit.
- 1 Electro-mechanical printer.

Operating Characteristics

- Circuitry bits of each character are handled in parallel circuits. Characters are handled serially, except that two instruction characters are transferred in parallel between high-speed memory and auxiliary (drum) memory.
- Operating code 7 bits (6 binary bits and 1 check bit). Instructions are stored in octal notation, enabling better use of storage facilities in the handling of instructions.
- Item, block, or message length variable.
- Facility for handling alphabetic data complete flexibility. Characters available include 16 special symbols and 11 control codes.
- Program code three address, automatic (non-programmed) sequencing.
- Conditions governing transfer of control comparison for equality, previous result positive, or previous result negative.

Magnetic Tape

- Description oxide coated plastic tape, 5% inch in width; reels are 2,400 feet in length.
- Recording density -125 characters each inch.
- Average storage capacity for each reel -2 to 3 million characters, depending upon average message length.
- Number of tape stations in the system from a few to a few hundred.
- Read-write speed -5 milliseconds to start or stop the tape plus .1 millisecond for each character. Maximum of 80 inches or 10,000 characters a second.

Rewind speed -80 inches a second.

Reel Handling and Switching

- Transfer of data on magnetic tape from one unit of equipment to another is effected by one of the following means:
 - (1) Manual mounting and dismounting of reels each tape station is permanently connected to a given unit of equipment.

- (2) Partial switching a switching unit, operated from the master console, allows flexible interconnection of the more active tape stations with the various units of equipment; less active stations, such as those with reference tapes, require manual handling of reels.
- (3) Complete switching the switching unit allows flexible interconnections between all tape stations and the dataprocessing units.

Interconnection increases system speed but requires additional investment in switching devices and cables.

Input Equipment

Document transcriber

Function – transcribes data coded on documents to magnetic tape. Documents are coded manually or by the Bizmac. Speed – 100 documents a minute.

Card transcriber

Function – converts data in punched cards to magnetic tape.

Medium – 80-column cards (converters for other type cards are under development).

Speed -400 cards a minute.

Data rearrangement – plug board provides for 10 split columns and data generation of dates or other characters.

Tapewriter

Function – converts, by manually operated keyboard, raw data into 7-channel perforated paper tape. Data are simultaneously typed on page copy.

Speed – 10 characters a second (maximum).

Verification – tapewriter-verifier, manually operated.

Paper tape transcriber

Function – transcribes 7-channel paper tape, produced by tapewriter or paper tape decoder, to magnetic tape. Speed – 200 characters a second.

speed – 200 characters a see

Paper tape decoder

Function – converts 5-channel (standard wire transmission) paper tape to 7-channel paper tape.

Speed -20 characters a second.

High-Speed Memory

Medium – magnetic cores. Capacity – 2,048 or 4,096 characters. Access time – .020 milliseconds.

Circuitry -2 characters normally handled in parallel.

Magnetic Drum Memory

- Capacity 16,368 or 32,736 characters (capable of storing 2,046 or 4,092 three-address instructions).
- Access time (average) -5.2 milliseconds.
- Read-write speed .02 milliseconds a character (50,000 characters a second) in each of two parallel circuits.
- Physical characteristics length 11 inches, diameter 4 inches, 5,860 rpm.

Sorter

- Separate unit which permits certain sorting, merging, and extracting operations to be performed independently of other processing.
- Programs, such as a sorting routine utilizing 4 work tapes, are permanently wired in.

Interrogation Unit

- Inquiries are put into the system by the interrogation printer keyboard. Data are then selected from the magnetic tape file and printed out.
- Interrogation is performed independently of processing operations.

Output Equipment

Electro-mechanical printer

Function – prints single or multiple sheets of paper from data on magnetic tape. Control symbols on the tape govern printing form and arrangement.

Speeds:

Printing – 600 lines a minute.

Skipping – 1,800 lines a minute.

Electronic printer

Function – high-speed printing from data on magnetic tape. Consists of three units: Ultratype camera, which reads magnetic tape and exposes film with data from the tape and with format and fixed data flashed from a slide; Film processor, which develops the exposed film; and Electrofax printer, which transcribes the image on film to electrophotosensitive paper. Speeds:

Ultratype camera – 2,000 characters a second (approximately 20 pages a second, depending upon number of characters and length of film for each document).

Film processor – about 30 minutes for each 100 feet of film.

Electrofax printer – 6 inches of paper a second, regardless of width.

Magnetic Tape Transcriber

Function – converts data on magnetic tape to 7-channel paper tape.

Speed -20 characters a second.

Paper Tape Coder

Function – converts 7-channel paper tape to 5-channel standard wire transmission paper tape.

Speed -20 characters a second.

Speed of Basic Arithmetic Operations (5 digit operands)

Addition or subtraction – .540 milliseconds. Multiplication – 5.210 milliseconds. Division – 22.000 milliseconds.

Physical Characteristics

Approximate floor space for a typical installation – 3,000 square feet.

Recommended floor strength -125 pounds for each square foot. Power - approximately 100 kva.

Cooling – approximately 35 tons of room air conditioning.

General Information

Courses provided for training of customer's programmers.

Installation and maintenance can be arranged by contract with RCA Service Co.

Orders currently are accepted for delivery in latter half of 1956.

May 5, 1955.

UNIVAC (Including UNIVAC II)

UNIVAC

Manufacturer

Remington Rand, Inc., 315 Fourth Avenue, New York 10, New York.

General Characteristics

- The Univac is a high-speed, general-purpose, electronic dataprocessing system. Raw data are transcribed to magnetic tape by key stroke with a Unityper. Data in punched cards are transcribed to magnetic tape with a card-to-tape converter. Magnetic tape is the principal input medium and is also used for permanent storage of data. Input can also be effected from the keyboard of the control console during the processing of a program. Internal storage units consist of mercury column acoustic delay lines.
- Output is recorded on magnetic tape. Data on output tapes are transcribed to punched cards by a tape-to-card converter, or to printed copy by a Uniprinter or by a high-speed printer.
- Alphabetic, numeric, and symbolic characters are accommodated in any combination in reading, writing, and processing operations.
- Buffer storage registers permit the central computer to continue processing while other data are being read from, or recorded on, magnetic tape.
- The system features several automatic self-checking techniques, including duplicate circuits for all computing operations.

Monthly Rental – Selling Price

The Univac system may be acquired by outright purchase, monthly rental, or five-year deferred payment plan. Rentals listed below are for one shift on the basis of a 40 hour, 5 day week. Monthly rentals include maintenance service and parts and installation (exclusive of site preparation costs) at the customer's premises. Selling prices are F.O.B. factory and subject to change without notice.

Unit	Monthly rental	Selling price
Central computer with power supply and		-
supervisory control	\$16,870	\$750,000
Uniservo (magnetic tape unit)	320	18,000
Uniprinter	390	22,000
Unityper I with one loop control device	390	22,000
Unityper II	90	4,500
High-speed printer	2,300	130,000
Card-to-tape converter	2,300	130,000
Tape-to-card converter	2,300	130,000

Operating Characteristics

Circuitry – chiefly serial.

- Internal operating code -7 bits (4 numeric pulses in excessthree, binary coded decimal notation, 2 zone pulses, and 1 check pulse).
- Word length 12 characters, including sign.

Block length -60 words.

- Facilities for handling alphabetic data complete flexibility; alphabetic and symbolic characters may be intermingled with numbers within the same word.
- Program code single address, automatic (non-programmed) sequencing.

Conditions governing transfer of control – quantitative comparisons (equal to or greater than).

Magnetic Tape

Description – phospor-bronze coated metallic tape, ½ inch in width; tape lengths may be 100, 200, 500, or 1,500 feet.

Recording density:

Unityper I - 20 characters an inch; a block (60 words) requires 36 inches. Space between blocks, 2.4 inches.

- Unityper II 50 characters an inch; 120 characters (a line or blockette) require 2.4 inches. Space between blockettes require 2 inches. Six blockettes equal one block. Space between blocks require 2.4 inches.
- Card-to-tape converter 120 characters an inch with a 2 inch record gap.

Univac:

For reprocessing in Univac or for permanent storage – 128 characters an inch.

For use with Uniprinter -20 characters an inch.

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Capacity of one 1,500 foot reel at 120 characters an inch – 1,440,000 characters.

Maximum number of tape units (Uniservos) -10.

Read-write speed -100 inches a second.

Rewind speed -100 inches a second.

Buffer storage – registers, each with a capacity of 60 words, allow simultaneous reading, computing, and writing operations.

Keyboard Tape Recording

- Unityper I records data on magnetic tape at a density of 20 characters an inch; printed copy produced only when used with a printing unit.
- Unityper II records data on magnetic tape at a density of 50 characters an inch; printed copy produced simultaneously.

Verifier

Function – threefold – verifies, types, and prints. When it is used as a verifier, recorded magnetic tapes can be checked for correctness. When it is used as a typing mechanism, mistakes in the original recording on magnetic tape can be corrected. As a printer, copy can be produced simultaneously with the other two functions.

Card-to-Tape Converter

Function - converts data on 80-column punched cards to magnetic tape.

Speed – instantaneous conversion of 240 cards a minute.

Recording density – 120 characters an inch.

Field rearrangement – provided for by detachable plugboard.

90-Column Card-to-Tape Converter

Function – converts data on 90-column punched cards to magnetic tape.

Otherwise, the operating characteristics are similar to those of the 80-column card-to-tape converter.

Tape-to-Card Converter

Function – converts data on magnetic tape to 80-column punched cards.

Speed -120 cards a minute.

Field rearrangement – provided for by detachable plugboard.

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Tape-to-90-Column Card Converter

Function – converts data on magnetic tape to 90-column punched cards.

Otherwise, the operating characteristics are similar to the tape-tocard (80-column) converter.

Uniprinter

Function – converts data on magnetic tape to typewritten copy in any desired format.

Speed -10 or 11 characters a second.

High-Speed Printer

Function – converts data on magnetic tape to printed copy in any desired format.

- Speed 600 lines a minute adjustable to 200 or 400 if desired; 130 characters a line.
- Field and line rearrangement detachable plugboard provides for selection of lines and columns to be printed and for suppression of zeros to the left of valid characters.

Card Punching Printer

Function – will print on both sides of a card and will punch a card. The card may contain a stub which later can be processed through a Univac system.

Internal Storage

Medium – acoustic delay lines (mercury columns). Capacity – 1,000 words (12,000 characters). Access time – .040 to .400 milliseconds.

Speed of Basic Arithmetic Operations

Addition or subtraction - .525 milliseconds (1905 a second). Multiplication - 2.150 milliseconds (465 a second). Division - 3.890 milliseconds (257 a second). Comparison - .365 milliseconds (2740 a second). (These speeds may be increased by minimal latency coding).

Physical Characteristics

Recommended floor space for a typical installation – 3,000 to 3,500 square feet.

Heaviest floor load – power supply unit, 295 lbs. a square foot.

Power – central computer requires 90 kva at 208/120 volts; 3 phase or 2 phase current.

Air conditioning – central computer and power supply require 35 tons of air conditioning (closed circuit chilled air system).

UNIVAC II

Announcement has been made of Univac II, a newer system which is reported to be approximately twice as fast as the original Univac system. Two major improvements are involved in the Univac II:

The 1,000 word mercury delay lines have been replaced with a 2,000 word magnetic core storage.

Input-output tape read and write speed has been increased to a rate of 20,000 characters a second.

Other changes in the Univac II are:

Replacement of 60 word input-output buffers with equivalent magnetic core buffers.

Reduction of start-stop time of magnetic tape to 15 milliseconds.

The ability to expand magnetic core storage from 2,000 words to 10,000 words.

The increase in recording density of magnetic tape to 200 characters an inch – thus increasing the storage capacity of one reel of tape to approximately 3,000,000 characters.

- A field select instruction applies the F register extract function directly to transfers into and out of the internal memory.
- A variable multi-word transfer replaces the 10 word with a 1 to 10 word transfer.

The complete self-checking feature has been retained in Univac II. All present programs for Univac can be run on Univac II and all present Univacs can be modified into Univac II's at the option of the user.

Prices for Univac II have not been announced.

General Information

Courses provided by manufacturer for training of customer's operators, programmers, and maintenance personnel.

Delivery schedule:

Univac I - 6 months to 1 year from date of order. Univac II - Deliveries will be made in late 1956.

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The Company has under way a program for the development of conversion equipment for use in transmission of data from decentralized locations to centralized data-processing facilities. This equipment includes punched paper tape to magnetic tape converters and magnetic tape to punched paper tape converters.

May 11, 1955.

UNIVAC FILE-COMPUTER

Manufacturer

Remington Rand, Inc., 315 Fourth Avenue, New York 10, New York.

General Characteristics

- The Univac File-Computer is a moderately priced, magnetic drum electronic data-processing system. Data may be entered directly into the system by the use of electric typewriters, key actuated tabulating card punches, and key actuated adding machines. Data may also be entered from magnetic tape, perforated paper tape, or punched cards. Internal storage consists of magnetic drums with a wide range of capacities.
- Output devices include key actuated tabulating card punches, electric typewriters, punched-card units, perforated paper tape units, and magnetic tape units. Most output devices are used also as input devices.
- The various components may be grouped into systems of various capacities as required.
- Direction of the system is accomplished by panel wiring (external programming) coupled with stored instructions (internal programming). Up to 24 input-output devices may be operated simultaneously by the use of a Multiplex Monitoring unit.
- All computing in the system is checked by automatic reverse checking. Random access to information on the magnetic drums is possible in an average time of 17.25 milliseconds.

Monthly Rental – Selling Price

The Univac File-Computer may be acquired by outright purchase, monthly rental, or five-year deferred payment plan. Rentals listed below are for one shift on the basis of 40 hour, 5 day week. Monthly rentals include maintenance service and parts and installation at the customer's premises. Selling prices are F.O.B. factory. All prices or rentals are subject to change without notice.

	Monthly	Selling
Unit	rental	price
Basic unit	\$1,900	\$105,000
Multiplexing unit	450	27,000
Large capacity drums:		
First drum	650	39,000
Each additional drum	350	20,805
High-speed drum:		
2,280 character capacity	1,250	75,000
11,880 character capacity	1,550	93,000
High-speed card sensing and	-	
punching unit	950	56,590
Alphanumeric keypunch	290	17,370
Perforated paper tape reader:		-
20 characters a second	190	11,460
200 characters a second	*	*
10 keyboard input with printer	140	8,225
10 key inquiry keyboard with printer	185	11,250
High-speed tape perforator - 60		
characters a second	*	*
Magnetic tape read-write units:		
Compatible with Univac system	*	*
Not compatible	*	*

* Prices not available at April 26, 1955.

Operating Characteristics

Circuitry – serial.

Internal operating code – 6 position code plus one check bit.

Word length -11 characters plus sign.

Unit record length – from 12 to 120 characters or any intervening number, except 25, equally divisible into 600.

- Facilities for handling alphabetic data complete flexibility; alphabetic and symbolic characters may be intermingled with numbers in the same word.
- Program code (internal) three address, automatic (non-programmed) sequencing.

Program panel control (external) - 48 basic steps.

Conditions governing transfer – plus, minus, zero, and unconditional transfer.

Magnetic Tapes

One type will be compatible with regular Univac magnetic tape. The use of this type will require a converter. A second type will not be compatible. Specifications have not been finalized but the tape probably will have a density of 100 characters to the inch and will move at a rate of 60 inches a second for reading, writing, and searching. The record gap will be $\frac{1}{2}$ to $\frac{3}{4}$ inch. Buffer storage probably will be magnetic cores with a capacity of 120 characters.

Perforated Tape

Description – 5, 6, or 7-channel code. Speeds of perforated tape readers: 20 characters a second. 200 characters a second. Speeds of perforated tape punches: 20 characters a second. 60 characters a second.

Card Sensing and Punch Units (Input-Output)

One type senses and punches the same 90-column card at a rate of 150 cards a minute.

A second type will sense and punch the same card, either 80 or 90-column, at a rate of 300 cards a minute. Since this type unit has two independent feed mechanisms, it is possible to read (sense) one card and punch a different card; with this arrangement the speed can be increased up to 600 cards a minute.

10-Key Keyboard with Input Printer

Description – enters up to 10 numbers, each with 11 digits plus sign. Similar to a conventional 10-key keyboard adding machine.

Key Actuated Tabulating Card Punch (Input-Output)

Description – regular 90-column key punch converted for use on the Univac File-Computer. Will punch information on the same card from which information was read.

Input speed – limited by operator.

Output speed – approximately 7 cards a second.

10-Key Inquiry Keyboard with Input-Output Printer

Description – same as the 10-key keyboard except that the Univac File-Computer can cause this device to print numbers only.

Electric Typewriter (Input-Output)

Description – specifications not yet available. To be used as inquiry device when records involved contain alphabetic or other information.

Multiplex Monitoring Unit

Description – by use of the Multiplex Monitoring unit, the Univac File-Computer can operate up to any 24 units of the various input-output devices simultaneously. This device, which may be considered part of the control unit, synchronizes the various input-output devices with the internal operations of the system. The unit is unnecessary if only one input-output device is to be operated.

Basic Storage

Description – magnetic drum. Consists of space (120 characters for each input-output device) to accept data from input or to deliver data to output. Also included, as intermediate storage, is space for 20 eleven character words plus sign.

Access time -2.5 milliseconds average.

High-Speed General Storage (Optional)

Description – magnetic drum. Used for storage of data and instructions.

Capacity – either 190 or 990 eleven character words plus sign. Access time -2.5 milliseconds average.

Large Capacity General Storage (Optional)

Description – magnetic drum. Any number of units, from 1 to 10, may be included in the system. Instructions stored in this device must be moved to other storage for operating purposes.

Capacity – 180,000 alphanumeric characters on each magnetic drum.

Access time -17.25 milliseconds average.

Speed of Basic Arithmetic Operations (including proof)

Addition or subtraction -1.638 milliseconds. Multiplication -1.638 milliseconds for each digit in multiplier. Division -3.276 milliseconds for each digit. Comparison -.546 milliseconds.

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Physical Characteristics

Floor space - varies with number of units comprising system.

Power – 208-230 volts, 3 phase, approximately 10 kva depending, of course, on units comprising the system.

Cooling – no separate cooling or refrigeration required. Each unit has own air cooling device.

Weight -- within range associated with punched-card equipment.

General Information

Courses are being planned for training of customer's personnel. Delivery date – deliveries are expected to start in first quarter of 1956.

April 26, 1955.

ELECOM 125

Manufacturer

Underwood Corporation, Electronic Computer Division, 35-10 36th Avenue, Long Island City 6, New York.

General Characteristics

- The Elecom 125 is a moderately priced, magnetic drum electronic data-processing system. Raw data are converted to inked-dot code on paper tape, to perforated patterns on paper tape, or to punched cards. Thus, printed tape, punched tape, and punched cards are the input media. Magnetic tape, prepared internally from such media, is the principal file storage and data-processing medium.
- Output consists of printed tape, punched tape, and punched cards. Final copy is obtained from standard punched-card tabulators or from line printers which operate at a maximum rate of 300 lines a minute.
- The Sort-Interfile-Select unit, a separate piece of equipment, provides for independent sequencing, collating, merging, and extracting of data stored on magnetic tape. Basic speed is 6,000 characters a second (excluding start-stop time).

Selling Price (approximate and subject to change)

Elecom 125 electronic computer						\$100,000
Elecom 125 electronic sorter						50,000
Auxiliary equipment:						
Magnetic tape units, each						10,000
Punched card input-output						16,500
Flexowriters, each				\$	3,00	00 to 5,000
Tapewriters, each						1,000
High-speed line printer			9	\$35	,000) to 50,000
Additional drum capacity						Variable

Operating Characteristics

Circuitry – serial.

Code — excess-three, binary coded decimal. Word length — 10 decimal digits plus sign. Block length:

Computer – variable, up to 50 words. Sorter – variable, up to 20 words.

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- Alphabetic facilities alphabetic and special characters require two decimal positions; mixed alphanumeric data handled by input editing.
- Program code two address, automatic (non-programmed) sequencing.

Transfer conditions – zero, positive, negative, and tally.

Magnetic Tape

Description – oxide coated plastic, ½ inch in width; reels are 1,200 feet or 2,400 feet in length.

Recording density – 100 digits an inch.

Read-write speed – 2,000 characters a second (excluding startstop time).

Capacity – approximately 1,000,000 digits for 1,200 feet of tape. Maximum number of tape units – any reasonable number may be connected to the computer.

Printed (Inked-Dot) Paper Tape

Description – paper, $\frac{1}{2}$ inch in width; inked-dot code plus small (readable) character.

Recording density -20 digits an inch.

Read (input) speed - 500 to 600 digits a second.

Punched Tape

Code – teletype code can be converted (at extra cost) for both input and output.

Read (input) speed – up to 400 characters a second. Punch (output) speed – 60 characters a second.

Punched Card

Read (input) speed - 240 cards a minute (80-column).
Punch (output) speed - 100 cards a minute (80-column).
Standard tabulators print a maximum of 150 lines a minute.
Optional system - low-speed input-output, using IBM Type 024 key punch.

Magnetic Drum

Capacity:

Main storage -1,000 to 10,000 words. Fast access storage -10 to 100 words.

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Access time (average):

Main storage - 8.3 milliseconds.

Fast access storage – 1.7 milliseconds.

Description $-9\frac{1}{2}$ inches in diameter, 6 inches in length; 3,600 rpm.

Internal Storage for Sorting Unit

Medium – acoustic delay lines (quartz). Searching index – 200 digit (400, 600, or more – optional). Record length – variable. Information transfer time – .888 milliseconds.

Storage Registers

Accumulator – 10 digits plus sign. Multiplicand-divisor register – 10 digits plus sign. Multiplier-quotient register – 10 digits plus sign. Control register – 10 digits plus sign. Control counter – 4 digits (one address). Buffer storage – 10 words on magnetic drum.

Speed of Basic Arithmetic Operations

Addition or subtraction -3.5 milliseconds. Multiplication or division -20.0 milliseconds.

Physical Characteristics

Dimensions:

- Computer unit 72 inches high, 79 inches long, 21 inches deep.
- Power supply and drum 62 inches high, 60 inches long, 21 inches deep.
- Sorting unit -62 inches high, 60 inches long, 21 inches deep.
- Magnetic tape units 51 inches high, 22 inches wide, 16 inches deep.

Control console – mounted in standard office desk.

Power $- \frac{120}{208}$ volt, 3 phase, 60 cycle; 7 kva.

Cooling – 100 degree maximum room temperature; air conditioning of room is recommended.

General Information

Training of customer personnel (included in purchase price): Programming and maintenance - 1 month each. Operation - 2 weeks.

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Executive course of one week is available.

Equipment may be obtained on a rental basis. Delivery schedule – approximately six to nine months after acceptance of order.

April 18, 1955.

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