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Internal control in electronic accounting systems

Haskins & Sells

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FOREWORD

The independent auditor's reliance upon the system of internal accounting control is based upon his study and evaluation of the control system. His review of the controls in electronic data processing systems will be facilitated through an understanding of various control methods which are unique in such systems. These control methods are described generally in this book.

HASKINS & SELLS

January, 1965

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OUTLINE OF THE CONTROL PROBLEM

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In the field of electronic data processing, the subject of primary interest to the independent auditor is internal accounting control. Despite the high inherent reliability of the machines and the application of advanced techniques in developing computer programs, it should not be assumed that good internal control automatically carries over into an EDP system from a previously used system. While there is no reason why control should not be at least as effective in the EDP system as in any other, the changes that accompany an EDP installation may present control problems that do not exist in less sophisticated systems.

Beyond the inherent reliability designed into the equipment, computer manufacturers have provided mechanical and electrical safeguards against malfunction and EDP programmers and systems analysts have introduced self-checking measures and other control practices to avoid error. Unquestionably, all such features have contributed importantly to operating efficiency in EDP.

But operating efficiency is only one of the objectives in the full scope of internal control. Internal control comprehends "all of the coordinate methods and measures adopted within a business to safeguard its assets, check the accuracy and reliability of its accounting data, promote operational efficiency, and encourage adherence to prescribed managerial policies."*

Internal control is basically the control of *actions* in the planning, initiation, execution, and recording of transactions. Control is *prescribed* by the establishment of policies and methods to regulate the actions; it is *evidenced* principally in the documentation of actions taken.

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* Auditing Standards and Procedures – Statements on Auditing Procedure No. 33, issued by Committee on Auditing Procedure, American Institute of Certified Public Accountants (1963); p. 27.

THE CHARACTERISTICS OF INTERNAL CONTROL

The characteristics, or components, of a satisfactory system of internal accounting control are summarized as follows:

> "A plan of organization which provides appropriate segregation of functional responsibilities,
>
> Personnel of a quality commensurate with responsibilities,
>
> A system of authorization and record procedures adequate to provide reasonable accounting control over assets, liabilities, revenues, and expenses, and
>
> Sound practices to be followed in performance of duties and functions of each of the organizational departments." *

These characteristics can be retained under electronic data processing, although their form, as compared with that found in other systems, is often changed considerably.

The responsibility for the adequacy of the system of internal accounting control of a company of course rests with its management. The independent auditor is concerned principally with the reliability of the financial records and the effectiveness of procedures and controls for the safeguarding of assets.

Organization and Personnel

From the viewpoint of internal accounting control, there are three primary functions associated with actions: operating, custody, and accounting. The separation of these functions among individuals and departments serves as a check upon unauthorized, erroneous, or wrongly reported actions.

Among other organizational features, EDP personnel should be separated from duties relating to the initiation or approval of data and custody of assets, and programmers and other designers of the processing procedures should not have access to the machines and the accounting records.

The qualifications of personnel are particularly important from the control viewpoint in two areas. One is the program development activity, in which the specialized skills of programmers and analysts should be supplemented by knowledge as to accounting functions and controls. The other is the post-auditing function where, conversely, accounting

* Ibid; pp. 28-29.

qualifications should be supplemented by adequate knowledge of the machines and the applications to provide comprehensive evaluation of the control system.

The System of Authorization and Record Procedures

In the context of internal control, the system of authorization and record procedures comprises (a) the form and content of media for the recording of actions and related data and (b) the procedures applicable to the processing of data. Documentation is built up principally in this component of the control system. The documentation consists of data supporting the actions taken, together with the record of what was done and by whom in consummating and accounting for transactions.

In the manual system, documentation typically includes media such as the following:

In the initiation of transactions: sales orders, purchase requisitions, hiring forms, payroll tickets, appropriation requests, and production orders and schedules.

In the execution of transactions: shipping tickets, receiving reports, invoices, checks, credit memoranda, production reports, tax returns, contracts, and minutes.

In the recording, classifying, and summarizing of transactions: journals, ledgers, and work sheets.

In the reporting of transactions: advices of action and financial statements and schedules.

In the manual system, documentation in plain language is found in the various media and in manuals or other descriptions of procedures. In the EDP system both the media and the procedures are different in certain respects from those found in the manual system. This occurs notably in connection with the operations by the computer. Certain media are converted into record formats stored within the computer and the data content of the formats undergoes change as each successive transaction is processed. The procedures for processing data are represented in a program of instructions which is also stored in the memory unit of the computer.

Documentation in plain language is retained in the EDP system only to the extent deemed essential. For example, in preparing the machine's program there may be a natural tendency among programmers and system analysts to work directly toward the machine's needs, omitting preparation of explanatory material in plain language. Similarly, in processing raw data into final reports, there may be a tendency to convert the data into machine language at the earliest point in the processing and to avoid printing "for the record" only. The point here is that computers need not print anything to do the processing.

However, documentation of data and procedures in the EDP system is represented in plain language at various stages. Data and certain procedures are in this form in source documents, transaction listings, master file change registers, computer-detected error listings, and output documents and reports. Also, the program of machine instructions is represented, wholly or in part, in plain or coded language, in block diagrams, instruction listings, and record layouts. While the program is readable, interpretation of its plain-language meaning requires some knowledge of the machines and the techniques of programming. From the viewpoint of review and evaluation of internal control, this program and its documentation is the principal unique feature of the EDP system.

Control Practices and Methods

Control practices and methods consist of specific checks made in approving the propriety of transactions, corroborating the correctness of various details, and proving the accuracy of processing. In any system, control is often obtained through duplication, or to use a computer-oriented term, "redundancy." In a manual system this is manifest in such control measures as the checking of prices and the keeping of control accounts. One is a redundant operation, the other is redundant data. Both are separate, positive measures that are imposed on the system as such; that is, the system could operate satisfactorily without them if mistakes were never made. In EDP systems, control also entails redundancy, both in the control of machine operation and in the control of human actions.

The high inherent reliability of the machines and their ability to detect their own errors are laudable features of electronic data processing. But in themselves the machines do not provide assurance of the accuracy and reliability of accounting data. The machines operate on programs and data prepared by people. And people may make mistakes – in programming, in coding source documents, in setting up the machines, and in running down exceptions thrown out by the machines. Moreover, the machines can compound these human errors. In short, the need for accuracy checks is not lessened in the EDP system. The essential steps in processing are the same as in other systems; only the means of processing are different.

The methods and practices used to control an electronic data processing system may be classified as follows:

System controls, comprising all of the clerical and electronic procedures that are imposed upon a system to regulate the processing.

Security controls, comprising the work practices that help protect data and equipment from accidental or intentional destruction.

Built-in controls, comprising a variety of machine checks that automatically detect errors caused by equipment malfunctioning.

System controls fall into three main categories: input controls, which cover the operations before computer processing; processing controls, relating to the programmed operations of the computer; and output controls, covering the final review and acceptance of results. Some of the system controls check the clerical operations and others monitor the internal operations of the computer. The latter are an integral part of the internally stored instructions that direct the operations of the computer and are known as "programmed controls."

System controls are needed, at each stage in the processing flow, to check the accuracy of accounting data. If source information is coded incorrectly, it will be processed incorrectly. Therefore, system controls should be provided to verify the information as originated. An EDP application often involves preliminary processing by "peripheral" machines. This entails conversion from one data medium to another, as from cards to magnetic tape or from paper tape to cards. Obviously, there can be a failure to process data, through loss of a punched card, improper operation of a machine, or otherwise. System controls therefore should be provided to substantiate the records at critical points in the preliminary processing. Similarly, when the records are turned over for processing by the computer, appropriate control over the information to be processed should be established. System controls also are needed to assure accuracy in various stages of processing by the computer.

Security controls provide protection against physical hazards, such as fire, humidity extremes, and excessive dust. They also provide measures to prevent accidental erasure of magnetic tape records, one of the hazards peculiar to electronic processing. Further, security controls limit the opportunities for fraud by such measures as restricting access to the computer console and to the stored programs and data media.

Built-in controls are a part of the "hardware." They are designed by the machine manufacturers to give the various units of equipment a self-checking ability. This has been done remarkably well; the machines can detect various errors, such as a bad recording on tape or the loss of a "bit" of information within the machine. However, some manufacturers feature built-in controls more than others, and, possibly because of the improved inherent reliability of components, certain controls which were formerly provided are not featured in current computer systems.

THE REVIEW OF INTERNAL CONTROL

Confronted with the seeming complexities of the EDP system, what should the auditor do to arrive at an informed opinion as to the system of internal accounting control? Is this a job solely, or predominantly, for specialists? What should be the scope of the review? These are the essential questions the auditor must resolve.

As to specialized knowledge, unquestionably some measure of it is a prerequisite. The auditor should understand the operation of the machines in the respects significant to him.

The question as to scope cannot similarly be answered categorically. The problem here tends to divide into segments which involve varying considerations.

Documentation: The Point of Reference

Procedurally, in reviewing the actual operation of the system of internal control, the auditor traditionally has followed the documentation. Completeness in documentation of course does not necessarily imply satisfactory control. However, in reviewing what is done and evaluating the effectiveness of control, the auditor's principal point of reference traditionally has been the documentation.

It must necessarily also be his principal point of reference in the review of control in the EDP system. Documentation in the EDP system should be no less complete than in the manual system. True, it may not be in understandable plain language at all stages but nevertheless it should be functionally complete.

In EDP terminology, documentation is classified into two parts. "Procedural documentation" embodies the instructions to the computer and directly associated steps in the processing. This documentation relates to processing procedures, as distinguished from the documentation of data. It is not "procedural" in the all-inclusive sense but rather as related to the computer operations and associated steps only.

Documentation in all other areas of the EDP system is referred to as the "audit trail"; again, not the trail in the all-inclusive sense but rather as related to plain language input and output only.

Scope and Evaluation

The principal problem faced by the auditor in considering the scope of his review of the EDP system is whether and to what extent he need review the procedural documentation and related functioning of the system. Solution of this problem is a matter for the auditor's judgment in each individual case. In all other respects, the scope of review generally may be determined, and the review conducted, in the traditional manner.

The effectiveness of the control system should be evaluated on the basis of control practices as a whole. The absence of a specific control measure does not create a weakness if other practices provide adequate protection in the circumstances.

The objectives of internal control should be construed from the viewpoint of their practical significance. The over-all objective is not control merely for control's sake; control is useful and is needed in the interest of orderly and efficient conduct of the business and to prevent unauthorized actions that would be detrimental to the business. However, control also involves the matter of economics; the cost of controlling some actions may be much greater than any conceivable damage that might occur in the absence of control. The need for control should be viewed in the light of such practical considerations.

CHAPTER TWO

THE FLOW OF DATA

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In a manual system, accounting information originates in a transaction and then flows in a stream of paper work into an account or report. The processing operations, which are largely clerical, are readily determinable through observation or reference to procedure manuals. Similarly, the nature of the transaction and its accounting is readily determinable, for summarization requires entry of the transactions in a journal and posting requires use of ledgers.

In an EDP system, accounting information also originates in a transaction and flows into an account or report. But here the resemblance ends. The information in these systems is encoded into machine language and caused to flow on cards and magnetic tape and in the electronic circuits and storage devices of the computer. The processing operations, which are performed electronically, are invisible and therefore not determinable through observation. To analyze the system through reference to computer programs requires translation from the coded language of the computer to plain language. Similarly, it is sometimes difficult to trace transactions because the printing of journals is no longer a necessary part of the summarization process and magnetic tape ledgers are "posted" by first erasing the previous balance.

Thus, the lack of visible or readily understandable documentation of (1) the processing procedure and (2) the information that is processed presents a special problem in the review of internal control and in auditing transactions. However, the documentation does exist, although in a form different from that found in other systems.

THE DATA CYCLE

There are four stages in the complete flow of data from origination to final recording and use. These are: data acquisition, data transmission, data processing, and data utilization. The relative roles of each vary from application to application, but all stages are present in every case.

Data Acquisition

Data acquisition involves the transcription of data into a language that is readable by machines. Three elements are involved at this point: source documents, conversion equipment, and processing media. When the source documents are readable only by human beings, the conversion equipment consists of a manually operated key punch, a tape punch, or an electronic typewriter; and the resulting processing media consist, respectively, of punched cards, paper tape, or magnetic tape. However, the source documents may be in a format which permits some of the data to be read by machine. Bank checks with magnetic ink recording are a familiar example. Others include gasoline charge tickets prepared from embossed credit cards and prepunched service bills issued by public utility companies. With these, the conversion equipment consists of character recognition devices or traditional punched card reproducing machines; and the resulting processing media consists, again, of punched cards, paper tape, or magnetic tape.

Thus, the conversion may be performed manually as in card punching, or automatically by special conversion devices. It may also be performed as a by-product of some other operation, such as occurs when a tape perforating device is coupled to a bookkeeping machine. Typewriters, adding machines, and other business machines may be equipped to produce either paper tape or punched cards containing selected portions of the data printed on the "hard copy" product of the machine.

Data Transmission

Data transmission effects the transfer of data from one location to another. Transfer may be made by physical movement of documents or media, using messengers, company-owned vehicles, mail service, or other means. Or it may be done by converting the data to electrical or electronic signals and transmitting the information in this form over telephone, radio, or microwave networks.

In-plant "systems" are available which automatically relay source data from a number of locations (timekeeping stations, storerooms, etc.) to a central receiving point. These are generally referred to as data gathering or data collection systems. Information is entered into the input stations of these systems from embossed plates, punched cards, employee badges, time clocks, or other sources depending upon the design of the equipment. Variable information is entered by setting dials or levers. In some of the systems, the data are punched into paper tape at the work stations, for later collection and processing at a central facility. In other systems, the input stations are connected by cable to the central facility, and the output, again depending upon the design of the equipment, may be punched into paper tape or tabulating cards.

Probably the most important development to date, and the one that is stimulating widespread interest in this field, is the adaptation of existing telephone circuits to accommodate data transmission. It is now possible to transmit business data from one telephone to another telephone at high speed and with the required degree of accuracy. The new speeds of 150 and 300 characters per second by telephone compare with the Teletype speed of 10 characters per second. The telephone circuits accommodate sufficient channels of coded information to provide checks upon the accuracy of transmission.

Using more highly specialized equipment, speeds ranging from 15,000 characters per second to 62,500 characters per second are attainable. Two methods are used. One employs microwave transmission, and the other utilizes grouped voice telephone channels. The communications equipment for speeds in this realm are custom-made and quite expensive; therefore, such systems are not commercially feasible for smaller companies.

Improvements have also been made in the low-speed, low-cost systems. These transmit at 10 to 12 characters a second in the five-channel code over telegraph and Teletype networks. Output consists of punched paper tape or Teletype printers. Where the speeds are adequate, the low cost of these systems will assure their continued popularity for some time to come.

The basic components of a data transmission system are: (1) a reader and transmitter, (2) a data subset, and (3) a receiver and recorder.

Reader and Transmitter

Readers accept data contained in, and expressed in, the code languages of punched cards, paper tape, or magnetic tape, and convert the data to the code form of the communications network. The reader and transmitter may be separate components, or they may be combined into a single "black box." Also, in some makes the reader and transmitter are also combined with the receiver and recorder.

Data Subset

The function of the data subset is to amplify the electrical energy of the message code and provide a carrier wave for transmission over the communications network. The subsets and related communication lines are provided by the telephone companies, usually on a monthly rental basis. The subsets provide for the transmission of voice as well as data. The usual procedure is for the operator at the transmitting station to pick up the handset, dial the receiving station, and establish voice contact with the party at the receiving end. Then, after both parties have switched to the data mode, the reading of data is initiated. Data subsets are available in several series, depending upon the speed required and whether or not two-way receiving and transmission facilities are required.

Receiver and Recorder

These units receive data from the transmitting unit in the code form of the communications network and convert the data to the code form of the media (cards, paper tape, or magnetic tape) to be used in subsequent processing.

The various transmitting and receiving units can be arranged in any desired combination. Thus it is possible to read cards at the transmitting station and to punch tapes at the receiving end, to read paper tapes and punch paper tapes, or to read paper tapes and write magnetic tapes, or any combination of the above. Also, it is possible to interconnect magnetic tape computers and to transmit from magnetic tape to magnetic tape or from the core storage of one computer to that of another.

Data Processing

When performed by electronic computers, the data processing stage in the flow of data generally consists of four procedural functions: input editing, arranging, processing, and output editing. A fifth function, file maintenance, also is involved, but this is an auxiliary operation so far as the flow of a transaction is concerned.

Each function may be performed as a separate machine run. Often, however, two or more are covered in a single run. The degree of consolidation is governed by the nature and capacity of the data processing equipment and the complexity of the job.

Input Editing

The object of input editing is to test the quantity and quality of incoming data. It is usually performed early in the processing in order to reject records which are unacceptable for further processing.

Arranging

Arranging, for the most part, is performed by sorting the records into a prescribed sequence. Arranging also includes merging and other procedures used in segregating data according to specified classifications.

Sorting routines are surprisingly complex and difficult to program. For this reason, "sort generator" programs usually are furnished by the computer manufacturers. These produce sort programs from defined file specifications. The generators are designed to accommodate widely varying files and therefore require considerable storage space in the memory unit of a computer. In the interest of efficiency, it is sometimes necessary to supplement the generators with handwritten instructions.

Processing

This is the key function in computer operations; here the objectives of the application are fulfilled. Several computer runs may be involved, each under the direct control of the stored program of instructions.

Output Editing

The results of data processing must be arranged and spaced to conform with the format of output documents and reports. This is the purpose of output editing. The edited data may be printed on-line in readable form. Or the data may be transferred to another medium such as magnetic tape or punched cards for off-line conversion to readable form.

File Maintenance

File maintenance involves the updating of master files. A master file is a group of records containing information that is relatively permanent or unchanging. The information does change occasionally, however, and when the file is large the number of changes in a given period may be voluminous. For example, in a payroll master file, the tax class of a given employee may change infrequently but the total number of changes in tax class for all employees during a payroll period may be rather high.

Often the records are updated in a separate computer run before the run in which they are passed against the transaction records. In other cases the runs are combined by merging the master file changes with the transactions and processing the changes for each master record immediately before processing the transaction.

A master file may or may not contain information fields that involve arithmetical operations, such as inventory quantities, accounts receivable balances, and similar "balance-forward" records. Because information of this type is subject to change each period, processing efficiency may require that it be recorded on a separate tape. Where this is the case, the updating of the quantity or amount fields is referred to as "file processing" to distinguish the operation from "file maintenance," which is reserved to describe the updating of nonperiodic changes in the master records.

Data Utilization

This is the fourth and final stage in the flow of data. It refers to the use of the final results. It includes the actions that are prompted by output documents and the decisions that result from consideration of the information reported by the system.

BASIC EDP METHODS

There are two principal EDP methods, known generally as sequential processing and random-access processing.

Sequential Processing

Typically, sequential processing is used when the master file is stored externally, on magnetic tape or punched cards. Under this method, the transactions to be processed are first grouped into batches and arranged into the sequence of the master file. Processing is initiated by reading (into the computer) the first master file record and the first transaction. The two records are compared and if the file record does not match the transaction record, the next file record is read in and examined. The searching process is continued until a match is obtained. After the records are matched, the master file is updated or information is extracted from the master file for use in further processing. Finally, the updated master file is written out on another reel of magnetic tape.

Nearly all magnetic-tape systems use this basic method. It is a traditional approach, for both the batching of transactions and the sequencing of records are outgrowths of long-established punched card procedures.

Random-Access Processing

Random-access processing is used where the master file is stored internally, as on magnetic disks or drums which serve as auxiliary units to the computer's main memory. Under this method, transactions are processed in random sequence, that is, in whatever sequence they occur. The related master records are located directly, eliminating the need for examining a number of sequentially filed records in order to find the one that is wanted. This method of processing requires an internal storage medium with sufficient capacity to contain all of the master records. In addition, the file must be equipped with means of locating any one record about as quickly as any other.

The ability to process transactions in random sequence means that they can be processed one at a time if desired, eliminating the delay inherent in batching and the machine time required in sorting. Thus, it is possible to process a transaction immediately after it occurs. By utilizing "point-of-origin" devices, information concerning transactions can be transmitted (usually by wire) to a central computer for immediate processing. The results can then be transmitted to the originating station in a matter of seconds. This type of processing is sometimes called "in-line processing." When the two-way flow of information is associated with a physical event or process taking place simultaneously, the operation is called "real-time" processing. Examples of the latter are found in the window operations of certain savings banks and the reservation systems of the major airlines.

Opportunities for applying in-line and real-time concepts to accounting and related information systems have not yet been fully developed and future extensions may be expected. Undoubtedly, the future development of large, inexpensive random-access memories having fast access speeds will have a pronounced influence on the design of accounting applications. However, sequential processing will probably continue to present the most economical method for many accounting and accounting-related information systems, because the time advantage of random-access processing is often unimportant. The unimportance is partly due to the increasingly faster speed of magnetic-tape processing which tends to offset some of the loss in searching time. It is also due to the tendency of accounting data to form natural batches (i.e., daily production records, weekly time cards, monthly sales summaries, etc.). In these situations, the waiting time that expires as transactions accumulate is unavoidable because only cumulative totals normally are required and these cannot be determined until the last item is known. Therefore, little would be gained from processing the items individually as they occur during the batching cycle.

Combination Methods

A third processing method utilizes random-access processing for the principal application and sequential processing for other applications. Random-access equipment is used. This combination method is used where the random method best meets the over-riding requirement for instant (in-line) or timely processing of the principal application, where there remains available computer time for other applications, and where sequential processing is best suited to such other applications. While the sorting step in sequential processing is unnecessary with random-access equipment, in some applications the addition of this step produces the most economical total processing cost. This occurs where the resultant reduction in cost of computer time is greater than the cost of sorting.

There are several variations of the combination method. The large memory capacities of random-access computers enable virtually simultaneous access to more than one complete set of master files in the processing of a single application. Thus, both files can be referred to or updated in a single pass of a transaction through the computer. Preceding the processing run, the transactions could be batched and arranged in the sequence of one of the master files. In the processing run, access to this master file would be made sequentially and, the other master file would be located by the random-access method.

In-line and real-time processing are not synonymous with on-line processing. On-line processing, in the terminology of EDP, refers to the operation of card readers, tape units, printers, or other input-output components under the programmed control of the computer. It contrasts with off-line processing, where certain input-output operations are performed independently. Off-line equipment is commonly used for converting cards and other input media to magnetic tape, processing cards punched by the computer, and printing reports from magnetic tape prepared by the computer. When data are transferred to and from magnetic tape with off-line equipment, the computer operation is commonly designated as being "tape oriented."

THE INTEGRATION OF DATA

In the more advanced EDP applications, accounting information is combined with other information and processed in a single flow that meets the combined needs of all concerned. For example, a magnetic tape record may include both inventory dollar amounts and quantities, the latter primarily producing information as to reordering and other inventory control functions. Similarly, accounts payable records may be created automatically in connection with the processing of the master files of the purchasing department. Again, a master bill of materials record may contain in one tape file all of the information needed by the engineering, marketing, and production departments, as well as the requirements of the cost accounting department.

In systems such as these it is difficult to designate a given computer run as "accounting" or "nonaccounting" and the flow of accounting information from source documents to final recording or reporting may involve several nonaccounting runs.

The ultimate integration of the information needs of all of the functional areas of a business is referred to as the "total systems concept." While the ultimate has not been reached to date, several companies are advancing rapidly toward this end.

CHAPTER THREE

PROCEDURAL DOCUMENTATION

Page

CHAPTER THREE

PROCEDURAL DOCUMENTATION

As stated earlier, the term "procedural documentation," in EDP terminology, relates only to those procedures involved in computer operations and steps directly associated with such operations.

A program of instructions for a computer cannot readily be interpreted by people. When it is stored on magnetic tape it cannot be seen, for the information is represented magnetically. When it is stored on punched cards or paper tape the holes can be seen, but visual interpretation of the individual characters is a slow and laborious process. Furthermore, when the program is interpreted by a machine and printed on paper it is still meaningless to persons who are not intimately familiar with the programming language of the computer. Nevertheless, for the reasons explained later there is a need in every installation for representation of the computer's program in a manner that is reasonably understandable.

Documentation fills this need. Documentation of EDP systems consists primarily of block diagrams and flow charts depicting the machine operations, but also includes set-up sheets and procedure manuals for the people who operate and control the system. In summary, documentation represents all of the readable evidence of: (a) the flow of data through a series of machine and human operations, and (b) the attendant operations which set up processing facilities and control processing results.

In actual practice, documentation in most cases is rather sketchy – formalized to a far lesser extent than it ought to be.

DOCUMENTATION PURPOSES

Despite the shortcomings sometimes found in practice, there is a growing recognition that the preparation of procedural documentation in understandable form is worth while not only in meeting the needs outside the data processing group but also in facilitating the work of the group itself.

An important purpose of documentation is to permit program revisions to be made with the least amount of effort and time. The maintenance programmer who must revise or "patch" the program frequently will not be the person who did the initial programming; it may even be that the person who did the initial work may no longer be employed by the company.

Good documentation facilitates the planning and control of system design and programming activities. For example, work assignments to programmers may be allotted directly from block diagrams and performance in the assigned areas may be compared with budgeted time allowances. Similarly, consistency in documentation techniques facilitates communication within the department, aiding such functions as the review by a systems analyst of the work of a programmer. Also, documentation improves the effectiveness of employee training programs.

Documentation includes instructions to the machine operators for the individual computer runs. Consistency in the format and content of this phase of documentation enables the operating personnel to perform their tasks accurately and efficiently without excessive supervision or assistance.

The advantages of adequate documentation are significant. Nevertheless, as mentioned earlier, in practice good documentation is the exception rather than the rule. Some programmers feel that flow charts and block diagrams are not essential or, in preparing such documents, use symbols and techniques of their own choosing. There is a tendency for individual programmers to be concerned solely with their immediate assignments. Adequate documentation is usually attributable to strong leadership within the department.

DOCUMENTATION METHODS

Because of the lack of uniformity in practice, it is unlikely that the auditor will find all of the types of documentation illustrated in the accompanying examples to be in general use. However, the examples will illustrate the procedures and methods involved.

Flow Charts

A flow chart is a graphical representation of the flow of information. The top-level chart provides a complete picture of the application from the receipt of source documents to the distribution of final reports. It links the four stages of the data cycle – data acquisition, data transmission, data processing, and data utilization, although these are rarely labeled as such. Flow charts also link the functions within the respective stages, showing, for example, the sequence in which the editing, arranging, and processing runs are performed in the data processing stage. Examples of such charts are shown in Figures 1 and 2. General flow charts of this type are an excellent starting point in acquiring an understanding of the application.

The various computer runs depicted in flow charts usually are supported with "run descriptions" which provide clear and concise explanations of the basic functions performed. Figure 3 illustrates a typical run description. In a fully documented application, each run is further supported with a "control memorandum" which explains the control methods and the reconciliation procedures to be followed in the event of a failure to conform with the controls.

The general or top-level charts are usually supported with detailed flow charts, sometimes called operational flow charts, which provide specific information concerning the respective clerical and machine operations. Job instructions, volume estimates, and time estimates for the various steps are also generally shown on the charts or on related documents.

Figure 4 (pages 38 and 39) illustrates an operational flow chart with related job instructions. In practice, the two documents are usually filed side by side in a loose-leaf binder.

Block Diagrams

Block diagrams also portray the flow of data. They are distinguished from flow charts in that they picture only the flow within a computer. They show the sequence in which logical and arithmetical operations occur in sufficient detail to serve the important purpose of facilitating program modification.

A general block diagram for a payroll run is shown in Figure 5 (page 40). Note its simplicity and clarity. There are no technical words or symbols. Each block represents a subroutine and the flow is apparent from the directional arrows and the alphabetical sequence of the blocks.

A detailed block diagram is shown in Figure 6 (page 41). This is an expansion of the FICA block in the general block diagram. The individual blocks are numbered, and their contents are sufficiently precise to convey

Figure 1. Flow Chart: Source Documents to Final Reports

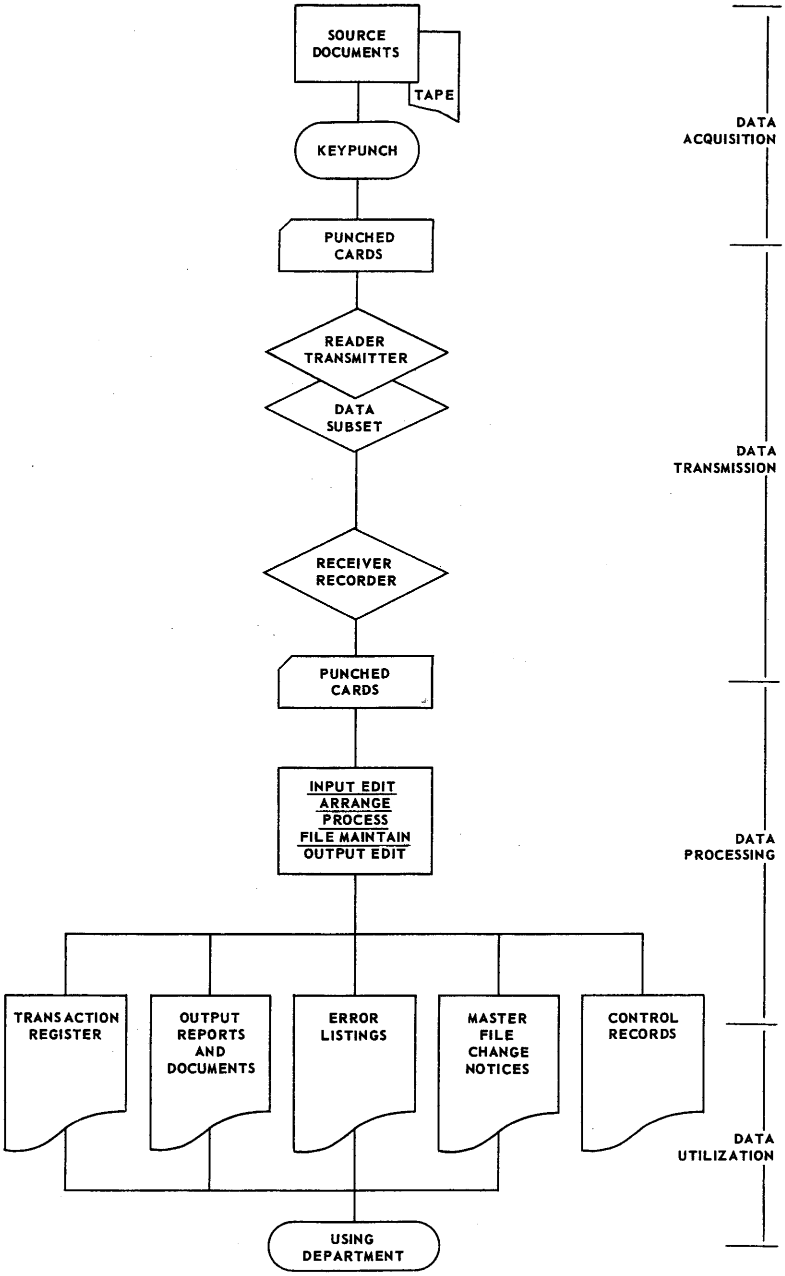


Figure 2. Flow Chart: The Data Processing Stage

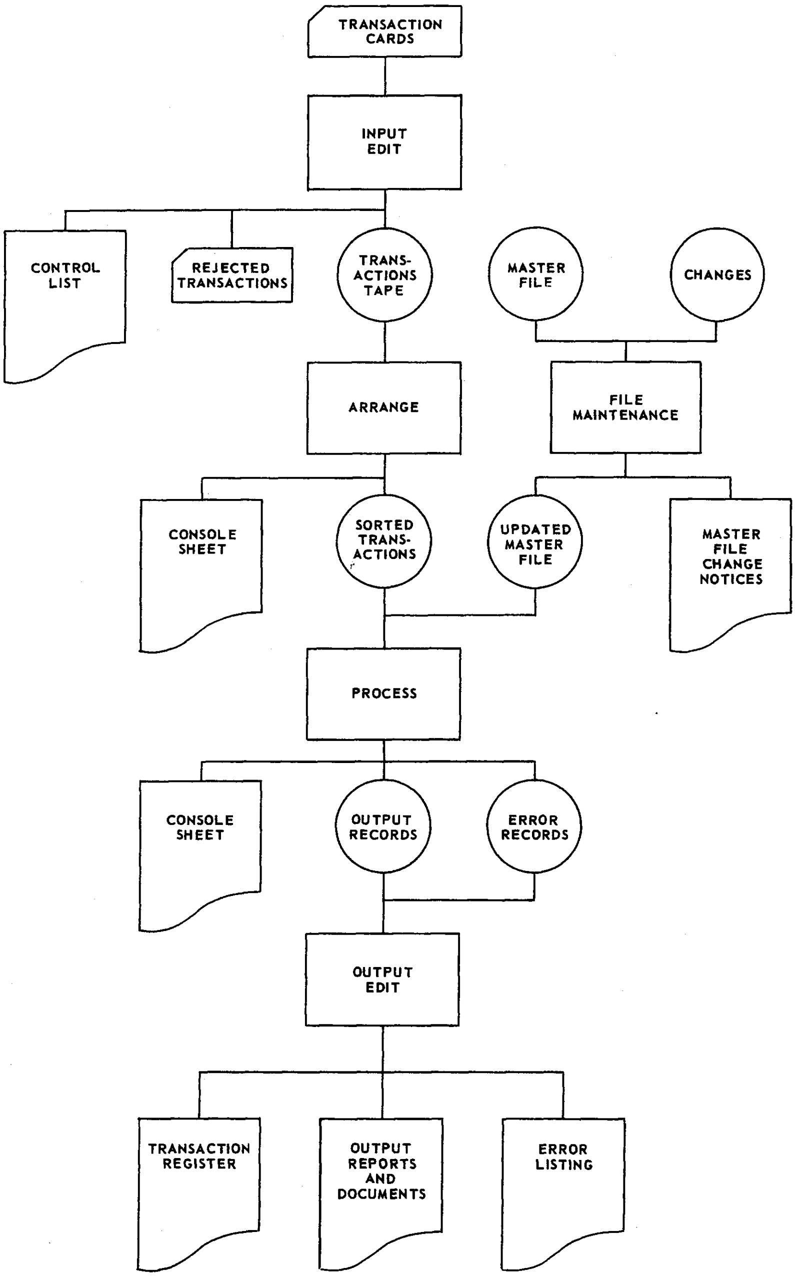
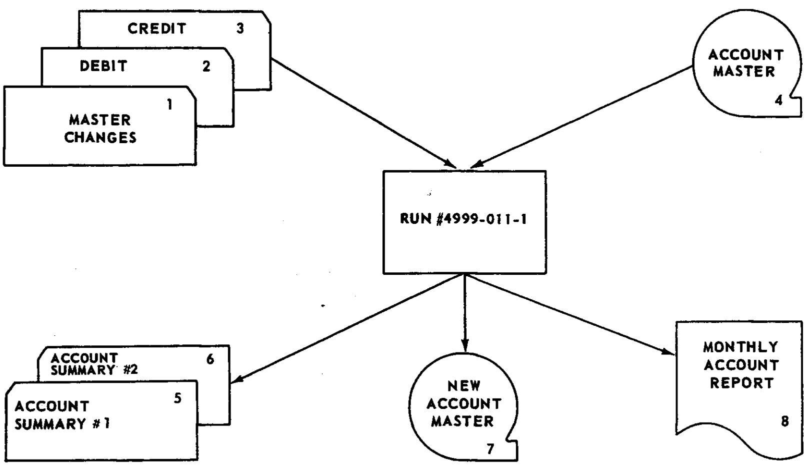


Figure 3. Run Description

PROCEDURES MANUAL			
EFFECTIVE	REVISED	SECTION	PAGE
April 15, 1965		III	22-9

TITLE: RUN DESCRIPTION

SCOPE: Update Account Master (4) with changes (1), debits (2), and credits (3) and create new Account Master (7). Account Summary cards (5 & 6) are punched for each Master active during the month. The Monthly Account Report (8) is a detail listing of activity for each account on the Account Master (7).



SEQUENCE: All files to be processed in customer number sequence.

all of the information required to write the program of instructions. The program itself is referenced to the detailed block diagram by assigning symbolic labels to the instructions. Each label contains the alphabetic reference to the related subroutine in the general block diagram and the numerical reference to the individual block in the detailed block diagram. An indexing method such as this permits rapid analysis of any segment of the run, facilitating outside review as well as program modification.

It will be observed that there are no "machine-oriented" terms in the detailed block diagram.

Record Layouts

Flow charts and block diagrams describe how data are processed, but they tell very little about the nature of the data or the information content of master records. This is the function of the record layout. In any installation, the fields of information to be processed must be designated for each type of record (transactions, master file changes, master file records, output reports and documents, etc.) and the exact number of characters in each field must be allotted in advance. Therefore, a separate record layout is usually prepared for each type of record. Since every record must pass through the computer, the design of the records must conform with operating characteristics of the machine. Technical considerations such as the size of the computer word and the capacity of input-output storage areas or buffers must be taken into account in preparing the layouts.

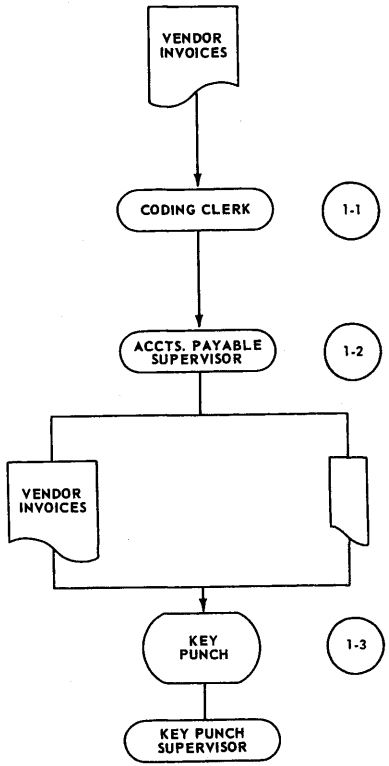
Generally, two layouts are prepared for each type of record. One depicts the layout in internal storage and the other shows the design of external media, such as punched cards, magnetic tape, and printed output. Either form will provide a complete picture of the kinds of information in each type of record.

An example of a record layout for magnetic tape is shown in Figure 7.

Forms Design

Documentation includes the formats of all reports and other forms designed as part of the computer application. In converting to EDP, input forms are generally redesigned in order to provide for coding or to simplify translation to machine language. Output reports usually change because of new capabilities of the system to provide information.

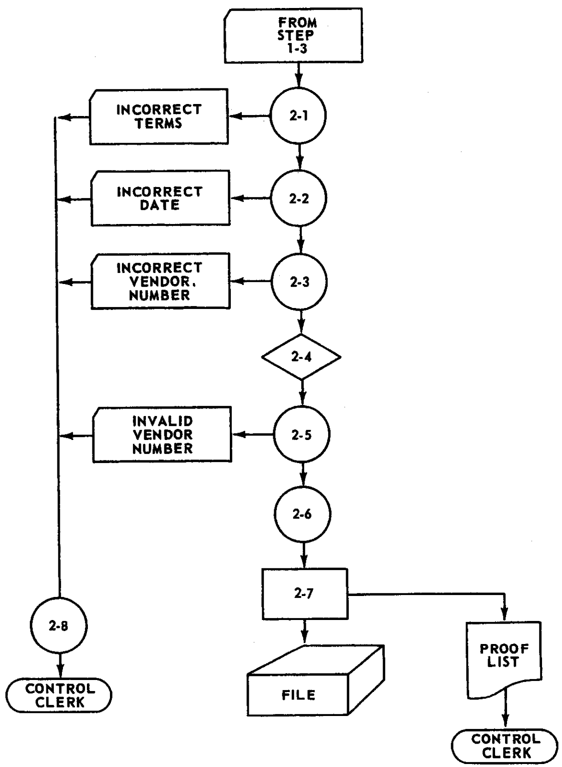
Figure 4. Operational Flow Chart



JOB NAME	JOB NO.	FREQUENCY	DUE IN TIME	DUE IN DATE	DUE OUT TIME	DUE OUT DATE
ACCOUNTS PAYABLE	1234-01	☒ Daily ☐ Weekly ☐ Bi-Weekly ☐ Semi-Monthly ☐ Monthly ☐ Quarterly ☐ Annual ☐ Other	-	-	4 PM	-

OPER. NO.	MACH. TYPE	ESTIMATED VOLUME	ESTIMATED TIME	DESCRIPTION
1-1	-	1000	10.00	Accumulate batch of approximately 100 vendor invoices. Process each batch as follows: A. Look up vendor code and write in the upper right hand corner. B. Look up quantity code on code list and write above quantity. C. Circle part number, amount due and purchase order number.
1-2	-	10	.50	Tape list the amount due. Enter the total amount and number of items on next line in the batch control book. Write line number on the tape list. Attach the tape list to documents and send to key punch.
1-3	024	1000	3.00	Key punch each batch separately and give to supervisor for delivery to the tab room.

Figure 4. Operational Flow Chart (concluded)



JOB NAME: ACCOUNTS PAYABLE				JOB NO. / FREQUENCY: ☐ Daily ☐ Weekly ☐ Bi-Weekly ☐ Semi-Monthly ☐ Monthly ☐ Quarterly ☐ Annual ☐ Other / DUE IN: TIME, DATE / DUE OUT: TIME, DATE
OPER. NO.	MACH. TYPE	ESTIMATED VOLUME	ESTIMATED TIME	DESCRIPTION
2-1	082	1000	0.10	Sort on terms field (Col. 12 - 13) If blank column of alpha punch hold for step 2-8.
2-2	082	1000	0.10	Sort on date received (Cols. 8 - 9) If no punch or alpha, hold for step 2-8
2-3	082	1000	0.30	Sort on vendor code (Cols. 14 - 19) If no punch or alpha, hold for step 2-8.
2-4	604	1000	0.50	Calculate vendor code check digit and compare with digit punched. If they do not agree, punch a control "X" in Col. 80.
2-5	082	1000	0.05	Sort on Col. 80. If X, hold for step 2-8
2-6	082	1000	0.10	Sort on batch code (Cols. 4 - 5)
2-7	1401	1000	0.05	Convert cards to tape and produce proof list on program No. 1234-207. Give listing to control clerk. Cards to file.
2-8	082	1000	0.30	Sort cards on vendor code (Cols. 14 - 19) and then batch code (Cols. 4 - 5). Give cards to control clerk.

Figure 5. General Block Diagram: Payroll Calculation

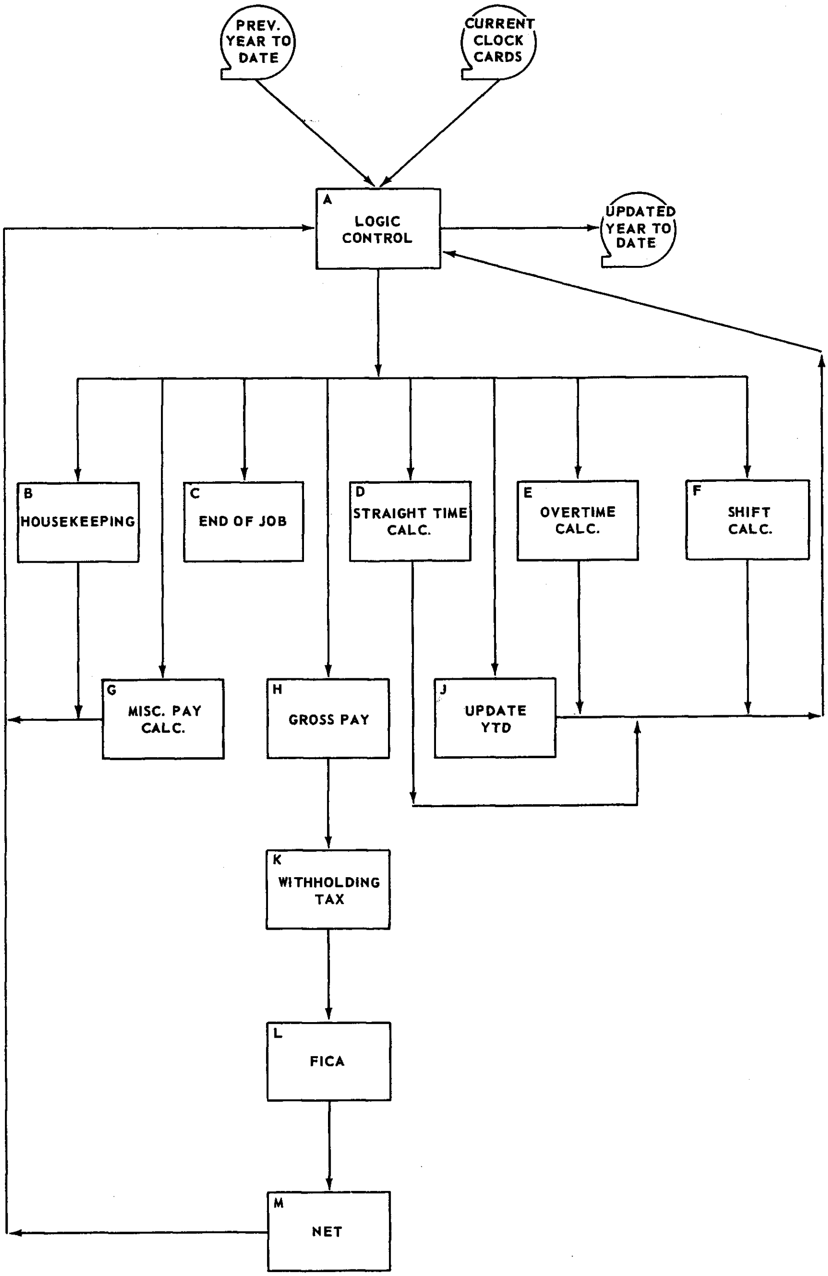


Figure 6. Detailed Block Diagram: FICA Calculation

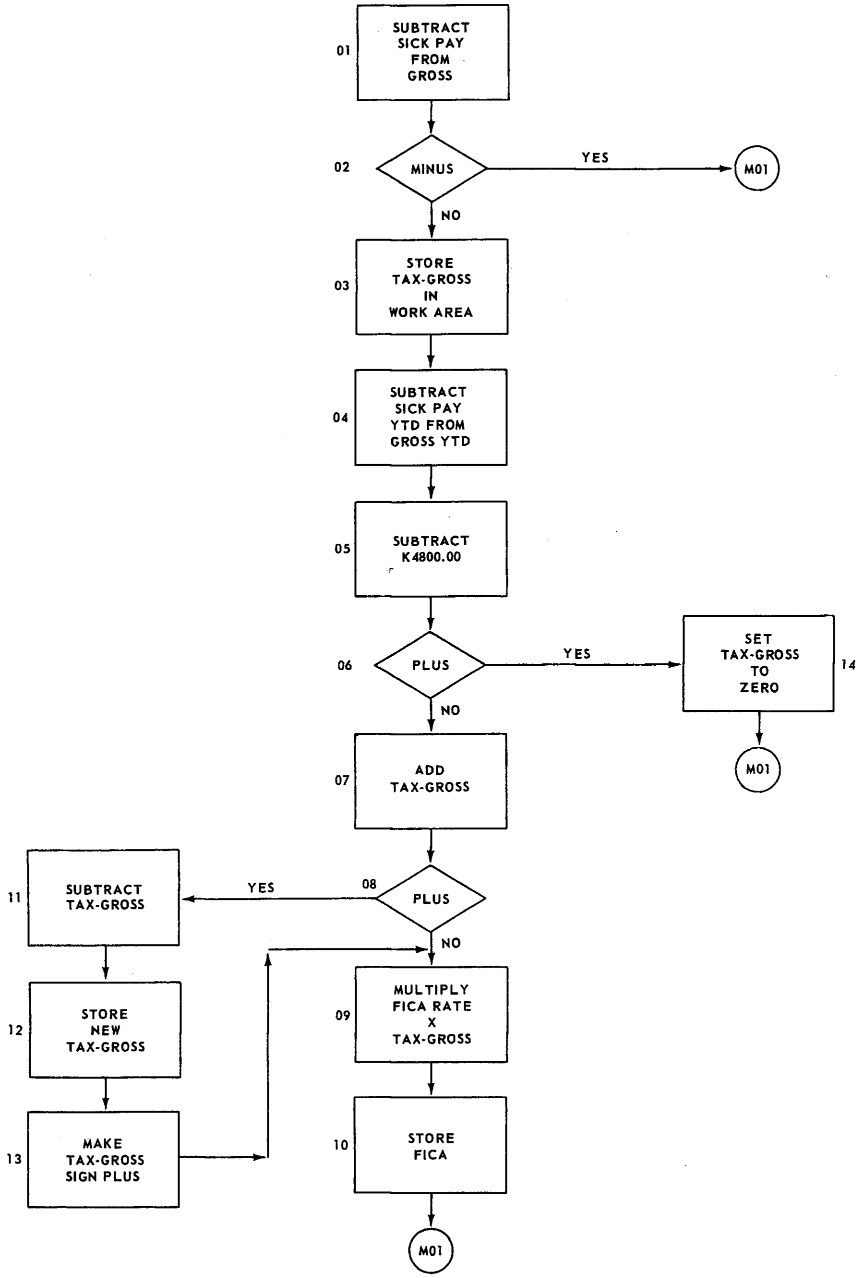
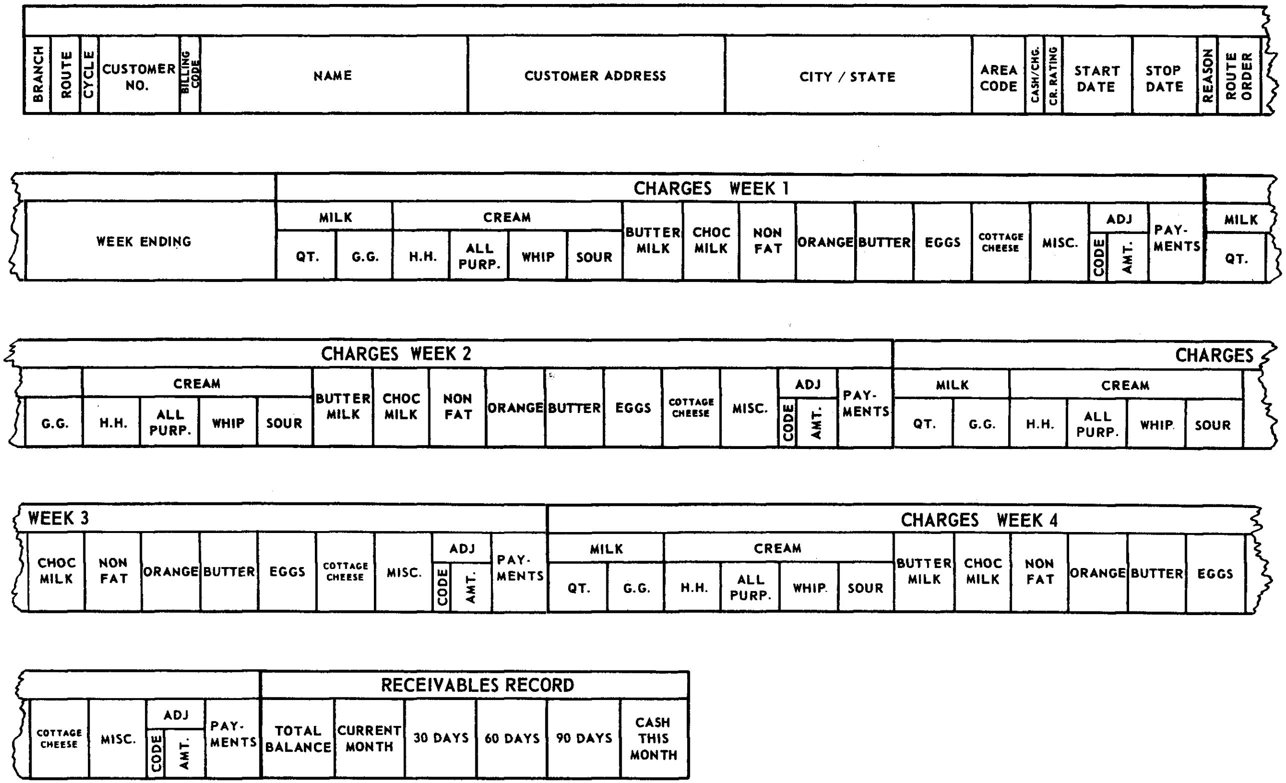


Figure 7. Magnetic Tape Record Layout



Other

A well documented application will also include the following:

Program Listings. There are two types of program listings: (1) those written or "coded" by the programmers, known as subject programs; and (2) those prepared by the computer from the subject program using assembly or compiler programs furnished by the manufacturer. These are known as object programs. As indicated earlier, in a well documented system the individual instructions in these listings are cross-referenced to the respective sections of the block diagrams.

Test Data. These consist of simulated records of every type (transactions, master file changes, master file records, etc.). They are prepared by the programmer for use in testing the programs by conducting trial runs on the computer. A well designed set of test data will cover the entire program, including all branches and exception routines.

Set-up Sheets. These are prepared for the console operator's use in conditioning the computer for operation. Normally, a separate sheet is prepared for each run.

Halt Lists. These identify the programmed halts and prescribe the action which should be taken in connection with each. In the case of large-scale computers, programmed halts are usually limited to those which aid program loading or indicate successful completion of the run, since it is generally uneconomical to stop the machine for other purposes.

Wiring Diagrams and Planning Charts. These are prepared to show the wiring of control panels of punched-card machines or other peripheral units. Wiring diagrams picture the wiring, while planning charts define the wiring in tabular format.

Key Punch Instructions. These contain instructions for setting up the card punch machine, punching the various fields of information, and handling exceptions in the source data.

Clerical Procedures. These describe procedures to be followed by input-output personnel, control clerks, and other clerical personnel within the department.

In a manual system, it is difficult to maintain a high degree of consistency in the performance of clerical work. Quality of work varies not only from person to person but also from time to time for the same person. The maintenance of procedure manuals that explain the operations that are to be followed in processing transactions and keeping related records aids in minimizing this problem.

In a computer system, the problem is a more limited one. Most of the procedures are mechanized and, as to these, consistency on the part of the computer is virtually guaranteed since the machine can perform only those steps that are indicated by the stored program. However, the problem as to people to some extent still remains. Clear instructions should be given to the computer operators to avoid misdirection of the processing. For example, the console operator should know in advance how to deal with machine errors, such as an inability to read a tape record; how to handle data errors, such as an out-of-balance batch; and how to restart the system after it is interrupted by a mechanical failure, such as a card jam or a paper break on an on-line printer. His instructions should be specified in writing so as to restrict the console operation to routine duties.

The stored program and the operator's "run book" are the counterparts of the procedure manual. Together they give the computer system procedural consistency that is superior to other systems.

The improvement in consistency often extends into the clerical procedures that surround the machine operation. This stems from the fact that a program for a computer cannot be developed without a complete and detailed study of the full system requirements. The study usually leads to a better understanding of the remaining clerical duties, resulting in a noticeable improvement in processing consistency.

CHAPTER FOUR

THE AUDIT TRAIL

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THE AUDIT TRAIL

In EDP terminology, the audit trail comprises all the documentation found in the inputs to and the outputs of the computer operations.

The change in the visible appearance of the audit trail is one of the more apparent effects of a conversion to electronic data processing. Source documents are nearly always redesigned and sometimes are eliminated entirely and the form and content of journals and ledgers may be considerably changed.

SOURCE DOCUMENTS

A source document is an instrumentality of internal control as well as a means of initiating transactions and accumulating data for accounting and managerial purposes. As a physical medium it displays visible evidence of the authenticity of a transaction and the approval of respective steps in the processing. As action paper, it regulates operating activities and assures the accumulation and processing of related data; it should be constructed in a manner that requires adherence to established procedures.

The manner in which internal control is effected through source documents often changes under EDP. To date, the change has not been significant because the customary documents, such as time cards, job tickets, vendor invoices, and material requisitions, are still in wide use. But the high cost and slow speed of preparing punched cards or other computer input media from the source documents is stimulating considerable current interest in devices and techniques that start the mechanization at an earlier point.

Data gathering devices are gaining acceptance as instruments for reducing the cost of key punching and other input preparation procedures. For example, in a factory operation a device may be installed in each production department. Direct labor is recorded through each device by inserting prepunched cards identifying the operator and the job or operation and by keying in the number of hours worked and the number of pieces produced. The devices immediately transmit source data from the point of origin to the computer center, producing computer media without manual transcription. The high reliability of data gathering devices assures greater accuracy in the data transmission and conversion operations. But operation of the devices requires careful control in order to prevent introduction of unauthorized transactions or inadvertent errors.

There is some concern over the possible use of data gathering devices to record source data without preparing legible "hard copy" documents. This, of course, would eliminate visible evidence of the authenticity of transactions. Under these circumstances, control might require concurrent observation as a substitute for post-audit verification procedures.

Greater use is also being made of mark-sense card reading, magnetic ink character recognition, and optical scanning. These utilize "turn around" documents that provide automatic re-entry of data into a computer system. A "turn around" document is one whose format includes basic information (such as a bank account number) in computer language. After other data (such as date and amount of a bank check) are added by the customer or other user, the form is "turned around" for processing in the system. As control instruments, such documents are superior in that they are difficult to falsify without access to equipment.

To sum up, increased mechanization of the data acquisition function changes the form of many source documents and places greater emphasis on the need for control at the point of origin. Except in special circumstances, source documents will not be eliminated for they are a necessary part of the audit trail and a source of internal control.

JOURNALS

Traditionally, the basic journals are as follows:

Type of Entry	*Journal*
Sales	Invoice register
Cash receipts	Cash receipts book
Accounts payable	Voucher register
Cash disbursements	Check register
Payrolls	Payroll register
Miscellaneous entries	General journal

The journals serve two important functions: They provide a means of accumulating totals of similar transactions for posting to individual accounts in the general ledger, and they provide a chronological reference in looking up the particulars of an individual transaction or entry.

Under EDP, these functions can be performed in a way that greatly alters the traditional image of the journal. Account totals can be accumulated internally, completely eliminating the need for the columnar array of transactions that is found in the typical journal. Similarly, the crossfooting check that is applied in manual systems to prove the mathematical correctness of the totals can be written into the computer program.

Preserving the reference function of the journal requires special procedures in electronic accounting. The printing of detailed transaction registers is not a natural part of an EDP application. In most systems, this impairs processing efficiency by requiring additional running time to prepare listings that are not needed in the main flow of the program. The print-outs are costly and therefore there is a tendency to eliminate the journal as such or to substitute informal proof listings prepared by peripheral machines.

However, transaction registers cannot be eliminated in all cases because the internal look-up needs sometimes require their continuance. In fact, most installations provide these registers whether they are really needed or not, simply because most users are reluctant to part with traditional abilities to reconstruct transactions.

LEDGERS

Ledgers serve several functions, including the following:

They provide account balances for use in preparing financial statements.

They control the bookkeeping process through the balancing of debits and credits.

They provide control accounts for use in balancing subsidiary ledgers.

They provide historical records of accounting activity within the individual accounts.

The first three functions can be mechanized and doing so presents no particular problem in internal control or maintenance of the audit trail. The fourth function implies that there is a permanent and visible record regardless of the mechanics involved in its preparation. This presents a problem in EDP systems. Where ledger records are maintained on magnetic tape, disks, or other computer medium, extensive quantities of historical information cannot be carried without adding a substantial cost to the system. Furthermore, since the records cannot be read without operating one or more units of electronic equipment, the requirement for a printed historical record may involve significant cost.

On the other hand, certain subsidiary ledger account-keeping is entirely compatible with the computer capabilities. Where account balances are cleared within short time periods and where there are comparatively few open items within an account at any time, the computer handles ledger work in an efficient manner. In these applications there is generally sufficient information in copies of billings or other print-out to provide an adequate audit trail.

MASTER FILE CHANGE NOTICES

An adequate audit trail will include notices prepared by the computer of changes made in master file information, such as name and address changes, price changes, and wage rate changes. There are several methods of reporting such information. A "before and after" report of information in the file may be prepared, either in the form of a listing of accounts or as separate notices for the individual accounts. The report may include all of the information in a record or only the information fields that were changed. Also, the contents of a master file record may be printed whenever a change is made, but with no indication of the status of the record before the change. The method used is unimportant provided it affords a means of ascertaining that the files were changed correctly.

ERROR LISTINGS

The initial run in a computer application often includes a thorough screening or "editing" of the incoming transactions. A number of transactions usually are rejected by the computer in such runs because they fail to qualify as valid records according to a predetermined set of qualifications. In subsequent runs other transactions may be rejected for other reasons, such as a failure to locate a matching master record. The rejected transactions must be reported to the department concerned for investigation and, if necessary, correction and re-entry into the computer. Generally, they are printed on a separate report which is referred to as an "error listing."

Error listings serve an important control function. By reporting the rejected records in detail they afford a check sheet for determining that all of the errors are investigated and cleared in one way or another. They are a part of the audit trail in that they constitute a record of unprocessed transactions.

CHAPTER FIVE

INPUT CONTROLS

CHAPTER FIVE

INPUT CONTROLS

Input controls relate to the data acquisition and data transmission stages in the flow of data. Their purpose is to insure correctness in the initial accumulation of data and any preliminary operations that may be involved in presenting the information to the computer. Specifically, they regulate and monitor the following activities:

The authorization of source documents.

The handling of source documents.

The conversion of data to a machine language.

For convenience in presentation, data editing within the computer is classified as a processing control rather than an input control.

Some of the input controls are quantitative, in that they guarantee introduction into the computer of all the data that are supposed to be processed. Others are qualitative, serving as checks on the accuracy of the information.

THE INPUT AREA

The input area of data processing is defined, for purpose of the discussion herein, to include all operations to the point where processing passes to the computer, under direction of a stored program of instructions. Typically, this transition occurs when data recorded on cards or paper tape by input mechanisms are transferred to magnetic tape under programmed instructions; or when cards are used as a medium of direct input to the computer, under programmed control.

SHIFTING THE FOCUS OF CONTROL

The term GIGO has come into usage as a term of reference, standing for "Garbage In, Garbage Out", in the vernacular of data processing. Whatever its aptness, nevertheless it suggests an important truism in electronic data processing: The correctness of the results is directly dependent upon the correctness of the input.

In nonelectronic systems it is possible to clean up source information as it is processed. For example, should the purchasing department fail to record the department number on an accounts payable invoice, one of the accounting clerks along the line would do so. Under EDP, the machine could be programmed to detect the absence of the number, but in most instances it would reject the invoice from further processing and print out an error message for follow-up. The corrected invoice would then be resubmitted during the next processing cycle.

Human intervention to correct errors is relatively inefficient in the EDP system and should be avoided whenever possible. In the input area, this principle is observed by placing rigid controls on the initiation of data. GIGO is minimized by shifting the emphasis for control purposes from clerical operations in intermediate processing back to the point where the transactions take place or data are first created. The people at this point should produce accurate data, acceptable to the machines, and develop batch totals or such other control records as may be needed to control subsequent processing. Sometimes this requires only a rearrangement of duties within the accounting department; in other cases, particularly in more highly integrated installations, other departments may be required to assume control responsibilities they have not had in the past.

Where the latter occurs, the shift may place control responsibility on people whose training and experience has not emphasized the importance of data discipline. Operating departments customarily have been responsible for submitting correct data to the accounting department, but the accounting department has filled in certain details and applied various control practices. In the EDP system, these duties in some cases devolve upon the operating departments. Fortunately, many semi-mechanical devices have been developed to lessen the tasks of preparing data and these are helpful in controlling accuracy. Nevertheless, effective control requires a recognition by supervisory personnel that if a shift in responsibility has occurred, appropriate control measures will be introduced.

AUTHORIZATION OF SOURCE DOCUMENTS

In the over-all subject of input control, the first question that arises concerns the authenticity of the data that enter the system. For example, if a bogus transaction is introduced into the EDP system, obviously all the controls to insure correctness in its processing are futile. The traditional method of controlling the authenticity of data entails use of source documents. Typically, the existence of a properly completed document is regarded as prima facie evidence of the genuineness of the transaction it represents.

Transactions

Control of the issuance and preparation of source documents is effected principally through separation of duties and accountability for individual documents. Since these controls are outside the mechanization process, they are not affected by the use of data processing equipment.

In a fully automated information system, source documents are unnecessary in the creation of certain kinds of data. For example, in the systems for booking airline reservations, information is transmitted to and from the central computer with a complete absence of paper work. As systems of this type are introduced into accounting areas, appropriate methods of controlling the creation of data should be provided.

However, in most EDP systems, source documents will continue to be used extensively. The documents provide tangible and visible evidence of the authenticity and nature of input data. In many situations, the initiation and possession of written source documents are needed and justified for various purposes, even though mechanical or electronic equivalents of the data could be substituted.

Master File Changes

In the EDP system, various factors used for calculating and processing are maintained in master files. These factors must be changed from time to time to conform with changing conditions and requirements. Examples are: customer files — selling price classifications, credit limits, and discount terms; payroll files — hourly rates or salary amounts, shift premium codes, and withholding tax exemptions; vendor files — discount terms and contract prices. Where such files are kept on magnetic tape or a similar processing medium, the information recorded in the files can be changed only by processing the files and the changes through the computer. Since the files are invisible and not subject to ready inspection, controls should be established to prevent introduction of unauthorized changes. Generally, this is done by instituting formalized procedures for documenting and processing the changes.

An effective technique is to require each request for a change to be authorized in writing (see Figure 8). A record (Figure 9) is then prepared by the computer, showing the data contained in the file both before and after the change. The report is then checked by the initiating department to determine that all of the changes were made, that they were made correctly, and that no unauthorized changes were made.

Program Changes

Price lists, commission percentages, and other "constants" are frequently carried as an integral part of a program of instructions for the computer. Procedures similar to those described above also should be established to control changes in factors stored in the programs.

Figure 8. Change Authorization

TO: Machine Accounting Dept. DATE: 11/25

FROM: Marketing

THE FOLLOWING PRICE CHANGES SHOULD BE MADE:

ITEM NO.	DESCRIPTION	NEW PRICE
12 2685	PEA SOUP	$ 6.001
12 3074	ORANGE JUICE	3.857
13 1111	HAND SOAP	2.200
13 2954	CONDENSED MILK	1.639
13 4182	TOOTH PICKS	.353

H. J. Manager
AUTHORIZED SIGNATURE

Source: See page 134

Figure 9. Change Register

CHANGE REGISTER				
DATE	ITEM CODE	DESCRIPTION	FACTOR BEFORE CHANGE	FACTOR AFTER CHANGE
11-26	12 2685	PEA SOUP	5.956	6.001
	12 3074	ORANGE JUICE	3.132	3.857
	13 1111	HAND SOAP	2.253	2.200
	13 2954	CONDENSED MILK	1.652	1.639
	13 4182	TOOTH PICKS	.352	.353

Source: See page 134

HANDLING OF SOURCE DOCUMENTS

After preparation, source documents may be worked on or used by various persons before the information in them is transcribed to a computer input medium. Further, the documents may be key punched and the resulting cards processed through a series of punched card machines before they are introduced to the computer or converted to another medium. Controls should be established to prevent loss of cards or documents as they are moved from one operation to another.

Following is a description of the more common techniques used to control the processing of source documents.

Registration

A register may be kept of the processing status of each document. A typical register shows the date the document is prepared or received, the date it passes each operation, and the date it is filed or returned to the initiating department. A register of this type for a simple billing application is shown in Figure 10. Here, documents are identified by serial number and the register discloses a missing or misplaced document and the extent of any delay in processing.

Figure 10. Order Register

ORDER REGISTER

MONTH October

DATE RECEIVED	ORDER NUMBER	DATE AUDITED	DATE BILLED	DATE SHIPPED	REMARKS
10/14	12831	10/14	10/18	10/18	
"	12832	"	10/16	10/16	
"	12833	"	"	"	
"	12834	10/15	10/17	10/18	
"	12835	10/14	10/16	10/17	
"	12836	"	"	"	
"	12837	10/15	10/17	10/19	
"	12838	10/14	"	"	
"	12839	"	10/15	10/17	
"	12840	"	"	"	
"	12841	"	10/16	10/17	
10/15	12842	10/15	10/17	10/18	
"	12843	10/16			Awaiting spec. instructions
"	12844	"	10/19	10/19	

Source: See page 134

A more elaborate register is usually maintained by the control section of an EDP center. Typically, the following information is recorded:

Source document or batch:

- Description or identification number
- Originating department
- Date received (also date due, if appropriate)
- Record count, batch total, or other control data
- Date returned to originating department

Error list:

- Number of errors (often analyzed by type)
- Date released to originating department

Report:

- Date prepared
- Date released (also date due, if appropriate)
- Distribution

The form of the register depends on the requirements of the particular installation. Often, separate registers are used for each type of document or for each application.

Sequence Checks

Where documents are numbered consecutively, they can be accounted for by arranging them in numerical sequence. This method not only provides proof that all documents have been processed but also facilitates document filing. When the numbers are prepunched into cards or imprinted for optical scanning, the sorting and sequence checking may be done automatically.

Matching

Where multiple copies of a document are prepared and each copy serves a separate purpose, the subsequent matching of copies provides control over the documents admitted to processing. The matching technique is also illustrated by the comparison of one document with another, such as matching time card totals for payroll purposes with the job ticket totals for distributing labor charges.

Document Counts

Document counts are a basic control technique where documents are processed in batches. The procedure is to establish a count of the number of documents in each batch and to verify the initial count, mechanically or otherwise, at appropriate stages in the transportation or handling of the documents. Since a count in itself does not provide a reference for use in locating missing documents, the technique often is used in conjunction with other control methods. Document counts are also used extensively to control batches of dissimilar items, such as master file changes and journal entries.

Card Counts

Where cards serve as source documents, card counts are a simple means of controlling punched card operations, since the counting can be done mechanically. The count is usually established immediately after the preparation of the cards by key punching or otherwise. Obviously, if the card is used as a document as well as a processing medium, the card count is merely a form of the document count.

Dollar Totals

Where accounting entries are being accumulated from source documents, the resulting dollar totals provide a natural basis for controlling subsequent operations. This is the most common of all control techniques. It is simple and effective, and, in many cases, a necessary part of the accounting process rather than a separate control measure.

Control Totals

Control totals can be established from any data field that is common to all items. Examples are number of hours worked, quantity of products shipped, and number of employee withholding exemptions.

Hash Totals

Where there are no quantitative data fields that are common to all items, it may be necessary to accumulate a "hash" total. This represents an accumulation of numbers that normally are not added together, such as account numbers, box car numbers, or employee numbers. Hash totals are seldom used as a document control but are frequently programmed into computer operations because the balancing usually can be performed at little or no extra cost in machine time.

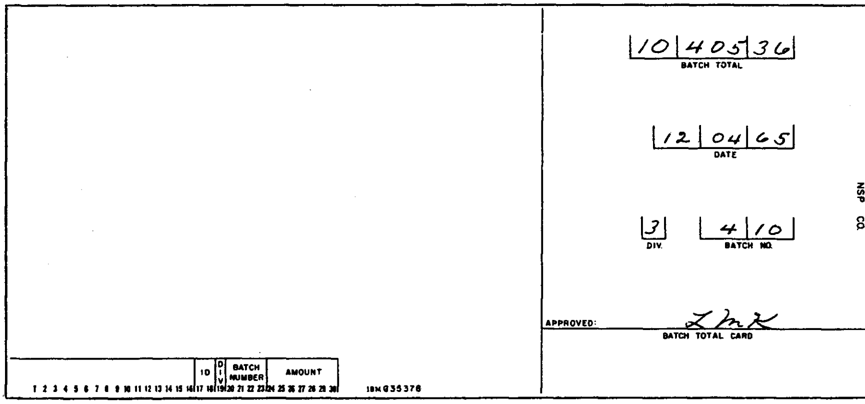
Batch Tickets

Control data may be recorded on the first document in the batch. Usually, however, it is preferable to prepare a separate form to accompany the batch. Figure 11 illustrates a card form that accommodates key punching of the batch data. Figure 12 illustrates a transmittal form which utilizes a document count and a dollar total. When it is desirable to fix responsibility for the movement of documents from one department to another, a routing slip (Figure 12) may be used. Where the volume of work is high, variations of the latter form may be used to control the various processing operations within a department.

Cancellation and Validation Stamps

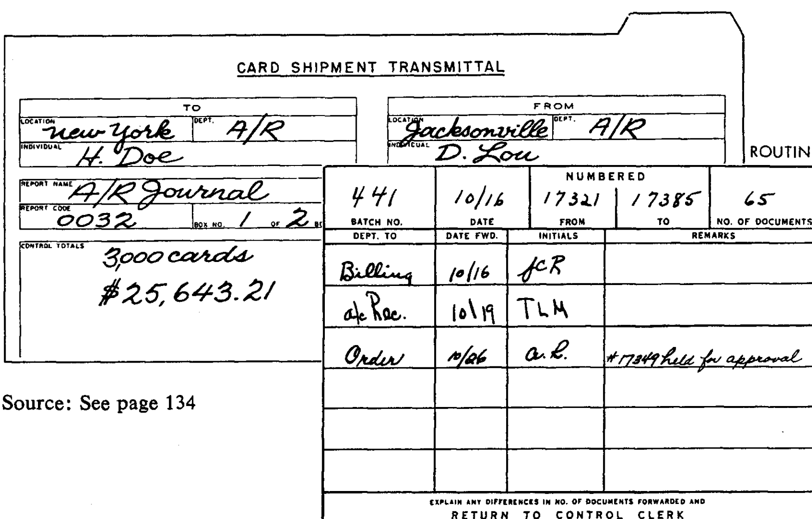
A document may be canceled by stamping, perforating, or imprinting to indicate that it has passed through a given department or control point. On

Figure 11. Batch Control Ticket


10 40536
BATCH TOTAL
12 04 65
DATE
3
DIV.
4 10
BATCH NO.
APPROVED: LMK
BATCH TOTAL CARD
ID
DIV
BATCH NUMBER
AMOUNT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
IBM 035378
NSP CO

an accounts payable invoice, for example, such a marking serves to prevent duplicate payment or fraudulent reuse of the document. An example of a time stamp cancellation is shown in Figure 13. A validation stamp serves a similar purpose. In this case the marking authorizes the transaction and

Figure 12. Transmittal and Route Slips


CARD SHIPMENT TRANSMITTAL

TO		FROM	
LOCATION: New York	DEPT.: A/R	LOCATION: Jacksonville	DEPT.: A/R
INDIVIDUAL: H. Doe		INDIVIDUAL: D. Lou	

REPORT NAME: A/R Journal
REPORT CODE: 0032 BOX NO. 1 OF 2
CONTROL TOTALS: 3,000 cards $25,643.21

ROUTING SLIP

BATCH NO.	DATE	NUMBERED FROM	NUMBERED TO	NO. OF DOCUMENTS
441	10/16	17321	17385	65

DEPT. TO	DATE FWD.	INITIALS	REMARKS
Billing	10/16	JCR	
A/c Rec.	10/19	TLM	
Order	10/26	a.R.	#17349 held for approval

EXPLAIN ANY DIFFERENCES IN NO. OF DOCUMENTS FORWARDED AND
RETURN TO CONTROL CLERK

Source: See page 134

any document that does not bear the marking would be rejected from further processing.

CONVERSION TO MACHINE LANGUAGE

The information in source documents must be converted to a machine language before it can be processed automatically. The most common method of doing this is to punch the data into tabulating cards.

Card punching can be done manually or, in appropriate circumstances, mechanically. The manual method is commonly referred to as "key punching." Because of the high cost of this method, the feasibility of alternatives should be considered.

Mechanical Card Punching

Mechanical card punching usually employs some variation of one of the following approaches:

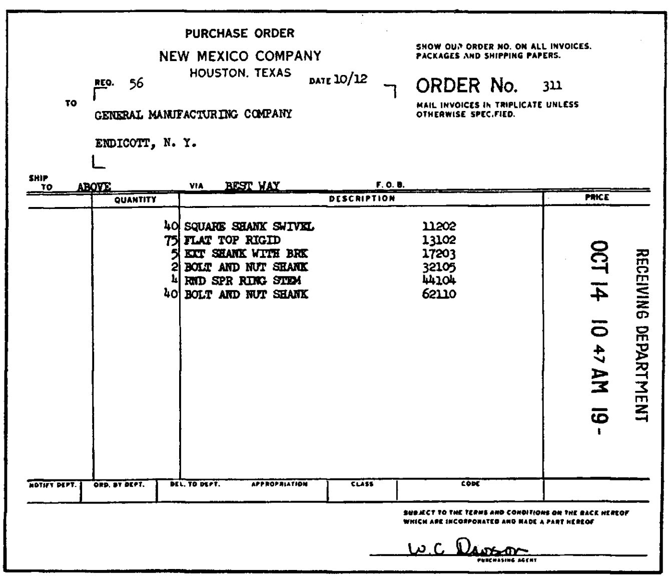
1. Use of a device that couples a keyboard machine, such as a bookkeeping machine, with a card punch machine, which provides a means of capturing data in punched cards as a by-product of a typing operation.
2. Use of machines that perforate paper tape which in turn is automatically converted to punched cards. The paper tape punching mechanism may be linked to an adding machine, to a typewriter equipped to read punched cards and/or paper tape, or to one of the so-called data gathering devices that relay source data from several points to a central data processing location.
3. Use of prepunched stubs, mark-sensed and prepunched cards, and other turn-around documents that can be converted to punched cards automatically.

When cards are produced by the first two of these methods, there is often an opportunity to verify the keystroke operation at the source. Thus, when a bookkeeping machine prepares cards as a by-product of its normal typing function, the information recorded by the keystroke operation on the journal or other document can be visually checked. Similarly, information punched by keystroke operation into paper tape can be checked against adding machine listings or "hard copy" documents prepared by the associated mechanism. The devices are sufficiently reliable to warrant an assumption that punching of the by-product cards or paper tape conforms with the keystroke operation. For this reason, it is accepted practice not to verify the punching in the cards or paper tapes.

It is accepted practice, however, to utilize batch totals at this point to ascertain that all of the records are punched into cards or paper tape. Furthermore, if the data are to be transmitted over telephone lines or other communications channel, it is customary to transmit the batch control information as the last card or the last record on paper tape. This provides the receiving location with a means of proving the completeness of the transmission. If the records are received on paper tape, the balancing also proves the completeness of the tape-to-card converting operation.

Turn-around cards of a stub form are usually reproduced into normal-size cards before processing. The reproduced cards are generally batched and totaled for control purposes as they begin their entry into the data processing routines. Mark-sense produced cards and other prepunched

Figure 13. Time Stamp Cancellation



PURCHASE ORDER
NEW MEXICO COMPANY
HOUSTON, TEXAS

SHOW OUR ORDER NO. ON ALL INVOICES. PACKAGES AND SHIPPING PAPERS.

REQ. 56 DATE 10/12

ORDER No. 311

MAIL INVOICES IN TRIPLICATE UNLESS OTHERWISE SPECIFIED.

TO GENERAL MANUFACTURING COMPANY
ENDICOTT, N. Y.

SHIP TO ABOVE VIA BEST WAY F. O. B.

QUANTITY	DESCRIPTION		PRICE
40	SQUARE SHANK SWIVEL	11202	
75	FLAT TOP RIGID	13102	
5	EXT SHANK WITH BRK	17203	
2	BOLT AND NUT SHANK	32105	
4	RND SPR RING STEM	44104	
40	BOLT AND NUT SHANK	62110	

RECEIVING DEPARTMENT
OCT 14 10 47 AM 19-

NOTIFY DEPT. | ORD. BY DEPT. | DEL. TO DEPT. APPROPRIATION | CLASS | CODE

SUBJECT TO THE TERMS AND CONDITIONS ON THE BACK HEREOF WHICH ARE INCORPORATED AND MADE A PART HEREOF

W.C. Dawson
PURCHASING AGENT

Source: See page 134

cards are controlled in a similar manner as they "turn around" and re-enter the system.

Manual Card Punching

Manual key punching remains as a necessary part of many EDP installations, and where it does, controls must be provided to make certain that the cards are punched within acceptable limits of accuracy.

In most cases a card punch operator is immediately aware of a mistake she has made and corrects it by punching another card. Occasionally she may fail to detect an error and, of course, there is always a possibility that she may misinterpret handwriting on the source document. Therefore, cards are usually checked in some manner after they are punched.

The checking can be done visually or by keyboard.

Visual Verification

Visual verification involves:

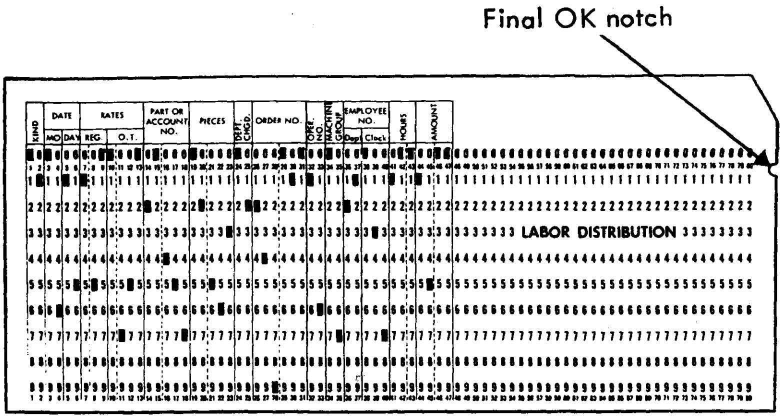
1. Initial use of a card punch that is equipped to print data at the top of the card during punching; or
2. Passing the cards through an interpreter which prints the data on the card; or
3. Printing a proof list from the cards.

Under each method, the information that is read is compared with that on the source document.

Key Verification

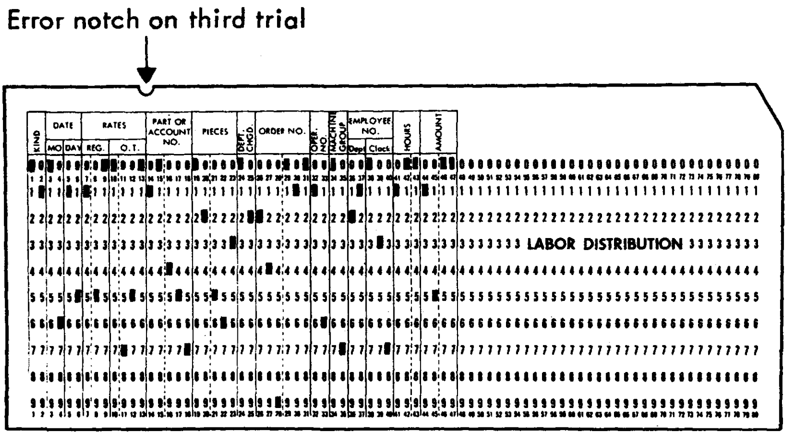
Machine verification entails an operation that is similar to the original punching. After a batch of cards has been punched, the source documents and the cards are taken to a second machine. With the documents in the same sequence as the cards to be verified, the verifier operator duplicates the key strokes of the card punch operator. Subsequent operations depend on the make of equipment. The verifier of one manufacturer is equipped with sensing pins which determine whether the verifying keystroke creates a pattern that "fits" the holes punched by the card punch operator. If it does, the card proceeds to the next character which is checked in a similar manner. If all of the characters pass the verifier test, a notch is automatically cut in the right edge of the card (see Figure 14). This is the "O.K." signal that makes it easy to separate the correct cards from the incorrect cards after the verifier operator has completed the task. The notch also serves as positive evidence that the cards were verified.

Figure 14. Correct Card



Source: See page 134

Figure 15. Error Card



Source: See page 134

If the verifier operator depresses a key other than the one the card punch operator selected in making the original hole, the verifier "lights up" and the keyboard locks temporarily. The verifier operator has two more chances to strike a key that agrees with that depressed originally by the card punch operator. If there is no agreement after three tries, the top edge of the card is automatically notched in a position that indicates the incorrect character (see Figure 15).

Another manufacturer approaches the machine verification process in a different manner. Key verification is done with the same machine that does the card punching. When the machine is operated in the verifier mode, depression of the keys slightly elongates all correct holes. The verified cards are then passed through a special-purpose verifier machine which causes an error-indicating card to drop on top of each incorrect card. When the cards are removed from the machine, the indicator cards clearly signal those cards requiring correction.

The Self-Checking Number

Key verification will not detect errors in coding the source documents, nor will it detect all card punching errors. To illustrate the latter, when the handwriting on a document is not clear, both the card punch operator and the verifier operator may read a number the same way, but both may be wrong. Errors of this type, particularly those involving account numbers, stock numbers, employee numbers, and customer numbers are troublesome in any system. But they are particularly so in an EDP system because there usually is no opportunity for visual inspection of the data during subsequent processing. For example, a transaction may be posted to the wrong account on magnetic tape and the situation may not be brought to light for some time, if at all.

Errors of this kind may be detected by assigning an extra digit to the number to be controlled. The extra digit, which is known as a "check digit," is determined initially through a mathematical manipulation of the digits in the basic number. The combination of the number and its check digit represents a "self-checking number," since its correctness may be established thereafter by recomputing the check digit.

The verification may be performed by the computer. Alternatively, it may be performed at the time the number is key punched if a special device is attached to the card punch machine. This device automatically calculates the check digit for the basic number and compares it with the assigned check digit.

If the digits are the same, a hole is punched in a designated position of the card to indicate that the self-check number was punched correctly. If an error is detected, a hole is punched above the units position of the self-check number, the keyboard locks, and an error light turns on. The operator then punches a duplicate card to determine whether the mistake was made in key punching or in coding the source document.

Figures 16 and 17 illustrate the arithmetic involved in determining check digits. A given device will perform one or the other of these calculations, but not both. The second method gives greater assurance that certain types of transpositions and compensating errors will be detected, but the first method affords sufficient protection in most applications.

Figure 16. Manual Method of Determining Check Digit, Modulus 10

Basic Account Number		7	3	0	7	4	
Units and every alternate position		7		0		4	
Multiply by two		2		2		2	
Product		14		0		8	
Digits not multiplied by two			3		7		
Crossfoot	1 +	4 +	3 +	0 +	7 +	8 =	23
Next higher number ending in zero							30
Subtract crossfooted total							—23
Check digit							7
Self-checking account number		730747					

Source: See page 134

Figure 17. Manual Method of Determining Check Digit, Modulus 11

Basic account number	4	5	6	2	6	7	
Multiply each position by the proper weight	7	6	5	4	3	2	
Crossfoot the products	28 +	30 +	30 +	8 +	18 +	14 =	128
Divide the sum of the products by eleven	128 ÷ 11 = 11 with a 7 remainder						
Subtract the remainder from eleven							11 —7
The difference is the check digit							4
Self-checking account number			4562674				

Source: See page 134

In most cases, the codes presently in use can be converted to self-checking numbers merely by determining the check digit for each basic code number and recording this check digit as a suffix to the basic number. In a few cases, however, it may be necessary to set up entirely new code lists using self-checking numbers. When this is necessary, other aspects may require consideration. Any change in widely used codes, such as those for stock numbers or account numbers, is an inconvenience to those who work with them and usually entails expensive redesigning of forms, catalogues, and cards.

Need for Card Verification

Card-by-card verification is expensive, particularly when card volumes are high. Clerical time is required whether the verification is done mechanically or visually. Therefore, the need for verification in detail should be carefully considered, as other checks within the over-all system may accomplish the same purpose. Frequently it is possible to limit key verification to a few card fields or to eliminate it entirely. There have been instances where statistical sampling of key-punch errors on specific applications disclosed that the errors consistently cost less than the cost of verification, so the key verification was discontinued.

Some of the alternatives to key verification are:

1. Dollar amounts, quantities, and "hash total" data in the cards may be proved by accumulating totals during a subsequent machine operation and comparing them with control totals established initially from the source documents.

2. Document serial numbers that are punched in the cards may be verified mechanically by sequence checking or by matching sets of two or more cards.

3. Account numbers, part numbers, customer numbers, or other indicative fields may be verified automatically at the time the cards are punched if a special self-checking device and numbering system is used.

4. Alphabetic information may require no checking where the errors would not affect subsequent processing operations or otherwise cause harm or inconvenience.

5. Account numbers and other coded information may be verified subsequently by the computer through input editing and other methods of programmed checking. Whether this justifies curtailment of key verification is a matter of economics that should be worked out for each situation.

CHAPTER SIX

PROCESSING CONTROLS

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PROCESSING CONTROLS

Processing controls, which are known also as programmed checks or programmed controls, are a part of the stored instructions that direct a computer's operations. To the extent that they are used, an EDP system becomes self-regulating, eliminating the need for clerical monitoring of results. This characteristic gives the computer a self-auditing capability which is superior to that of any other processing system.

THE ROLE OF PROGRAMMED CHECKING

The extent to which programmed checks are used is primarily a matter of economics: The costs of checking should be balanced against the costs of not detecting errors. This equation, although easy to state, may be difficult to apply.

The costs of checking include: (1) extra systems design and programming time, and (2) longer computer running time. Both of these are affected by the storage requirements of a checking routine. If memory space is ample, the costs may be insignificant. If it is "tight," the cost may be material because inclusion of the check may involve intricate programming and an additional computer run.

The costs of not detecting errors include: (1) manual error detection, investigation, and correction procedures; (2) various less precisely measurable factors that are peculiar to a given type of error, such as the effects upon management efficiency or customer good will. Some of these costs or possible effects are difficult or impossible to measure. Therefore, to some degree the extent to which programmed checks should be employed is a matter of judgment. In practice, the possible effects of not detecting errors sometimes are dismissed rather summarily and, as a consequence, programmed controls are minimized.

Electronic data processing requires four basic ingredients: equipment, internally stored programs, data, and human operators. Programmed checks oversee the effectiveness of each of these. Thus, the objectives of programmed checking are to monitor:

1. The accuracy of the computer;
2. The adequacy of the programs;
3. The quantity and quality of data; and
4. The correctness of human intervention.

The first objective – the monitoring of computer accuracy – varies in significance from machine to machine. The reliability of electronic equipment is extraordinarily high to begin with. This high inherent reliability is supplemented with a variety of built-in checks that automatically detect malfunctioning. Therefore, so far as computer accuracy is concerned, programmed checks for the most part merely provide comforting assurance that all is well. However, there is a recent trend among manufacturers to discontinue providing some of the built-in checks that heretofore have been considered necessary. Such a trend may increase the need to monitor computer accuracy through the use of programmed checks.

The second objective – the monitoring of program adequacy – is particularly applicable during the pre-operational stage when programs are being tested. At this stage, the checks help in the "debugging" process by proving the logic of the instruction lists. Later, when the application is operative, the checks detect deficiencies in the programs only rarely but nevertheless frequently enough to warrant their continued use. Deficiencies are frequently disclosed several months after an application is put into operation.

The third objective – the monitoring of the quantity and quality of data – is quite important from a control viewpoint. If bad input is received, bad output will result. Therefore, some check is needed at the input stage to detect loss of data and to verify the accuracy and consistency of various fields of information. The customary practice is to make a series of checks as the records are read in for processing. Some of the checks are quantitative in nature, while others are qualitative. The quantitative checks serve a double purpose. They determine whether or not the number of detail records received agrees with the control count established outside the data processing activity (if such a control was established) and they establish counts for use in controlling subsequent data processing operations. When agreement is not reached, a message is usually written out indicating the type of proof attempted, the specific control figures, and the differences. The qualitative checks test the validity, appropriateness, and accuracy of data. Records that fail to pass a qualitative test usually are rejected from further processing and printed on an error listing.

The fourth objective — monitoring the correctness of human intervention — is likewise an important element of control. Inadvertent mistakes made at the console often can be detected through use of programmed checks. Deliberate manipulation also can be detected in some instances, although more positive detection is obtained through use of console typewriters that provide an automatic record of intervention.

Programmed checking also promotes operating efficiencies in the machine room. Costly reruns can be avoided. Adherence to established schedules is facilitated by internal screening of data and self-checking of results. These benefits of the program checks warrant their use even when they may not be essential from an internal control viewpoint. For example, the accounting department may set up rigid controls over data sent in for processing and over the results that are received back. In such a situation, the data processing center should incorporate corresponding balancing steps into its programs.

The following sections relate to methods of programmed checking.

QUANTITATIVE CONTROLS

As previously mentioned in the discussion of the input area, a control record, such as a transaction count or a dollar total, usually is established before data reach the computer. This provides control over the machine operations and enables the departments responsible for the initiation of information to retain control over it.

The failure to establish such controls may constitute a basic deficiency in internal control. However, it must be recognized that the establishment of ideal control over input data sometimes is impractical and therefore limited or selective controls are appropriate in the circumstances. For example, in a billing operation it is easy to establish control over the number of invoices. However, to extend the control to content of invoices (as a safeguard, for example, against omission of a line or misstatement of a quantity in the course of processing) would involve the accumulation of separate control totals by the originating departments which might require more time and cost than is deemed to be justified. In such circumstances, as a minimum, the data processing department should establish control records for its own use.

It is the responsibility of the data processing department to process all of the records it receives and to transfer out of the system all of the records it generates internally. Control records evidence the transfer of accountability for data to the EDP department. In addition, they provide assurance that no records are lost in the processing operations.

Record Counts

Counts are used extensively to control the handling of documents, punched cards, and other unit records. The need is apparent in these input operations, as there is always a possibility that one or more of the detail items will be lost in the process of moving from one operation to another.

Counts also are used extensively to control information (generally referred to as "records") stored on magnetic tape. The need here is not so apparent, since individual records placed on tape cannot be misplaced physically. Nevertheless the need is real. A machine failure or a programmed error detection that halts the processing exposes the system to a possible loss of records. This is because operations may be restarted at the wrong point in the program, resulting in failure to process one or more records or in multiple processing of certain records. While it is true that a valid program normally will cause all of the records to be processed (and no more), it is sound practice to build into the program an automatic monitoring system that will flag any discrepancy in number of records.

When a transaction count is supplied with the input record of the detail items, the count usually is converted to tape as the last record following the transaction records. As the tape is read, the machine is programmed to count the detail records and compare the total with the control count. If a control count is not supplied, the count is made anyway if the application requires a control for succeeding operations.

Record counts are also used to control master files. The total number of records in the file is carried in a control record at the end of the file. Each time the file is processed, the input count is verified and a new control count is developed that takes into account the records that are added or deleted during the processing. In this manner, any loss of records in the transfer of data from one tape to another is automatically brought to the attention of the operator, usually in the form of a message typed by the console typewriter.

Record counts also should be used to control output records. If the records are written on tape, counts can be established to control the subsequent production of punched cards, printed documents or listings, or other nonelectronic media. If cards are punched directly by the computer, a card count can be punched into a separate control card.

There are many adaptations of this general method of controlling through use of record counts. Tape records are frequently organized into groups or blocks, either because of design characteristics of the computer or because of the programmer's desire to minimize tape starting and stopping. Often it is more convenient to establish "block counts," rather than individual record counts, in these situations. Also, when a file comprises several reels of tape, record counts may be carried at the end of each reel rather than at the end of the complete file. These variations should not affect the effectiveness of the basic counting technique.

Where the input consists of more than one punched card per transaction, the computer can be programmed to determine that the correct number of cards is received for each transaction.

Record counts are easy to program, require little additional storage space, and add virtually nothing to computer processing time. Their practicability is recognized by the machine manufacturers, most of whom provide "canned" input-output routines containing the instructions needed to perform this important control function.

Record counts do not control the correctness (quality) of information in the records, nor do they isolate the records that are involved in a failure to balance. Therefore, other techniques are often needed to supplement the record counts.

Control Totals

The most commonly used quantitative control, as indicated previously, employs the use of control totals. In the input operations, a batch of transactions is accumulated at the initiating point and a control total is established to govern all subsequent handling and processing. Dollar totals are usually developed where dollar information exists. Otherwise, some other significant field of information is accumulated, such as employee hours or production quantities. Occasionally, hash totals are developed from stock numbers or other descriptive fields in order to prove the correctness of the subsequent copying operations.

In the final input operation, transaction cards may be proven to the control total on a punched card machine before the detail items and control total are converted to tape. Even so, it is advisable to prove on the computer also. There is always a possibility that cards may be misplaced or tampered with after they have been proven but before they are converted to tape. The risk is greater, of course, when time delays are significant or physical transportation or handling operations are extensive.

Computer proving to transaction control totals is usually done in a preliminary "editing run," where the data are also screened and conditioned for the actual processing. If the transactions are passed through several additional runs – sorting, processing, output formatting, etc. – the control totals are carried from tape to tape through the entire procedure.

In many applications, additional control totals are developed during the computer processing. For example, in a payroll system, the initial control may be in terms of hours. At the point in the processing where the hours worked by an employee are extended by his rate, new controls usually are developed from the resulting dollar amounts.

Control totals are used extensively in tape files containing balance-forward amounts, such as an accounts receivable subsidiary ledger, a general ledger, or an employee earnings record. They function as control accounts, which, in fact, they often are.

Control totals are a natural part of systems that process master files sequentially. The transactions to be processed in these systems must first be arranged, in the input operations, into the same order as the items in the master file. This requires an accumulation or batching, and it is fairly convenient at this point to develop, usually by adding machine, the control total. Subsequently, the total is proved as the transactions are processed by the computer.

Random-access systems require special consideration. Direct access may be made by the computer to any record in a random-access file without reference to other records in the file. Therefore, transactions can be allowed to enter the computer in random sequence (or any other sequence). Since sorting is not required, there is no need to accumulate the items and there is no natural point at which to develop control totals. Nevertheless, as a practical matter, many applications for random-access computers do employ batching and control totals. This is because a preliminary sort of the transactions can minimize the total time required to locate random-access records stored on magnetic disks or drums. Control totals thus established externally may be balanced internally by the computer.

In on-line and real-time applications, the recording of a transaction is performed on a device that is connected "on line" with the computer so that the processing can be done immediately and, if the system requires, the results reported immediately, or in "real time." In these situations, there is no opportunity for batching or for the use of predetermined control totals. However, there is no need for them if the use of the device is adequately controlled, the device and associated communication equipment are sufficiently reliable, and adequate record is obtained of transactions handled by the device.

Sequence Checks

Computers should be programmed to check the sequence of records as they are read into the system and at various points in the processing to ascertain that the desired order has been maintained. Sequence checks provide a simple but effective indication that all is well in the processing stream. When the records are consecutively numbered, sequence checking provides a ready means of detecting missing items and duplicate numbers.

QUALITATIVE CONTROLS

Qualitative controls relate to the data content of the individual records. They test the consistency of record arrangement ("record format"), the presence or absence of specified items of data, the accuracy of data that can be proved arithmetically, and the reasonableness of certain kinds of data. When the tests relate to incoming data, they are often referred to as input editing checks. When they relate to the manipulation of data or the generation of output records, they are referred to as processing checks.

Input Editing

Input data are normally "edited" rather completely within the computer before they are passed along for main-line processing. Most of the screening merely tests the compatibility of the data — that is, its suitability and acceptability in terms of the program – although some of the tests do check the reasonableness or apparent validity of specific segments of information. In this latter sense, editing checks test the quality of data. However, machines do not have the capability to detect a fictitious entry that meets the programmed editing tests. They can detect only the items that cannot meet the requirements of a set of predetermined rules.

Editing checks vary widely because they relate to the requirements of specific applications and the character of the individual input records. They do not test the accuracy of the machine since their function relates solely to the incoming data.

Some of the commonly used checks are:

1. Coding checks
2. Combination checks
3. Check digits
4. Matching checks
5. Composition checks

Terminology for these checks has not been standardized in the industry.

Coding checks reject data codes that do not conform with established coding lists. For example, suppose normally there should be only three types of entries in a given procedure – A, B, and C. If a given entry is neither A nor B, a positive test establishes whether it is C. In Figure 18, a check is made to see whether the entry is C. If it is not, an error exists that otherwise would not have been detected.

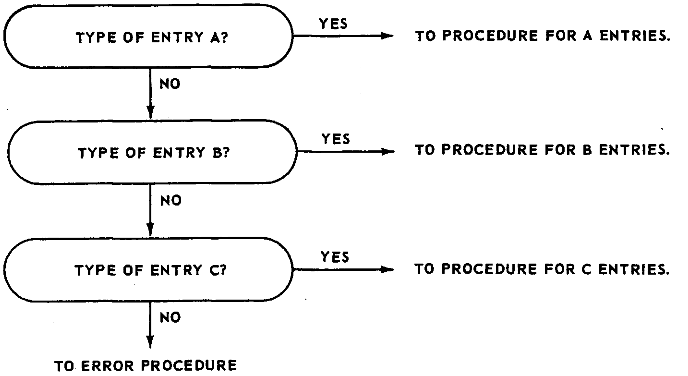
However, the procedure cannot detect an improperly coded entry if it is coded A, B, or C.

Combination checks are an extension of coding checks. Under program control, a computer can recognize valid relationships between two fields of coded information and reject impossible combinations. To illustrate, assume the following assignment of territories to salesmen:

Salesman	*Territory*
Jones	Illinois and Iowa
Smith	Illinois
Brown	Iowa and Missouri

If the coded representation of these combinations is stored internally, a computer can detect improper relationships, such as an entry that purports to credit Jones with a Missouri sale. It should be noted, too, that this

Figure 18. Coding Check



look-up ability can be utilized to eliminate initial coding (and key punching) in many situations. For instance, assume the following arrangement:

Salesman	*Territory*
Jones	Illinois
Jones	Indiana
Smith	Iowa
Brown	Missouri

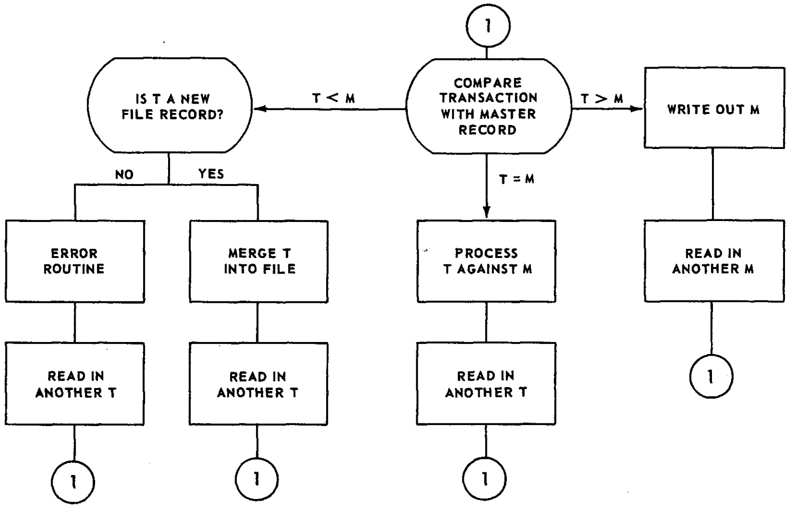
Here the territories are exclusive, although one salesman, Jones, can sell in two states. If the input entry is coded for territory, the computer can supply the salesman's code (and name, if desired), making it unnecessary to code this information in the input operations.

A variation of this method of editing is sometimes used to verify the coding of account numbers. Where the chart of accounts is relatively complex, requiring long account numbers, the entire chart may be stored in the computer's memory. This provides a table of acceptable numbers against which the incoming records may be checked.

Check digits were explained in the preceding chapter in the discussion of self-checking numbers. Where the extra digit has been assigned to coded numbers, a computer can perform the arithmetic needed to establish the probable correctness of the number. This would eliminate the need for the special device that otherwise is required to be attached to the card punch machine. Under this method, however, the errors would not be detected until a later stage in the processing cycle.

Matching checks detect improperly coded transaction numbers in file maintenance programs that are processed sequentially. The basic logic of the operation is shown in Figure 19. If both the transactions and master file records are intended to be in ascending numerical order, a determination that the transaction number is less than the master number, followed by a determination that the transaction is not a new record for the file, is an indication of some type of error. Investigation will disclose that the transaction number is out of sequence, that a master record for the transaction should have been added to the file previously, or that the transaction number is incorrect.

Figure 19. Matching Check



Composition checks test the appropriateness of data in a variety of ways. Data fields may be tested for blanks to determine whether any significant information is missing from the input records. Numeric fields may be tested to locate extraneous alphabetic characters. Amount fields within a record may be crossfooted where it is possible to prove the accuracy of the individual fields. In general, the character of the job and the skill of the programmer will determine the number, nature, and effectiveness of the composition checks that are employed.

Internal Operations Checks

After records have been screened and allowed to proceed into the main processing steps, certain controls can be programmed to assure correctness in manipulating the data. Such checks are used sparingly, because the reliability of the hardware is sufficient assurance of processing accuracy in most situations.

Posting checks are a case in point. As their name implies, these checks are provided to avoid mispostings, which in electronic data processing may have serious consequences. For example, in random-access files the storage address of a record often is calculated by the computer from an actual number, such as a part number or a customer's account number. There are several arithmetical methods of doing this, but none of them guarantees generation of separate or unique addresses for every number. The methods recognize the probability that duplicate addresses will be computed on occasion. Therefore, a check must be made after an address has been calculated to determine whether or not the record at that location is the one that is really wanted. This is done simply by storing the actual number in the file record and comparing it with the incoming data.

The same principle often is applied in sequential processing. When there is a possibility that the input identification number may be incorrect – as there is when the number is manually coded without a check digit – the advantages of the technique should be considered. A comparison may be made of any field of information that is common to the file and the data to be processed. For example, in an accounts receivable application that employs a master file of open items, the input and file records would first be matched on customer number. It may then be appropriate to compare invoice number and invoice date in addition to invoice amount before changing the master file.

It is now generally considered unnecessary to check the arithmetical operations of a computer. However, arithmetical proofs are often programmed as a means of checking the reasonableness or completeness of over-all processing. The most common checks are the limit check, the crossfooting check, and the sign check.

Limit checks test the reasonableness of data by comparing them with established tolerances. The tests may be applied to input records as they are read. They may also be applied to output results as they are written or used to update a master file. For example, in a public utility billing application the reasonableness of metered consumption (input) can be tested by calculating "high-low" limits for each account, based on historical usage, seasonal variations, and other factors. Similarly, payroll computations can be compared with predetermined maximums, invoice extensions exceeding a prescribed amount can be flagged for attention, and issues from a storeroom in unusually large quantities can be marked for special consideration. In theory, limit tests can be applied to nearly every business factor involving time, money, or other quantitative units. In practice, they are applied selectively.

Crossfooting checks prove the arithmetical accuracy of individual records and/or a group of records. Just as a clerk checks a schedule by crossfooting columnar totals, a computer can crossfoot individual records, such as gross pay to net pay, accumulate the respective amounts, and crossfoot the final totals. The technique is a simple way of establishing over-all completeness and accuracy. It is especially effective at the conclusion of lengthy jobs, since these may be subject to interruption for mechanical or scheduling reasons and thus may be vulnerable to restart errors.

Sign checks, as their name implies, test the algebraic sign of a field of information. For example, the machines can detect a negative balance in inventory, an excess of payroll deductions over gross pay, or a change in an account balance from debit to credit. The checks frequently are used to indicate a failure to receive data. This could be the case, for example, when issues from stock are deducted before the receipt of goods is processed.

Real-time computers present a special control problem. When many point-of-origin devices are connected to a central computer, some definite measures should be provided to prevent insertion of erroneous data, incorrect modification of master files, or the reading out of unauthorized information. The design of the devices usually restricts usage to some specified function, and for nonaccounting applications these built-in controls are adequate. But when on-line stations become prevalent as channels of accounting information, additional control techniques must be developed. Programmed checks may prove to be one of the more effective methods of controlling the use of the on-line input devices.

OPERATOR CONTROLS

Some of the programmed checks previously discussed detect errors caused by erroneous assistance or intervention by a machine operator. For example, an out-of-sequence condition may result from an inaccuracy on the part of the operator; or it may represent an error in the input data or a machine failure. The source of the error is not determinable from the nature of the check, nor is this important in most situations.

There is one type of programmed check that is intended exclusively for use in controlling operator functions. This is the internal tape label.

Important records may be destroyed unintentionally by placing the wrong reel on an output tape drive. It is also possible to mistakenly process a transaction tape more than once, to update a superseded master file tape, or to fail to process one or more reels of a series of transaction tapes. Errors of this type are serious. They cause operating delays in all cases, and at times create inaccuracies in the records that are difficult to detect and correct.

To avoid such errors, rigid work rules are often established regarding the handling and filing of tapes. These rules are discussed later in conjunction with security controls and organization matters.

But even though such precautions are taken, errors may occur occasionally. For example, an exterior label may be lost or placed on the wrong reel of tape. Therefore, an internally programmed check is needed to detect an error in mounting the reels to the tape drives. Assurance that the right tapes are placed on the designated drives should be an automatic part of each operating program. This is done by recording a magnetic label as the first record on the tape to identify the contents of the reel. The computer then examines the label before starting the main processing and compares it with identifying data that was previously loaded into memory with the stored program. If the comparison fails, the actual label and the correct label are printed out on the console typewriter or printer and the computer stops. In some programs the print-out also is made when the labels agree, to show that the test was not by-passed and that processing is proceeding as planned.

The following information may be recorded in a label:

1. Label identification. This distinguishes the label record from other types of records and directs the computer to the label checking routine.
2. Tape serial number. This is a permanent number that is assigned to the particular reel of tape when it is first used. It identifies the reel for inventory purposes and provides a basis for maintaining history of its usage and performance.

3. Program number. This ties the tape to the specific computer run. Obviously, the information is not needed in every label because some files are used in many runs.
4. File number. This identifies the contents of the tape, such as inventory transactions or accounts receivable master records. The file name also may be recorded.
5. Reel sequence number. For multiple reel files, the individual tapes are numbered consecutively to avoid failure to process an entire reel or to process out of sequence.
6. Date of origin. This is the date the information was recorded on the tape.
7. Purge date. This is the date when the reel can become available for use as a "scratch tape" (written over). Its purpose is to prevent unintentional erasure.

Labels are often designed to meet the needs of the particular installation. For example, they may include responsibility codes, such as branch or department number, and they may provide for a count of the number of times a reel is used. In some systems, the tape station for a given tape file may be specified in the program; in these instances, the label may include the number of the tape station.

Computer labeling routines are often supplied by the equipment manufacturer as part of an input-output "package program." In any event, a standardized system of tape labels and label processing procedures should be used in each data processing installation to control every computer run.

CHAPTER SEVEN

OUTPUT CONTROLS

CHAPTER SEVEN

OUTPUT CONTROLS

Output controls provide accountability over documents prepared by the computer. They regulate the assembly and distribution of reports and provide a means of comparing results with predetermined control information. Output controls are not concerned with the accuracy of processing as such, since this is a function of system controls in the input and processing stages.

EXTERNAL REVIEW OF OUTPUT

A computer can be programmed to determine that it processes correctly all of the data it receives. Nevertheless, where the nature of the application permits, the output should be reviewed by someone outside the data processing department to determine the accuracy or reasonableness of the results. Normally the review may be confined to over-all results, accepting the premise that if totals are right the detail constituents are also correct. Control totals, record counts, and other data supplied by an initiating department should be compared to the output whenever the output is adaptable to such comparisons. Where control amounts, quantities, and counts are not involved, the reasonableness of results should be established by comparison with averages, trends, and other independent data.

CONTROL OF OUTPUT RECORDS

Where appropriate, programmed checks can be provided to control the conversion of magnetic tape output to printed documents, punched cards, and other nonelectronic media. For example, record counts and control totals can be developed as the output records are generated. The control records can be accumulated for each type of output. They can be printed on the console typewriter or they can be written on the magnetic tape that is destined for off-line preparation of final output copy.

In this connection, it should be noted that development of control counts and totals serves no purpose if the off-line operations are performed by persons in outside departments who do not check the totals for agreement with the controls.

HANDLING OF REPORTS

There are a number of procedures that follow the mechanical preparation of final output media. Continuous listings must be "bursted" and bound into report covers, multicopy forms must be separated and arranged for convenience in routing, and the reports and documents must be distributed to designated recipients. Generally, these procedures are performed by data processing personnel. Appropriate controls should be established to assure prompt and correct handling.

An output register may be used to record the dates the reports are prepared and released, or the output information may be matched with input control data and recorded in a combination input-output register. Sometimes a report release form, containing delivery instructions for each copy of the report, is used to assure proper routing. Such a procedure is particularly useful where confidential material, such as payroll data, is involved.

EXCEPTION REPORTING

Part of a computer's capability is its ability to analyze records and determine whether or not human attention or action is in order. Through exception reporting, items that require follow-up are printed out and the others remain in the machine's "bookkeeping department." This relieves people of the chore of scrutinizing an entire file of records in order to select those that require human handling. However, the procedure raises a natural question in control: What assurance is there that the computer doesn't overlook a record and fail to report a critical condition? The solution lies principally in programmed control totals and record counts. If these prove out at the end of a job there is very little chance that the entire file was not processed. In the rare event a record is skipped because of operator error or machine malfunctioning, it will be examined by the computer the next time the application is run and be reported out at that time if it is still in the exception status.

CONTROL OF ERROR DATA

When an error is detected by a programmed check, processing branches into a programmed error routine. In some instances the error will be relatively insignificant, in which case the error routine should permit processing of the item to continue after the nature of the error has been written out on an error tape or printed out on the console typewriter. In other instances, the error will be critical enough to warrant rejection of the item from further processing. The control problem here is apparent. What assurance is there that the errors are investigated and, where appropriate, entered into another processing cycle?

There is no single answer to this question, since the character of an error determines the manner in which it should be handled. If error data are reported on a continuous listing, the listing may serve as a check-list in the follow-up procedure. If the data are reported on punched cards, a card count by type of error could be developed by the computer. If the error involves a master file record, an indication that an error condition has been reported can be posted to the master file to serve as a tickler. In this case, the computer, in a subsequent processing cycle, could issue a reminder notice if the error remains uncorrected at that time.

The use of standardized error codes and error reporting formats is helpful in the investigation and control of errors. Such codes designate specific reasons for the various types of errors, thus facilitating correction and reintroduction of the records into the computer.

If a batch of transactions does not prove to a predetermined dollar total, some method of accounting for the difference must be devised. One method is to charge or credit the amount to a suspense account and continue to process the transactions. Details of the batch are printed out, together with the original total and the computer-determined total. After the error is investigated, an appropriate debit or credit entry is processed during the next cycle, clearing the suspense account and completing the procedure.

In general practice, the computer center does not attempt to ascertain that errors and rejects are investigated and resubmitted for processing. It can be of assistance in this area, if assistance is requested by the initiating department. But the EDP center functionally is a service agency and an attempt on its part to control the follow-through actions of the departments being served would be an unwarranted assumption of responsibility.

There is a "law" in computer circles that is generally credited to someone named Murphy. The law states flatly that "anything that can happen will happen." Theoretically, one of the things that can happen is a break in the chain of control at the point of error detection. The computer may reject an item, and the accountable department may fail to investigate the error and return the item for a second try. This possibility should not be overlooked in considering control procedures.

CHAPTER EIGHT

SECURITY CONTROLS

CHAPTER EIGHT

SECURITY CONTROLS

Security controls consist of policies and work rules governing the operation of electronic data processing equipment. They are provided to protect the equipment, data, and programs from known hazards. These include: (a) fire, power loss, humidity extremes, excessive dust, wear and tear, and other physical hazards; and (b) inadvertent or deliberate destruction or alteration by the machine operators.

The auditor's principal interest in security controls relates to those measures that govern or limit the activities of machine room employees. In the system of internal control as a whole, the importance of measures that provide control over the console and restrict access to program tapes and data tapes should be emphasized.

Various security controls provide protection against physical hazards and wrongful actions by employees. Some companies provide fog nozzles or conventional sprinklers within the tape room. Many equip the machine room with fire extinguishers that are designed to smother fires in electrical apparatus. Some prohibit smoking, not because the smoke is troublesome as a form of dust, but because smoking is a fire hazard. In an air-conditioned room, dust control is primarily a matter of cleanliness and reasonable care. Rules should be laid down as to maintenance of tape files, and access to them, and the use of tape labels. Tapes should be kept in enclosed containers and transported in carts made for that purpose.

Security controls usually are designed primarily to promote operating efficiency. From the viewpoint of internal accounting control, however, the principal importance of security controls lies in controlling the operators — against the possibility of inadvertent mistakes or, through taking advantage of weakness in the system, fraud.

OPERATING SECURITY

Computers are equipped with push buttons, levers, dials, and display lights—instruments used in operating and monitoring the system. In many computers these are housed in a desk-like unit that also accommodates an on-line typewriter; in others, they are grouped conveniently on one panel of the central processing unit. In any case, the instrument arrangement is referred to as the console.

The console is the sole means of starting and stopping operations, examining the contents of selected storage areas, and determining the status of the computer and its on-line units at a given point in the program. Also, in some systems it enables the operator to run the machine at slow speed, which is useful in checking individual steps of a program. In addition, it displays information that is useful for maintenance purposes. The console performs many useful functions.

Unfortunately, these multi-purpose uses of the console also afford a degree of latitude to the operator which constitutes an exposure from the viewpoint of internal control. The console operator has complete control over the machine at all times. He can stop its operation at any desired point and modify the contents of internal storage. In so doing, he can alter a transaction or a master file record, change the related control totals, insert a fictitious entry or cause a valid one to be passed over, or even change the course of processing by inserting a program of his own choosing and design. The only way to discourage an irregular intervention of this sort is to adopt countermeasures that make it impossible (short of collusion) for the operator to capitalize on wrongdoing.

The principal countermeasures are, first, to separate data processing personnel from other accounting duties and from all authorizing and custodial duties; second, to impose system controls that will enable the initiating departments to detect any serious tampering with the records; and third, to apply security controls which will prevent unauthorized use of the computer console and, as far as practicable, restrict access to the stored programs and data records.

The Console Typewriter

Ideally, a complete record of console operations would be printed out automatically by the computer and stored in a locked compartment. The operator would not be able to suppress the recording or alter the "log" and, as with cash registers, access to the record would be limited to supervisory or auditing personnel. This ideal has not been reached. Although most of the large-scale computers include a console typewriter, many type only under program control and none provide a locked compartment for keeping a copy of the log.

However, effective use can be made of a computer's ability to log its operations under program control. If desired, the computer can be programmed to display visible evidence of the correctness of its work, recording information such as:

(1) Counts and totals developed by the computer in its balancing of input records.

(2) Tape labels that it has read and checked.

(3) Counts or dollar totals of rejected error data.

(4) Output tape record totals.

Information thus printed out should, of course, be checked manually. Counts and totals should be traced by control personnel to internally developed batch totals and, when applicable, from one run sheet to another. Tape label data should be verified by the machine operator.

As an alternative approach, computers with console typewriters may be programmed to display control data only on an exception basis. As long as record counts, totals, labels, etc., agree with established controls, nothing would be printed out under this method. Obviously, this method is more nearly automatic and therefore requires less time of control clerks. However, many users prefer to know exactly where each application stands at all times, and the choice of approaches may be a matter of preference. The important point is that checking should be done internally by the computer in every case where it is practicable; whether or not it is printed out "for the record" is of secondary importance.

In the normal course of operations, a considerable quantity of console printing takes place that is meaningful to the operators but is virtually undecipherable by others. If the console sheet is to be used as a control record, measures should be adopted to avoid typing an apparent jumble of figures. The format for control counts and totals should be standardized, data should be appropriately labeled, and the use of codes and nonmnemonic abbreviations should be held to a minimum.

In certain systems the typewriter automatically registers some of the activity at the console. For example, in one system, depression of the stop key on the console causes an automatic typing of the nature and location of the instruction being performed at that instant. Also, a read-out of the contents of a specific location in storage is displayed by the typewriter rather than by lights on a panel. In another system, data introduced to memory from the console are automatically recorded by the typewriter. These features provide a permanent, visible record of these operations – a record that would contain tell-tale evidence of a deliberate misuse of the equipment.

Where console intervention is automatically registered in a manner similar to this, the typewriter sheets should be prenumbered, accounted for numerically, and filed in a permanent binder. The sheets should be reviewed by supervisory personnel as soon as feasible after the processing is completed.

Machine Time Records

Continuous time records should be kept at the console. For each production program, the records should show the complement of equipment used (tape units, printers, etc.), the time started and finished, and the nature of any machine-detected errors. In addition, the records should account for all other time in appropriate classifications (testing, rerun, maintenance, idle, etc.).

Machine utilization records are used for many purposes, including:

1. Determining machine rentals.
2. Determining intracompany charges for data processing services.
3. Scheduling the installation.
4. Accumulating equipment performance statistics.
5. Controlling nonproductive time.
6. Analyzing errors.

In addition, machine time records provide evidence that may be useful at times for internal control and auditing purposes. Where machine time is accounted for on a continuous basis, an irregular running would require some entry in the record – one that may be revealing to a discerning auditor or departmental manager. Also, it is conceivable that any "doctoring" of a regular run may require a noticeable increase in machine time, which might also be discernible from the time records.

Figure 20 is a reproduction of a form for recording machine usage.

Rotation of Personnel

To the extent practicable, operating personnel should be rotated from position to position and from shift to shift. This practice tends to minimize any risks that may be involved in allowing an operator to become too familiar with particular programs and associated accounting routines.

Some companies rotate programming personnel through the operating positions. This is done primarily for training purposes, but it is also a measure of internal control.

Operating employees should be required to take periodic vacations.

Investigation of Errors

Operators should have no duties related to the investigation and correction of error data and other rejected items. Error listings prepared by the computer, together with any related source documents, should be returned to the originating departments. Where clerical procedures are necessary to assure subsequent reprocessing, the duties should be performed by control personnel who do not have access to the computer or to the files of magnetic tape.

EQUIPMENT SECURITY

Reasonable care should be taken to assure maximum availability and error-free performance of the electronic equipment. This entails, first, the adequacy of machine maintenance, and, second, the availability of alternative facilities.

Maintenance

There are two types of maintenance, preventive and remedial. Under usual leasing arrangements both are the responsibility of the manufacturer; even when the equipment is purchased, maintenance can be obtained from the manufacturer under contract.

Figure 20. Machine Time Record

DAILY LOG

DATE ______________ PAGE __________

RUN NUMBER	DEPT.	TIME										ERRORS		COMPONENTS USED					REMARKS
		On	Off	Elapse	Code	Production	Preparation	Idle	Rerun	Maintenance	Other	Machine	User	CPU	T/U	C/R	C/P	Printed	

PRODUCTION

01 ACTUAL RUN COMPLETE
02 ACTUAL RUN INCOMPLETE – MACHINE ERROR
03 ACTUAL RUN INCOMPLETE – OPERATOR ERROR
04 ACTUAL RUN INCOMPLETE – INSTRUCTION ERROR
05 ACTUAL RUN INCOMPLETE – DATA ERROR
06 OTHER *

* INDICATE ON REVERSE SIDE

PREPARATORY

07 ASSEMBLY
08 TESTING
09 CHECK OUT
10 PARALLEL RUN
11 DEMONSTRATION
12 MACHINE SETUP
13 OTHER *

IDLE

14 AVAILABLE TIME NOT USED BY OPERATOR
15 AIR CONDITIONING
16 POWER
17 OTHER *

RERUN

22 MACHINE ERROR
23 OPER ERROR
24 INSTR ERROR
25 DATA ERROR
26 OTHER *

MAINTENANCE

21 SCHEDULED MAINT.
22 UNSCHEDULED MAINT.
23 SPECIAL MAINT.

ERRORS

MACHINE

30 ALU
31 STORAGE
32 TAPES–MECHANICAL
33 TAPES–R/W CORR.
34 TAPES–R/W UNCORR.
35 CARD READER
36 PRINTER
37 CARD PUNCH
38 TYPEWRITER
39 OTHER *

USER

43 OPER. ERROR
44 INST. ERROR
45 DATA ERROR
46 OTHER ERROR *

Source: See page 134

The growing demand for maintenance personnel occasionally taxes the capacity of a manufacturer to furnish adequate maintenance service; accordingly, a prudent EDP manager will watch this aspect of his installation carefully and take steps to obtain needed service.

Alternate Facilities

If the nature of a company's operations is such that a loss of a day or two of computing time would be serious, arrangements for alternative processing should be worked out beforehand with a nearby service bureau, data processing center, or another user. This is more than a matter of locating an installation with the same model of computer. It involves finding a computer equipped with a comparable configuration of tape drives, printers and special features, and with sufficient memory capacity to handle each program.

DATA SECURITY

The use of magnetic tape as a medium for recording accounting information presents risks that are peculiar to EDP installations. The principal risk is the unauthorized obliteration of data, since one of the characteristics of electronic processing is automatic "erasure" of information on tape incident to and immediately before the writing of new information. The more common controls to protect data stored on magnetic tape are discussed in the paragraphs that follow.

Tape Retention Policies

A systematic tape retention plan is desirable for several reasons: First, it will prevent the accumulation of an unnecessarily large number of tapes; second, it will assure the preservation of tapes that are needed in the reconstruction of current data, if a reconstruction becomes necessary; and third, it will help prevent accidental or intentional erasure of current data. It is not unusual for a large installation to stock a supply of several thousand reels of tape. When there is no specific retention policy, the usual tendency is to save data tapes for too long a time "just in case we need to rerun the job." A systematic retention plan may materially reduce a company's investment in tapes.

On the other hand, the consequences of releasing a data tape prematurely may be serious. Live data can be destroyed, requiring time-consuming reconstruction procedures. Or, worse, historical data can be erased, eliminating the very means of reconstructing current data if it becomes necessary to do so.

A basic retention plan is known as the "grandfather" method. Here, three generations of tape are involved, the first (grandfather) being insurance against loss or malfunctioning of the second (father) in the process of writing the third (son). In other words, a tape is not allowed to be released for other uses until it becomes a grandfather. This plan works well with master files and associated input transaction tapes.

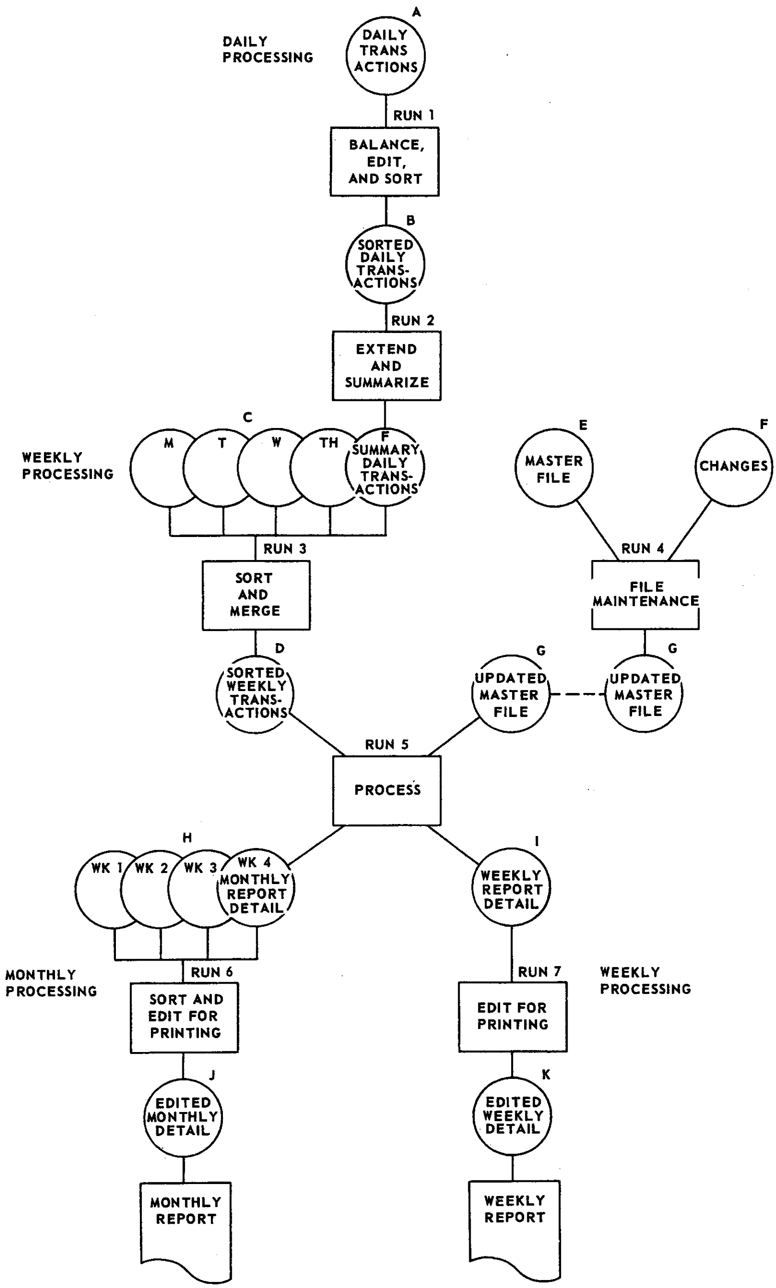
Figure 21 is a flow chart of a series of daily, weekly, and monthly runs which will serve to illustrate an application of the grandfather principle. Tape A expires when Tape C, a grandson, is prepared. Thus, it expires on the same day it is prepared. Tape B, on the other hand, is held until the end of the week when Tape D is prepared. The C tapes for the five days in the week are retained until Tape D is processed in Run 5. Tape D is the grandfather of the weekly report tape, K. It is also the grandfather of the monthly report tape, J; therefore, D expires at the month-end. Tapes E, F, and G expire on the basis of the weekly updating of the master file. Thus, Tape E will become a grandfather and expire when Tape G is used in the following week to produce a new master file tape. Tape F will expire on this basis also.

The grandfather rule is not applicable to certain types of tapes. For example, report tapes should be retained until the printed report is accepted by the recipient. On the other hand, work tapes that are used in sorting runs may be released for other uses immediately.

An appropriate plan should designate a date, computer run, or other expiration basis for each tape that is placed into service. The entire schedule should be reviewed periodically to determine whether retention bases require modification and to determine whether additional tapes should be purchased.

Retention data should be catalogued for reference purposes. In addition, descriptions of individual tapes should be entered on the exterior tape labels. Where appropriate, expiration dates may also be recorded on interior tape labels. This procedure is designed specifically to protect "live" data tapes from being written on and erased. Where necessary, the date of an output tape is calculated by the computer from the label of the related

Figure 21. Flow Chart to Illustrate Tape Retention Requirements



input tape. Before any new data are written on an output tape the label of the tape is inspected by the computer to make certain that its retention date has expired.

In order for this plan to work effectively, however, every program should include a label-checking routine for output tapes; otherwise, the possibility exists that a current data tape will be assigned to an output station of one of the programs that does not include the label-checking routine. Testing programs, single-use programs, scientific programs, and similar programs normally do not include this routine. A supply of tapes should be reserved for these uses. Obviously, because of application requirements or the changing nature of processing schedules, it is not practicable to develop firm expiration dates in all cases.

Exterior Labels

Magnetic tape is visually identified by exterior labels. The descriptive data for a tape are written on an adhesive backed paper label or other medium that can be readily affixed to the reel. Color codes may be used to afford quick identification of tape contents, and the numbering of the reels is often related to indexed storage racks in the tape library. Labels should contain only the information needed to identify the data and facilitate normal usage of the reels. Additional information generally is pointless and can be confusing. Typical labels include the following types of information:

Run number

Date produced

File number or data code

Reel number (for multiple reel jobs)

Date of the work processed

Number and address of tape unit

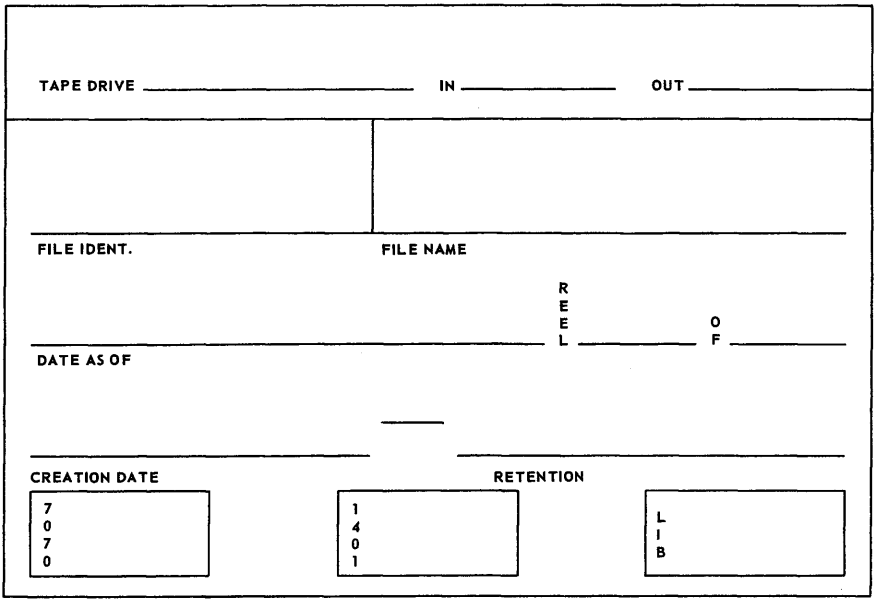
Disposition (next run number)

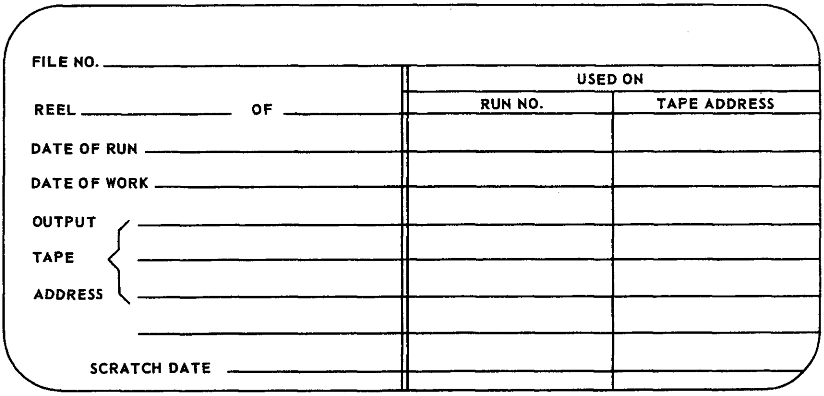
Expiration date

Retention period (number of working days)

Two examples of exterior labels are shown in Figure 22.

Figure 22. Exterior Labels





There should be a clear placement of responsibility for preparing and affixing the exterior labels. In one installation, the labels are printed on the console typewriter and the console operator has the responsibility to see that the tape handlers label the tapes properly. In another installation, the labels are printed in advance on off-line equipment and affixed to the reels by the librarian at the time the tapes are issued.

File Protection Devices

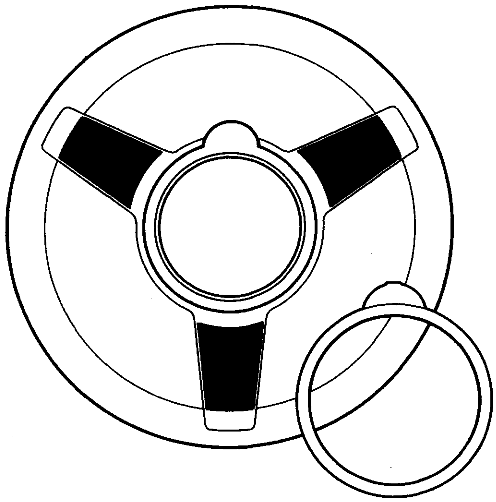
Equipment manufacturers generally provide some device to help protect tape records from accidental erasure. One manufacturer provides a plastic ring that fits into a groove in the tape reel (Figure 23). As soon as an output tape is prepared, the ring is removed from the reel. The computer cannot write on the reel unless the ring is inserted. The protection afforded here is that an extra physical act is required to ready a tape for writing; that is, inserting the ring gives the operator an opportunity to check the exterior label.

Another manufacturer follows the same principle, but reverses its application by requiring removal of the ring to ready a tape for writing. Still another manufacturer provides, in addition to the ring, a manually removable interlock on the tape unit panel which, through programming, can be set automatically after the tape is rewound at the end of a processing run. Until the interlock has been removed, the computer cannot activate the tape unit. For example, in a file maintenance operation, this feature would insure removal of the new file tape before another program could be processed that might erase the contents of the tape.

Tape Library

Tape reels should be stored in an orderly manner to facilitate operations and preserve essential records. Generally, tape reels should be filed in a central location, preferably in a separate room adjacent to the computer room. Storage racks should be appropriately indexed and labeled, and the manufacturer's specifications regarding humidity, temperature, and dust control followed. One person should be responsible for the tape files, either as full-time tape librarian or as a part-time duty. This librarian should be instructed not to issue program tapes or data tapes to systems analysts, programmers, or other unauthorized personnel, since only machine operators should have valid needs for them.

Figure 23. File-Protection Ring



The librarian should keep records appropriate to the number of reels and the frequency of their issuance. The records should contain the following information:

1. The present physical location of any given file (of one or more reels).
2. The name of the person to whom a file or reel has been issued.
3. Designation of copies which have reached their retention ages and are available for use as output tapes.

Fire risks can be minimized by storing certain tapes elsewhere on the premises. One generation of master file tapes and other "grandfather" tapes may be stored in this manner. Duplicate copies of program tapes and permanent or semi-permanent data tapes should be stored similarly.

Some companies maintain separate facilities for storage of permanent records, including the use of underground vaults at remote locations. The records, including tapes, are duplicated and stored at these facilities.

PROGRAM SECURITY

Reasonable care should be taken to prevent accidental or deliberate alteration of machine programs. Block diagrams, test data, program card decks, program tapes, program listings, and other materials making up the completed programs should be physically marked for identification purposes and suitably stored. Duplicate copies of the program materials should be stored for safekeeping in a separate location. Program tapes (and data tapes as well) should be kept under lock and key except during normal working hours. During regular hours they should be issued to equipment operators only upon presentation of set-up sheets or some form of requisition. Library records showing dates of issue and names of persons receiving the tapes should be kept for each program tape.

Program changes should be authorized in writing by the head of the systems development group. Changes initiated by other departments, or those which may affect clerical procedures, similarly should be approved by the heads of the initiating departments. Changes should be fully documented with block diagrams, revised forms, and narrative descriptions, and the completed work should be approved and accepted for production by the persons authorizing the changes. A simple record of changes should be kept showing the effective date of each change and a cross-reference to superseded block diagrams and other materials.

CHAPTER NINE

BUILT-IN CONTROLS

CHAPTER NINE

BUILT-IN CONTROLS

The components of a computer, although inherently highly reliable and long-lived, are subject to external influences which may cause malfunctioning. Examples of such disturbing influences are loss of power, transient electrical disturbances, accumulation of dust, temperature and humidity extremes, and mishandling by operators. The computer manufacturers, recognizing that malfunctioning is bound to occur occasionally in a system composed of many parts, have provided built-in controls which enable the machines to detect automatically the more common types of errors. For the most part these controls are always operative, requiring no additional programming and no manual assistance on the part of an operator.

Built-in controls provide a means of detecting errors immediately after they occur, permitting corrections to be made in the most efficient manner. While built-in controls are important in providing efficient operation, their sole purpose is the detection of errors caused by equipment malfunctioning – a limited purpose as compared with system controls, which are directed at the chain of processing as a whole.

Built-in controls are not designed to detect erroneous data. They are intended only to bring to light erroneous handling of the data within the equipment.

MAGNETIC TAPE UNITS

Magnetic tape operations are subjected to a number of built-in checks. The checks are very effective – to the point that in most systems an auditor may assume that all errors in the reading and writing of tape will be detected. Commonly employed checks are discussed below.

Vertical Parity Checking

A character on magnetic tape is represented by a number of rectangular spots which have been magnetized on the ferric oxide coating of the tape. An individual spot is called a "bit", which is a contraction of "binary digit" and a term which is also used to express the smallest unit of information within a computer. In certain systems, any number, alphabetic character, or special symbol may be represented in a single column of bits across the width of the tape; in others, the digits 0 to 9 are represented in one column, but alphabetic characters and special symbols require two columns. In either case, the vertical parity check is a technique that provides assurance that the column contains a valid representation of data.

This technique is known also as lateral parity checking, frame parity checking, and character code checking. It is accomplished by maintaining either an even number of bits in every column of information on tape or an odd number of bits in every column. (In principle there is no difference between odd and even "parity"; the choice is purely a matter of machine design.) In an "even" parity system, the check bit is added to any character that would otherwise have an odd number of bits. When the tape is read, the character is examined to determine whether it consists of an even number of bits. Every column should have an even number of bits, either because the character itself is made up of an even number of bits or because the check bit has been added to make the count even.

Horizontal Parity Checking

Data are recorded on tape in blocks. A block is the quantity of information that the computer reads or writes in executing a single instruction. As a block is written, the number of bits recorded in each horizontal row is counted. At the end of the block, an extra bit is written in the rows having an odd number of bits. Thereafter, the tape is checked as it is read by developing an odd-even count of the bits in each row of the block. If any row of the block indicates an odd number of bits after it is read, an error is indicated. The technique is known as horizontal parity checking or longitudinal record checking.

Some systems maintain an odd number of bits in the horizontal rows. The difference, again, is one of technique rather than principle.

Automatic Error Correction

When parity is checked vertically and horizontally, a computer can be designed to isolate a detected error. The process may be compared with footing and crossfooting a payroll register, where an error in a line and an error in a column will identify both the employee and the amount entered in error. One line of machines features an ability not only to isolate an error in this manner but to correct the tape record as well. The technique is partly automatic and partly program-controlled. An instruction is available to the programmer which causes the computer to write the horizontal parity bits of a tape record in "Orthotronic" control words, which become part of the record written on tape. Subsequently, when the tape is read, the rows are "crossfooted" automatically. If an error is detected, processing transfers to a programmed routine which locates the erroneous bit position and corrects the tape record. The procedure eliminates manual intervention and idle computer time, factors that are frequently associated with other error correction and restart procedures.

Reading After Writing

In certain tape units, a reading head is stationed immediately behind the writing head. This enables the computer to read information immediately after it is written. Vertical and horizontal parity checking is thereby performed automatically during tape writing. It is performed again, of course, when the tape is read in a subsequent run.

Dual Level Sensing

The ability to read immediately after writing affords another means of checking, which the manufacturer calls "dual level sensing." Here, the signal strength of each bit of recorded data is tested to determine whether it meets certain standards. The test may disclose that the recorded signal is too weak or that random "noise" on the tape is interfering with the recording. In either case, the machine may be instructed to backspace the tape and rewrite the record, again checking for an error in parity or signal strength.

Character Counting

When a system operates on "words" containing a fixed number of characters, an automatic count of the number of characters in each word transferred to or from tape may be provided. An error condition would develop whenever the full number of characters in the word is not transferred.

In other systems, the character counting check is based upon groups of words. In one system, the character count error occurs when a multiple of six characters (one word) is not available to read or write. In another system, error is indicated when more or less than 720 characters (one block of sixty twelve-character words) is transferred from magnetic tape to the input area.

Dual Recording

In one line of computers, the bits of each character are recorded in duplicate across the width of the tape. This provides high probability that at least one set of bits will be recorded correctly. If either one of the two records for a single bit passes the parity check (made immediately after the character is written on tape) the recording is accepted as a valid character.

PROCESSING UNITS

The reliability of the internal operations of a computer is without parallel in other methods of data processing. On infrequent occasions, however, a bit may be dropped or gained in the flow of data through the electronic circuitry, or some other type of malfunctioning may occur. Therefore, certain built-in checks are provided by the manufacturers to detect processing errors.

Parity Checking

As in magnetic tape operations, internal parity checking is accomplished through use of "redundant" bits. In many systems, an extra bit is associated with every digit or character within the system that otherwise would contain, say, an odd number of bits. The parity bit would not be affixed to characters that contain an even number of bits. In these systems, every character is checked at various times to ascertain that it contains an even number of bits.

The parity bit sometimes is applied to words or portions of a word rather than to individual characters. Thus, in one system a word consists of three alphanumeric characters plus a parity bit if one is needed to make an even number of total bits. Internal checking is accomplished by generating and storing the parity bit when the word is transferred to memory, and recomputing and verifying the presence of the parity bit when the word is read from memory.

Parity checking stations are located at various points in the circuitry – in the circuits which transfer data to and from core storage, and sometimes elsewhere as well. Also, as previously mentioned, stations are often placed between the tape units and the input-output areas, which may be "buffer" areas that are separated from the main memory.

Some systems make no provision whatever for internal parity checking and therefore have no means of checking the storage and transmission of characters or words. Bits are lost or gained occasionally in all computers and in a given application such an error, if undetected, could lead to serious consequences. For example, a loss of one bit could change a seven to a six in a typical computer. If this occurred without detection when two equal numbers were being compared during a computer program, processing would branch incorrectly to the sub-routine provided for unequal items.

The problem as to parity checking is similar to that concerning key verification of manual card punching. Obviously, it is unnecessary to check every item of information that is key punched and it is similarly unnecessary to check the internal processing of every item of information. But mistakes in certain data fields cannot be tolerated. To detect mistakes in these critical fields, system checks should be provided through programming or otherwise when the computer does not feature built-in parity checking.

Validity Checking

A character may pass the parity check and still be invalid, in that the configuration of bits may not comprise a meaningful representation to the computer. Therefore, in many systems an automatic "validity check" is performed on the characters that are processed. The technique is also referred to as the "illegal character check." In smaller machines, the check may be applied only to the reading of characters from the principal input unit, such as the card reader. In large-scale systems, however, the check may be applied to the transmission of data from all input units, including magnetic tape, to memory and from memory to the various output units. In some large-scale systems, it is also applied to all movements of data from memory to any point within the system.

Validity checks also are used extensively to test coded combinations of two or more characters. Small-scale systems usually are designed to detect automatically an improper storage address, and the larger systems are designed to test the validity of operation codes as well. Such tests are usually limited to the composition of instruction codes. Checks also may be provided to test the validity of data codes, such as account numbers and transaction codes. However, checks of this type are not built-in and therefore must be programmed.

Fixed Count Checking

In one of the large-scale computers, a decimal digit is represented by a combination of only two bits, under a system known as two-out-of-five coding. An alphabetic or special character is represented by two decimal digits. This provides a means of checking that serves the same function as that of parity checking. The check is simply a test of every digit that is moved to and from core storage to assure that it has two bits, no more and no less.

Duplicate Circuitry

Duplicate "circuitry" refers to the duplication within the computer of certain electronic elements as well as circuits. The duplicate facilities are provided for one reason alone – to check the accuracy of selected processing operations. Most manufacturers believe that the checking circuits are not worth their additional cost in view of other available checking methods.

An early large-scale computer featured the following duplicate circuitry: (1) duplicate arithmetic units, including a comparing device and registers for storing numbers to be operated on and the results of the operations; (2) duplicate transmission lines between the registers and the memory; and (3) duplicate counters concerned with the sequencing of instruction addresses. The facilities provide for a continuous comparison of the contents of the storage and transmission elements and of the results of all arithmetic and comparing instructions. The checking is done automatically (without stored instructions), without loss of computer time.

Double Arithmetic

In lieu of duplicate circuitry, double arithmetic may be provided as a built-in means of checking the accuracy of arithmetical operations. In one method, each arithmetical operation is performed twice, first with the original operands and then with complement numbers, and the results are compared. The checking is done automatically, without additional programming.

Interlock Circuits

Interlock circuits of one type or another are provided in all computers. These preserve a record until it has been completely processed, protecting it from premature obliteration by another record. For example, interlock circuitry may be provided to inhibit: (1) the reading of data from an input unit while the input buffer or storage area is engaged in transferring other data; (2) the writing of data on an output medium while the output buffer or storage area is engaged in transferring other data; and (3) the initiation of a tape instruction while the tape specified is moving or rewound and locked.

RANDOM-ACCESS STORAGE UNITS

Random-access storage units, like magnetic tape storage media, are subject to the hazards of illegible writing and inadvertent erasure. Therefore, the built-in control techniques that are provided for magnetic tape storage are provided also for the random-access storage units.

Random-access devices come in various forms, including magnetic disks, magnetic cards, and large-capacity magnetic drums. The control techniques, however, are similar regardless of the form of the device.

Parity Checking

Parity checking is employed to one extent or another in all random-access storage devices currently available. It is universal practice, for instance, to carry parity bits as part of the data in the files. Generally, the method employed follows that used to control the internal operations of the computer. Thus, if characters are manipulated internally in a seven-bit character code with a check bit to maintain an odd parity count, the same coding and checking method also is applied to the operations of the random-access device. Similarly, if the check bit is associated in the computer with a word or a portion of a word rather than with an individual character, the same plan is carried over into the random-access device. Normally, the parity bit is proved when data are added to the file or the file is changed in some way and it is proved again when data are read from the random-access storage device.

Another technique involves the use of "check characters." These characters are generated by counting bits in the respective positions of every character of a disk record. The count is recorded automatically on the disk and, when the information area is read in a subsequent operation, new check characters are automatically generated and compared with the check characters previously placed on the disk. The technique is similar, both in function and method, to horizontal parity checking in magnetic tape operations.

Reading After Writing

Several systems provide for an immediate comparison of data written on the random-access medium with the data in the memory locations from which the data were written. In some systems, the comparison is fully automatic so that all writing is checked while it is being done. In others, it is performed at the option of the programmer, using a special instruction that causes a character-by-character and bit-by-bit comparison.

Address Checking

Several systems feature an automatic means of ascertaining that the correct record in the random-access file is located. The "record" may be a customer's account, an employee's earnings record, or whatever may be applicable to the particular application. The address of a record is carried as a part of the data content of the record. Selection of a record is verified by comparing the address specified in the program with the address contained in the record actually located. The comparison is automatic in that it does not require programming.

COMPUTER-CONTROLLED INPUT-OUTPUT UNITS

On-line input-output units are largely electromechanical in nature and therefore not as inherently reliable as the purely electronic hardware. Accordingly, most of these units are equipped with built-in checks to detect mechanical errors in the input-output operations.

Card Readers

The most effective built-in check on the reading of cards into the computer employs two reading stations, each containing a separate set of reading brushes. In readers equipped in this manner, a reading error at one station would ordinarily be caught at the other station, there being little chance of a compensating error in both stations. In one system, the information read at the two stations is compared in detail. In another, counts are made at each station of the holes in each column of the card, and the counts are compared before the information is transferred into storage.

The reading check is usually supplemented with a validity check or a parity check, the method varying from system to system. In one system, a validity check is performed as the card is read. This determines whether the conversion of the punched card character results in a valid character in the computer's code. It permits detection of an invalid character before the information is placed in the input buffer. In another system, a parity check is made as the card is read. This determines whether the resulting computer character contains an odd number of bits, as it should in the particular system. In this case the check is made after the information is placed in the input buffer, but before it is transferred to the main memory.

In one system, the reading is not checked by hole-count or otherwise, and the conversion to computer coding is not checked for parity or validity. The first check occurs when the data are moved from the buffer to the main storage. At that time, each digit is checked for validity. In another system, even this test is omitted, resulting in a complete absence of checks on the reading of cards and the transmission and storage of related data. Obviously, the necessity for providing other controls, including programmed controls, should be carefully considered in installations of this type.

Card Punches

Where the computer produced cards as an output of processing, built-in controls serve to check the accuracy of card punching. Effective checking of card punching operations also requires the use of two stations. The punching is performed in the first station and the holes are read in the second. In some systems, the reading is checked back against an exact "image" of the data which were previously stored in the output buffer. In other systems, hole counts are made in each station and the punching is accepted if the two counts agree. The counting may be done vertically for each card column or horizontally for each row, depending on the make of the equipment.

This check is not featured in all systems. In one large-scale system the only check on the punching operations is a validity check performed as data are moved from the output buffer to the punch unit. In one medium-scale system the only check is the so-called "double-punch blank-column detection" test. This test, which is used extensively in standard punched card machines, is effected by wiring an external control panel for the particular column to be tested. If a column should always be punched with a numerical digit, the test would automatically detect punching of an alphabetic character (double punching) or failure to punch (blank column).

Line Printers

The "echo check" is the most common method of checking on-line printing operations. Here, the position of the print mechanism for an individual character is sensed at the moment printing occurs. The mechanism may be a print wheel, a type bar, a wire head, or a revolving chain. The "echo" created by this sensing operation is checked to insure that it represents the same character that was sent from storage. It is not a positive check, for the "echo" that is relayed back to the output storage is not a reading of the character that actually was printed. But it is an adequate check for all practical purposes.

Systems that do not feature echo checking rely chiefly on parity checking. This may be performed when characters are read into the print buffer, when they are read out of the buffer, or at both times. Also, the parity bit may be associated with each character or it may be associated with a group of characters or "word." These systems also provide for a continuous checking of mechanical synchronization to assure that the printing mechanism and internal timing pulses agree.

Paper Tape Readers and Punches

On-line paper tape readers are usually equipped to check all characters for correct (vertical) parity if the tape contains parity punches.

Parity checking is also used in the on-line punching function. The check is made when information is transferred from memory to the punch unit.

Magnetic Ink Character Readers

Many computers may be equipped to read MICR (Magnetic Ink Character Recognition) documents, which represent a form of input used principally by banks in the United States. Generally, the reading is performed by a document-handling machine that has the ability to sort checks and other documents, either as the data are read into the computer or as an off-line operation.

Validity checking circuits are usually provided in the readers. These enable the machines to detect a character that does not represent one of the fourteen characters (ten digits and four symbols) prescribed by the American Bankers Association. In addition, a count is made of the number of characters in a field to determine the validity of the length of the field.

In the typical reading operation, a parity bit is affixed to each character when it is converted to the internal code of the computer. Parity is then verified when the character is received by the computer.

Certain MICR readers may be equipped with a self-checking number device which permits automatic verification of encoded account numbers during the reading or sorting operations. This checking technique is classified as an input control.

Optical Scanning Equipment

Optical scanning, or optical character reading, is a term used to describe the mechanized reading of data which are printed or written in a form that is also readable by a human being. The data read in this manner may be transferred directly into the memory of a computer or translated into punched cards, paper tape, or magnetic tape. In a typical process, a character on a source document is illuminated by an intense beam of light. The resulting reflection is focused onto a revolving disk containing a series of slits. The image passes through the slits to a photo-sensitive tube which converts the reflected light into electrical impulses. The pattern of "black and white" signals created in this manner is then analyzed in a series of tests which enable the equipment to "recognize" specified characters.

Optical scanning is gaining acceptance as an input method. It is used, for example, to create paper tape records from data recorded by credit card imprinters. It is also used by public utility companies to read cash payment stubs and meter reading records.

Optical readers do not contain facilities for checking the scanning and interpreting operations. Where practicable, therefore, critical fields of information should be checked in some other fashion. One method is to employ check digits with account numbers and similar codes. Calculation of the check digit would be proved on the computer, either immediately after an on-line reading operation or in a subsequent processing of media created by the reader. Where it is not practicable to provide an effective system check, the importance of the data should be considered carefully in order to evaluate the consequences of inaccuracy.

Parity checking facilities are generally provided in optical scanning equipment. Usually the parity bit is generated when a character is converted to the machine code and verified when it is read into the computer.

CONVERSION UNITS

As used here, conversion refers to the transfer of data from one medium to another, such as from punched cards to magnetic tape or from magnetic tape to printed copy. In the larger installations these tasks are performed by one or more auxiliary computers whose sole function is to relieve a larger computer of these relatively time-consuming operations. The preceding discussion of built-in controls applies in all respects to conversion operations performed in this manner, since the various card readers, tape units, card punches, and printers are operated on-line by the auxiliary computer under this method.

Often, however, the conversion functions are performed off-line by independent units of equipment. Here, the control techniques are the same as those used in on-line operations but they may be combined in various ways because of the variety of available machines and media. A few examples will be cited.

Cards to Magnetic Tape

In one system, the off-line conversion of data from punched cards to magnetic tape is verified through use of a second reading station to check the card operation and a read-write head on the tape unit to test vertical and horizontal parity immediately after a record is written. In addition, the record transmitted to the tape unit is compared against the record read from the card. This is accomplished by developing an odd or even indication of the bit structure of the horizontal rows of the card. After the characters are converted to machine code and sent to the tape unit, they are reconverted to card code. A second indication of the odd or even bit structure of the rows is then developed and compared with the first indication.

Magnetic Tape to Cards

The off-line conversion of data from magnetic tape to punched cards involves use of a number of standard checking techniques. In one system, each character is tested for parity and validity and a horizontal parity check is made of the record to be punched. In addition, row counting is utilized to check the record received from tape with the record that is actually punched. An odd or even bit indication of the number of bits for each bit row is developed as each character is translated to card code. After the card is punched, it is read at a checking station and an indication of the number of bits for each row of the punched record is developed. The two sets of odd-even indications are then compared for equality.

Magnetic Tape to Printed Copy

Off-line printers generally contain facilities for checking the vertical and horizontal parity of records read from magnetic tape into the print storage unit. In addition, an "echo check" is provided to check the printing operation. This involves sensing the position of the printing mechanisms at the instant printing occurs and comparing the information indicated by the sensed positions with the information in the print storage unit.

In standard-speed printers (150 lines per minute), the echo check is performed on a line-by-line basis. It represents a comparison of two indications of the odd or even content of the bits in each horizontal bit row of the record. On high-speed printers (500 or more lines per minute) the echo check is usually performed on each individual character.

TRANSMISSION UNITS

The various types of facilities for transmitting data over telephone, telegraph, and microwave networks are discussed in Chapter Three. In these systems, the distance factor increases the need for control. The techniques for controlling the initial issuance of source documents and the final review of output reports and error data are especially pertinent to these situations. Similarly, system controls are important in controlling the transmission operation; record counts, hash totals, and other methods are usually needed to control the quantity and quality of data transmitted.

Built-in controls supplement the more basic controls by providing for the immediate detection of transmission errors.

Five-Channel Paper Tape Facilities

Five-channel paper tape is used principally for transmitting data via telegraph and Teletype circuits. It is not a self-checking means of data communication, because the system does not provide for transmitting parity bits. However, the operations can be checked automatically with the aid of accessory devices. The tape punch at the sending location may be equipped with a "code generating unit." During the perforation of the tape, this unit automatically counts the number of holes punched in the tape and punches an indication of the count in a check code at the end of the record. At the receiving end the transmission can be verified when the paper tape is converted to cards. A comparing unit must be attached to the converter. This unit develops an independent count of the punched holes as the body section of the record is punched into cards. The count accumulated by the comparing unit is compared with the check code punched in the tape and an indication of the results of the comparison is punched in a designated column of the card.

Other Facilities

Accuracy in long-distance data transmission is more readily achieved with media other than 5-channel paper tape. These include 6, 7, and 8-channel paper tape; punched cards; and magnetic tape. Data transmitted in one medium can be received in another (e.g., data sent on punched cards can be received on magnetic tape). The information also can be received as printed copy. In fact, cards, tape, or other media can be bypassed entirely in systems that link two computers with a direct flow of data from one core memory to another.

Standard checking techniques are incorporated into the new transmission facilities. These include vertical and horizontal parity checking, record counting, and retransmission on detection of error. The extent to which automatic checking is featured varies from model to model.

CHAPTER TEN

ORGANIZATION AND PERSONNEL

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A system of internal control is essentially a system of checks and balances designed to assure the integrity of reported transactions. The segregation of duties and responsibilities of personnel is a vital part of the system. Most transactions involve a series of actions – and all transactions require more than one action. Control is founded upon the principle of participation by different persons in the actions required to effect a transaction. The participation should be real, not merely perfunctory.

More precisely, control usually involves a separation of the authorizing, custodial, and accounting functions in the plan of organization.

Typical arrangements providing control over various types of transactions and activities are illustrated in Figure 24. Among other features, it will be observed that accounting for the transactions is performed by the controller's department, which functions independently of the departments that authorize the transactions or have custody of related assets. Similar separations of functional responsibilities should be maintained under an EDP system.

ORGANIZATION – EDP DEPARTMENT

EDP personnel should have no duties or responsibilities relating to the authorization or initiation of transactions or the custodianship of funds or physical assets. This requirement generally is met when the data processing group reports to the chief accounting officer or one of his staff. It is not met when the data processing center is attached directly to an operating or custodian department.

Figure 24

ILLUSTRATION OF
THE FUNCTIONAL SEGREGATION OF RESPONSIBILITIES
AND DUTIES IN A SYSTEM OF INTERNAL CONTROL

Purchasing

Authorization

Purchasing Agent (Manufacturing) receives purchase requisitions, obtains bids, and prepares purchase orders.

Custody

Stores Department (Manufacturing) prepares purchase requisitions, checks materials against receiving reports, accepts materials, and enters account distribution.

Receiving Department (Manufacturing) receives and counts materials and prepares receiving reports.

Accounting

Accounts Payable Department (Controller) compares vendor invoices with purchase orders and receiving reports, checks prices, extensions and terms, prepares accounts payable vouchers, checks account distribution, and records liabilities in voucher register.

Cash Disbursements

Authorization

Authorized personnel prepare check requests.

Custody

Cashier (Treasurer) issues checks, with appropriate counter-signatures, from approved vouchers and check requests, cancels supporting documents, and mails checks and enters them in check register.

Accounting

Accounts Payable Department (Controller) enters payments in voucher register.

General Ledger Department (Controller) posts vouchers payable control account.

Charge Sales

Authorization

Order Department (Sales) prepares sales orders.

Credit Manager (Treasurer) approves credit terms.

Custody

Shipping Department (Manufacturing) ships from approved orders.

Accounting

Billing Department (Controller) enters and checks prices and prepares sales invoices.

Accounts Receivable Department (Controller) posts customer accounts.

General Ledger Department (Controller) posts accounts receivable control.

Organizational independence occurs in natural course in most EDP installations because operating needs usually require assignment of the EDP responsibility outside the departments being served. However, the objectives of control are not achieved through organizational independence alone. Effective control requires appropriate arrangements of duties, system controls, sound practices, and qualified personnel.

Arrangement of Duties and Responsibilities

The data processing unit should be organized in such a way that duties relating to the handling of source documents and related input media, the operation of the machines, and programming and systems analysis, are assigned to separate individuals or sections.

Programmers and Operators

The separation of programmers and console operators generally presents no problem in the initial stages of the development of an application. It is customary for the groups to report to separate supervisors and for the supervisors to report to a manager of the over-all data processing function. In the final stages of programming it becomes more difficult to enforce the separation. The organizational lines remain, but the requirements of program testing and parallel operation bring the programmers and machine operators together in a common effort. There are no control objections to this as such because the programs are not operational at this point. But permissible intermingling of functions at this stage should not carry over as operating practices; for example, programmers should not be permitted to run the console under operating conditions.

From time to time a need arises for further programming after the initial programs have been completed and put into operation. Changes become necessary in order to improve the efficiency of the original program, to give effect to changes in system requirements, or to accommodate changes in the configuration of equipment. Also, it is not unusual to encounter minor errors in a program long after it has become operational. Program "patching," as this work is called, is often assigned to a person known as a maintenance programmer. It is not unusual for this person to report to the manager of computer operations rather than to the manager of programming; the latter practice is preferable for internal control purposes. The position requires intimate familiarity with the company's programs and a knowledge of machine operating procedures and schedules. Security controls, which regulate and document console operations and access to programs, apply particularly to this position.

Close consideration should also be given to the position of console operator. Generally, the person in this position develops considerable skill in programming through his participation in program testing. Even though he may have no programming duties as such, his combined knowledge of programming and machine operations dictates a need for strict control of his activities.

Input-Output Personnel

Source documents should be handled only by control clerks, key punch operators, and others who are directly engaged in transcribing the source data to cards, magnetic tape, or other input media. Such employees should have no duties relating to the operation of the EDP equipment and, conversely, the computer operators should not be required or permitted to handle the source documents.

Control Clerks

Control clerks are retained in larger installations to check the receipt of source documents or input media, to determine that output results agree with batch totals and other predetermined control records, and to monitor the disposition of output documents and reports. Obviously, these employees should have no duties relating to programming or processing.

The Tape Librarian

Custody of a company's supply of magnetic tape is sometimes assigned to a tape librarian, either as a part-time or as a full-time duty. The main function of the librarian is to accept, store, and issue reels of tape according to an organized system of filing and labeling. When hundreds or thousands of tape reels are in use, a systematic approach must be followed in order to avoid accidental destruction of records and to expedite machine set-up operations.

When the responsibility is delegated to one person, additional controls can be applied to discourage unauthorized manipulation of program tapes, master file tapes, and data tapes. For example, the librarian alone should have access to the tape files. Issues to operating personnel should be made on a requisition basis or under an approved schedule for repetitive runs. The separation of programming and operating functions can be sharpened by instructing the librarian to issue tapes to operating employees only.

Qualifications of Personnel

In the EDP system, the importance of employee competence is accentuated. While the machines do much of the work, competence in programming and other functions spells the difference between successful and unsuccessful processing by the machines. Errors can be made at any point in the flow of data where human assistance is involved. For example, errors can be made in preparing the source documents, in punching cards, in setting up the equipment, in analyzing error conditions detected by the computer, and in the handling of output reports and documents. Some of the errors could escape detection and those which are brought to light require investigation, which is time consuming.

Competence in the programming group contributes greatly to a smooth and orderly conversion to electronic data processing. It is also important to the development of an adequate system of internal control. Programmers and system designers having accounting backgrounds are often more control-minded than nonaccounting employees, and for this reason applications developed by accounting employees are apt to contain a more effective network of controls.

There are a number of practices which are helpful in developing and maintaining a staff of qualified employees. Careful determination of the educational and experience requirements of each position will provide a sound basis for hiring new employees. On-the-job training programs will help the employees attain the required skills. In addition, records of employee performance will prove helpful in determining an employee's readiness for promotion or transfer to a new position. In this connection, useful information may be obtained from two records from the machine room: machine time records, showing the time spent on reruns and other indications of inefficiency, and error records, showing the types of errors detected by the computer and the frequency of their occurrence.

THE ELIMINATION OF CLERICAL CROSS-CHECKING

An installation of EDP equipment usually results in the mechanization of clerical duties previously performed by many people. On the surface this may appear to be a weakening of internal control, since it eliminates the opportunity to apply cross-checking controls. In a manual system cross-checking from person to person serves two important control functions: (1) it promotes accuracy and consistency in the processing operations, and (2) it discourages dishonesty by imposing a need for collusion. When the cross-checking operations are mechanized, there is a natural question whether some loss of control over these functions may be involved.

Actually, the reverse usually is true. From a mechanical viewpoint, accuracy and consistency in the processing can be taken for granted in electronic data processing since the machines cannot, in the absence of intended manipulation, deviate from the system prescribed in the programs. Diagnostic tests and preventive maintenance work by service representatives lend additional assurance that the high inherent capacity for error-free performance will be maintained. Thus, when a system is properly programmed and the machines are properly operated, accuracy and consistency in the processing are virtually guaranteed.

Similarly, elimination of the cross-checking operations generally does not lessen the need for collusion to effect an intentional irregularity. The clerical duties that are mechanized usually relate to the accounting function and those that relate to the initiation and custody functions continue to be performed manually.

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