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Auditing On-Line Real-Time Electronic Data Processing Systems.

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DATA PROCESSING SYSTEMS.**

**The Louisiana State University and Agricultural
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Accounting**

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AUDITING ON-LINE REAL-TIME
ELECTRONIC DATA PROCESSING SYSTEMS

A DISSERTATION

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Accounting

by

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ABSTRACT

It is rapidly becoming evident, with the advent of on-line, real-time (OLRT) systems, methods of control and auditing procedures devised for batch processing systems are becoming obsolete.

In an OLRT system it will no longer be feasible to audit "around" the computer comparing source documents with final output. Neither can reliance be placed on independent confirmation or physical observation. The auditor may find it necessary to be on hand regularly in the client's place of business to assure himself that proper controls are being effectuated.

In developing new techniques to audit technologically advanced systems the auditing profession must concern itself with: the technical orientation of the auditor; his participation in system design; the utilization of test decks; and the time period of the audit. This study places these issues within a proper framework and sets down guidelines to be used in auditing an OLRT system.

To be effectively controlled and audited, an OLRT system must be understood. It is impossible for an untrained person to adequately evaluate the properties of such an advanced system. Since the auditor must have a workable knowledge of the concepts, hardware and system configurations applicable to real-time systems, a detailed coverage of these technical matters is presented in the study.

Once the auditor is familiar with the system configuration and equipment capabilities, he is in a position to evaluate existing internal controls. An evaluation of controls developed for batch processing systems shows them to be inadequate for OLRT systems. A further analysis of

controls shows the following to be of prime importance: (1) controls to assure that all messages sent are properly received and processed; (2) checks to prevent unauthorized data transmission and receipt, destruction of internally stored data, and simultaneous updating of internally stored files; and (3) provisions for emergency procedures.

The adequacy of internal control serves as the basis for collecting competent evidential material. Although the development of OLRT systems will have no effect on the function of the auditor, drastic changes in auditing techniques will occur, since traditional techniques are no longer feasible due to the nature of such systems: (1) there is an absence of source documents in a majority of instances; and (2) once an error is introduced into the system, it can go undetected indefinitely.

With the coming advance and implementation of such systems more emphasis must be placed on the use of the computer to perform auditing tasks. In addition to more stringent use of programmed controls, it is proposed that the auditor increase his use of test decks and exception reporting and develop special computer programs to perform previously manual tasks. Two case applications serve to illustrate the practicality of these proposals.

This study emphasizes throughout that, in a real-time system, auditing tasks must be performed along with regular processing on a continuous basis rather than once a year.

CHAPTER I

INTRODUCTION TO THE STUDY

Historically, auditors have been viewed as backwards looking persons, interested only in yesterday's transactions. However, due to modern technology, the role of the auditor (both internal and independent) has been expanded to include nearly every phase of business activity. With the advent of electronic data processing, the auditor must look forward and develop his role in light of contemporary circumstances.

Function of an Auditor in an EDP System

Since it is generally accepted that the role of the auditor has been greatly influenced by electronic data processing, it is first necessary to analyze the extent and nature of this influence.

The best starting point in detailing duties of the auditor is to first define management's responsibility. The American Institute of Certified Public Accountants has made the following statement:

Management has the responsibility for adopting sound accounting policies, for maintaining an adequate and effective system of accounts, for the safeguarding of assets, and for devising a system of internal control that will, among other things, help assure the production of proper financial statements.¹

¹American Institute of Certified Public Accountants, Statements on Auditing Procedure, No. 33, (New York: American Institute of Certified Public Accountants, 1963), p. 9.

Therefore, the responsibility for the preparation of accurate and adequate financial statements rests with the management of a firm. The objective of the audit is to examine the records of a company in sufficient detail to express an opinion as to the adequacy and accuracy of management's statement or results of operations, and this objective remains whether the system being audited is manual or electronic.

Basically, the objective of auditing can be reduced to three necessary fundamentals:

1. To determine that the source-accounting data validly records the occurrence of a transaction or the existence of an asset or liability.
2. To check the accuracy of the processing and summarizing of the source-accounting data.
3. To review the completeness of the disclosure of the processed and summarized data in financial reports.²

The most substantial impact of EDP on auditing is on the second object, that of checking the accuracy of the processing and summarizing of the source data.

It must be remembered in considering the effect of EDP on auditing that there is nothing unique in the basic concept of data processing. The arrangement of transactions into meaningful information, whether done manually, by punched cards, by accounting machine or by computer is essentially the same procedure. Therefore, the introduction

²Kenneth G. Cadematori, "Auditing Automated Data Processing," Federal Accountant, Vol. 8 (June, 1959), p. 27.

of a computer is merely another way of performing the same task. However, when the computer takes over more and more of the familiar operations the function of audit becomes more deeply involved with EDP.

With respect to the internal auditor, the audit functions fall into four distinct, but related, aspects, regardless of the processing methods employed. They are:

1. Assure that data-processing procedures have been correctly performed.
2. Ensure that each transaction has received proper authority for its origination and that these authorities lie within organization policies.
3. Ensure that the results of data processing operations lie within organization intentions, forecasts and policies, and that deviations are examined and acted upon.
4. Assure that planned policies and forecasts correctly reflect appropriate action by management to remove or reduce deviations in future budgetary cycles.³

The first two aspects are concentrated upon mainly in manual data processing systems, while the introduction of EDP brings the latter into being and, "indeed, may well focus audit on these aspects rather than on the detail of the data processing operations themselves."⁴

Charles E. Grody, general auditor for New York Life Insurance Company, views the role of the internal auditor in the electronic era as being dual.

³D. W. Hooper, "Impact of E.D.P. on Audit Technique, With Particular Reference to the Internal Auditor," Vol. 148 (February 23, 1963), p. 217.

⁴Loc. cit.

First, he must be prepared to provide advice and assistance in the establishment of new procedures based upon the use of electronic data processing equipment and, second, he must review his own techniques and approaches in order that he may effectively review and appraise the data produced under these new procedures.⁵

The introduction of EDP appears, therefore, to have little impact on auditing as an art; however, it apparently gives the auditor a broader sphere in which to fully develop the audit function.

Impact of EDP on Auditing

Computer utilization has been responsible for expansion in both the scope and operation of business information systems, and today the auditor faces not only automation but also a whole new systems concept.

A suitable framework for analyzing the effects of EDP on auditing would be a study of the objectives, standards and procedures which are generally accepted by the auditing profession.

Effect on Objectives

It was previously established that EDP has not altered the basic auditing objectives which still remain:

1. To determine the validity of the source data.
2. To check the accuracy of the processing and summarization of the data.
3. To review the completeness of the disclosure of the processed data in financial reports.⁶

However, while the objectives of the audit remain unchanged the procedures used to accomplish these objectives have been altered in

⁵Charles E. Grody, "Auditor Encounters Computers," Internal Auditor, Vol. 16 (March, 1959), p. 32-3.

⁶Kenneth G. Cadematori, op. cit., p. 28.

certain instances. These procedural changes will be discussed subsequently.

Effect on Auditing Standards

It seems reasonable that auditing standards, established in light of the forementioned objectives, would be independent of the accounting system and method of data processing. Here it is necessary to review the three groups of standards (general, field work, and reporting⁷) approved by the American Institute of Certified Public Accountants. These standards are as follows:

General Standards

1. The examination is to be performed by a person or persons having adequate technical training and proficiency as an auditor.
2. In all matters relating to the assignment an independence in mental attitude is to be maintained by the auditor or auditors.
3. Due professional care is to be exercised in the performance of the examination and the preparation of the report.

Standards of Field Work

1. The work is to be adequately planned and assistants, if any, are to be properly supervised.
2. There is to be a proper study and evaluation of the existing internal control as a basis for reliance thereon and for the determination of the resultant extent of the tests to which auditing procedures are to be restricted.

⁷It is assumed that the standards of reporting are completely independent of the system being audited and, therefore, they are not given detailed treatment in this study.

3. Sufficient competent evidential matter is to be obtained through inspection, observation, inquiries and confirmations to afford a reasonable basis for an opinion regarding the financial statements under examination.

Standards of Reporting

1. The report shall state whether the financial statements are presented in accordance with generally accepted principles of accounting.
2. The report shall state whether such principles have been consistently observed in the current period in relation to the preceding period.
3. Informative disclosures in the financial statements are to be regarded as reasonably adequate unless otherwise stated in the report.
4. The report shall either contain an expression of the opinion regarding the financial statements, taken as a whole, or an assertion to the effect that an opinion cannot be expressed. When an over-all opinion cannot be expressed, the reasons therefor should be stated. In all cases where an auditor's name is associated with financial statements the report should contain a clearcut indication of the character of the auditor's examination, if any, and the degree of responsibility he is taking.⁸

Of the three types of standards, the general standards deal with the auditor's qualifications and quality of his work. Furthermore, these general standards are very much related to the standards of field work and reporting.

Technical Proficiency. The first general standard acknowledges that regardless of an individual's proficiency in business and finance, he cannot meet the requirements of the auditing standards without specific

⁸American Institute of Certified Public Accountants, op. cit., p. 15-16.

education and experience in the field of auditing. This standard implies that the auditor must have a knowledge of accounting practices and the system in use, and this, in turn, infers an understanding of the basic nature of computers and electronic data processing equipment.

John R. Spellman, principal in the Chicago office of Arthur Andersen and Company, in charge of the firm's professional activities concerned with the data processing field, states:

A basic understanding of the various equipment components comprising a complete data-processing system, the functions performed by each component, and their interrelationship in an operating system is an essential part of the auditor's elementary [emphasis added] knowledge. . . . This is the minimum knowledge essential to an adequate appraisal of client's procedures and internal controls.⁹

Adequate technical training is generally considered to be composed of two parts: formal education and on-the-job instruction. A certain amount of EDP knowledge can be obtained through exposure to the procedures employed during routine audit work. However, a more effective way of acquiring this knowledge is through "a direct, well-planned educational program of training for auditing under electronic data-processing systems."¹⁰ It should be emphasized that it is not mandatory that the auditor learn to operate and program the equipment, but rather that he know how an operator or programmer may influence the processing.

⁹John R. Spellman, "Auditing the EDP System," Illinois CPA, Vol. 25 (Winter, 1962), p. 54.

¹⁰Loc. cit.

The second general standard requires that the auditor be independent. This is not relevant in the realm of this study and, therefore, will not be discussed.

Due Care. The final general standard necessitates that the independent auditor perform his work with due care. This standard of due care imposes a responsibility upon the auditor to observe the standards of field work and reporting.

The following paragraph appearing in Cooley On Torts is often cited in discussing the due care principle.

Every man who offers his service to another and is employed assumes the duty to exercise in the employment such skill as he possesses with reasonable care and diligence. In all these employments where peculiar skill is prerequisite, if one offers his service, he is understood as holding himself out to the public as possessing the degree of skill commonly possessed by others in the same employment, and, if his pretensions are unfounded, he commits a species of fraud upon every man who employs him in reliance on his public profession. But no man, whether skilled or unskilled, undertakes that the task he assumes shall be performed successfully, and without fault or error. He undertakes for good faith and integrity, but not for infallibility, and he is liable to his employer for negligence, bad faith, or dishonesty, but not for losses consequent upon pure errors of judgment.¹¹

This standard, as it is related to EDP, is dependent upon the previous one of technical training. The auditor must possess enough familiarity with the equipment to know whether or not he is exercising due care. Obviously, an EDP novice is not in a position to determine the amount of care necessary.

¹¹Cooley On Torts as quoted from the American Institute of Certified Public Accountants, op. cit., p. 21-2.

The standards of field work relate to the actual work performed on the audit rather than to the auditor's qualifications to perform such tasks. These standards are concerned with:

1. Adequate planning.
2. Evaluation of internal control.
3. Obtaining adequate evidential material.

Adequate Planning. The first standard of field work pertains to planning. The auditor should be informed as to the applications processed by the computer, thus, enabling him to make any necessary changes in audit procedures. At the same time he will be able to provide advance notice to the processing department detailing the data required for the audit. This is especially important where files are maintained on magnetic records and would be difficult to reconstruct in the future. In addition, advance notice of audit requirements will enable the processing department to schedule any additional computer processing time needed.

Evaluation of Internal Control. The second standard of field work relates to the review of internal control. The four components of internal control are:

1. plan of organization;
2. system of authorization and record procedures;
3. sound practices of control; and
4. quality of personnel.¹²

This area of internal control has been so materially affected by

¹²C. Herbert Willis, "The Auditor and the Computer," Haskins and Sells Selected Papers, 1964, (Haskins and Sells, 1965), p. 157.

electronic data processing, that the subject is treated in depth in Chapter III.

Evidential Material. The final standard of field work is the one requiring evaluation of the accounting information being processed. Kenneth G. Cadematori states that "assumptions based upon representations of EDP equipment sales personnel or even specialist of the client, do not meet generally accepted auditing standards requiring examination of evidential matter."¹³ The implications of this standard will be discussed throughout this study.

The preceding standards, set forth by the AICPA, are mandatory to any competent audit, whether it be independent or internal. Furthermore, not only should the auditor know these standards, but he also should be aware of their implications on the auditing of electronic systems.

Effect on Procedures

Auditing standards, established in view of objectives, are relatively independent of the accounting system. However, the standards of field work are guides to procedure, and auditing procedures have been affected by electronic data processing.

These procedural changes have been caused by problems which are unique to EDP systems, among which are:

1. Absence of visible records in the form of listings or punched cards.
2. Computer operations that will not provide an audit trail back to an original document.

¹³Kenneth G. Cadematori, "Internal Control, Audit Trail, and Electronics," New York CPA, Vol. 29 (June, 1959), p. 429.

- a. Magnetic tape or punched card records destroyed before the auditor arrives on the scene.
 - b. Records that will be originated during computer processing through media other than visible records.
 - c. Master records changed internally within the machine without discharging the results on external records.
3. Inability to test a computer result without the use of special programs to select the required information for print-out or without repeating the entire operation manually.¹⁴

Therefore, the major area of auditing that has been affected by electronics is the area of paper evidence, or what has come to be called the "audit trail."

The term "audit trail" is defined as being:

a method of providing a path or track which may be followed in tracing output data back through the processing steps used in converting input data to its final output form.¹⁵

The audit of electronic systems must be designed to fit the situation, but regardless of the plan used "the audit of any EDP system must be based on the sound verification of reliable source data."¹⁶ The techniques employed to verify such data will be explored in Chapter IV.

¹⁴Thomas J. Kelly, "Impact of Electronic Data Processing Upon Auditing Procedures," Internal Auditor, Vol. 19 (Winter, 1962), p. 21.

¹⁵C. Orville Elliot and Robert S. Wasley, Business Information Processing Systems, (Homewood, Illinois: Richard D. Irwin, Inc., 1968) p. 583.

¹⁶Ibid., p. 337.

Nature of the Problem

It has been seen that the computer has made its presence very much felt in the field of auditing, and that new auditing techniques are mandatory when facing an electronic system.

Generally, electronic systems may be divided into two main categories: batch processing systems and on-line, real-time systems.

System Characteristics

In batch processing systems the items to be processed must be coded and collected into groups before processing can take place. Such systems, while being far superior to manual methods, suffer from the serious disadvantage that sufficient items of a like nature must be collected in order to make processing feasible. This results in a time lag somewhat impairing the usefulness of the information. In light of this problem on-line, real-time (OLRT) systems have been developed.

An on-line system may be described as

. . . one in which the input data enter the computer directly from their point of origin and/or output data are transmitted directly to where they are used.¹⁷

And a system defined as real-time is one that

. . . controls an environment by receiving data, processing them and returning the results sufficiently quickly to affect the functioning of the environment at that time.¹⁸

Therefore, a real-time system functions quite differently from a batch processing system, in that in order for a real-time system

¹⁷ James Martin, Programming Real-Time Computer Systems, (Prentice-Hall, Inc.: Englewood Cliffs, New Jersey, 1965), p. 376.

¹⁸ Ibid., p. 378.

to be operative transactions must be processed in random order as soon as they occur.

Such systems have become workable due to the following technological improvements in the field of EDP:

1. The storage capacity of computers has been increased manyfold without a commensurate increase in cost.
2. The speed of access to stored data has also been increased manyfold without a corresponding increase in cost.
3. The operating speed of computers has increased from millionths to billionths of a second for one calculation with an actual decrease in cost of the equipment.
4. Terminals have been developed to directly link the computer with a telecommunication network.
5. Completely new programming techniques have been developed to cope with the problems created by this type of data processing whereby it is possible for many remote terminals to make inquiries of the computer at the same time.¹⁹

Purpose of the Study

Thus, it is apparent that a second revolution²⁰ is taking place in the field of data processing. Furthermore, it is rapidly becoming evident, with the advent of OLRT systems, that methods of control and auditing procedures devised for batch processing systems are becoming obsolete.

As information systems shift toward on-line, real-time systems, the system designers, internal auditors and external auditors face a new set of problems with respect to internal control. In addition to the

¹⁹Elliot and Wasley, op. cit., p. 325.

²⁰The "first" revolution was the introduction of the computer. The second is the design of OLRT systems.

loss of the audit trail and the lack of source documents, the traditional separation of duties, checks and balances, and network of authorization and lines of responsibility must be reexamined in view of the new environment.

Traditionally, system designers, internal auditors and external auditors have had somewhat conflicting objectives. The system designers have been intent on providing relevant, timely information in the most economical manner. On the other hand, internal auditors desire the assurance that information transmitted to management is valid, but usually press only for a minimum of control, while the external auditor will demand more assurance of control than is normally sought by the internal auditor.

It is felt that the increasing popularity of OLRT systems will see a convergence of these three different objectives. System designers will forego economy for controls, internal auditors will demand more controls, and external auditors will look more to procedures incorporated within systems as a basis for expressing an overall opinion about the company's financial position.

In an OLRT system it will no longer be feasible to audit "around" the computer comparing source documents with final output. Neither can reliance be placed on independent confirmation or physical observation. The auditor may find it necessary to be on hand regularly in the client's place of business to assure himself that proper controls are being effectuated. Such changes comprise widespread use of a new technique-- the continuous audit.

In developing new techniques to audit technologically advanced systems the auditing profession must face the following selected issues:

1. Should the external auditor perform a technically oriented review of computer programs?
2. Should test decks be used in reviewing advanced computer systems?
3. To what extent should the external auditor participate in the design of advanced systems?
4. In what time period should the audit of a company with an OLRT system be scheduled?

It is, therefore, the purpose of this study to place the preceding issues within a proper framework and set down guidelines to be used in auditing an advance computer system.

Scope and Limitations

This study will concentrate on overall system audits, without considering the audit of specific assets, liabilities, and owner equity items. Such a detailed analysis would be too cumbersome for a study of this scope and too general to be worthwhile.

In addition, no attempt is made to distinguish between the functions of the internal auditor and those of the external auditor. It is felt that if the functions are being performed, it is immaterial as to who is performing them.

Preview of the Study

Since it has been previously determined that it is essential that the auditor have a knowledge of the system and how the equipment functions, the next chapter deals with on-line, real-time system design and related hardware.

After an adequate real-time systems background has been established, the study logically proceeds with an analysis of internal control. Chapter III considers the changing nature of controls and the types of controls applicable to electronic systems with special emphasis on those controls

peculiar to OLRT systems.

After evaluating internal controls, the auditor must obtain evidential matter to judge the accuracy of the information being processed. Therefore, Chapter IV is concerned with the auditing techniques applicable to OLRT systems in obtaining such evidential matter.

Chapter V presents a case study illustrating the capabilities of the computer in performing self-auditing tasks.

Finally, Chapter VI summarizes the study, presents pertinent conclusions and recommendations, and attempts to answer the previously posed questions concerning technical orientation, use of test decks, systems design, and the time period of the audit.

CHAPTER II

REAL-TIME SYSTEMS DESIGN AND EQUIPMENT

One of the responsibilities of the auditor in an electronic data processing system is that of approving changes in procedures. This means that he must understand the system well enough to evaluate the implications of procedural and equipment changes. Franz E. Ross states:

The real-time digital system is at the border of engineering and business. It is a highly complex system engineered from various data processing, communications and sometimes other components to accomplish a job in business, industry, science or defense. It has to be understood to be effectively controlled and audited.¹

Therefore, the purpose of this chapter is to acquaint the reader with the characteristics, concepts and configurations of real-time systems.

Real-Time System Applications

There are many definitions for "real-time" in present use, nearly all of which agree materially with the following:

Paralleling data processing with a physical process in such a fashion that the results of the data processing are immediately useful to the physical operation.²

¹Franz E. Ross, "Internal Control and Audit of Real-Time Digital Systems," The Journal of Accountancy, Vol. 119 (April, 1965), p. 55.

²Robert V. Head, "Planning for Real-Time Business Systems," Systems and Procedures Journal, (July-August, 1967), p. 10.

The question as to what is "immediately useful to the physical operation" takes into consideration the concept of "response time." Response time is the time it takes the system to react to a given input or "the time interval between the operator's pressing the last key and the terminal's typing the first letter of reply."³ Different systems require different response times and while a response time of a half an hour or more is adequate for some users, and airline reservation system gives a response time of about two seconds, whereas a radar scanning system requires a response time of milliseconds.⁴

Therefore, in order to be "real-time" a system must control a situation, and the speed of the system depends upon the pattern of activity being controlled.

Some of the first applications of real-time systems were to military purposes.

Military Applications

In the exploration of outer space by manned vehicles, the data processing system for PROJECT MERCURY determined whether or not the craft would be properly inserted into orbit. In the process of placing the spacecraft in orbit, inputs arrive at the rate of 1,000 bits per second,⁵ and the flight is cancelled if the launch is considered unsuccessful.

If the launch is successful, input is transmitted to the computer for the purpose of predicting the craft's position and velocity, controlling

³James Martin, Design of Real-Time Computer Systems, (Englewood, Cliffs, New Jersey: Prentice-Hall, Inc., 1967), p. 5.

⁴Ibid.

⁵William H. Desmonde, Real-Time Data Processing Systems: Introductory Concepts, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1964), p. 2.

the firing of the retrorockets, and predicting the landing location upon re-entry.

Another complex situation requiring immediate control is the Air Force's Semiautomatic Ground Environment System (SAGE) utilizing computers for the air defense of the United States. Inputs consisting of all aircraft approaching the continent are read into computer memory and at all times the computer possesses a picture of the air traffic in its area. The presence of a hostile aircraft can be ascertained, and the computer can determine the forces necessary to destroy the aircraft, contact human control centers, and yield instructions for the firing and dispatching of defensive weapons.

The last most heralded military real-time system is the Ballistic Missile Early Warning System (BMEWS) used in the detection of missiles approaching the continental United States. This system operates in much the same manner as SAGE.

Although real-time systems such as these have been operating successfully for several years, the early 1960's have marked the true beginning of the real-time era.⁶ Important nonmilitary concern in real-time problem solving during this period, paralleled with technological advancement and equipment availability have made commercial applications of such systems feasible.

Commercial Applications

Perhaps the best known commercial real-time system is American Airlines SABRE system. Through this system, more than one thousand agents scattered throughout the United States are able to handle approximately

⁶Robert V. Head, loc. cit.

"40,000 passenger reservations, 30,000 seat availability inquiries, and 20,000 ticket sales"⁷ daily. When a customer requests a reservation the agent checks the SABRE computer to determine if the desired space is available. If it is, the reservation is made and all pertinent information is stored in the computer. This system is an active control facility, for it keeps up with changes in the status of reservations and/or the flight operations.

Another area in which the use of OLRT computers is becoming well established is banking. Banks and other financial institutions are using on-line data transmission to send transactions from branches to a central computer installation. Real-time terminals are utilized at tellers' windows to check customers' balances and to produce statements and process customers' negotiations.

Real-time systems are also of major importance in the automation of certain types of plants and factories, and in the control of industrial processes. Industries where real-time controls are utilized include petroleum refining, steam-electric generating, paper making, and chemicals, cement, and steel manufacturing. It is estimated that approximately 4,000 real-time process control systems will be installed by 1970.⁸ Future applications of real-time systems defies imagination.

Real-Time Concepts

In order to understand the technical workings of the previously described real-time applications, it is first necessary to understand

⁷William H. Desmonde, op. cit., p. 4.

⁸Op. cit., p. 9.

the basic concepts peculiar to such systems.

Standard Interface

The primary technical characteristic which makes a real-time system possible is the concept of the "standard interface." An interface is a "boundary between systems or parts on a system."⁹ An input/output (I/O) interface, therefore, is the "boundary between an I/O device and a channel. Across this boundary must flow signals that control I/O device operation as well as the I/O data itself."¹⁰

Previous computer systems were characterized by the limited input/output devices which they could use. Therefore, a system was either a "card system" or a "tape system", but not both. This past limitation on the use of I/O devices was due to the fact that each type of device required a different series of control signals for its operation.

The new design departure rests in having each type of I/O unit associated with its own control unit, and in connecting the control unit to the channel. Then, in response to I/O commands sent by the channel, the control unit can transmit the specific control signals required by its I/O device. The ability of a system to use many different I/O units is the concept of the "standard interface."

Channels

One of the characteristics of commercial data processing is a high ratio of input/output activity to a low ratio of central processing unit (CPU) activity. The problem of idle CPU time while the equipment is waiting to execute I/O commands is solved through the use of channels.

⁹IBM Programmed Instruction Course, Introduction to System/360, (IBM, February, 1968), p. 3.

¹⁰Ibid.

Channels are small computers which utilize "main storage to hold programs which they select and execute, in response to initial instructions from the CPU."¹¹ These channels direct and control the flow of data between I/O devices and main storage. The execution of one of these programs results in channel commands to the control unit, thereby relieving the CPU of the burden of controlling I/O operations.

Once the channel program has been initiated, the CPU can start another input operation, or continue processing data for the same or another job. By keeping the central processing unit active in this way the system has the ability to input, process, and output data concurrently.

There are two types of channels, (1) the multiplexor and (2) the selector. The multiplexor is intended for use with relatively slow speed devices such as card and paper tape readers, console typewriters, and the like, while the selector is designed for use with high speed devices such as magnetic tape or disk.

Operating System

In order to analyze an OLRT computer system a basic understanding of the operating system is necessary. "An operating system is a group of programs, in residence in the computer system, which facilitates every phase of system operation."¹² The two basic components of an operating system are the control or supervisory programs and the application or processing programs.

¹¹Op. cit., p. 5.

¹²Op. cit., p. 13.

The control program schedules the data processing jobs, handles the routine tasks within the jobs, deals with input and output data, and is always located in main storage. The processing programs carry out the required data processing messages, correspond to the data processing programs of conventional systems, and are unique to each system. Thus, the control programs coordinate and schedule the work of the processing programs and carry out service functions for them.

Direct Access Storage

Before the advent of direct access storage devices (DASD) files were stored on media which were read sequentially and had to be sorted frequently to place them in an order suitable for processing. Direct access storage (utilizing drums, disks and data cells) is high capacity auxiliary storage with a wide range of data speeds. Its primary characteristic is its ability to locate any record directly, without having to scan the preceding records.

Many data processing jobs, due to their nature, are best performed sequentially, such as payroll, while others lend themselves to a random approach. When random processing is in order DASD generally increase processing efficiency:

1. With the libraries of processor programs on DASD (always available to the system), the length of time required for a job is reduced by the reduction of setup time.
2. With the data files on-line, presorting is reduced or eliminated.
3. Peak loads can be reduced by processing more often, with small batches, or by performing some jobs inline.¹³

¹³Op. cit., p. 211.

Furthermore, DASD offer flexible processing, affording the following advantages over sequential devices:

1. They can access any record, without extensive searching of other records. This allows:
 - a. Inline processing of transactions.
 - b. Accessing records from one file during the processing of transactions against another file, with both files on the same device.
 - c. Processing a file of records either directly, as transactions are reported, or sequentially in a batch.
2. They reduce setup time by holding processing programs and accessing them when needed.
3. They decrease the length of time required for jobs, by reducing setup time and reducing, or eliminating, presorting.¹⁴

The features of DASD greatly facilitate many data processing tasks and without it some would be impossible to perform.

Teleprocessing¹⁵

Teleprocessing (TP) is an IBM registered term combining the words telecommunications and data processing. The term denotes "systems that transmit data from one point to another in the course of processing."¹⁶

A teleprocessing system allows processing of data to take place at a point remote from the origin of the data through the use of transmission facilities. Where communication must be immediate and where conventional data transmission is too slow, teleprocessing affords a significant

¹⁴Op. cit., p. 213.

¹⁵Trademark of IBM.

¹⁶Robert V. Head, Real-Time Business Systems, (New York: Holt, Rinehart, and Winston, Inc., 1964), p. 356.

advantage through remote data processing. Data may be introduced into the system at its source, improving the timeliness of reports.

Other advantages resulting from being able to capture data at its source and enter it into the system are as follows:

1. Because data can be entered into the system at its source and in relatively raw condition, the time required to reflect the effect of that data on the system is reduced.
2. The effort to enter the data into the system is reduced. Simplicity of preparation of data for entry into the system is usually designed into the TP operation.
3. The expense is reduced, again by accepting the entry of relatively raw data, the expense of converting and communicating the data by other methods are significantly reduced.¹⁷

The three major types of teleprocessing are (1) data transmission, (2) data collection, and (3) data communication.

High speed and high volume characterize data transmission.

Magnetic tape-to-computer communications are examples of data transmission.

Data collection is the process of information being transmitted from scattered remote points to one control location. It is generally associated with limited amounts of data and slow speed transmission devices.

Finally, data communication may have elements of both data transmission and data collection. Besides data being entered from remote devices, inquiries may also be made at the terminal of some centrally held data. Generally, the volume of data being transmitted makes the operation appear closely related to data transmission; however, at other times numerous

¹⁷IBM Programmed Instruction Course, op. cit., p. 319.

transactions may be entered at each terminal and the system becomes predominantly one of data collection.

Every teleprocessing system is composed of (1) terminals, (2) lines, and (3) controls. In TP, an I/O device at the end of a transmission facility is called a terminal, and data to and from the terminals are carried by "lines" which may be composed of telephone lines, cables, micro wave links, and similar media. Controls refer to the interconnection between the computer and line, which may or may not be made directly into a channel.

Multiprocessing

Teleprocessing involves entering data into a computer and/or receiving data from a computer. A unique case of teleprocessing where direct communication takes place between computers is known as multiprocessing.

In multiprocessing, more than one processing unit is required. Each processor runs as an independent unit and all may have direct access to the main storage area of another. In order for one processor to access another's main storage, one CPU must be able to communicate to the other CPU that such an action is about to take place. This communication must occur because only one operation may take place in main storage at any given time. Therefore, CPUs may not access main storage simultaneously. Multiprocessing systems are discussed further in a subsequent section of this chapter.

Multiprogramming

"Multiprogramming" is a technique that has been developed to further increase the usage of the processing time available on the computer.

Multiprogramming is defined as a "technique for handling several programs simultaneously by overlapping or interleaving their execution."¹⁸

One solution to eliminating CPU idle time is to store more than one processing program in memory at the same time. Whenever one program pauses, control is transferred to another program. The more programs stored in memory, the greater is the possibility of having a program available to use the CPU whenever another program is stalled.

It is important to understand that programs are executed concurrently and not simultaneously. This is due to two significant characteristics of the computer.

First, regardless of the number of programs in main storage, the CPU executes only one instruction at a time. Simultaneous execution of two programs cannot occur with one central processing unit.

Second, channel programs perform the actual input/output operations, and are executed independently of the program using the CPU. While channel operations are occurring, the central processing unit is available for further execution of instructions.

Therefore, programs may overlap and run concurrently although execution of instructions cannot occur simultaneously.

Real-Time Hardware

Once the auditor is familiar with the concepts of a real-time system it is mandatory that he become acquainted with the hardware that carries out the real-time applications. This section is intended as a general

¹⁸Robert V. Head, op. cit., p. 347.

introduction only, since a detailed analysis of all the equipment specifications of all the EDP equipment manufacturers is beyond the scope of this study. Furthermore, with all of the equipment options available today, each real-time system application must be studied individually by the auditor. However, the following hardware generalities hold true for most OLRT systems.

Central Processing Unit

Real-time CPUs are generally third generation computers with large high-speed storage capacities, numerous communication facilities, and fixed and variable-length field capabilities. This design has been brought about by a technological change--solid logic technology (SLT)--the micro-miniaturization of components and circuits. There are numerous desirable features that any real-time processing unit should possess, varying with the complexity of the system. Some of the more common ones are discussed here.

Storage and Equipment Additions. Data processing history shows that the main barrier to expanding the amount of work done on a computer has been the amount of addressable core storage that is available. Therefore, the computer should be such that additional core storage can be readily added.

Besides utilizing more core storage, it may, at times, be necessary to add more peripheral equipment, or to take advantage of improved I/O devices. Therefore, the system must be open-ended allowing for an equipment expansion without a major upheaval.

System Interrupts. It is most desirable that any real-time system, other than the very simplest, have an interrupt feature. An interruption system is an automatic procedure that alerts the system to exceptional

conditions (receipt of a new message, the end of an I/O operation, machine error, and so on) and executes the appropriate routine following the detection of such an event.

Concurrent Input/Output. Input/output devices should be independent of the CPU. The processing unit should not remain idle during the I/O operation, waiting for some action to be completed. A channel directs the flow of information between the processing unit's main storage and the I/O unit that the channel controls, thereby relieving the processing unit of directly communicating with input/output and permitting processing to take place concurrently with I/O operations.

Time Sharing. Many systems possess time sharing capabilities, enabling numerous users at remote terminals to utilize the CPU as if each were its only user. The processing unit actually switches among many terminals, processing many programs, giving each a small portion of the available time.

With many users accessing main storage, it is quite possible that at any one time the size of all programs being processed may exceed the capacity of main storage. Through the use of dynamic address translation¹⁹ only the active portion of programs reside in core storage; the remaining parts are disposed on secondary storage devices. When these parts are summoned into main storage as needed, they are put in any available location.

While these capabilities of the CPU are impressive, even greater capabilities are achieved through proper use of peripheral equipment.

¹⁹IBM Systems Reference Library, IBM System/360 System Summary, File No. S36-00, Form A22-6810-8, p. 15.

Telecommunication Facilities

There are two major differences between OLRT systems and the more common batch processing systems. First, batch processing input is scheduled while real-time input is unscheduled. Second, batch processing is usually sequential, whereas real-time processing is random. These two differences require the use of telecommunications equipment in real-time systems.

Requirements of Telecommunications. Most data-handling systems utilize existing telecommunication facilities such as telephone, telegraph, micro wave, and broadband telephone. Any telecommunication facility must meet the following requirements:²⁰

1. Transmission control capability--Since the system will be servicing many remote locations on common or separate lines, the equipment must be capable of handling multiple random inputs.
2. Program switching--The control program initiates several switches among various programs during the processing of a single transaction; therefore, the CPU must be designed to accomplish very rapid switching.
3. Program relocation--The processing unit must possess the ability to relocate programs in storage during normal processing, because various types of transactions may necessitate calling a program from peripheral storage into a location in main storage.
4. Storage protection--With many programs residing in storage and constant switching and relocating taking place, it is mandatory that there be an available facility that can prevent one program from altering

²⁰Op. cit., p. 65.

another's instructions and data.

Transmission Directions. Transmission lines may enter computer equipment on-line or off-line, and the circuits may be of three types: simplex, half-duplex, or duplex. These circuit types describe directional capabilities only.

Simplex circuits transmit data in one direction only, while half-duplex circuits transmit in two directions, but only in one direction at a time. On the other hand, duplex circuits can transmit in both directions simultaneously.

Transmission Grades. Transmission speed is described in bauds, one baud being one bit of data per second.²¹ Circuits are graded into four types, based on their transmission rates in terms of characters per second, bits per second, or words per second.

Broad band circuits, such as micro wave or radio signals, transmit data at a speed that is limited only by the band width available.

Voice grade circuits transmit 2,400 bits per second, while subvoice grade circuits operate at a transmission rate of less than 600 bits per second.

Finally, telegraph circuits transmit at generally 45 to 75 bauds.

Modes. Data transmission can be either synchronous, asynchronous, or parallel.

Asynchronous transmission (sometimes referred to as start/stop) requires the use of start and stop bits to designate the beginning and ending of characters. This type of transmission is used on teleprinters and keyboard devices without a buffer, and also for continuous transmission.

²¹Martin, op. cit., p. 279.

Synchronous transmission, used when two devices transmit to each other continuously, eliminates the need for start and stop bits. Here a special pattern of bits is periodically sent, keeping the transmitter and receiver operating in unison.

Parallel transmission permits all bits of a character to be transmitted simultaneously by providing one circuit for each bit in the code structure.

Modulation. Data is normally transmitted in binary form. Modulation is the process of converting digital signals of business machines into audio frequency signals for transmission over communications lines. Demodulation reconverts the data for machine use. The circuitry for carrying out the process of modulation and demodulation is generally referred to as a modem or data set.

Terminals

"Terminals" refer to those devices which enter and receive data transmitted over communications line. The scope of this definition ranges from an entire data processing system to a single device such as a teleprinter, special keyboard, light display, and so on.

Since there are numerous terminal devices which can be attached to a computer, and since the terminals chosen depend on the particulars of the application, this subject can be handled in generalities only. However, in deciding the type of terminals to secure the following must be considered.

First, the nature of the input data must be considered. This includes determining answers to the following questions.

1. What is the physical media of the data: paper tape, punched cards, magnetic tape, and so on?
2. What is the volume, frequency, and message length of data transmitted?
3. Is the information to be transmitted numeric or alphanumeric?

Second, the type of output desired must be considered, for often a device must be utilized for output as well as input. Output requirements deal with the following:

1. Is a permanent record of the output necessary, or will visual or audio output suffice?
2. Will the user of the output be an individual or a group?
3. What is the physical quantity of the output information?

The answers to the above questions will determine the terminals most suitable for each system. In designing the use of terminals for man-machine interaction, the terminal and the way in which it is utilized must appear as familiar and as easy to understand as possible.

System Configurations

With a fundamental knowledge of real-time concepts and equipment, an understanding of the basic combinations of these components is necessary. An examination of the basic real-time system configurations will provide a framework in which the audit function must be performed.

- The most common classification of system configurations consist of:
- (1) simplex system;
 - (2) master/slave system;
 - (3) shared-file system;
 - (4) duplex system; and
 - (5) multiprocessing system.

Simplex System

A system in which there is no standby equipment to take over processing when the CPU becomes unoperative is referred to as a simplex system (Figure 1).

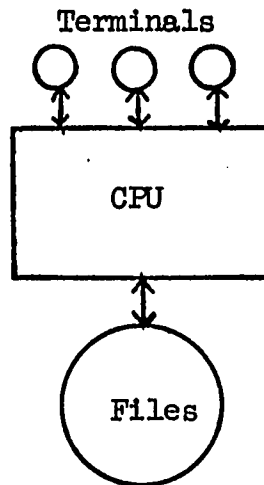


Figure 1. Simplex System

This configuration permits simplicity in the software subsystem, and offers substantial savings in equipment rentals and programming costs. Of course, these savings are offset by decreased performance standards when the central processing unit is not operative.

The simplex system just described can be modified by the addition of multiplexors. Multiplexor channels separate the operations of high-speed devices from those of lower-speed devices. The multiplexor is a stored program computer in its own right, and the autonomy permitted the multiplexor may vary considerably, and it may be able to operate even though the central processing unit is unavailable.

A system may simply be a simplex system with I/O multiplexor (Figure 2), in which case it can communicate information to and receive information from the processing unit, performing all input/output functions.

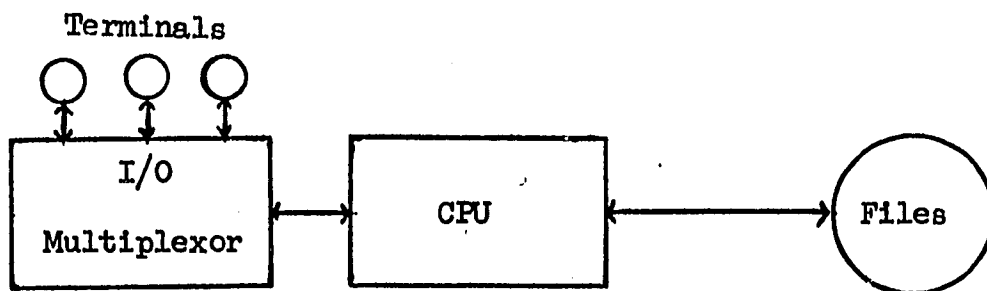


Figure 2. Simplex System with Input/Output Multiplexor

On the other hand, the CPU can be stripped of all communication functions by not only the addition of an I/O multiplexor, but also by a file multiplexor (Figure 3). This multiplexor issues commands to initiate the file storage access mechanism.

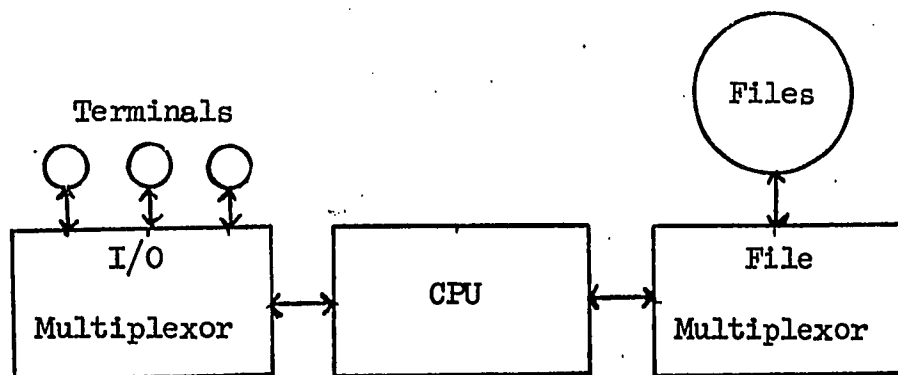


Figure 3. Simplex System with I/O and File Multiplexors

Master/Slave System

Where two or more computers are operating jointly, one is sometimes a master and the other slaves (Figure 4). The master can interrupt the slaves upon request only. In this system all housekeeping and scheduling operations are performed by the master, leaving the slave free to concentrate on problem solving.

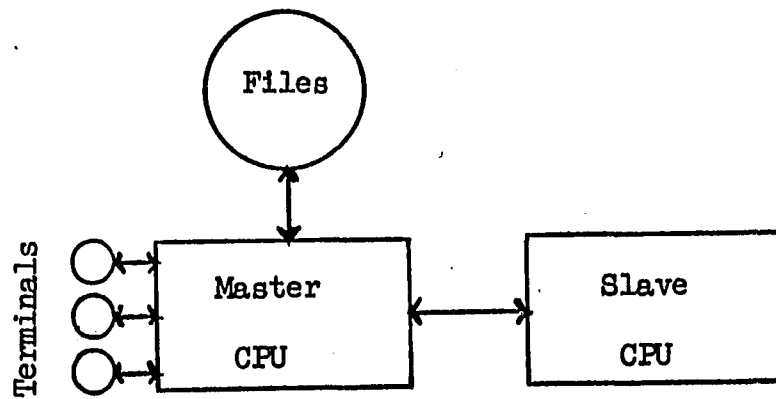


Figure 4. Master/Slave System

Shared-File System

The shared-file system (Figure 5) is somewhat similar in purpose and organization to the master/slave system. Here A is the controller and scheduler, receiving job requests from terminals and placing them in file storage according to a priority sequence in a predetermined location. When B is looking for a job it checks this location and commences processing.

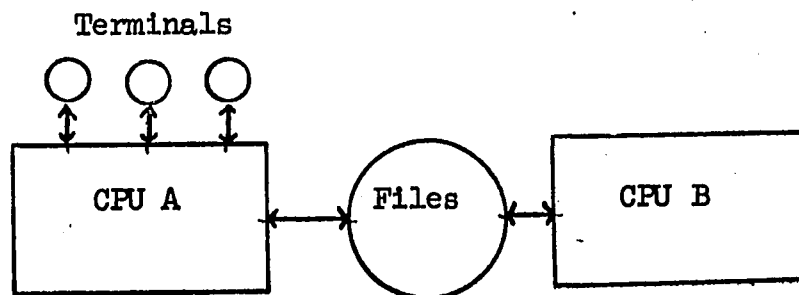


Figure 5. Shared-File System

Duplex System

In a duplex system (Figure 6) the required hardware is exactly duplicated so that a switchover can occur if the on-line system fails.

In this system, either A or B processes all the on-line transactions, and the other computer performs other work. If the on-line computer fails, a switch over occurs.

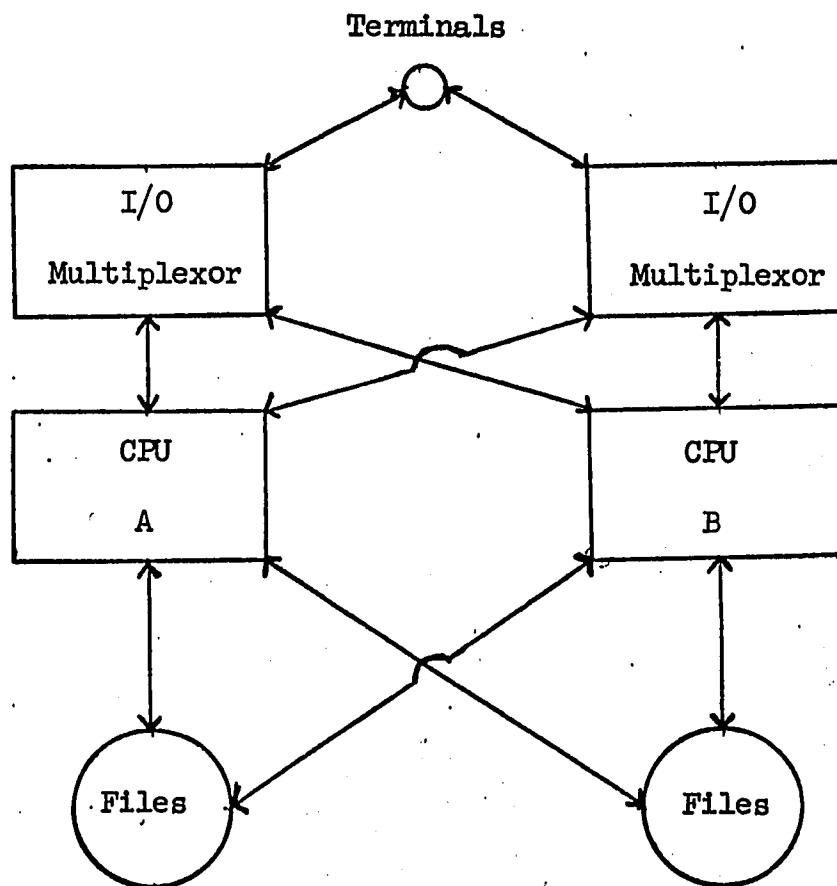


Figure 6. Duplex System

Multiprocessing System

A Multiprocessing system (Figure 7), in contrast to the duplex system, does not use one computer solely as a standby in case of equipment malfunction.

In a multiprocessing system several separate interrelated operations are carried on simultaneously by two or more computers, each concentrating on a particular assignment, but capable of communicating with the others.

It must be remembered that the preceding configurations are only basic and many variations of them may appear in actuality.

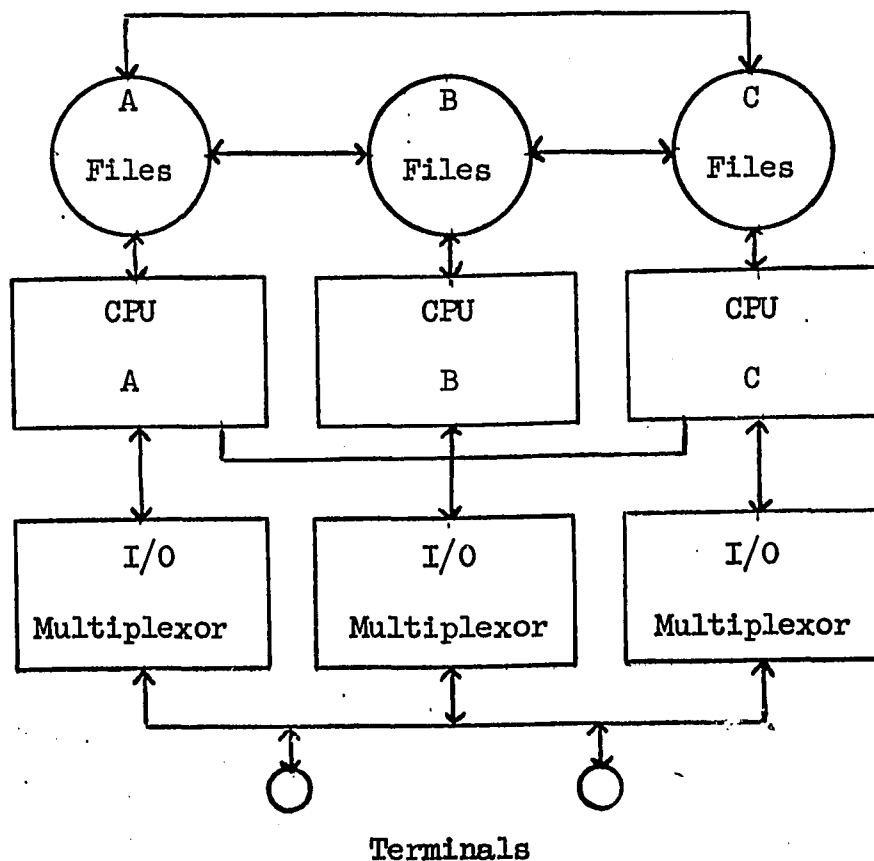


Figure 7. Multiprocessing System

Summary

A real-time system is one in which the processing of data within an environment takes place in such a manner that the results of the data processing are immediately useful to the environment.

In order to be "real-time" a system must control a situation, and the speed required of the system depends upon the pattern of activity controlled. Some of the first activities to be controlled by OLRT systems were of a military nature, such as PROJECT MERCURY, SAGE and EMEWS.

Important nonmilitary concern in real-time problem solving in the early 1960's, coupled with technological advancement and equipment availability have made commercial applications of such systems feasible. Perhaps the best known commercial real-time application is American Airline's SABRE system. Other commercial applications include banking, automation of certain types of plants and factories and the control of some industrial processes.

Such applications have become possible due to the development of the following real-time concepts.

1. Standard interface--the ability of a system to use many different I/O devices.
2. Channels--small computers which direct the flow of data between I/O devices and main storage.
3. Operating system--a group of programs, in residence in the computer system, which facilitates every phase of system operation.
4. Direct access storage--high capacity auxiliary storage with a wide range of data speeds. Its primary characteristic is its ability

to locate any record directly, without having to scan the preceding records.

5. Teleprocessing--transmitting data from one point to another in the course of processing.

6. Multiprocessing--communication between computers.

7. Multiprogramming--a technique for handling several programs concurrently by overlapping their execution.

Once the auditor is familiar with the concepts of a real-time system, it is mandatory that he become acquainted with the applicable hardware.

Real-time processing units are generally third generation computers with large high-speed storage capacities, numerous communication facilities, and fixed and variable-length field capabilities.

Some of the most basic features of any real-time CPU should include the following:

1. the capability of increasing core storage and adding more peripheral equipment when the need arises;

2. the possession of an interruption system which alerts the CPU to exceptional conditions and executes the appropriate routine following the detection of such an event;

3. I/O devices independent of the CPU, permitting processing to take place concurrently with I/O operations; and

4. the possession of time sharing capabilities, enabling numerous users at remote terminals to utilize the CPU concurrently.

In an OLRT system, the transmission of data to and from the processing unit requires the use of telecommunication facilities.

Telecommunication facilities must meet the requirements of: (1) transmission control capability; (2) program switching; (3) program relocation; and (4) storage protection. Telecommunication circuits may be simplex, half-duplex, or duplex, depending upon their directional capabilities.

Terminals are those devices which enter and receive data transmitted over communications line. The type of terminals used will depend upon the nature of the input and the requirements for output. Terminals include such devices as telephones, teleprinters, special keyboards, light displays, and so on.

Real-time system configurations may be classified as follows:

1. Simplex system--a system in which there is no standby equipment to take over processing when the CPU becomes unoperative.
2. Master/slave system--two or more computers operating jointly, one of which performs all the scheduling and housekeeping functions, leaving the others free to concentrate on problem solving.
3. Shared-file system--very similar to the master/slave system.
4. Duplex system--a system in which the required hardware is exactly duplicated so that a switch over can occur if the on-line system fails.
5. Multiprocessing system--a system in which several separate interrelated operations are carried on simultaneously by two or more computers, each concentrating on a particular assignment, but capable of communicating with the others.

CHAPTER III

THE EDP INTERNAL CONTROL SYSTEM

Once the auditor is familiar with the system configuration and equipment capabilities, he is in a position to perform the second standard of field work which states:

There is to be a proper study and evaluation of the existing internal control as a basis for reliance thereon and for the determination of the resultant extent of the test to which auditing procedures are to be restricted.¹

An Overview of Internal Control

Quite often internal control is considered to be control over items such as cash and inventories in order to preclude threat of theft and to ensure detection of fraud. While this is one part of the over-all control plan, the precise definition of internal control is more inclusive.

Internal control comprises the plan of organization and all of the co-ordinate 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.²

¹AICPA, op. cit., p. 27.

²Loc. cit.

The scope of this definition takes into consideration more than just the protection of assets, recognizing that a system of internal control extends beyond matters directly related to financial functions. It is concerned with the over-all operations of a company.

Since electronic data processing equipment are generally accepted as the most accurate devices ever utilized in accounting, it would appear that the records produced are always accurate and reliable-- that internal control is inherent in an electronic system owing to the high inherent reliability of the machines. However, EDP does not lessen the need for an evaluation of the internal control system in any manner.

On the contrary, it seems that increased emphasis must be placed on the review of internal control to ascertain its effectiveness. This is due to the centralization and concentration of data processing in an EDP system and the appearance of new controls which must be evaluated.

Essentials of Internal Control

Internal control in an EDP system is "basically the control of data fed into the system, control of the machine operation and control of the output of the machine."³ It is generally recommended that the same balance of controls as existed in the predecessor system be maintained. This is accomplished by requiring that a new control be established to replace each control lost due to the nature of the EDP system. In an attempt to maintain this balance it is first

³Frank J. Curka, "Effect of Electronic Data Processing on Auditing," N. A. A. Bulletin, Vol. 42 (April, 1961), p. 85.

necessary to understand the essentials of a good system of internal control

The first essential of a good system of internal control is the separation of duties and responsibilities among employees or groups of employees in such a manner that no one person has complete accounting control over substantially all phases of a business transaction. Since the definition of internal control is tied so closely to the concept of separation of duties, there is a failure to distinguish separation of duties within the accounting process from the fundamental separation required. The basic fundamental is that there should be a separation between those people who authorize a transaction, as well as those required to have custody of any asset acquired, from those people who record the accountability for the asset. This basic separation in accounting as well as in other functions, must be retained in order to have satisfactory internal control.⁴

The second essential of good internal control consists of procedures formulated to ensure the accuracy and completeness of the original reporting of the source data.

The third requirement of a good system of internal control is the existence of procedures to ensure consistent and accurate processing of source data.

The fourth necessity of internal control is an intermediate review of documents and records by authorized, knowledgeable employees.

⁴Gregory M. Boni, "Impact of EDP on Auditing," The Journal of Accountancy, Vol. 116 (September, 1963), p. 42.

Finally, the last essential of good control is review and interpretation of the end results of the accounting system.

Effects of EDP on Control and the Establishment of Alternatives

There is nothing in the nature of electronic data processing which is basically inconsistent with the aforementioned essentials of good internal control. However, the means of implementing these fundamentals have been altered in some instances.

Separation of Duties. The opportunities for dividing duties and responsibilities among employees are restricted by the integrated nature of EDP, which concentrates much of the responsibility within the equipment and in the hands of a few employees controlling the equipment.

Prior to the advent of electronic systems most individual departments performed their own clerical work to a great extent. Today, in order to establish control, a new organizational entity has emerged--the data processing center--and this entity generates reports for the various operating departments as the basis for carrying on their individual operating activities.

Furthermore, electronic systems are characterized not only by centralization of report generation, but also by physical centralization of data processing activities due to relatively high equipment cost. This centralization of data processing functions into one department emphasizes the importance of proper control of the data processing center.

To combat this centralization, the data processing center should be established as a separate responsibility center independent of the

employees originating or authorizing source data and of the employees utilizing or approving the end results. In addition, controls should be established over employees operating the equipment by:

1. Closely accounting for processing time, since human intervention necessary to any manipulation by the operator is quite time-consuming.
2. Management review of processing time and the print out of the console typewriter;
3. Requiring two operators to be present for all processing, and rotating operators between shifts to avoid having the same operators controlling the same processing runs each time.⁵

In practice it is imperative that input, output, processing and control functions be carefully segregated. The division of responsibility within the EDP department must be substituted for a division of responsibility within the company.

Source Data Control. Correct and complete source data are important not only for control purposes, but also for effective uninterrupted equipment operation. The capability of an electronic system to accept data in its original form, without refining, sorting, and summarizing, eliminates the need for many of the normal operating procedures present under a "manual" system. Therefore, the following methods of adding to the reliability of source data have been developed:

⁵ Kenneth G. Cadematori, "Experience of Auditors with EDP," Price Waterhouse Review, Vol. 4 (Summer, 1959), p. 20.

1. requiring more extensive controls and checks in the operating departments at the time when the data is first recorded;
2. using independent control totals of source data to check the electronically processed totals;
3. machine editing of input for the logical relation of data and limit checks;
4. machine listing of the source data processed to be reported back to the point of origin for review; and
5. review of the final processed data by personnel at the source area.

Processing Control. Barring human intervention, electronic equipment can process data with rigid consistency and accuracy far surpassing any previously available method. In addition to this inherent accuracy and the built-in controls of EDP equipment, further control is offered by preventive maintenance designed to detect equipment malfunctions, and programmed checks.

Intermediate and Final Review. Electronic data processing severely limits intelligent review of intermediary records due to the sparse amount of visible intermediary records required in an electronic system. This problem has been somewhat overcome by requiring a print-out of a computation or transaction. However, in this area, there is generally a willingness to rely on the accuracy of the equipment and the end results.

One of the advantageous aspects of an electronic system is its ability to produce various analyses and reports of end results not available under predecessor manual systems. It is now possible to obtain information highlighting unusual transactions, regardless of the nature of their origin.

Thus, former controls, no longer possible due to the concentration of responsibility, have been replaced by making more extensive use of the accuracy and flexibility of the EDP equipment to provide alternative controls.

The Nature of EDP Controls

The adequacy of internal control establishes a point of departure in auditing since it serves as a guage of the effectiveness of a system in following its procedures. Therefore, a consideration of the effect of electronic data processing on auditing should place considerable emphasis on the nature of the internal control system which arises in conjunction with the use of computer processing.⁶

The purpose of this section is to briefly reacquaint the reader with types of controls commonly used in a conventional off-line EDP system. This is necessary in order to point out the inadequacies of such controls in an OLRT system, and further, to serve as a basis for the subsequent discussion of OLRT controls.

In discussing controls a distinction is usually made between administrative controls and internal accounting controls. The Committee on Auditing Procedures of the American Institute of Certified Public Accountants makes this distinction in the following manner:

- a. Accounting controls comprise the plan of organization and all methods and procedures that are concerned mainly with, and relate directly to, safeguarding of assets and the reliability of

⁶Felix Kaufman, Electronic Data Processing and Auditing, (New York: The Ronald Press Co., 1961), p. 123.

the financial records. They generally include such controls as the systems of authorization and approval, separation of duties concerned with record keeping and accounting reports from those concerned with operations or asset custody, physical controls over assets, and internal auditing.

- b. Administrative controls comprise the plan of organization and all methods and procedures that are concerned mainly with operational efficiency and adherence to managerial policies and usually relate only indirectly to the financial records. They generally include such controls as statistical analyses, time and motion studies, performance reports, employee training programs, and quality controls.⁷

Bower and Schlosser state that "the basic purposes of internal controls are to bring reliability into the financial information."⁸

And while it appears from the above distinction that the auditor is primarily concerned with "accounting controls," certain "administrative controls" are absolutely essential to a well planned, properly functioning EDP system.

Administrative Controls

Administrative controls in electronic systems should be related to the formation, documentation and implementation of operating procedures in systems design, programming, and computer operations. It would appear that these administrative controls are more essential to OLRT

⁷AICPA, op. cit., p. 28.

⁸James B. Bower and Robert E. Schlosser, "Internal Control--Its True Nature," Accounting Review, Vol. 40 (April, 1965), p. 339.

systems than to their predecessors.

Systems Design. The complexity of electronic systems necessitates detailed systems design which must be sufficiently documented in order to evaluate and alter the system. Without proper documentation management is unable to determine the stage of system implementation and what further steps must be taken in order to make the system operational. Furthermore, when adequate documentation is absent, serious delays in systems modification occurs as a result of employee turnover.

Why is documentation any more important to an OLRT system than to a conventional system? Robert V. Head, Vice President and Manager for the Systems Planning Division of the Security First National Bank of Los Angeles, states:

All of the aspects of real-time systems--size, complexity, newness, vitality, and disruptability--add up to an integration approach different in degree if not in kind from non-real-time commercial installations.⁹

In conventional systems, documentation rarely consists of little more than the diagrams so familiar to batch processing. (See illustration in Figure 8.) These diagrams, when coupled with input record layouts and the format of the output were sufficient to allow the preparation of detailed flowcharts, program coding and system testing. While these same basic steps are necessary in an OLRT system, they must be much more stringently defined.

⁹Head, op. cit., p. 75.

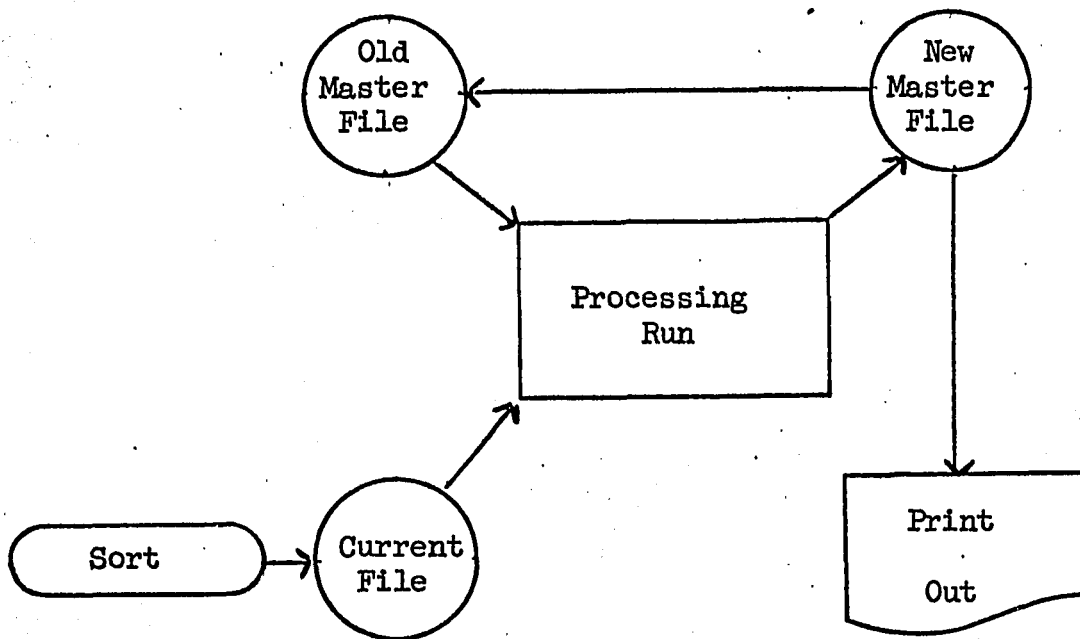


Figure 8. Illustration of Batch Processing Documentation

Programming. Computer programming deals with the preparation of flowcharts, program listings and computer operating instructions. During the planning and installation of a system or application, it is necessary to document all facets of program development as precisely as possible. This documentation is more vital in OLRT systems than those of a conventional nature, due to the numerous integrated relationships found in a real-time system. James Martin of the Systems Research Institute of IBM states:

In writing programs for a batch-processing commercial application or for scientific calculations, the programs operate largely independently of one another. The work of one programmer does not interact with that of others, except in a very minor way when it uses the same records or input data. One of the big differences in real-time systems. . . is that the programs all fit into an integrated system. They are all in the machine at the same time, and, although they are not all in core at once, many different combinations of them will be in core

together. There are many different interactions between them. One program affects the functioning of others in many, and sometimes surprising ways.¹⁰

Therefore, adequate program documentation is mandatory. William H. Desmonde of IBM advocates that such documentation include the following information in the following order:

1. Title index from the assembly program¹¹ (titles are the headings preceding instruction groups).
2. List of the instructions from the assembly program.
3. Constants and areas after assembly.
4. Symbolic analyzer assembly (cross index of where various data and constants are referred to in the program.) This is useful when changes must be introduced into the program.
5. Memory print of the program block.¹²
6. Patches (inserts) listings. It is often not economical to reassemble a program when an alteration is necessary. This is particularly the case when errors are found in debugging, or when system requirements are changed.
7. Detailed flowchart, cross-referenced against coding by page and line number.

¹⁰James Martin, Design of Real-Time Computer Systems, op. cit., p. 137.

¹¹An assembly program is what is more commonly known as an object program, or the machine language version of the source program.

¹²"Block" is used in real-time systems to describe I/O of working storage areas in main memory and units of record storage in auxiliary memory. (From Robert V. Head, op. cit., p. 335.)

8. Program specifications.
9. Data specifications.¹³

Furthermore, in addition, and prior to program documentation, a programming manual should be developed and maintained, containing a written record of all policies, procedures and techniques which are to be standard throughout the organization. Its existence will facilitate communication and prevent the development of duplication of procedures or conflicting procedures.

Computer Operations. Computer operations are classified at times as procedural controls rather than as administrative controls. Therefore, it appears that the applicable procedures can be discussed more logically in the subsequent section. It will suffice here to simply state that tight discipline on the operators of an on-line system is essential.

Procedural Controls

Once the plan of organization has been determined and administrative controls designed, a system must be developed which records, processes, summarizes and reports transactions in accordance with organizational responsibility and policy. In order to assure the accuracy of information and adherence to company policy, procedural controls relating to input, processing, and output must be developed and strictly followed.

Input Controls. Stringent controls must be established with respect to the input of data into a computer system, for machines will

¹³William H. Desmonde, op. cit., p. 143.

operate just as effectively with incorrect data as with correct data.

Professors Elliot and Wasley feel that there are three problem areas associated with error elimination in the input function.

These problems are: to assure that raw data are properly transcribed into machine-acceptable language, that the data to be processed include all of the transactions that took place, and that the transactions are processed only once.¹⁴

The two major categories of input controls used to combat these problems are transcription controls and control totals. Controls which check the accuracy of the conversion of raw data into a machine acceptable media are referred to as transcription controls. After the data has been converted to machine-sensible form, some type of verification must be performed to ensure the accuracy of the conversion. The methods of verification vary depending upon the media of input; however, the following are among the more common:

1. Mechanical key stroke verification--After the key punched card is produced it is placed in a verifier which is similar to the key puncher except that its function is to compare the holes already punched with the verifier operator's key strokes.
2. Visual verification--If printed material is produced and punched cards or paper tapes are created as a by-product, a visual check of the printed copy will also be a check of the machine input.
3. Verification by self checking numbers--Identification numbers can be verified by a type of redundancy check which uses self-checking digits.

¹⁴ Elliot and Wasley, op. cit., p. 343.

4. Mechanical verification during creation-- Certain punching devices have add and subtract abilities. Batch totals are entered and individual cards are subtracted as they are punched, to arrive at a zero balance.
5. Tabulating listings--Another method of proving the accuracy of key punching of quantitative data is through the tabulation of input transactions on tabulating equipment or on the computer and verifying the resulting totals.¹⁵

The use of control totals aids in directing the movement of data through the system. Control totals are usually taken on batches, or groups, of source documents which are preselected and sequenced logical transaction groups. The three major types of control totals are batch totals, hash totals and record counts.

A batch total is the sum of specific data contained in documents having similar characteristics. This type of total helps assure that all the data of the batch have been properly processed. The summation of nonsignificant items (such as customer numbers or inventory numbers) are referred to as hash totals. The total is used merely for checking purposes, and no importance is attached to the numeric value of this type of total. Record count controls vary considerably, depending upon the particular system in use. If prenumbered documents are used, a check may be made to determine that all documents are accounted for. On the other hand, when data are recorded in punched cards, a simple card count is a good control technique.

¹⁵Robert Young, "Internal Control in Electronic Data Processing Systems," The New York CPA, Vol. 37 (January, 1967), p. 45.

While in a conventional EDP system the use of the above mentioned input controls prove to be adequate, in an on-line, real-time system they become virtually obsolete. The value of transcription controls becomes negligible in many instances, due to the absence of source documents. Data is directly entered into the system at the point of origin. Control totals also become useless, since in an OLRT system data is very rarely accumulated and processed in logical transaction groups, and these controls cannot be applied before the processing occurs.

Processing Controls. The accuracy of the actual processing of data is dependent upon the accuracy of the programming and programmed checks included in the programs, and the checks designed and built into the equipment by the manufacturer.

The extent to which programmed controls are utilized depends upon the originality of the programming staff, the demands of their superiors, the capabilities of the equipment, and the need for controls as opposed to the costs incurred due to the additional processing time required. In effect, programmed controls provide an automatic means of detecting three kinds of errors:

1. erroneous or incomplete data;
2. machine malfunctioning; and
3. operator malfunctioning.¹⁶

¹⁶Robert G. Wright, "How Do You Audit EDP?" Haskins and Sells Selected Papers, 1964, c. 1965, p. 139.

Some of the more common programmed checks include the composition check, which tests the completeness of data; the limit check to determine the reasonableness of data; the coding check to test the validity of transaction codes or employee numbers; and the combination checks to determine the independence of data.¹⁷

Recently David H. Li of the University of Washington has devised a new programmed control--a structural check of input data.¹⁸ Professor Li's check tests the logical relationship between debit and credit accounts by means of a chart of transaction combinations, and he advocates its use in computers with multiple-access capabilities (a characteristic of OLRT systems).

In addition to programmed controls, all EDP equipment manufacturers have checks built into the equipment to ascertain that data is correctly read, processed, and transferred within the system and recorded on output media. These checks, sometimes referred to as "hardware" controls, include parity checks, dual read-write heads, dual circuitry and file protection rings. These controls are described in detail in the various manuals prepared by the equipment manufacturers.

The use of on-line, real-time systems has greatly increased the importance of existing processing controls and has given rise to new controls. These new processing controls are discussed subsequently.

¹⁷Haskins and Sells, Internal Control in Electronic Accounting Systems, (New York: 1965), pp. 73-84; W. Thomas Porter, Jr., Auditing Electronic Systems, (Belmont, California: Wadsworth Publishing Company, 1966), pp. 17-19.

¹⁸David H. Li, "A Structural Check of Accounting Input Data in a Computer System," The Journal of Accountancy, Vol. 123 (June, 1967), pp. 54-7. Joseph A. Greco, "Comments on the Structural Check of Input Data in a Computer System," The Journal of Accountancy, Vol. 125 (June, 1968), p. 46-52.

Output Controls. Output controls determine that the processed data do not include any unauthorized alterations by the computer operations section, that data are substantially correct and reasonable, and that all errors detected in processing have been corrected. Good output control requires a regular, systematic review to determine whether the established requirements are being met, by making use of such yardsticks as departmental budgets and standards. Output control is basically the same, regardless of the type of electronic system in use.

Thus, with a basic understanding of the controls found in a conventional EDP system, it is now possible to analyze those controls peculiar to an OLRT system.

Controls in On-Line Real-Time Systems

The only way in which an auditor can achieve the necessary confidence in the operation of an OLRT system is through a basic understanding of how the system operates, how results are obtained, and what safeguards have been instituted and are actually utilized.

The previously discussed conventional control concepts, painstakingly designed over the past years for batch processing systems are no longer adequate. The utilization of on-line communication facilities, duplex equipment configurations, multiprocessing and multiprogramming necessitates the development of additional, more complex controls, if these systems are to process information accurately and efficiently.

On-Line Controls

The concept of using communication lines to transmit data in OLRT systems requires the use of an on-line remote terminal through which messages are transmitted to, or received from, a computer. When operating in this manner it is important to ensure that all data transmitted are received and properly processed. To prevent messages from being lost or improperly processed, the following controls provide a routine check on messages sent through the system.

Message Identification. Every message transmitted is normally composed of two parts: header and text. The header contains information necessary to direct the message to its destination, in addition to other control information. The text is that portion of the message which is to be received by another terminal or processed by a program.

Usually the message header contains control information such as:

1. One or more destination codes.
2. The code name for the originating terminal.
3. The input sequence number.
4. A message type indicator.
5. Any other necessary control type data.¹⁹

The destination codes identify the terminal(s) or processing program which is to receive the message. The message type indicator can be used to identify a message that is to be processed in a special

¹⁹ IBM Systems Reference Library, IBM System/360, Disk Operating System QTAM Message Control Program, Third edition, July 1968, File No. S360-30, Form C30-5004-2, p. 23.

manner. Any other necessary control information may also be included, such as the date and time the message is sent, the date and time it is received, and the output sequence number.

The above information is necessary to ensure proper message flow and processing. If a message with an incorrect header is received, it should be rerouted for correction or rejected with a request to the originating terminal for retransmission of the entire message.²⁰

Message Transmission Controls. Message transmission control is accomplished by assigning each message a number and subsequently verifying the sequence of the message numbers received. These sequential message numbers may be either operator-added or computer-added.²¹

With operator-added serial numbers, the operator assigns a sequential number to each message sent. The receiving computer checks to ascertain that the serial number on the message is one higher than the number on the last message sent from the terminal in question. If the system becomes unoperative and restarts after a period of down time, each operator retransmits his last message and the computer checks to be certain that all serial numbers are in the proper sequence and that no message is stored twice. Furthermore, in addition to the operator sequentially numbering each message transmitted to the computer, the computer maintains a sequential number list for each message sent

²⁰ Robert F. Moloney, "New Generation EDP Controls," Management Services, (March-April, 1968), p. 16.

²¹ James Martin, Design of Real-Time Computer Systems, op. cit., p. 550-52.

to each terminal. Therefore, the operator is able to determine whether or not all output sent by the computer has been received.

On the other hand, in some systems it is not the operator who assigns the message a sequence number, but rather the computer itself. The serial number is temporarily written on the file records which the message causes to be updated. If it is necessary for restart procedures to occur the computer is then capable of determining whether or not a certain file has been updated by a particular message number.

Detection of Transmission Errors. While the assignment of sequence numbers provides an adequate control in assuring that all messages sent are received, it in no way determines the correctness of the information received. Communication circuits of on-line systems are subject to a variety of environmental conditions that do not affect off-line operations. Some of these conditions (nearby high voltage lines, accidental induction between circuits, impulses caused by lightning) may create "noise" in the circuit and cause unpredictable errors in transmitted messages. A necessary requisite for accurate system performance is the ability for detection of such errors, and correction where possible.

On most systems, some form of redundancy is built into messages so that, when they are received, they may be inspected for errors. This inspection can be performed at the character level and/or at the message level. Character checking is normally accomplished through

the addition of an extra bit²² to the data bits comprising the character code so that the total number of 1 bits in any character is always odd (or always even).²³ The receiving unit checks each character for proper parity. This method of checking is called vertical redundancy checking (VRC).

While VRC detects all errors involving the picking up or dropping of a single bit, it is incapable of detecting double errors. It does not detect multiple bit errors or missing characters. To overcome these deficiencies, it is necessary to accumulate parity longitudinally along a message as well as vertically across characters.²⁴ In this technique, known as longitudinal redundancy checking (LRC), a special character is inserted at the end of a message or message block so that the total of the settings along the same bit position in all characters is always odd. Therefore, through LRC missing characters are detected.

Data Protection Controls

Due to the on-line capability inherent in real-time systems, these systems must be must more reliable than conventional electronic systems. The reasons for this are: first, the system is more automatic and errors can easily remain undetected; and second, due to the nature of the system, serious inconveniences occur when the system ceases to function.

²²Contraction of binary digit.

²³IBM Systems Reference Library, IBM System/360, Introduction to Teleprocessing, Second edition (July, 1968), File No. S360-30, Form C30-2007-1, p. 20.

²⁴Ibid.

Since information housed in memory is available to terminal operators upon their request, there is a good possibility of data being used by unauthorized personnel, or destroyed or improperly processed due to carelessness. Therefore, programmed controls must be devised which will eliminate any possibility of improper use of data, incorrect file updating, and destruction of data and programs stored in memory.

Unauthorized Data Usage. The prevention of unauthorized data usage can usually be accomplished by the use of lockwords and authority lists.²⁵ Lockwords, otherwise known as "keywords" or "passwords", are composed of several characters in a data file which the input message must match in order to gain access to the file. This type of control can be sophisticated through the use of several lockwords. Thus, one set of characters transmitted to the file would allow the file to be retrieved for reading purposes only; another group of characters would allow the file to be retrieved for reading from and writing into the file. Such lockwords should be entered into the system in a non-print mode to prevent unauthorized users from gaining access to the code.

Another form of data protection is the use of authority lists. In this instance the password identifies the person transmitting from the remote terminal. After the operator has made contact and identified himself, the computer checks to determine what type of information the individual is authorized to send and receive.

²⁵ Robert F. Moloney, op. cit., p. 17.

The use of lockwords and authority lists provide adequate protection provided the code system remains unbroken. In addition to the use of such codes, a monitoring routine should be developed which would count the number of unsuccessful attempts made to enter the system and after some predetermined number of attempts failed, would signal a downline station of the apparent unauthorized activity.

Incorrect File Updating. The types of errors which can occur during data transmission are easily detected through edit routines and the use of the previously described controls. However, serious consequences can arise in a multiprogrammed system when two transactions attempt to process the same file simultaneously. Without provisions to ensure that only one transaction can update a file at a time, the changes created by one transaction will be erased when another transaction, occurring simultaneously, is recorded.

In the IBM system software package there is a procedure (referred to as "exclusive control") which permits only one transaction at a time to update a file.²⁶ This "exclusive control" is achieved by requiring each transaction to gain the permission of the supervisory program to update a file. If the file is available, the supervisory program grants permission and the requesting transaction updates the file. During this period no other transaction is granted permission to access the file.

Destruction of Internally Stored Information. In a multiprogrammed system the control program, operational programs, and queues of messages

²⁶Ibid.

(awaiting processing or in the act of being processed) will all be stored in memory. Through a program or machine error (usually the former) an operational program could exceed its applicable storage area, thereby altering or destroying other internally stored information. Therefore, every system must provide some type of memory protection.

Damage to files occurs very infrequently, but when it does happen a detailed means of file reconstruction must be present. The traditional magnetic tape system uses the concept of "grandfather," "father," and "son" tapes. A record is read from the father tape, updated and written on the son tape (without erasing the father). If the son is destroyed, it can be reconstructed from the father tape. Likewise, if necessary, the father can be reconstructed from the grandfather.

However, in a real-time system such a procedure is impossible. Here a record is read, updated, and the new record written back in the same location, erasing the previous one. In this case the file may be periodically "dumped" leaving sufficient information in some temporary storage media to reconstruct changes made since the file was last dumped.

Another method of facilitating reconstruction procedures is through the use of a log which is a constantly kept record of the transactions being processed.²⁷ Subsequent to a computer failure the restart procedures center around the use of the log. The transaction log is kept by the computer, and it is generally desirable

²⁷ James Martin, op. cit., p. 552.

that the writing of the log be the first action taken when a message is received.

The primary control technique to ensure that a program and/or data do not infringe upon previously allocated storage is the concept of the boundary register. This type of control requires additional equipment, in the form of an upper and lower boundary register. Special instructions define the upper and lower core storage addresses of a program when it is loaded into the processor. Then the machine compares every instruction to be processed with the boundary registers. If the address of an instruction is outside these limits, it is not executed. In this instance an interrupt occurs, and control is transferred to the supervisor program for appropriate action.

Therefore, it can be seen that the approaches to protecting memory vary, depending upon the equipment in use.

Emergency Procedures

Real-time systems must operate without stopping for fixed periods of time, the duration depending upon the system configuration. When a malfunction occurs in some component while the system is in operation, a decision must be made as to whether to halt the processing or to continue after switching to some routine to handle the problem. With respect to OLRT systems, the rule is to keep the system operating if at all possible. The two major methods of reinforcing computer reliability during periods of hardware malfunction are fall-back and duplexing.

Fall-Back. Fall-back, sometimes referred to as "graceful degradation," occurs in a non-duplexed system when an equipment component becomes unoperative but the loss is not serious enough to close down the entire system.

Fallback means that the system modifies its mode of operation to circumvent the error. . . .A system may be designed with more than one computer, spare file units, and alternative data paths so that some type of fallback can be used whenever a single component failure occurs. . . .Any functions for which a fast response is not mandatory may be temporarily shelved.²⁸

There are four classes of equipment failure for which fall-back procedures must be devised. These are:

1. Failure of an input or output unit. Under these circumstances the unoperative unit may be replaced by an alternative unit.
2. Failure of a file or drum. Use of an alternative file or drum means that two copies of important data files should usually be kept updated.
3. Failure of a multiplexor or line input device. This failure drastically curtails the performance of the system, unless switchover to a duplicate multiplexor can be made. However, key information may still reach the processor through alternative I/O units.
4. Failure of the main computer. The designing of a system with a satellite computer prevents complete failure when the main computer becomes unoperative.²⁹

²⁸James Martin, op. cit., pp. 54-5.

²⁹James Martin, Programming Real-Time Computer Systems, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1965), pp. 236-37.

In systems which operate 24 hours a day, fall-back procedures are necessary not only for equipment failure, but also, for the performance of preventive maintenance.

Duplexing. If the fall-back procedure does not provide sufficient reliability, it may be necessary to duplex the main computer. This is accomplished through the use of duplicate computers and files, so that in the event of any particular component failure an alternative one can enable the system to continue operating. (See Figure 6, page 37.)

Therefore, it can be seen that emergency procedures must be considered from the beginning in the design of a real-time system.

It has been shown that if auditors are to review such complicated applications, it is necessary that they be familiar with the real-time controls necessary to ensure that the desired results are produced.

Summary

The scope of the definition of internal control takes into consideration more than just the protection of assets, recognizing that a system of internal control extends beyond matters directly related to financial functions. It is concerned with the over-all operations.

Internal control in an EDP system encompasses control of data input, machine processing, and output, and increased emphasis must be placed on the review of controls due to centralization and concentration of data processing in an electronic system.

The essentials of control in any system (electronic or otherwise) consists of:

1. the separation of duties and responsibilities among employees in such a manner that no one person has complete accounting control over substantially all phases of a business transaction;
2. formulation of procedures to ensure the accuracy and completeness of the original reporting of the source data.
3. the existence of procedures to ensure consistent and accurate processing of source data;
4. the intermediate review of documents and records by authorized, knowledgeable employees; and
5. review and interpretation of the end results of the accounting systems.

There is nothing in the nature of electronic data processing which is basically inconsistent with these essentials; however, the means of implementing them have been altered.

In discussing controls a distinction is usually made between administrative controls and accounting controls. Administrative controls in electronic systems should be related to the formation, documentation and implementation of operating procedures in systems design, programming, and computer operations. Accounting controls must relate to input, processing and output.

Stringent controls must be established with respect to the input of data into a computer system, for machines will operate just as effectively with incorrect data as with correct data. The two major types of input controls are transcription controls and control totals; however, they become virtually obsolete in an OLRT system. The value of transcription controls becomes negligible in many instances, due

to the absence of source documents. Data is directly entered into the system at the point of origin. Control totals also become useless, since in an OLRT system, data is very rarely accumulated and processed in logical transaction groups, and these controls cannot be applied before the processing occurs.

Processing controls include programmed, machine and output controls. The use of OLRT systems has greatly increased the importance of existing processing controls and has given rise to new controls.

The concept of using communication lines to transmit data in OLRT systems requires the use of on-line remote terminals through which messages are transmitted to, or received from, a computer. When operating in this manner it is important to ensure that all data transmitted are received and properly processed. To prevent messages from being lost or improperly processed, the following controls must be present:

1. Message identification--to ensure proper message flow and processing.
2. Message transmission control--to ensure that all messages sent are received.
3. Detection of transmission errors--to determine the correctness of the information received.

Information housed in the memory of an on-line system is available to terminal operators upon their request. Therefore, a good possibility exists of data being used by unauthorized personnel, or destroyed or improperly processed due to carelessness. Thus, programmed controls must be devised which will eliminate any possibility of improper data usage, incorrect file updating, and destruction of data and programs

stored in memory.

Furthermore, real-time systems must operate without stopping for fixed periods of time, the duration depending upon the system configuration. When a malfunction occurs in some component while the system is in operation, procedures must exist to ensure the continuance of the system.

CHAPTER IV

PRESENT AND PROPOSED ELECTRONIC SYSTEMS AUDITING TECHNIQUES

Once the adequacy of internal controls has been established, the auditor may begin collecting competent evidential material. The manner in which this task is carried out in investigating an electronic system differs significantly from investigating a conventional pen-and-ink system, due to the loss of the audit trail (as discussed in Chapter I).

In order to place the execution of the audit function in proper perspective, it is necessary to look at the audit techniques applicable to electronic systems which are currently being employed.

Present Electronic Systems Auditing Techniques

Under a manual system, each transaction is manipulated a step at a time, with justification for each step appearing in written form.

However, in an electronic system the computer performs all manipulations internally with output provided in the form of end results on magnetic tape or disk. The justification for intermediate manipulations or output is lacking.

These changes create new difficulties for the auditor. Due to the lack of written records, the traditional methods of auditing in the area of evidential matter can no longer be readily accomplished.

In the face of this dilemma two approaches to testing and verifying the accuracy of source data used in electronic systems have developed-- the "around the machine" approach and the "through the machine" approach.

"Around the Machine" Approach

In a majority of electronic systems audits which have been performed the "around the machine" approach has been utilized. This method "involves a direct verification of the output from the source data without really considering the method of source data conversion to its computer input form or the actual method of processing the data."¹

The primary assumption under this method is that if the input to the system is correct and the output is properly handled, then the intermediate processing is necessarily correct.²

The advantages in the use of this auditing method are simplicity and familiarity to the auditor, coupled with the fact that the "around the machine" approach minimizes the need for specialized knowledge concerning the operation of electronic processing systems.

However, the simplicity of this approach is outweighed by the following three associated problems:

First, the apparent or actual disappearance of the audit trail may make it difficult, if not impossible, to trace other than very large groups of data from its output form back to its source. Second, changes in operating instructions might make the sampled items used in a test applicable to only a limited number of transactions. And third, a large variety of transactions coupled with a large volume can make the testing of samples of data impractical from the standpoint of cost in comparison with the results obtained.³

¹C. Orville Elliot and Robert S. Wasley, Business Information Processing Systems, Revised edition, (Homewood, Illinois: Richard D. Irwin, Inc., 1968), p. 337.

²Donald H. Sanders, Computers in Business: An Introduction, (New York: McGraw-Hill Book Company, 1968), p. 343.

³Elliot and Wasley, op. cit., pp. 337-38.

In spite of these disadvantages, the majority of the electronic systems audits which have been made have utilized the "around the machine" approach.⁴

"Through the Machine" Approach

The alternative to the previously discussed method of auditing electronic systems is the "through the machine" approach. "This method involves a detailed examination of EDP operations and an evaluation of the accuracy and propriety of these procedures."⁵

The logic of this approach is that if the source data is correct and internal machine processing is properly conducted, then the output can be assumed correct. While this approach is preferable for large, sophisticated systems, the application requires comprehensive knowledge of electronic data processing.

In utilizing the "through the machine" approach the testing of records is de-emphasized, and concentration rests upon testing the system that produces the records. The most common means of performing a test on the system consists of the use of test decks.

Test decks are sets of punched cards designed by the auditor to test computer programs. The decks are usually composed of imaginary transactions, however it is not uncommon to include actual transactions selected from the client's files.⁶ In addition, the test decks may

⁴Donald H. Sanders, loc. cit.

⁵Elliot and Wasley, op. cit., p. 338.

⁶Robert G. Wright, "How Do You Audit EDP?" Haskin and Sells Selected Papers, 1964, c. 1965, p. 143.

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include transactions that are erroneous in one way or another to test the effectiveness of programmed controls. The auditor manually determines the correct answers for the tests and compares these with the computer results to determine the accuracy of processing procedures.

In developing and using test decks, there are several important factors which the auditor must reflect upon. These are:

1. the exact point in the system where the test decks are to be entered;
2. the types of transactions to be included in the tests decks;
3. when to obtain the master records to process against the test transactions and to compute the predetermined results for comparison with the output resulting from the test processing;
4. consideration of the effects that the processing of test transactions will have on the results of the system produced under normal operating conditions;
5. obtaining the client's regular processing programs and assuring himself that the program is used to process actual, as well as test, data; and
6. making necessary arrangements to get the test data prepared and processed, and to get the output in the desired form.

In spite of the complexities, the test deck technique is here to stay and is much superior to techniques employed under the "around the machine" approach.⁸

⁷W. Thomas Porter, "Evaluating Internal Controls in EDP Systems," The Journal of Accountancy, (August, 1964), p. 36.

⁸Wayne S. Boutell, "Auditing Through the Computer," The Journal of Accountancy, (November, 1965), p. 43.

Future Problems Inherent in Present Auditing Techniques

The proponents of each of the present approaches to auditing electronic systems are quite adamant in their views.

Advocates of the "around the machine" approach contend that sound conclusions regarding internal control can be developed without a review of computer procedures. In support of this they stress the following facts: (1) it is impracticable to review procedures which are often poorly documented; and (2) the important controls are found outside the machine room--they are placed upon the data processing department by outside departments. The results of their contentions is the permitting of internal control reviews to be made by accountants having no specialized EDP knowledge.

On the other hand, advocates of the "through the machine" approach insist that the essence of internal control in an electronic system is the machine's program of instructions. They will concede that outside controls upon the processing department are indeed necessary, but not sufficient. The inadequacy of outside control alone stems from two causes: (1) the controls may be imposed by outside personnel who are not sufficiently control minded; and/or (2) the mechanized procedures may be so complex that outside controls alone are inadequate. Therefore, the advocates of this approach feel it is absolutely necessary to review computer procedures.

The real problem here is not a case of "around the machine" versus "through the machine," for these terms tend to be misleading. Auditing "around the machine" seems to imply that the computer can be completely ignored, but this is not the case. The auditor should always consider the control framework in which the computer processing is carried out,

irregardless of the auditing method being employed. In addition, both approaches are predicated upon the testing and verifying of source data. In reality, in choosing an audit approach the point at issue should be the determination of the effectiveness of the cost of the computer procedure versus the effectiveness and cost of the manual alternatives.

While a combination of the two approaches has proven adequate for electronic batch-processing systems, this will not be the case with technological advancement being made in the development and adoption of on-line, real-time systems. Although such systems will have no effect on the functions of the auditor, they will serve as impetus for a drastic change in techniques, because neither an "around the machine," nor a "through the machine" approach is applicable to an on-line, real-time system.

This statement can be made in light of the following two factors. First, in a completely real-time system there is an absence of source documents in a majority of instances. This is due to information being entered directly into the system at the point of origin, resulting in virtually a total loss of the audit trail. Second, since any error in such a system can easily go undetected indefinitely, due to the absence of source documents and intermediate reports, techniques must be implemented which will discover errors at their initial introduction into the system.

It must be emphasized that sacrifice of the audit trail is a small price to pay for the type of reporting afforded by an on-line, real-time system, and the auditor must be prepared to adjust accordingly.

Proposed Electronic Systems Auditing Techniques

Valid achievement in the area of real-time management information is yet to come. . . . It is doubtful that any but the very large organizations will be effectively using real-time management information systems, in the full sense of the term, within the next five years. Real-time systems for medium-sized organizations are perhaps ten years away.⁹

With the coming advance and implementation of this type of system the auditor will have to update his techniques, adopting alternative procedures and placing more emphasis on the use of the computer to perform auditing tasks, rather than auditing around it.

Furthermore, the opportunity for the auditor, trained in electronic data processing, to increase the scope of his control can be immensely expanded through the utilization of electronic data processing equipment.

Audit checks in an OLRT system must be continuous and occur simultaneously with processing, and not be dependent upon retrospective evaluations. This can be accomplished primarily through more stringent use of programmed controls and the use of the computer to perform currently manual auditing tasks.

Increased Use of Programmed Controls

The real-time environment necessitates that a control system be designed and installed as an integral part of the overall processing system. Although electronic processing is far from unerring, numerous self-checks and controls can be programmed into all computer systems. If this is done, the possibility of an error in processing once data are

⁹J. D. Maclean, "Real-Time Systems--A New Tool for Management," Canadian Chartered Accountant, Vol. 92, No. 1, (January, 1968), p. 34.

correctly introduced, is small in most well designed systems where an adequate number of built-in and programmed checks and controls are provided and are operating.

Essential Input, Processing, and Output Controls. The utilization of on-line communication facilities, duplex equipment configurations, multiprocessing and multiprogramming necessitates the development of additional, more complex programmed controls. These controls were discussed in detail in Chapter III. However, it will suffice at this point to briefly reacquaint the reader with the essential input, processing, and output controls necessary to OLRT systems.

1. Input Controls. When operating in an on-line, real-time mode, it is important to ascertain that all information sent is received and properly processed. This is accomplished through use of message identification and message transmission controls, and controls to detect transmission errors.

2. Processing Controls. Since information housed in memory is readily available to terminal operators, controls must be instituted which will prevent unauthorized data transmission, destruction of internally stored data and simultaneous updating of internally stored files.

3. Output Controls. The most important output control is the assurance that only output terminals cleared for confidential data can receive such information.

Use of Test Transactions. Perhaps the most important control at the disposal of the auditor is the introduction of test transactions into the system.

The test data, prepared by the auditor, should be designed so as to check on the accuracy of input, processing, and output controls.

Therefore, these test transactions should necessarily include sufficient amounts of incomplete, erroneous and inconsistent data.

Ideally, the test data should be mingled with actual transactions. In order for this to be done, the processing program must have the capability of recognizing test data by a certain code so as to refrain from adding them to total operating results or permanent records.

Control by Exception. Another type of audit technique which makes considerable use of the computer is the application of the concept of exception reporting. If processing programs are designed so that any data introduced into the machine is processed correctly, the machine can further be programmed to reject any data which is considered to be an exception. Programming the system so that it will produce exceptions is a simple task, requiring only the determination and incorporation into the program of certain standards for evaluating actual transactions. Transactions not conforming to the standards would be printed out in visible form for further analysis.

Since a real-time system provides transaction details and summary information on a current basis, it is possible for the "control by exception" technique to be broadened so as to include a management review of exceptions in time for immediate intervention, rather than after the fact correction. In addition, exception reporting offers the advantage of utilizing the computer as the primary control instrument, rather than imposing extraneous controls on the system--an imposition which might make processing in a real-time mode an impossibility.

Use of Computer Programs In Auditing

Another technique which should be universally utilized is the use of special computer programs to perform auditing tasks. Of the new

techniques available to the auditor, the development of audit programs offers the greatest opportunity for increasing auditing effectiveness and efficiency.

Although the basic procedures in each program will differ, their basic function will be to automatically check the routine items and select unusual or incorrect ones for further perusal. The value of being able to quickly dispose of routine and correct items is readily apparent.

Computer programs can be used for any computational or comparative task for which selective criteria can be established. Examples of these types of auditing tasks are:

1. Testing extensions and footings
2. Summarizing data and performing analyses useful to the auditor
3. Examining records for quality--completeness, consistency, invalid conditions, etc.
4. Selecting and printing confirmations
5. Selecting and printing audit samples
6. Comparing the same data maintained in separate files for correctness and consistency
7. Comparing audit data with company records.¹⁰

The common characteristic of these tasks is the fact that they can be clearly and precisely defined.

The benefits derived from utilizing the computer to aid in auditing

¹⁰W. Thomas Porter, "Generalized Computer-Audit Programs," The Journal of Accountancy, (January, 1969), p. 54.

procedures are as follows:

1. It permits more extensive audits.
2. It permits better selection of items for follow-up.
3. The experience of senior auditors can be incorporated into programs conducted by juniors; less supervision of junior auditors will be required.¹¹

There are two primary means of utilizing computer audit programs. The first involves adding a loop of instructions to the client's program. When necessary, this special routine would be put into operation by use of a program alteration switch and would perform a series of tests to check both the accuracy of the data being processed and the data internally stored.

The second approach necessitates the development and use of generalized computer-audit programs which test and evaluate records produced by the system. One such set of generalized computer-audit programs--Auditape--has been developed by Haskins and Sells.¹² This system is applicable to brokerage firms, and has been used very successfully by Haskins and Sells in performing audit procedures and by their clients in analyzing files for management purposes.

The advantage of incorporating an audit loop in the operating program is that it does not require an additional computer run to use the program. However, the use of a separate audit program is preferable, since it gives the auditor the flexibility of deciding as to when he will use this program--he does not have to carry out his audit when the operating program is being processed, nor need his check be confined only

¹¹Kenneth G. Cadematori, "Auditing Automated Data Processing," Federal Accountant, Vol. 8 (June, 1959), pp. 35-6.

¹²W. Thomas Porter, loc. cit., pp. 54-62.

to data being processed at that time. In addition, a separate program may be retained under the auditor's special control, thus preventing leakage of knowledge of the program's operations and opportunities for program alteration.

Obviously, in a real-time system, auditing tasks must be performed along with regular processing on a continuous basis rather than once a year.

The next chapter presents two auditing case applications. In the first, edit routines and exception reporting are built into the regular processing program. The second shows the development of a special audit program to be used to perform a currently manual auditing task.

Summary

Two major approaches to auditing electronic systems have been developed over the past years. The "around the machine" approach involves the direct verification of the output from the source data without consideration being given to either the method of source data conversion to machine readable form, nor the actual method of processing the data. The alternative to this is the "through the machine" approach. The logic of this method is that if the source data is correct and internal machine processing is properly conducted, then the output can be assumed correct. Both of these approaches are predicated upon the testing and verifying of source data.

While either, or a combination of these two approaches is adequate for auditing present systems, neither will be applicable to the rapidly developing OLRT system. First, in a completely real-time system there is an absence of source documents. And second, unless techniques are implemented which will discover errors at their initial introduction

into the system, such errors will be indefinitely undetectable.

Audit checks in an OLRT system must be continuous, occurring simultaneously with processing, and not be dependent upon retrospective evaluations. This can be achieved through increased use of programmed controls peculiar to real-time systems, and the development and implementation of special audit programs.

CHAPTER V

SELECTED COMPUTER AUDIT APPLICATIONS

To illustrate the feasibility of using the computer to perform continuous self-auditing routines, selected areas of Louisiana State University's financial administrative procedures were analyzed. The cooperativeness of the LSU administration and staff made the records an excellent data base from which to work, and care was taken to select areas for analysis that would be applicable to profit as well as non-profit institutions. More specifically, the areas analyzed concerned compliance with budgetary requirements with respect to the payroll for salaried personnel, and the audit of student fees. Such studies would apply to any item which must comply with budget restrictions, and any receipt of fees, the amount of which varies with certain circumstances.

However, before beginning the procedural analysis, it is first necessary to briefly acquaint the reader with Louisiana State University's hardware system.

An Overview of Available Hardware

The Office of Data Processing houses an IBM 360 Model 30 with 64,000 bytes of storage and the following peripheral equipment:

1. Two selector channels with four magnetic tape drives interfaced to one (2402 Mod II tape drive) and four Model 2311 magnetic disk drives on the other.
2. One multiplexor channel with the following I/O units interfaced to it:
 - a. One 1050 keyboard printer.

- b. One 2701 data communications terminal located remotely at the Data Processing printing office.
 - c. One 1231 optical mark reader.
 - d. Two 1403 eleven-hundred line per minute printers, one 2540 card reader/punch, and one 2501 card reader.
3. One model 1050 remote terminal to allow real time keyboard entry of data via the communications channel.

The IBM/360 core is currently partitioned as follows: (1) the supervisor occupies 10K; (2) background (BG), 36K; and (3) foreground (F1), 18K. Presently the Office of Data Processing operates in a two partition (BG and F1) multiprogramming mode.

With this necessary background, a detailed analysis of the application of budgetary requirements to the payroll for salaried personnel is now possible.

Salary Budgetary Requirements Audit Application

LSU has three personnel departments: (1) the Office of Classified Personnel; (2) the President's Office, which handles academic and non-classified personnel; and (3) the Graduate School, which administers assistantships and fellowships.

Through these three departments are funneled all payroll action forms from all hiring units on campus. After being processed by the appropriate personnel department, the forms are then forwarded to the Office of the Auditor. (See Appendix A for Organizational Charts of the Office of the Auditor.)

These personnel action forms are of two types: (1) appointments of new personnel; and (2) changes in payroll information concerning continuing employees.

The appointment form contains information concerning the budget account(s) from which the individual is to be paid, annual salary, proposed beginning and ending dates of employment, insurance deductions, retirement fund participation, and all other fringe benefits the employee may wish to participate in.

The change form contains data regarding desired changes in any of the above mentioned information.

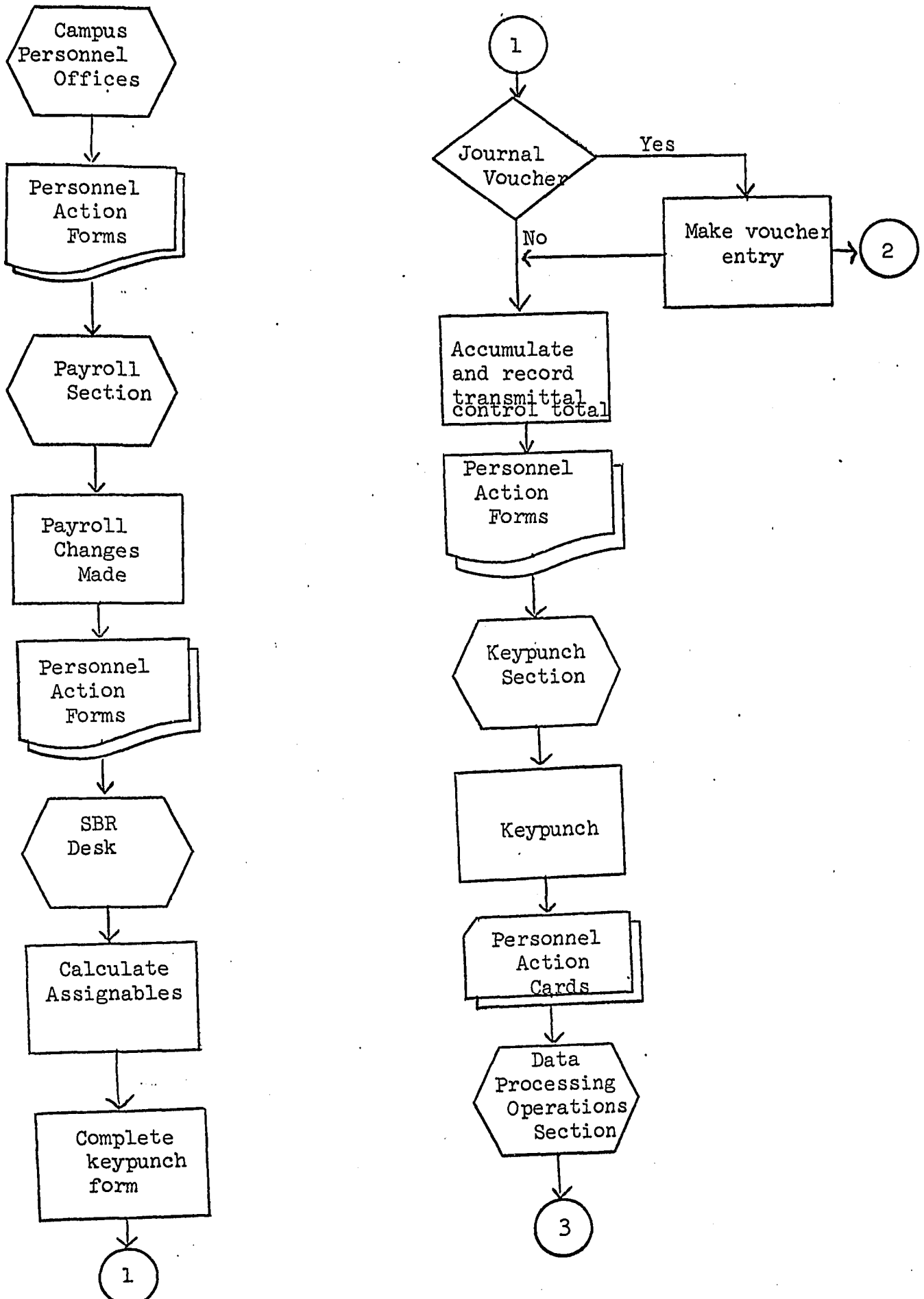
Current Processing Procedures

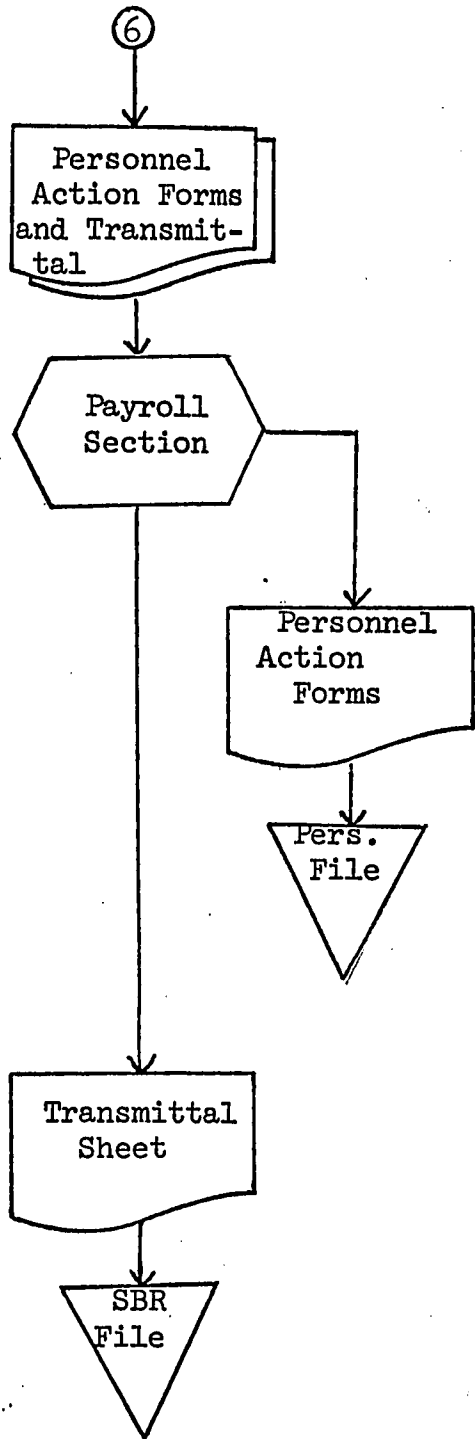
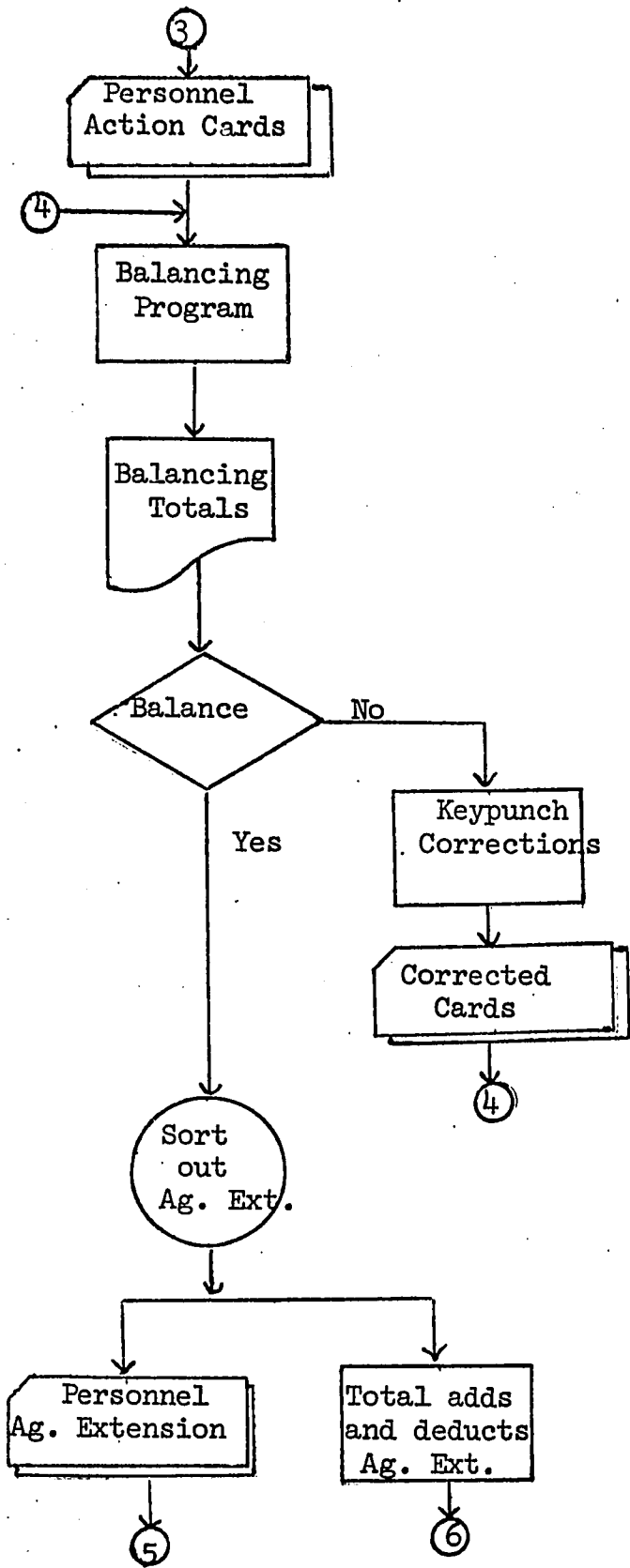
When the personnel action forms reach the Office of the Auditor they are given to the payroll section, as can be seen in Exhibit 1. Here forms are filled out (see Appendix B) to submit to data processing in order to make the necessary payroll additions or changes. These keypunch forms are forwarded to data processing and the personnel action forms are sent on to the salary budgetary requirements (SBR) desk.

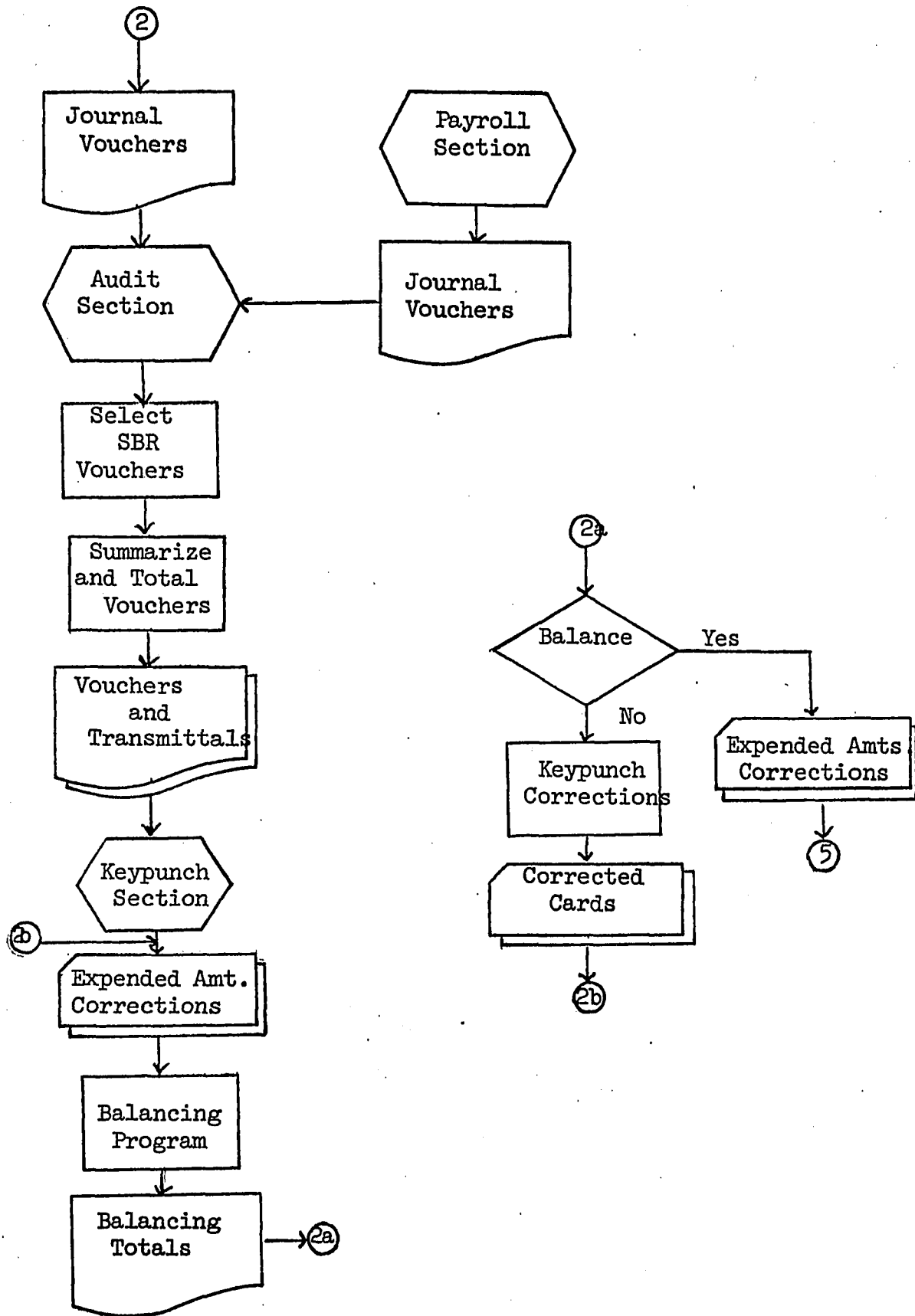
Here, at the SBR desk, the amount of funds needed to pay an individual from each applicable budgetary account is calculated. This calculated amount is referred to as an "assignable"--that portion of a fund which is committed to a future use. The assignable amounts are coded and sent to data processing, accompanied by a transmittal sheet containing control totals.

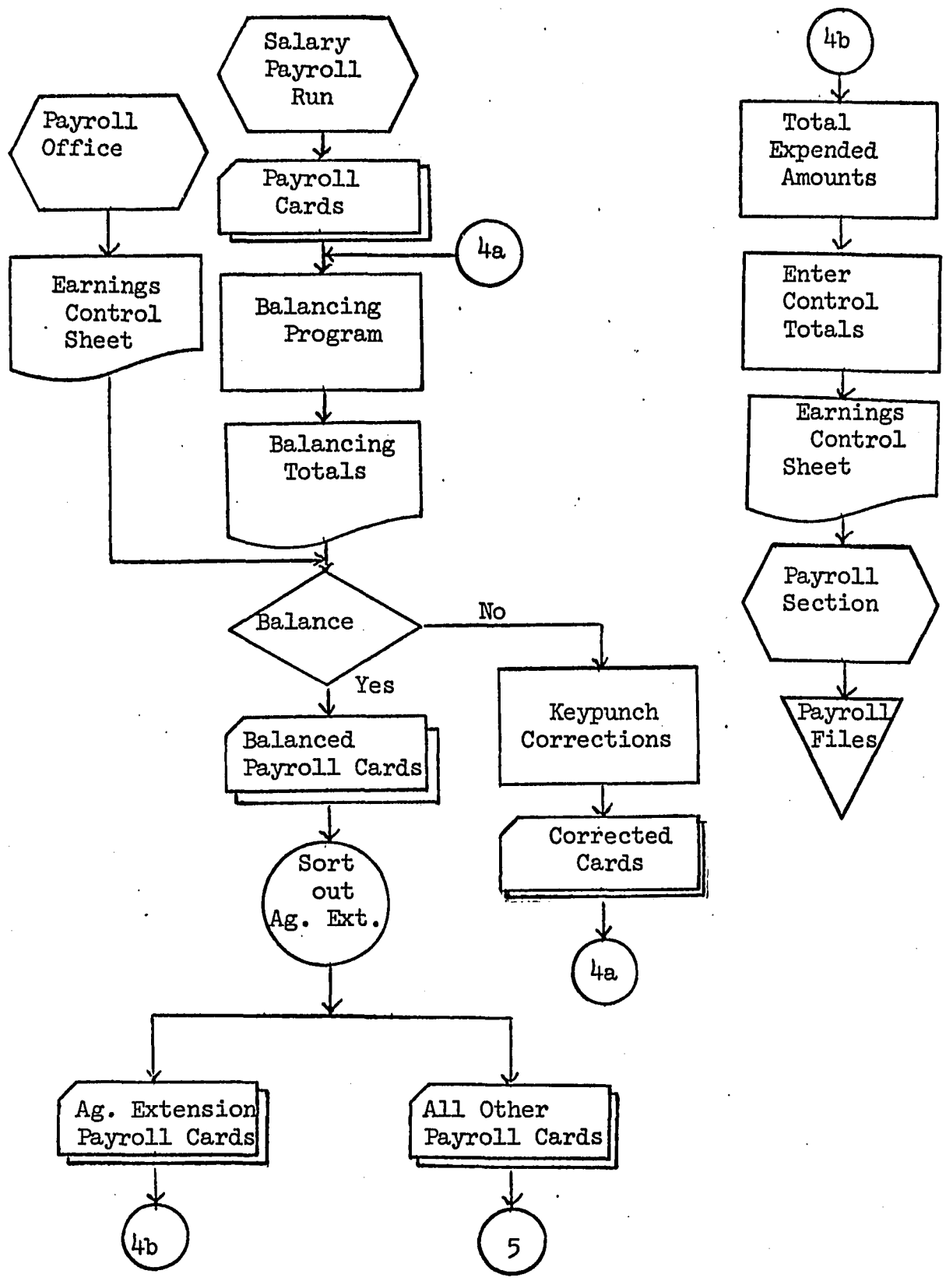
If a delay has occurred in processing a personnel action form it is quite possible that an individual may have already been paid from the incorrect budgetary account. When this is the case a journal voucher correcting entry is coded at the SBR desk. These journal voucher entries are also routed to the keypunch section along with a transmittal sheet giving control totals.

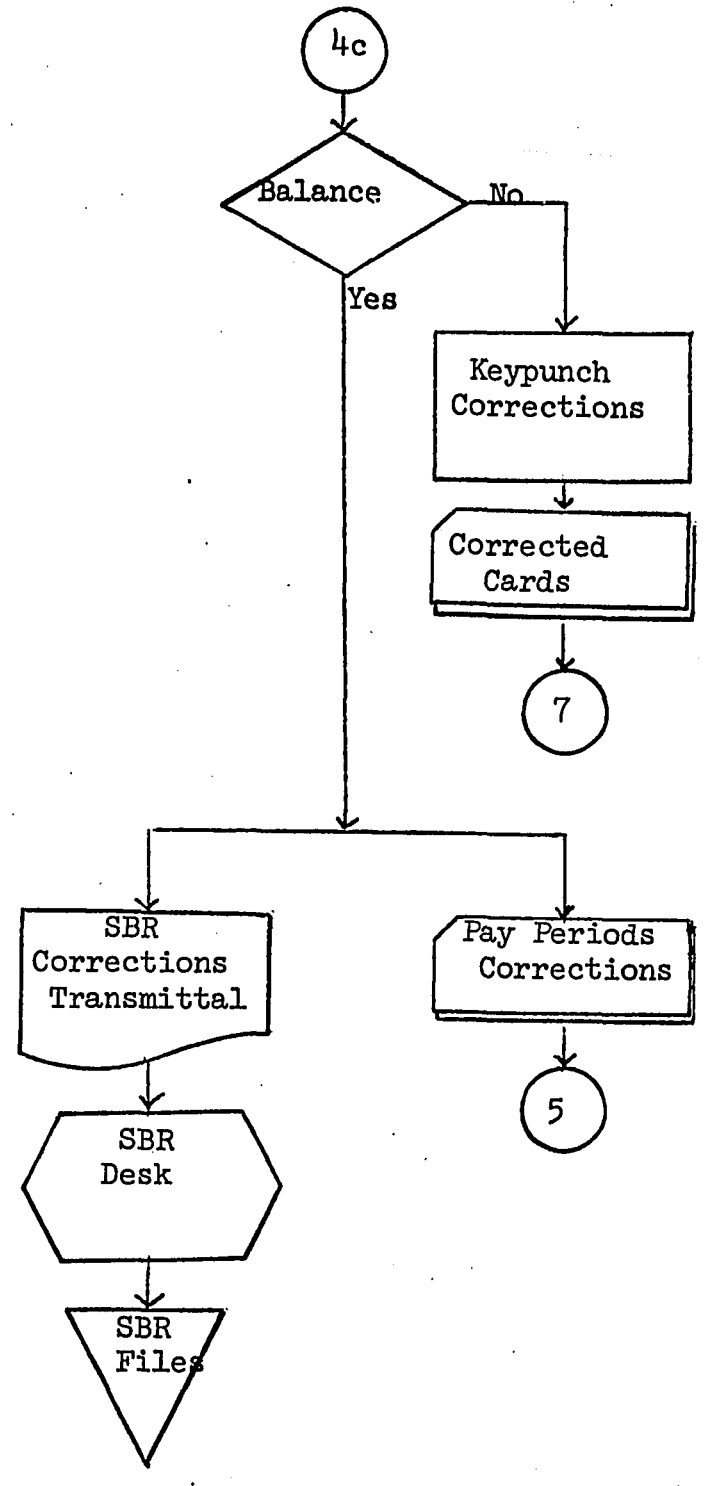
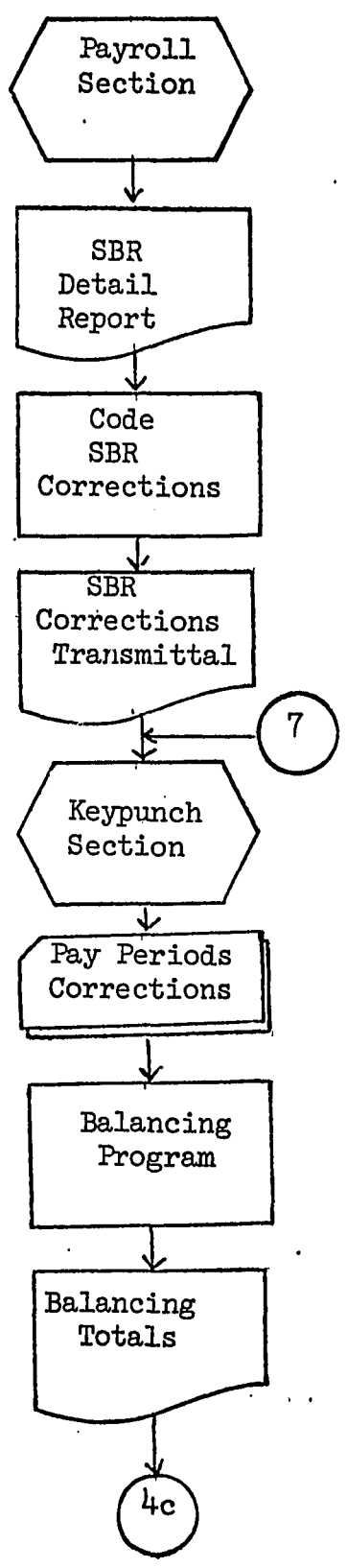
Exhibit 1. Current LSU Payroll
and SBR Procedural Flowchart

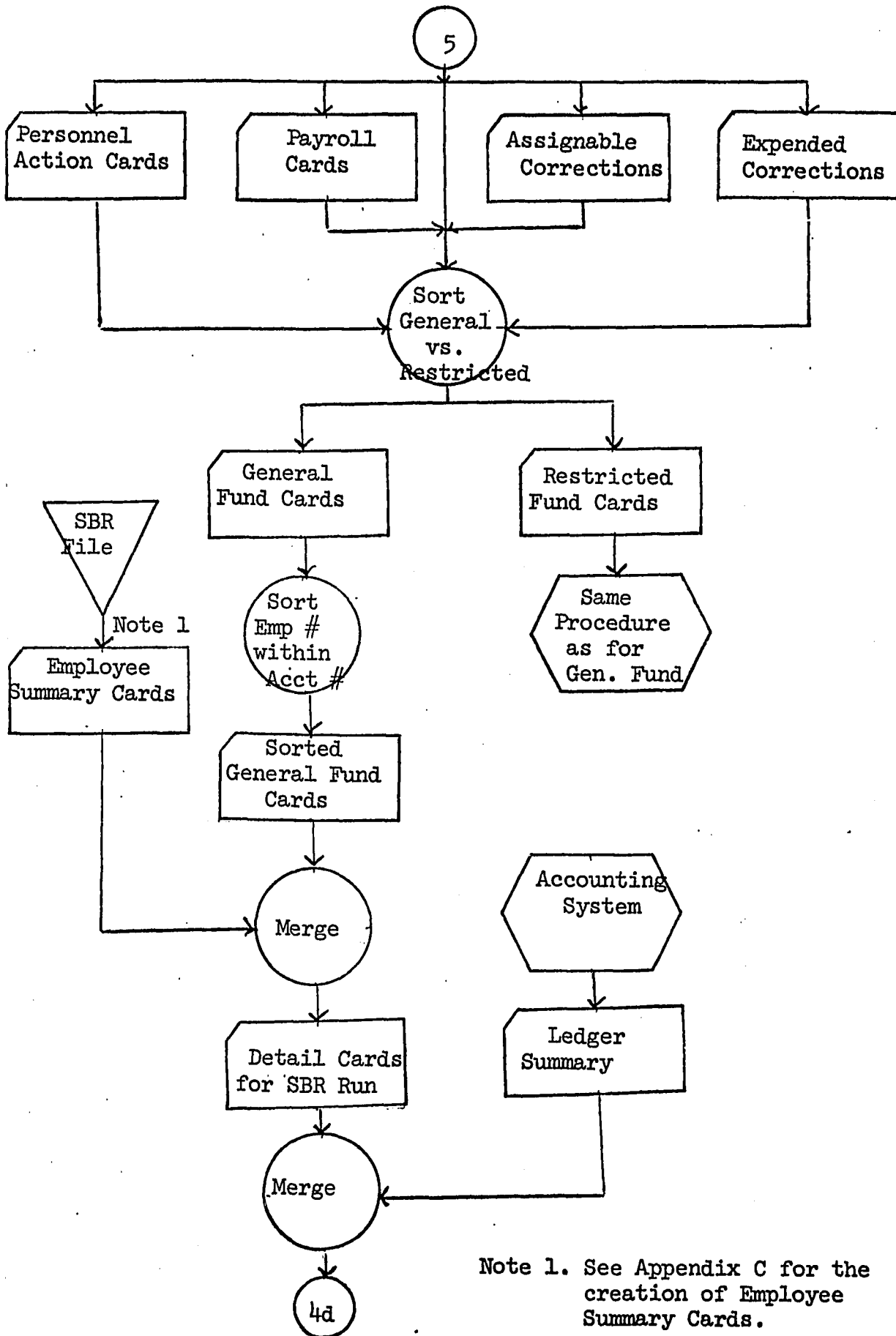




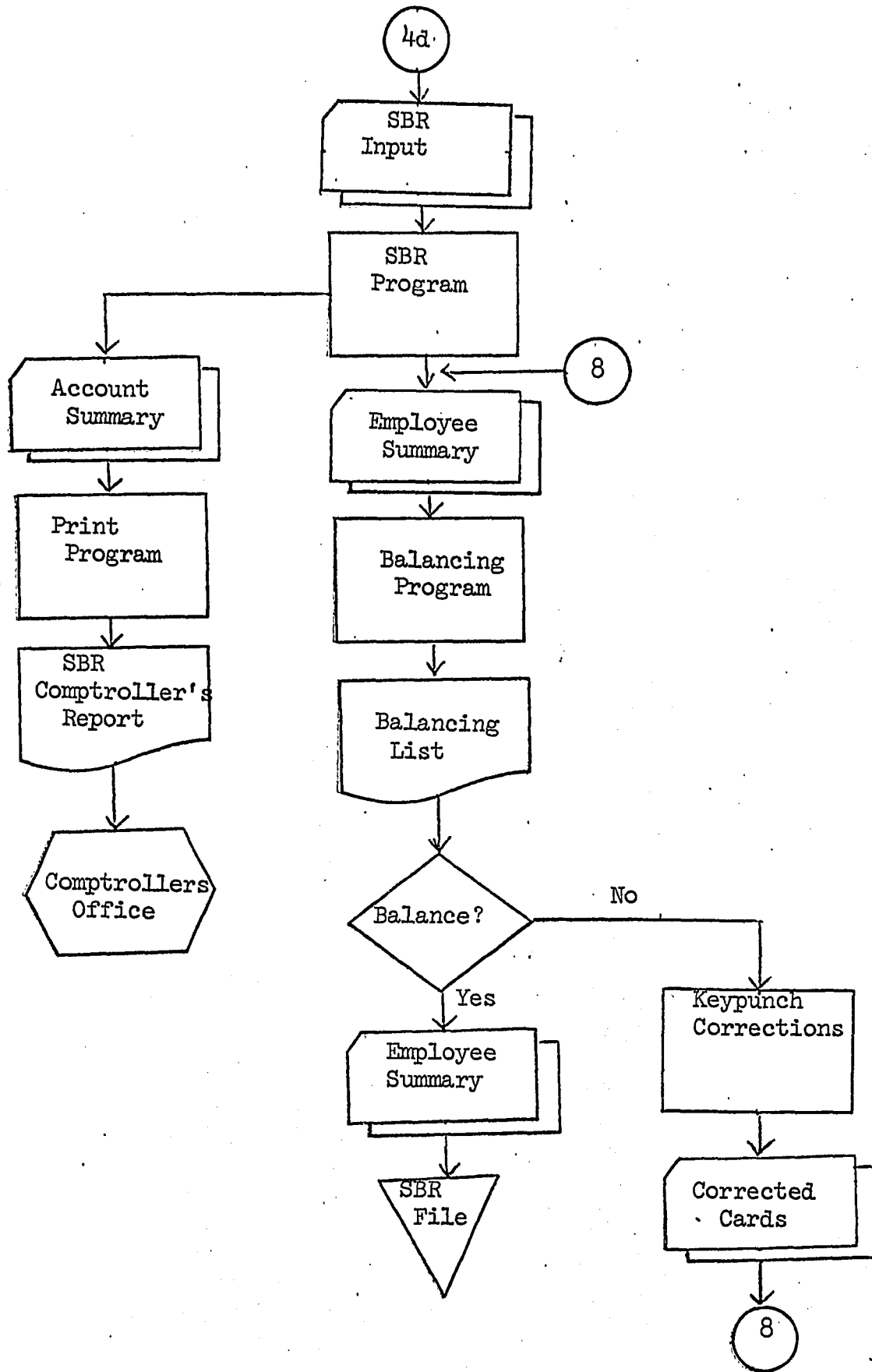








Note 1. See Appendix C for the creation of Employee Summary Cards.



From here the flow of data can easily be followed in Exhibit 1 (pages 88 through 94). The major processing steps include:

1. Balancing all payroll transactions, assignable calculations, and journal vouchers to control totals.

2. Running the payroll.

3. Running the detailed SBR report¹ which shows each employee's annual salary, monthly pay rate, the number of pay periods remaining for the employee, the amount of the fund expended on the employee, and his assignable amount. The assignable amount should always be equal to the number of pay periods remaining multiplied by the monthly pay rate.

Any variations are manually checked out and corrections made when the cause of the error is located.

4. Ledger summary cards showing expenditures other than salaries for each budgetary account are merged with the SBR cards, and a report showing the activity and balance for each account is prepared and forwarded to the Comptroller.

These are the important basics of the present system. A more detailed flow of the present SBR procedure is available in Exhibit 1 for those interested.

Problem Areas in the Present SBR System

There are several major problem areas in LSU's present SBR system. Currently, the SBR desk is used as the breaking-in place for new employees in the Office of the Auditor. Once an employee masters this assignment

¹Employees are listed by employee number within account number.

he is moved on to another. Therefore, the SBR desk is nearly always staffed by an inexperienced, temporary employee.

Furthermore, as with any organization that operates under strict budgetary requirements, it is imperative that all employees are paid from the appropriate budgetary accounts so that fund balances will reflect correct amounts, allowing intelligent decisions to be made regarding future expenditures.

However, the present procedure of calculating assignables by hand is slow and tedious, and at times there is a backlog of some unprocessed personnel action forms dating back six months.² This does not mean that the individuals in question are being paid incorrect amounts, (since the forms have already been processed by the payroll section), but rather, that they are being paid from the wrong budgetary accounts.

This time lag, coupled with the lag involved in creating ledger summary cards from the account summary file, causes the Comptroller's report to be as much as two months late. In fact, the Comptroller never receives an SBR report summary report giving the unexpended fund balances any sooner than at least one month after the fact, thereby destroying all timeliness and usefulness of the report.

In addition to the problems caused by time lags, the accuracy of the present SBR processing can be seriously questioned. The average number of personnel action forms to reach the Office of the Auditor on any working day is between 50 and 75, except for the one week period at the beginning

²Complicated transactions tend not to get processed by the inexperienced SBR personnel. They are "put aside until tomorrow."

of each new semester when approximately 150 to 275 forms are received each day. In light of these statistics, a sample of 50 previously processed personnel action forms was taken and the assignables were recalculated, account numbers scrutinized, etc. to determine accuracy. Of the sample taken, 20 per cent had originally been processed incorrectly in one aspect or another.

It is apparent that due to the time lags and inaccuracies in processing, improvements are needed in the SBR system if any type of adequate budgetary control is to exist.

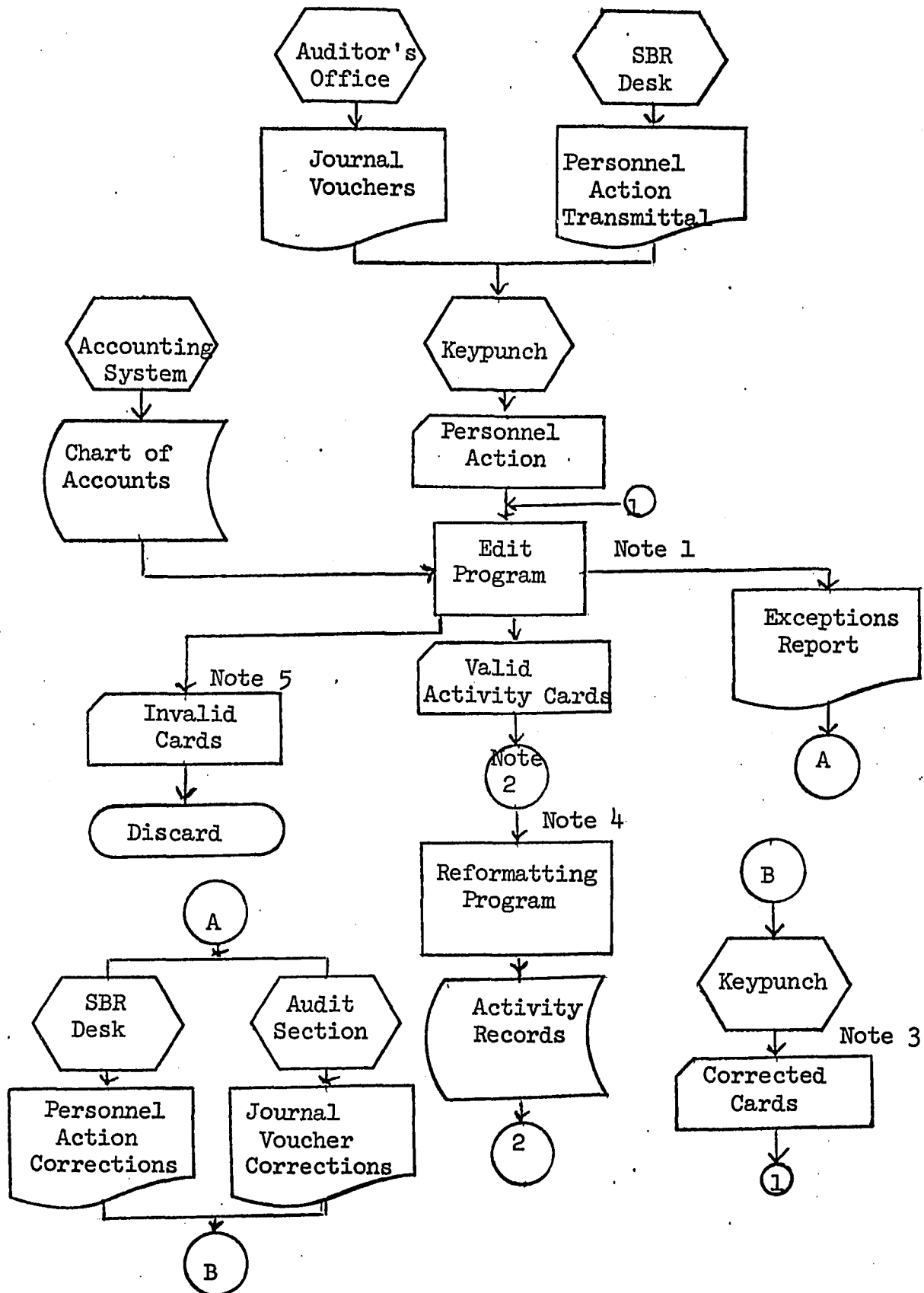
Proposed SBR System

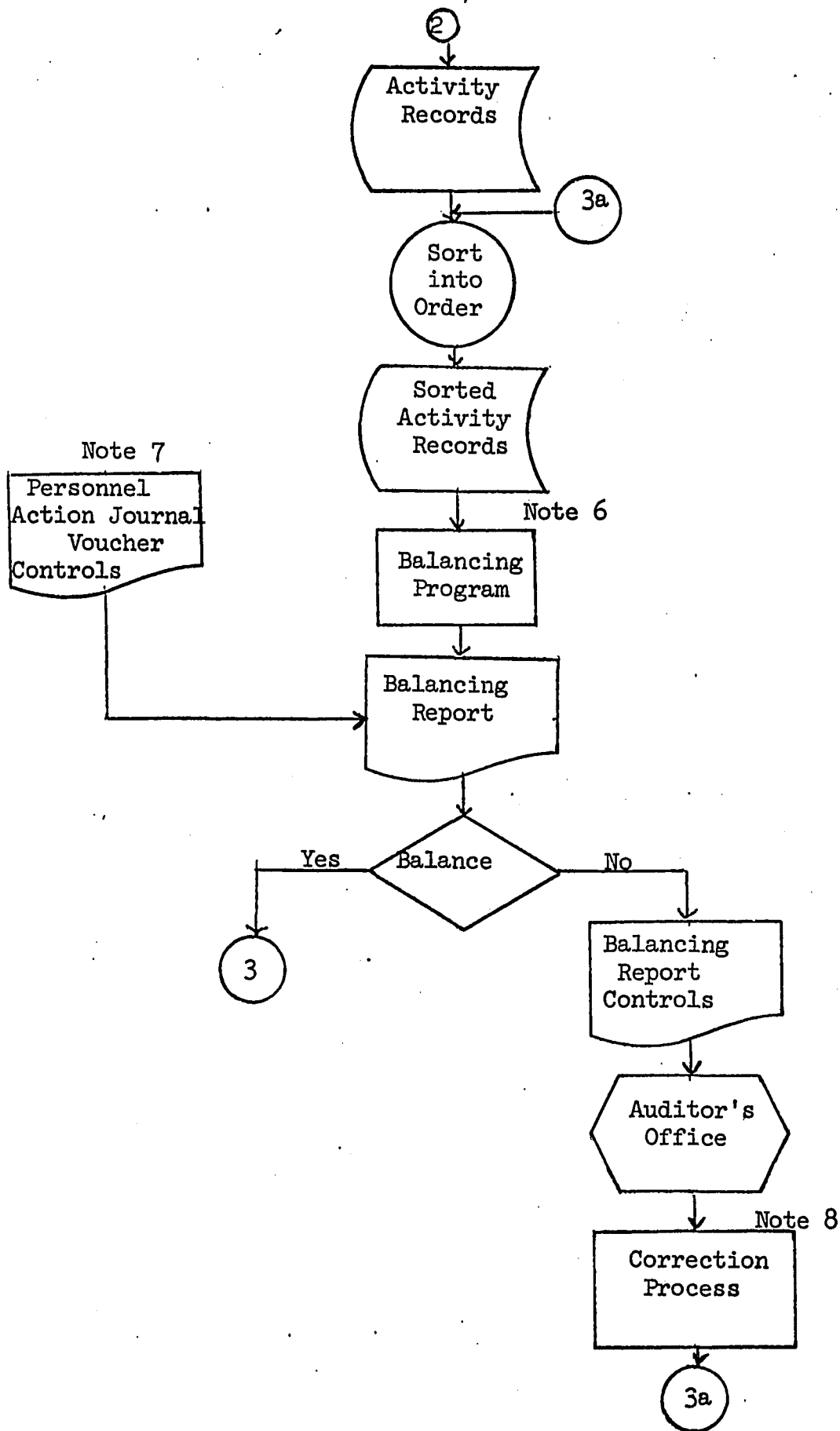
The following proposal is made in light of the existing hardware and personnel capabilities. True, more elaborate recommendations could be made, but they would be unrealistic given the existing resources.

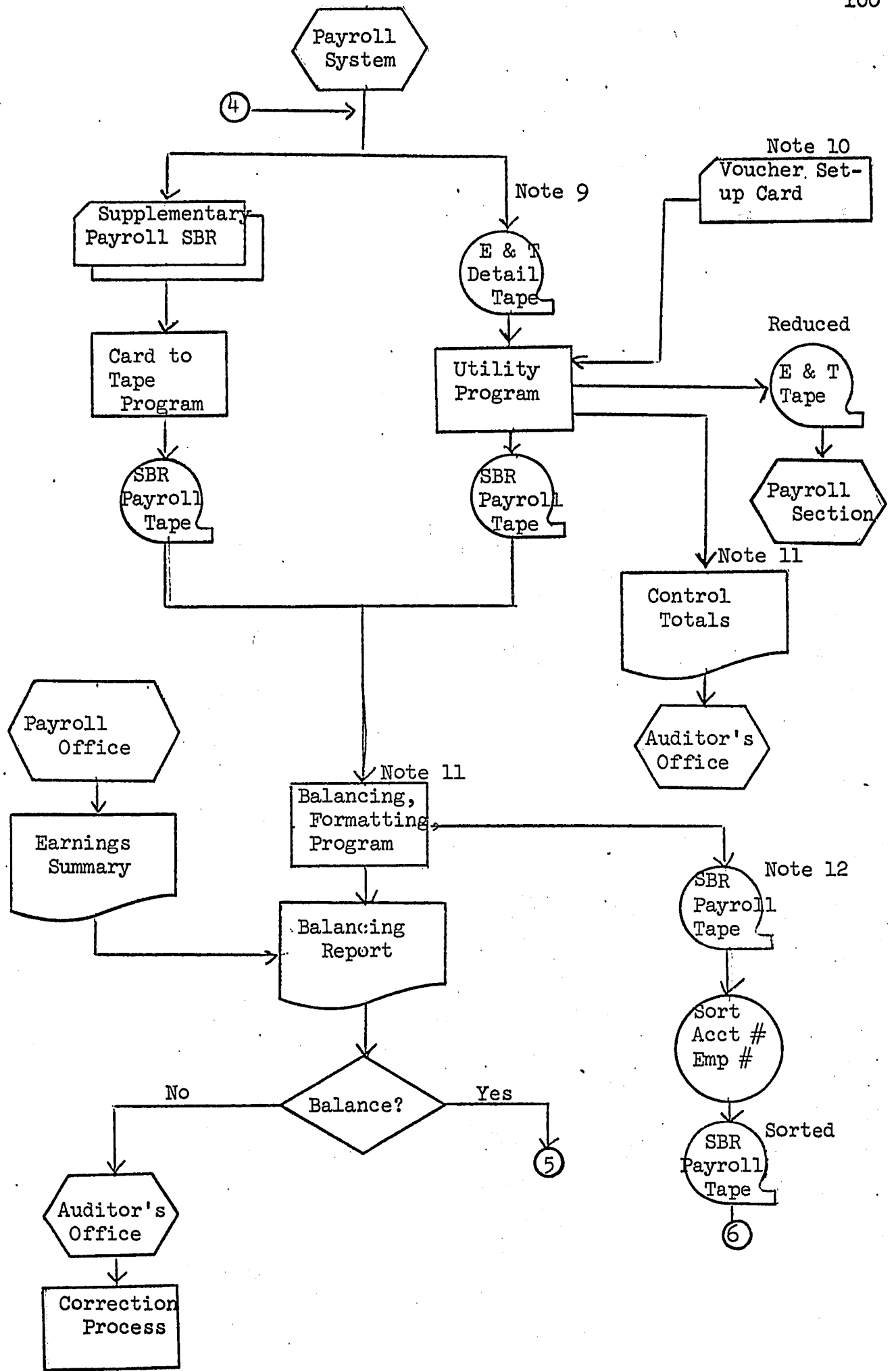
It is recommended that the assignables be calculated by computer,³ rather than manually as is currently being done. As can be seen in Exhibit 2, the information necessary for the calculations can be coded at the SBR desk. Furthermore, this coding function should be upgraded in job classification and given to a full-time, permanent employee in the payroll section, since knowledgeable familiarity is a requisite for accurate coding. A test was made and it was found that 50 forms (an average day's receipt) could be coded in slightly less than an hour.

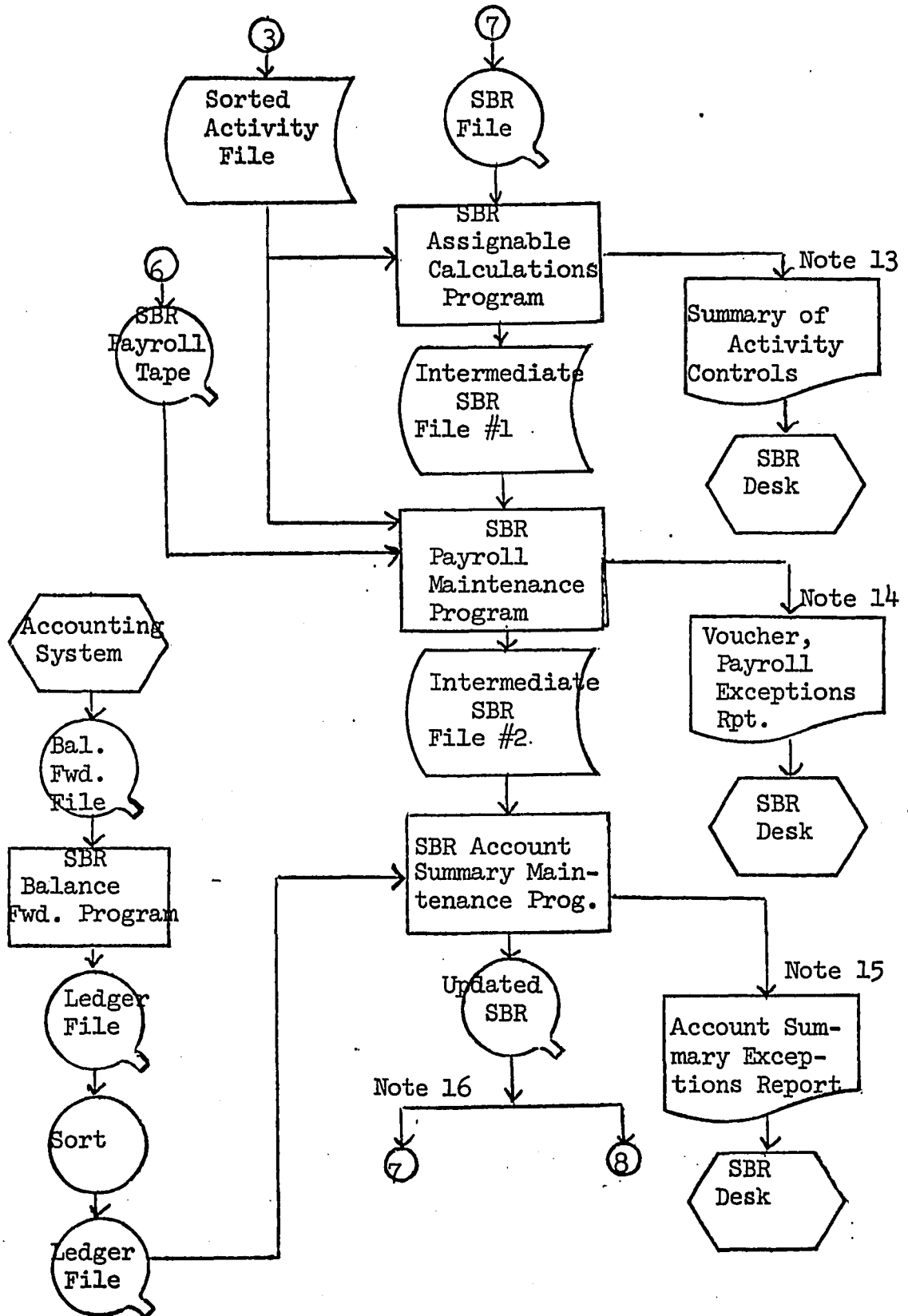
³See Appendices D and E for a flowchart of the proposed assignables calculation program.

Exhibit 2. Proposed SBR Procedural Flowchart









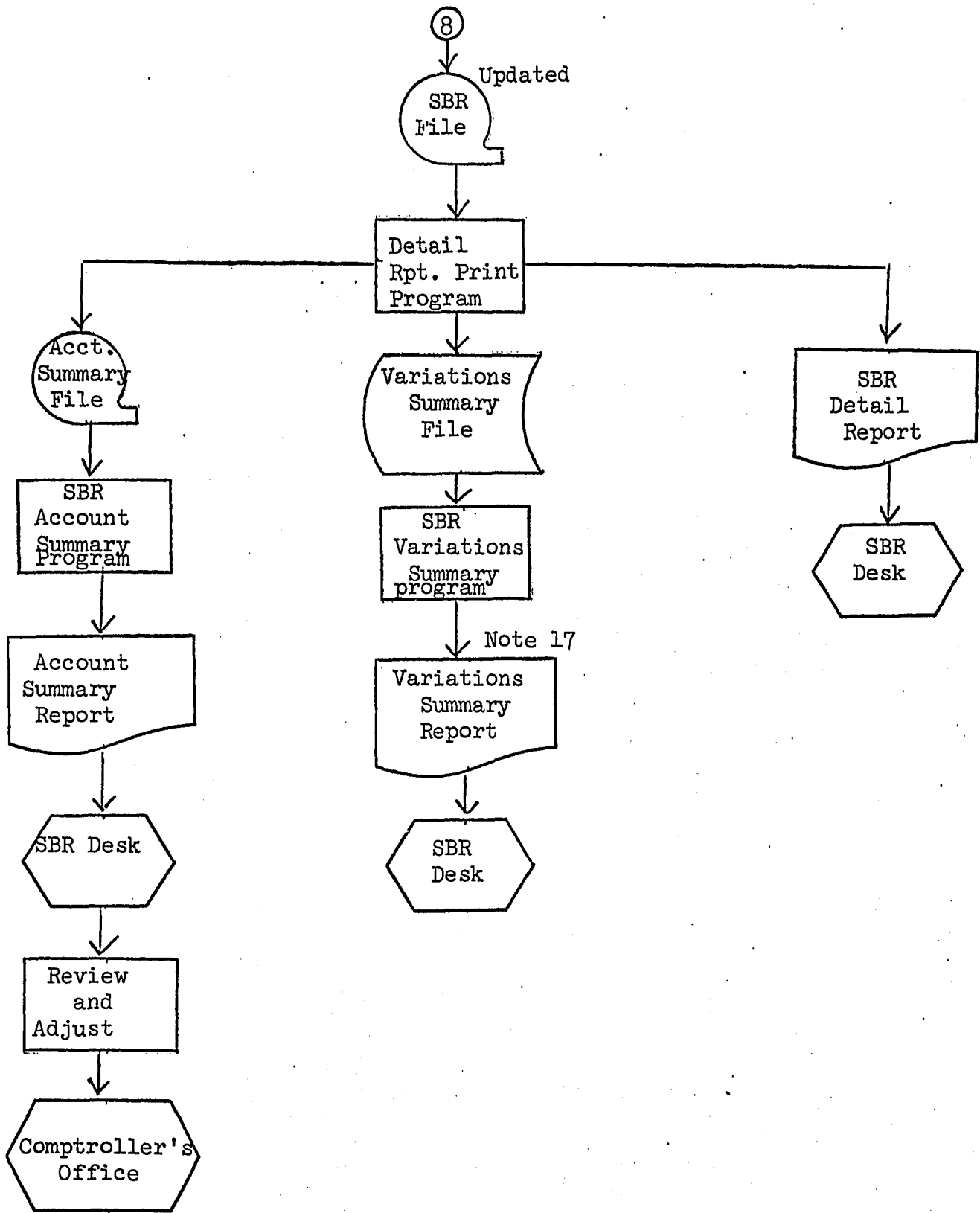


Exhibit 2 Diagram Notes

1. The edit program makes the following edit checks:

a. Personnel Action Cards

1. Employee number--numeric
2. Account number--numeric and for validity against chart of accounts
3. Title code--numeric
4. Pay basis--numeric and validity
5. Annual--numeric
6. Assignable dates--beginning date with no ending date and ending date with no beginning date are invalid
7. Assignable amount--numeric
8. Assignable sign code--must be present if there is either assignable dates or amount
9. Transmittal number--numeric

b. Journal Voucher Cards

1. Employee number--numeric
2. Account number--numeric
3. Voucher number--numeric
4. Amounts--numeric

c. Program will also verify that fields 1-5 are always completed.

2. Processing will not continue past this point until all cards are valid or permission has been received from the Office of the Auditor to exclude certain error cards.
3. Correction cards will have the same format as the original Personnel Action and Journal Voucher cards.
4. Reformatting program adds a code to each record identifying it as a General or Restricted account.
5. Invalid cards will be ejected to a special card reader pocket as they are detected to prevent manual separation.

6. The balancing program will list all activity while balancing voucher records on adds and deducts by voucher number and personnel action records on add and deduct dates and amounts by transmittal number. Totals for Agricultural Extension are reflected.
7. Control must reflect adjustments due to corrections from exceptions report or cards omitted from run.
8. Correction process may require submitting additional cards which would require returning to the edit routine.
9. The Earnings and Tax Detail Tape must be expanded to include account number and a record type for SBR records.
10. The setup card contains voucher numbers to be pulled from the Earnings and Tax Detail Tape.
11. Controls by voucher number. Also, totals on Agricultural Extension are to be printed.
12. Tape does not include records for Agricultural Extension. It does have a code (account type) to distinguish general from restricted accounts.
13. Summary of Activity will reflect control totals on additions and deductions to assignable amounts. These figures will include assignable adjustments submitted directly and those calculated.
14. This report will identify voucher and payroll activity for which there was no record on the SBR file. This should prove useful in locating delinquent Personnel Action forms.
15. This report will identify those salary accounts for which there are no SBR records.
16. The SBR file at this stage, after the print programs, is to be used in the following month's run. For security purposes, a three tape cycle will be established.
17. This report will isolate variations and should be helpful in correcting discrepancies.

The coded personnel action forms could then be routed to key punching, and subsequent to key punching be run through an edit program to eliminate any incorrect data (see Exhibit 2, Note 1, page 103 .) After corrections have been made the activity cards will be sorted according to employee number within account number, balanced against the control totals, put on magnetic tape and processed against the master SBR tape.

To eliminate any time lag in getting the Account Summary Report to the Comptroller, it is recommended that the expenses charged against each account (other than salaries) be picked up directly from the Account Summary File, rather than creating ledger summary cards from the file tape, as is currently being done. Thus, the Comptroller should be in possession of the Account Summary Report (showing the unexpended balance of each account) within at least two weeks after the end of each month--a very considerable reduction in the current time lag.

Of course, any such system change has advantages and limitations, both of which should be carefully analyzed.

Advantages of Proposed SBR System. The advantages of the proposed SBR system over the present one are numerous, each one deserving of special attention. These advantages are as follows:

1. Reduction of Card Handling--The only card inputs are from Personnel Action forms, Journal Vouchers and Supplemental Payroll runs. These cards are immediately put on tape or disk and all manipulations of data are done on these two media, thereby reducing card handling and processing time.

2. Calculation of Assignables--Approximately 95 per cent of the assignable calculations can be done easily by the computer. Notable exceptions are:

- a. Persons who resign with vacation pay on the books; and

- b. Persons who resign with fractional parts of days vacation on the books.

Provisions have been made in the Personnel Action input card to allow for direct entry of assignable amounts as opposed to assignable dates. (The need for entry of amounts rather than dates is to be determined by the person coding the input.)

3. Identification of Exceptions--Exceptions, such as delinquent Personnel Action forms, can be easily identified by use of the exceptions reports to be printed. Variations will also be isolated on the Detail Report and printed as a separate report to aid the correction process.

4. Editing of Input Data--Personnel Action cards and Journal Voucher cards will be edited carefully; therefore, it is less likely that invalid data will get into the SBR file.

5. Simplification of Input--Corrections to individual SBR records will be made with only two types of cards: the Journal Voucher card and the Personnel Action card. The Journal Voucher card must be completed each time it is used. However, the Personnel Action card need only contain the first five key fields plus any correction entries.

6. Account Identification--The account titles will be picked up from the chart of Accounts file and will be available for all print outs. No transaction will be processed against invalid account numbers.

7. Foreground Processing--All programs will be designed for foreground processing and minimal use of I/O devices, and will be written in COBOL, thereby eliminating a group of SPS programs. This elimination of the existing SPS programs will eliminate the need for the additional hardware which translates them, thus freeing several thousand data processing dollars per month to more productive processing use.

8. Elimination of Invalid Cards--Personnel Action cards and Journal Voucher cards determined to be invalid by the Edit Program will be ejected into a separate pocket on the card reader, eliminating the task of manually pulling them to prevent entry into the data stream.

9. Balancing to Control Totals--The burden of balancing to controls should rest with the Auditor's Office; i. e., in cases where computer produced totals do not agree with totals supplied by the Auditor's Office, that office has the responsibility of reconciling the discrepancy and giving the signal to continue processing. In the past, the decision to continue processing in light of discrepancies had to be made by the machine operator, who in most cases is not qualified to judge the seriousness of a discrepancy.

While these advantages seem impressive, they are not without their limitations.

Limitations of Proposed SBR System. Any objective study must present the disadvantages as well as the advantages, and the proposed SBR system is not without its limitations, which are as follows:

1. Journal Vouchers--The proposed SBR system will be unable to calculate and prepare journal voucher entries at the time it calculates assignables. While the calculations are possible, the mechanics of submitting the input data for the calculations are too cumbersome. Therefore, the person coding the SBR input must determine the necessity for a journal voucher entry and calculate the amount.

2. Variations will be calculated as they are done under the present system, i.e., as the difference between rate multiplied by pay periods remaining and balance. The problem of having built-in variations for persons whose contract ends on other than the end of a month is unavoidable.

Several alternate methods of calculating variations are possible, and were considered in detail, but all proved to be too cumbersome to be practical.

3. Dependence Upon Other Systems--The SBR system will still be dependent upon other systems for input; therefore, in order to generate reports soon enough to be timely all systems must function on schedule.

4. Assignable Calculations--Unfortunately not all assignables can be calculated using the computer. The multiplicity of pay basis precludes the development of a single formula for all assignable calculations. The person at the SBR desk will be called on to make value judgments as to whether a given assignable can be computer calculated or must be undertaken manually.

The Office of the Auditor felt that the advantages of the proposed system far outweighed the limitations. Therefore, the proposed SBR system is currently being implemented, and plans have been made to parallel the new system with the old system for the months of April and May, 1969 beginning in June, 1969.

It can be seen from this application, that everytime the SBR run is made the computer audits all input data through the edit program. Any errors of such a nature that would not be caught in the edit program would show up in the exceptions report. The system could be audited at any time by inserting test transactions into the SBR run and observing the manner in which the system handles them. Any erroneous transactions which are not caught by the edit program could be analyzed and the edit program could be adjusted accordingly.

Further Recommendations

While making the preceding study, several means of system improvement became evident, and although not currently feasible, will, due to technological advancement, be practical in the future.

First, there should be one centralized personnel office on campus, rather than the current three; and furthermore, all hiring units should use standardized personnel forms. Presently, it is estimated that nearly 50 different types of personnel action forms are in existence, thereby, posing problems in obtaining uniformity in coding input.

Second, this centralized personnel office should be on-line to the central processing unit, allowing for direct transmittal of pertinent information to the Master Payroll File. This Master Payroll File should be revised so as to serve as the complete personnel file for the entire campus.

Third, and ideally, the head of each hiring unit would have a remote terminal in his office and would have access to information concerning only those persons for which he is responsible. These remote terminals would not be capable of entering information into the system--only of retrieving certain pertinent information from the system.

With proper hardware, controls and personnel, such an on-line personnel system would be a most efficient tool for the LSU administration.

Audit of Student Fees

The second area analyzed dealt with the audit of student fees. Such an application would be pertinent in any situation where the amount of fees received varies with certain predetermined circumstances.

Current Audit Procedures

At present, all student fees are audited manually. This manual audit takes place three times a year during the Fall, Spring, and Summer semesters, and is performed by the Office of the Registrar.

The problems involved in this manual audit are twofold. First, the Office of the Registrar does not have sufficient information to begin the

audit until five or six weeks of the semester have elapsed. Second, the audit function must be performed by the regular Registrar's full-time staff on a part-time basis. Since this is a very time consuming task, being performed on an irregular basis, the audit is very seldom completed until very near the end of the semester. Of course, this time lag creates serious problems with those students who must be assessed additional fees, since they no longer have the available funds to pay these additional amounts. In addition to the time lag problem, due to increased enrollment, the manual audit of student fees is becoming too large a task to be performed by the Office of the Registrar without an increase in personnel--an impossibility due to lack of funds.

Proposed Audit Procedures

Currently the Office of Data Processing maintains three files:

1. Class Tape--yields class schedule of each student.
2. Fee Distribution File--gives a complete breakdown of all fees paid by each student, in addition to any exemptions allowed.
3. Registered Student File--contains information concerning students' residency status.

These three files, which are available approximately two weeks after registration, provide all the information necessary to make a computerized audit of student fees without the creation of additional input. A basic flow diagram of the proposed audit procedure can be seen in Exhibit 3, page 111.

The audit function would be performed as follows:

1. A check of hours scheduled and University Fee paid would be used to classify students into one of four categories:

Exhibit 3. Proposed Fee Audit System

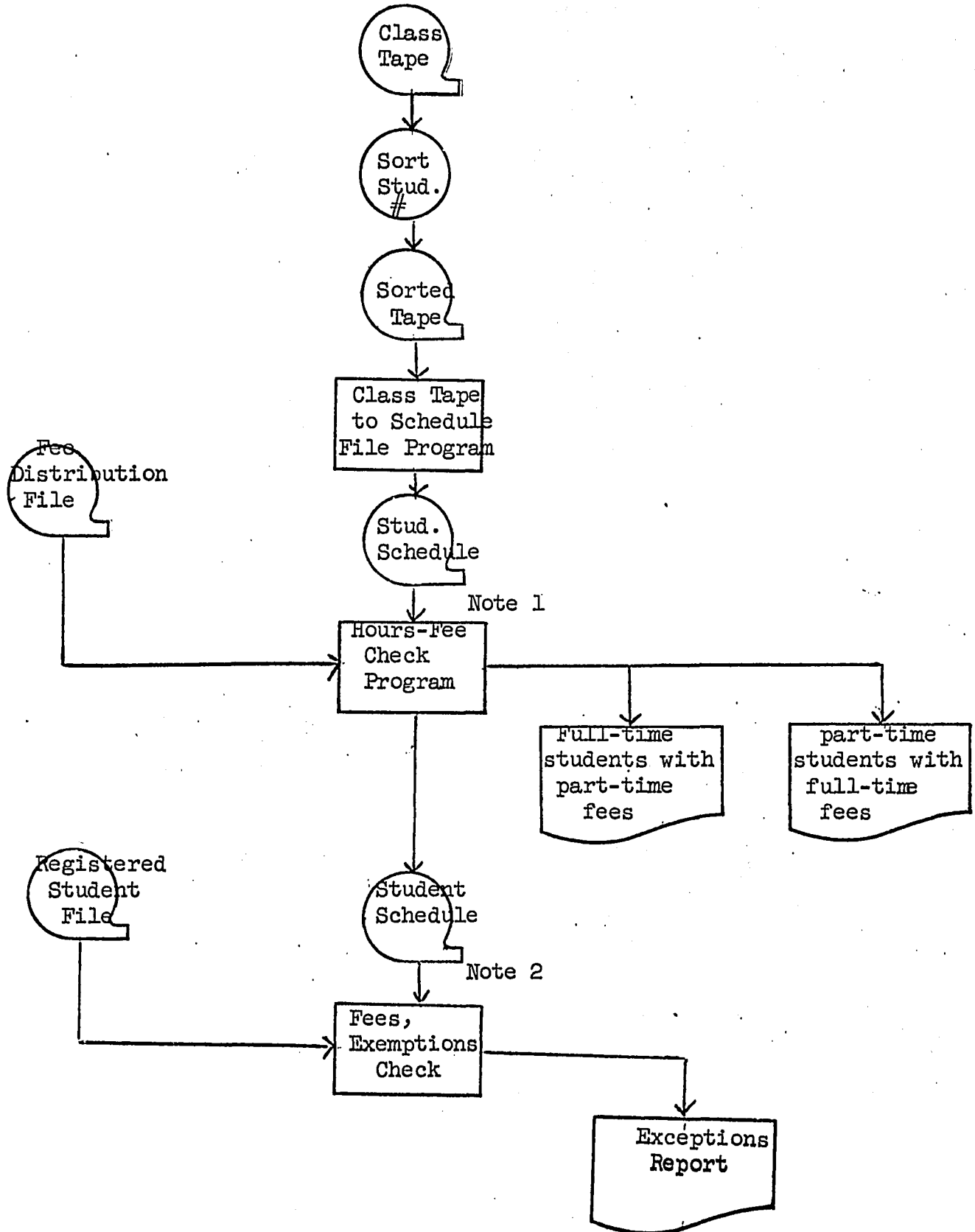


Exhibit 3 Diagram Notes

1. a. Program checks classification, hours scheduled, and fees paid.
 - b. Full-time students with full-time fees and part-time students with part-time fees are written out to tape.
 - c. Full-time students with part-time fees are written out on an exception report.
 - d. Part-time students with full-time fees are checked further. Those that can be identified as legitimate are written out to tape. The others are written out to an exception report.
2. This program checks the following:
 - a. Special courses for special fees.
 - b. Resident code against resident fees.
 - c. Part-time fees for correct amounts.
 - d. Exemption codes for correct amounts.

- a. Full-time students paying full-time fees (FT/FT).
 - b. Part-time students paying part-time fees (PT/PT).
 - c. Full-time students paying part-time fees (FT/PT).
 - d. Part-time students paying full-time fees (PT/FT).
2. Any student classified at FT/PT would be written out to an exception report, for under no circumstances is this a legitimate classification.
3. Students classified as PT/FT would be checked for legitimacy. Any graduate student holding an assistantship and carrying less than 9 hours, or any other student carrying less than a full-time course load and paying a diploma fee is a legitimate PT/FT. Any other cases will be written out to an exception report to be checked by the Registrar.¹
4. All FT/FT, PT/PT, and legitimate PT/FT students will be run through a series of programs checking hours carried against the amount of University and Non-resident fees (if applicable) paid. In addition, those courses requiring special fees and the accuracy of any exemptions allowed will be checked. Any discrepancy and the reason for discrepancy will be written out to an exception report for further scrutiny by the Office of the Registrar.

The advantages of the proposed system are quite obvious. First, the audit function can be performed without the creation of additional input. Second, all student fees can be audited within $2\frac{1}{2}$ to 3 weeks after registration. And third, any increase in enrollment can be easily handled without the hiring of additional personnel. This proposed fee

¹In certain cases a student may be allowed to pay full-time fees when carrying less than a full-time course load in order to reside in a dormitory. The only way this can be verified is through a letter on file in the Registrar's Office.

audit system is being implemented by the LSU administration and should be operational no later than September, 1969.

Future Recommendation

An ideal audit situation would exist where fees could be audited as the final step in the registration procedure. This would be possible where remote terminals were present at the registration site. Class schedules, fees and residency status could be entered directly into the central processing unit and any discrepancy could be discovered and corrected on the spot.

Conclusions

With the use of edit programs to check the accuracy of incoming data, it can be seen that the above proposed systems are, in part, continuous self-auditing systems.

In addition, such systems can be easily audited at any time by any party (internal or external) through the use of test decks.

CHAPTER VI

SUMMARY AND CONCLUSIONS

It has been well established that the computer has made its presence very much felt in the field of auditing, and that new auditing techniques are mandatory when facing an electronic system.

Generally, electronic systems may be divided into two main categories: batch processing systems and real-time systems. In batch processing systems the items to be processed must be coded and collected into groups before processing can take place. Such systems, while being far superior to manual methods, suffer from the serious disadvantage that sufficient items of a like nature must be collected in order to make processing feasible. This results in a time lag which somewhat impairs the usefulness of information.

In light of this problem the on-line real-time (OLRT) system has been developed. An OLRT system is one in which input enters the system at its point of origin and output is transmitted directly to where it is used. In addition to this random order of processing, results are obtained quickly enough to affect the functioning of the environment at that point in time.

It has become evident, with the advent of OLRT systems, that methods of control and auditing procedures devised for batch processing systems are becoming obsolete. In an OLRT system it will no longer be feasible to audit "around" the computer comparing source documents with final output. Neither can reliance be placed on independent confirmation and physical observation, alone.

In setting down guidelines to be used in the auditing of advanced electronic systems, special consideration must be given to the technical orientation of the auditor, the auditor's participation in the system design, the feasibility of utilizing test decks in auditing, and the time period of the audit.

Technical Orientation of the Auditor

It has been clearly pointed out that to be effectively controlled and audited, an OLRT system must be understood. Due to the peculiarities of such advanced systems, and the obsolescence of batch processing audit techniques, it is impossible for an untrained person to adequately evaluate the properties of a real-time system.

In order to be considered technically competent, the auditor must have a workable knowledge of the concepts, hardware, possible system configurations and internal controls applicable to real-time systems.

Real-Time Concepts

In order to understand a real-time system it is necessary to understand the basic technological concepts which make such a system possible.

The basic concepts peculiar to any OLRT system are:

1. Standard interface--the ability of a system to use many different I/O devices.
2. Channels--small computers which direct the flow of data between I/O devices and main storage.
3. Operating system--a group of programs, in residence in the computer system, which facilitates every phase of system operation.
4. Direct access storage--high capacity auxiliary storage with a wide range of data speeds. Its primary characteristic is its ability to locate any record directly, without having to scan the preceding records.

5. Teleprocessing--transmitting data from one point to another in the course of processing.

6. Multiprocessing--communication between computers.

7. Multiprogramming--a technique for handling several programs concurrently by overlapping their execution.

Real-Time Hardware

In addition to a familiarity with the concepts of a real-time system, it is mandatory that the auditor be acquainted with the hardware that carries out the real-time applications.

OLRT systems are usually composed of third generation computers with large, high-speed storage capacities, numerous communication facilities, and fixed and variable-length field capabilities.

Any real-time central processing unit usually includes most of the following basic features:

1. the capability of increasing core storage and adding more peripheral equipment when the need arises;
2. the possession of an interruption system which alerts the CPU to exceptional conditions and executes the appropriate routine following the detection of such an event;
3. I/O devices independent of the CPU, permitting processing to take place concurrently with I/O operations; and
4. the possession of time sharing capabilities, enabling numerous users at remote terminals to utilize the CPU concurrently.

In addition to the central processing unit, the transmission of data to and from the processing unit requires the use of telecommunication facilities. These facilities must meet the requirements of: (1) transmission control capability; (2) program switching; (3) program relocation;

and (4) storage protection. The types of facilities used will depend upon the nature of the input and the requirements for output.

System Configurations

With a fundamental knowledge of real-time concepts and equipment, an understanding of the basic combinations of these components is necessary, since the system configuration provides the framework in which the audit must be performed.

Real-time system configurations may be classified as:

1. Simplex system--a system in which there is no standby equipment to take over processing when the CPU becomes inoperative.
2. Master/slave system--two or more computers operating jointly, one of which performs all the scheduling and housekeeping functions, leaving the others free to concentrate on problem solving.
3. Shared-file system--very similar to the master/slave system.
4. Duplex system--a system in which the required hardware is exactly duplicated so that a switch over can occur if the on-line system fails.
5. Multiprocessing system--system in which several separate interrelated operations are carried on simultaneously by two or more computers, each concentrating on a particular assignment, but capable of communicating with the others.

OLRT System Controls

The auditor is not in a position to perform a study and evaluation of the existing internal controls of a system until he is thoroughly familiar with the equipment capabilities and system configuration.

The only way in which the auditor can achieve the necessary confidence in the operation of an OLRT system is through a basic understanding of how the system operates, how results are obtained, and what safeguards

have been instituted.

Conventional electronic controls, painstakingly designed over the past years for batch processing systems are no longer adequate. The two major traditional controls (transcription controls and control totals) have become obsolete in an OLRT system. The value of transcription controls becomes negligible in many instances, due to the absence of source documents. Data is directly entered into the system at the point of origin. Control totals also become useless, since in an OLRT system, data is very rarely accumulated and processed in logical transaction groups, and these controls cannot be applied before the processing occurs.

The use of real-time systems has greatly increased the importance of existing processing controls and has given rise to new controls. The concept of using communication lines to transmit data in OLRT systems requires the use of on-line remote terminals through which messages are transmitted to or received from a computer. When operating in this manner it is important to ensure that all data transmitted are received and properly processed.

Information housed in the memory of an on-line system is available to terminal operators upon their request. Therefore, a good possibility exists of data being used by unauthorized personnel, or destroyed or improperly processed due to carelessness. Thus programmed controls must be devised which will eliminate any possibility of improper data usage, incorrect file updating, and destruction of data and programs stored in memory.

Furthermore, a real-time system must operate without stopping for fixed periods of time, the duration depending upon the system configuration. When a malfunction occurs in some component while the system is in operation, procedures must exist to ensure the continuance of the system.

Therefore, it can be seen that to perform a competent audit of an OLRT system, the auditor must be technically oriented, for such a system must be understood to be effectively controlled and audited.

Participation in System Design

The acquisition of a working knowledge of the system configuration (how it operates, what it can do, input and output media, programming, etc.) can best be accomplished by the auditor through participating, where possible, from the very beginning.

It is highly desirable that the auditor (both internal and external) become familiar with a system and its programs at the earliest possible stage--being present throughout the various discussion stages in the development of the system. This will permit the auditor to evaluate internal controls, counsel the company and plan for subsequent examinations.

While it is not the function of the auditor to design the system he should scrutinize the following factors:

1. soundness of proposed controls;
2. segregation of functions among the source information group, machine operation center and accounting control group;
3. source, form and control of input and output; and
4. adequacy of the audit trail.

When shortcomings are noted they can be discussed with management, and changes implemented, if deemed necessary. Due to the complexity of real-time systems and the interrelatedness of their programs, such necessary changes may be completely out of the question at a later date. Furthermore, not only can the auditor assure himself that necessary controls are implemented, but, in addition, he can gain an overall appreciation of the system, giving him a better insight into the types

of controls which are, as compared to those which are not, feasible.

Although the knowledge gained by the auditor present at the planning stage of a new system is tremendous, not everyone can be in on the ground floor of an installation. Many who will come upon the scene in subsequent years will not have had the opportunity of being in on the initial system development. However, this group can gain valuable insights from the experience of their predecessors, and can further enhance their knowledge by keeping abreast of changing developments within the system.

These initial stage contacts between auditor and system designer will enable the system designer to see the need for controls at the expense of economy, and will give the auditor the confidence to look more to procedures incorporated within the system as a basis for expressing an overall opinion about the company's financial position.

Feasibility of Test Decks

Once the system is clearly understood and the adequacy of internal controls has been determined, the auditor may begin his collection of evidential matter. However, the collection of this material from an OLRT system is quite different from that of conventional batch processing systems.

This difference results from the fact that neither an "around the machine" nor a "through the machine" approach is applicable to an on-line, real-time system. This inadequacy of the current approaches to the auditing of electronic systems is a result of two factors. First, in a completely real-time system there is an absence of source documents in a majority of instances. This is due to information being entered

directly into the system at the point of origin, resulting in virtually a total loss of the audit trail. Second, since any error in such a system can easily go undetected indefinitely, due to the absence of source documents and intermediate reports, techniques must be implemented which will discover errors at their initial introduction into the system.

Perhaps the most important technique available to the auditor facing an on-line, real-time system is the introduction of test transactions into the system.

The test data, prepared by the auditor, should be designed so as to check on the accuracy of input, processing, and output controls. Therefore, these test transactions should necessarily include sufficient amounts of incomplete, erroneous and inconsistent data.

Ideally, the test data should be mingled with actual transactions. In order for this to be done, however, the processing program must have the capability of recognizing test data by a certain code so as to refrain from adding them to total operating results or permanent records.

While the use of test transactions is important, other techniques must also be employed, such as increased use of programmed controls and the development and implementation of special audit programs.

Time Period of the Audit

Audit checks in an on-line, real-time system must be continuous and occur simultaneously with processing, and not be dependent upon retrospective evaluations. The real-time environment necessitates that a control system be designed and installed as an integral part of the overall processing system.

The development of OLRT systems requires continuous availability of the auditor. System design changes occur throughout the year and audit tests are most effective when made on an irregular surprise basis. Furthermore, techniques utilizing the equipment to test itself must be performed at the time of processing, or shortly thereafter, before files are changed or destroyed. This scheduling of the performance of the auditing function over a longer time period will result in greater cooperation and coordination between internal and external auditors.

In a real-time system auditing tasks must be performed along with regular processing on a continuous basis rather than once a year.

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A P P E N D I C E S

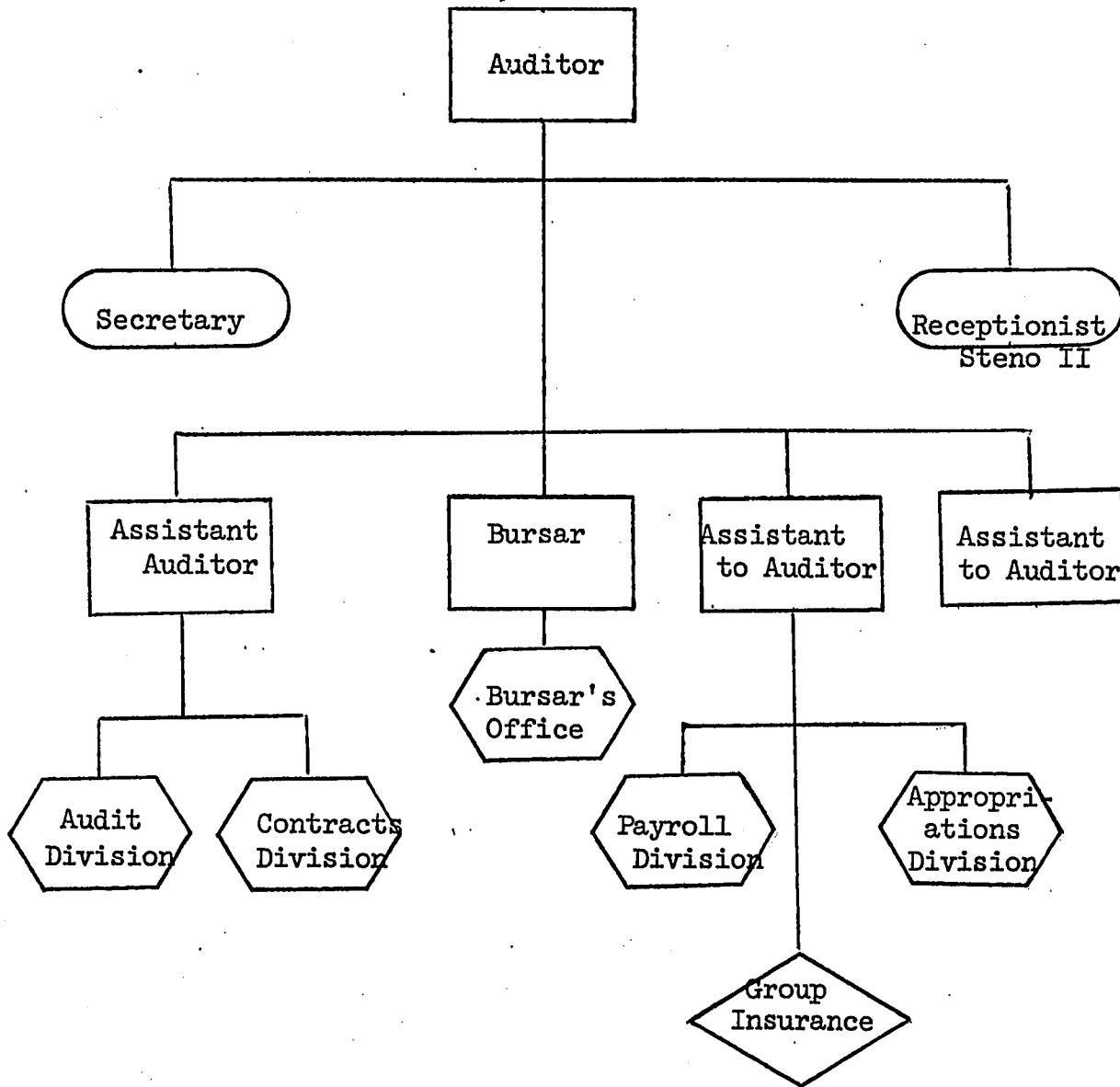
Appendix A: Organizational Charts of Louisiana State University's
Office of the Auditor

LOUISIANA STATE UNIVERSITY

OFFICE OF THE AUDITOR

ORGANIZATIONAL CHART

November 21, 1968

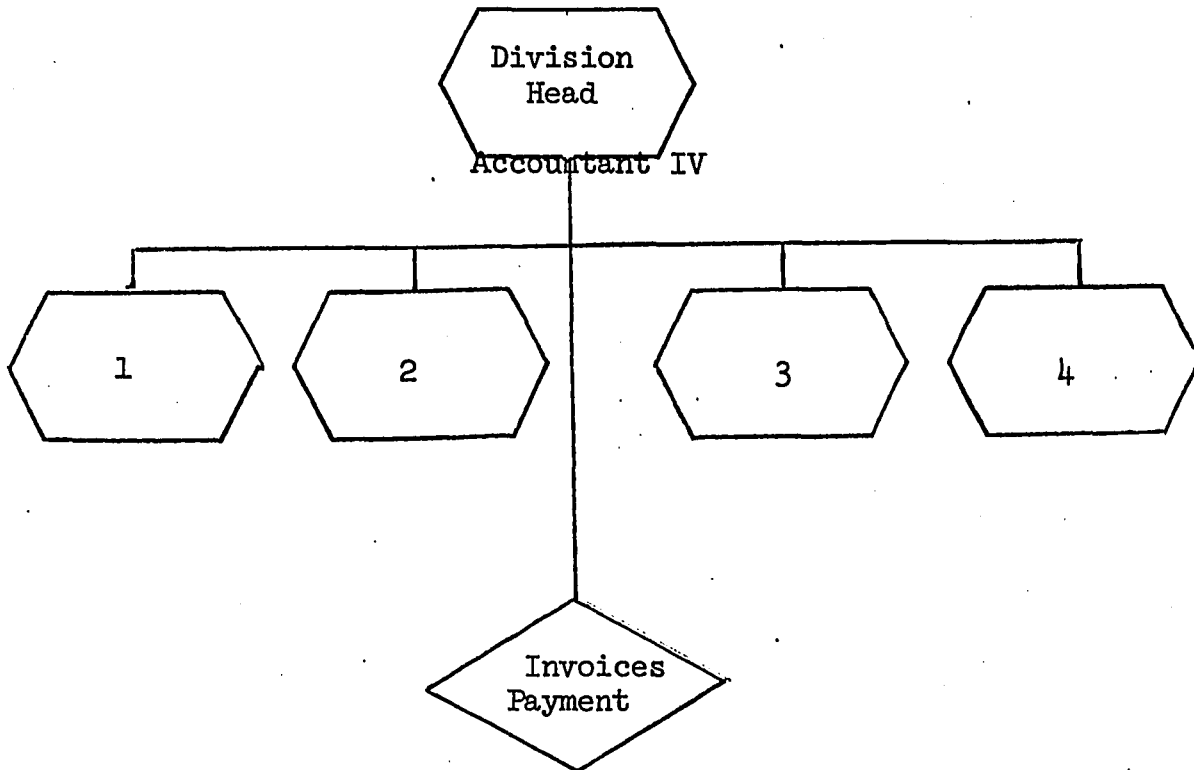


LOUISIANA STATE UNIVERSITY

APPROPRIATIONS DIVISION

ORGANIZATIONAL CHART

November 21, 1968



1--Interdepartmental Vouchers, Cash Vouchers Summarization

2--Invoices Approval, Ledger Controls, Verify Checks

3--Travel Reimbursements

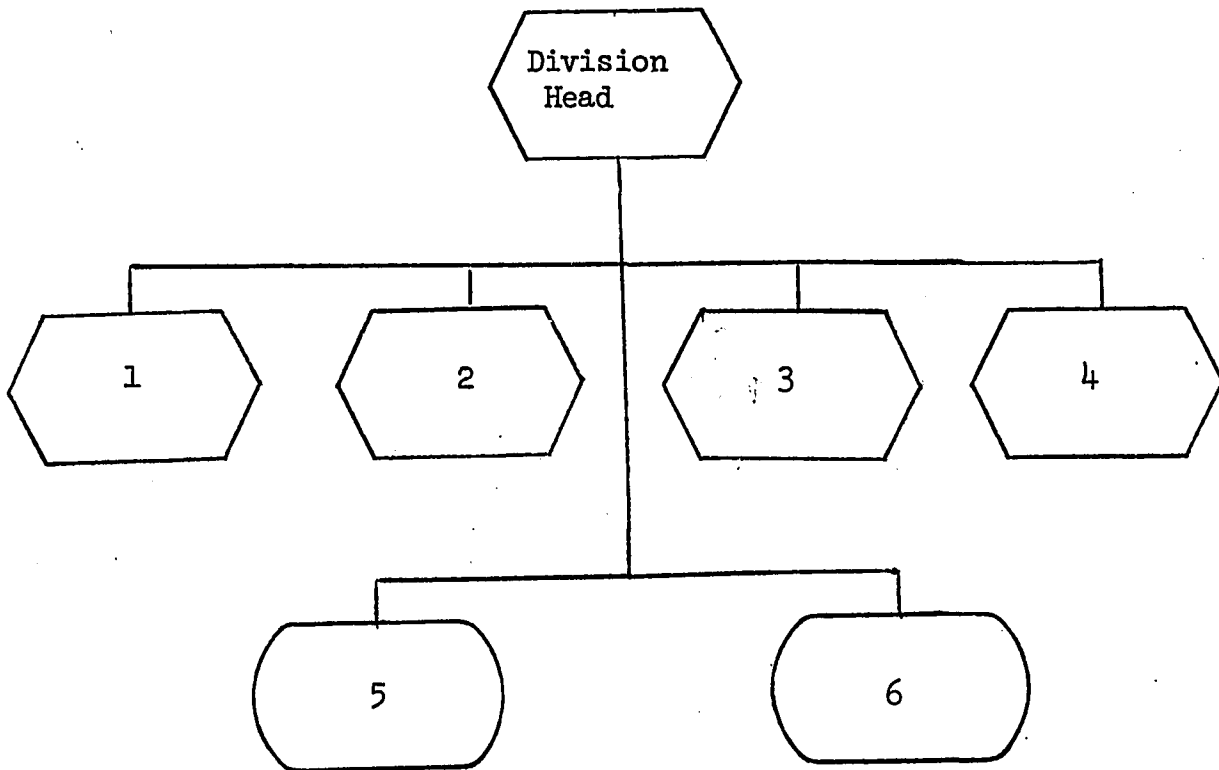
4--Mail Files

LOUISIANA STATE UNIVERSITY

AUDIT DIVISION

ORGANIZATIONAL CHART

November 21, 1968



1--Income Tax, Social Security, Savings Bonds, Auxiliaries

2--LSU Foundation Questionnaires, Surveys, Reports

3--Advances, Petty Cash, Plant Fund, Bond Coupons

4--Bank Reconciliations, Cash Control, Petty Cash

5--Telephone Vouchers, Agency Funds, Room and Uniform Deposits

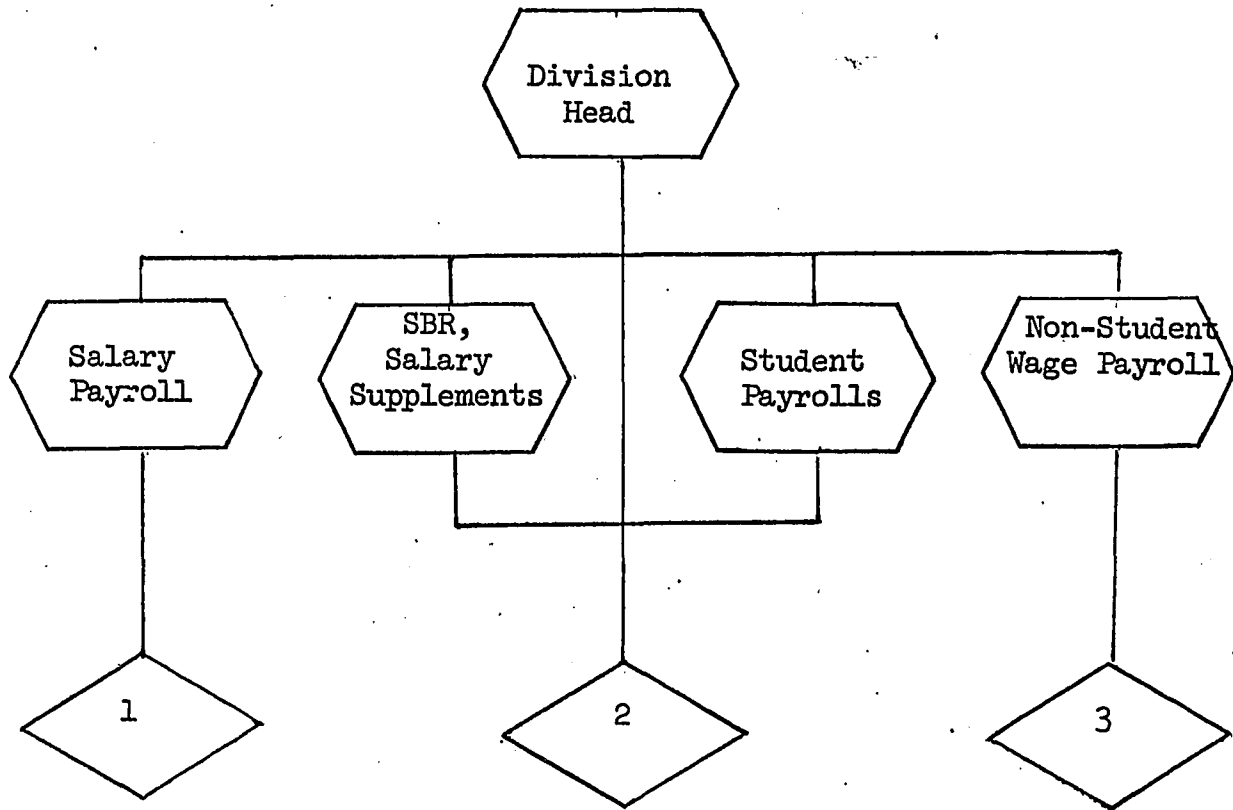
6--Special Checks, Chart of Accounts, Budget Adjustments

LOUISIANA STATE UNIVERSITY

ORGANIZATIONAL CHART

PAYROLL DIVISION

November 21, 1968



1--Processing Salary Personnel Actions

2--Check Signing, Mail and General Typing

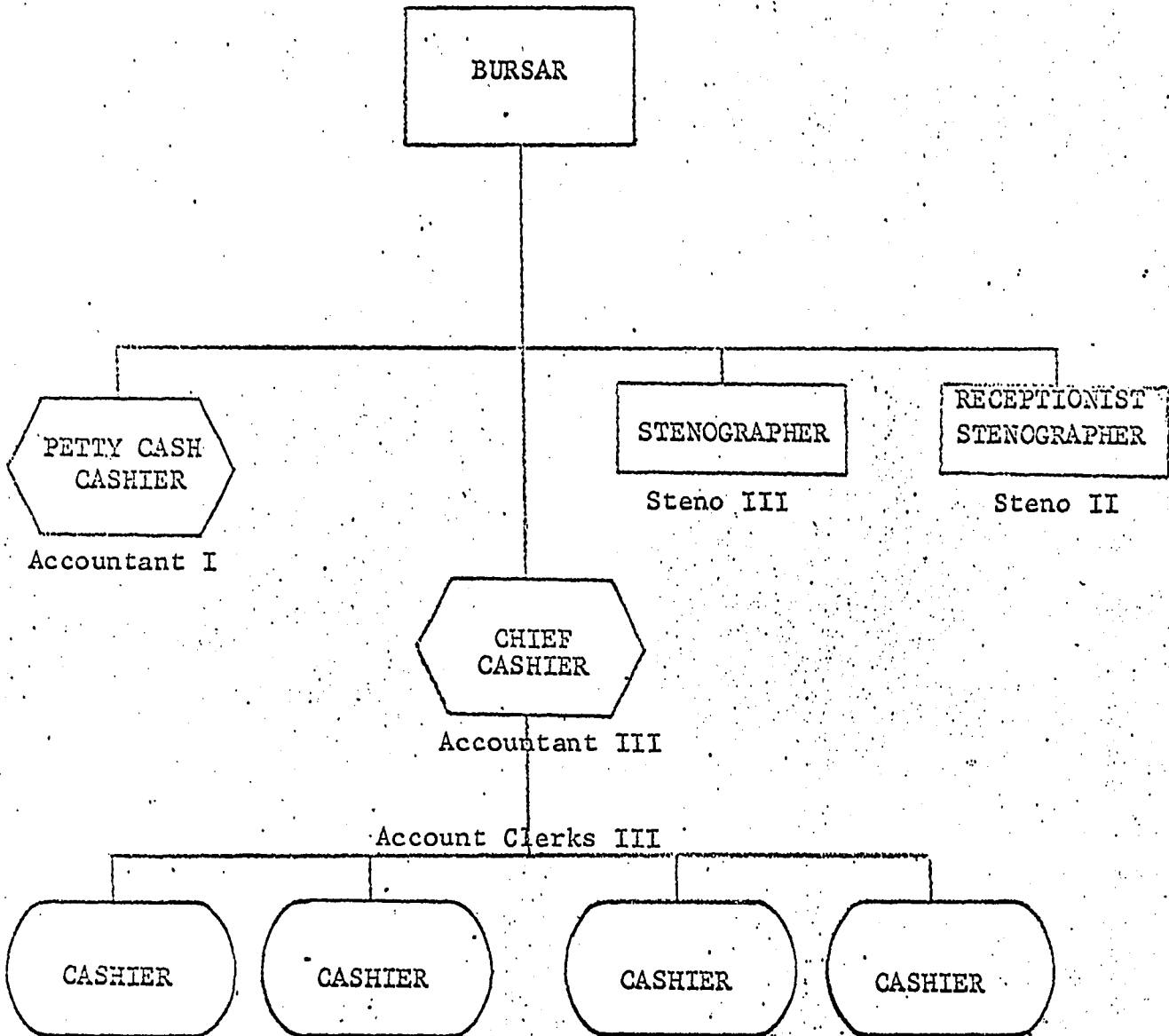
3--Processing Non-Student Wage

LOUISIANA STATE UNIVERSITY

BURSAR'S OFFICE

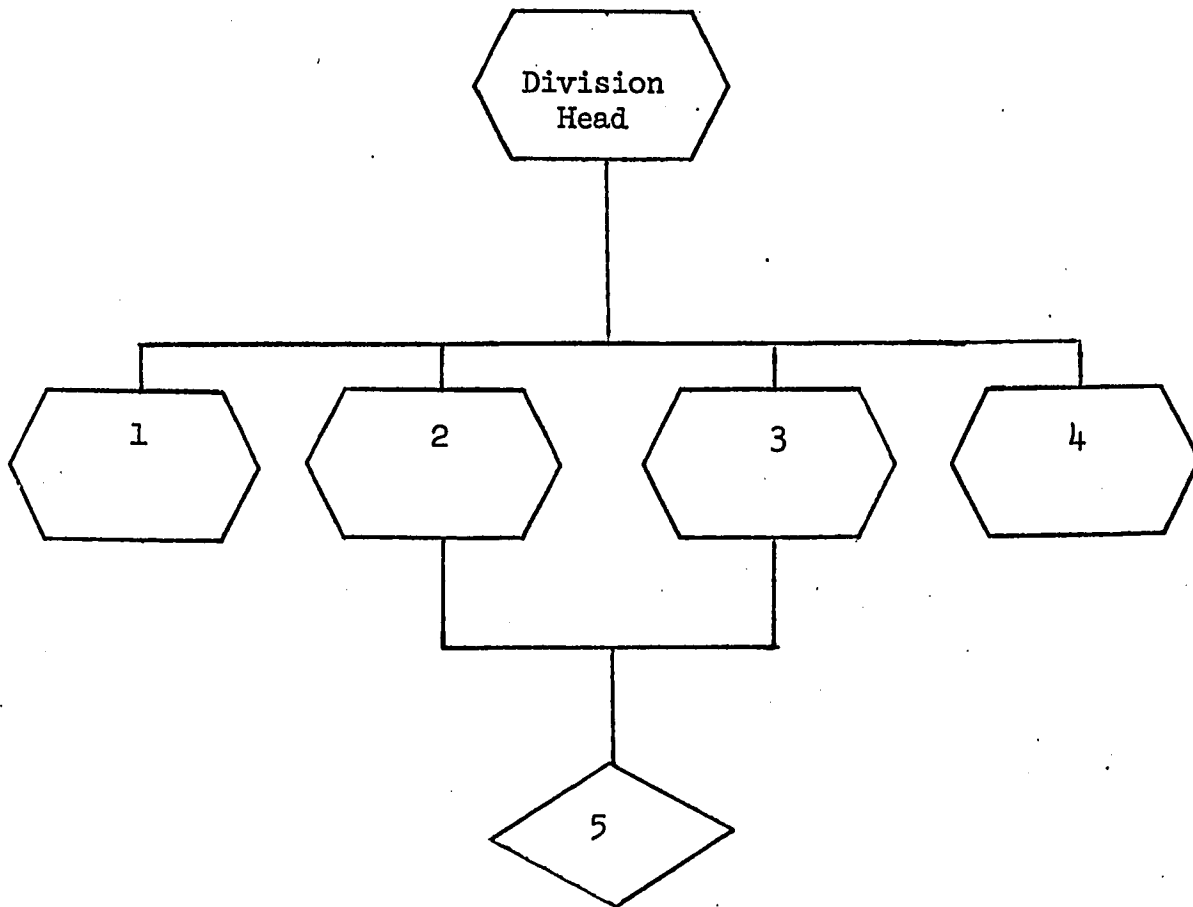
ORGANIZATIONAL CHART

November 21, 1968



LOUISIANA STATE UNIVERSITY
ORGANIZATIONAL CHART
CONTRACTS ACCOUNTING DIVISION

November 21, 1968



1--USPHS Funding and Fiscal Reports, Correspondence

2--Cost Reimbursables, Indirect Costs, Posting and Reports

3--Budgeting NASA and AEC Funding and Reports

4--NSF Funding and Fiscal Reports, Salary Requirements

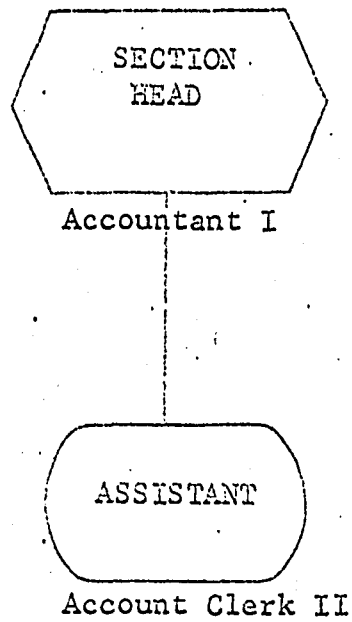
5--Typing Reports and Budgets

LOUISIANA STATE UNIVERSITY

ORGANIZATIONAL CHART

GROUP INSURANCE SECTION

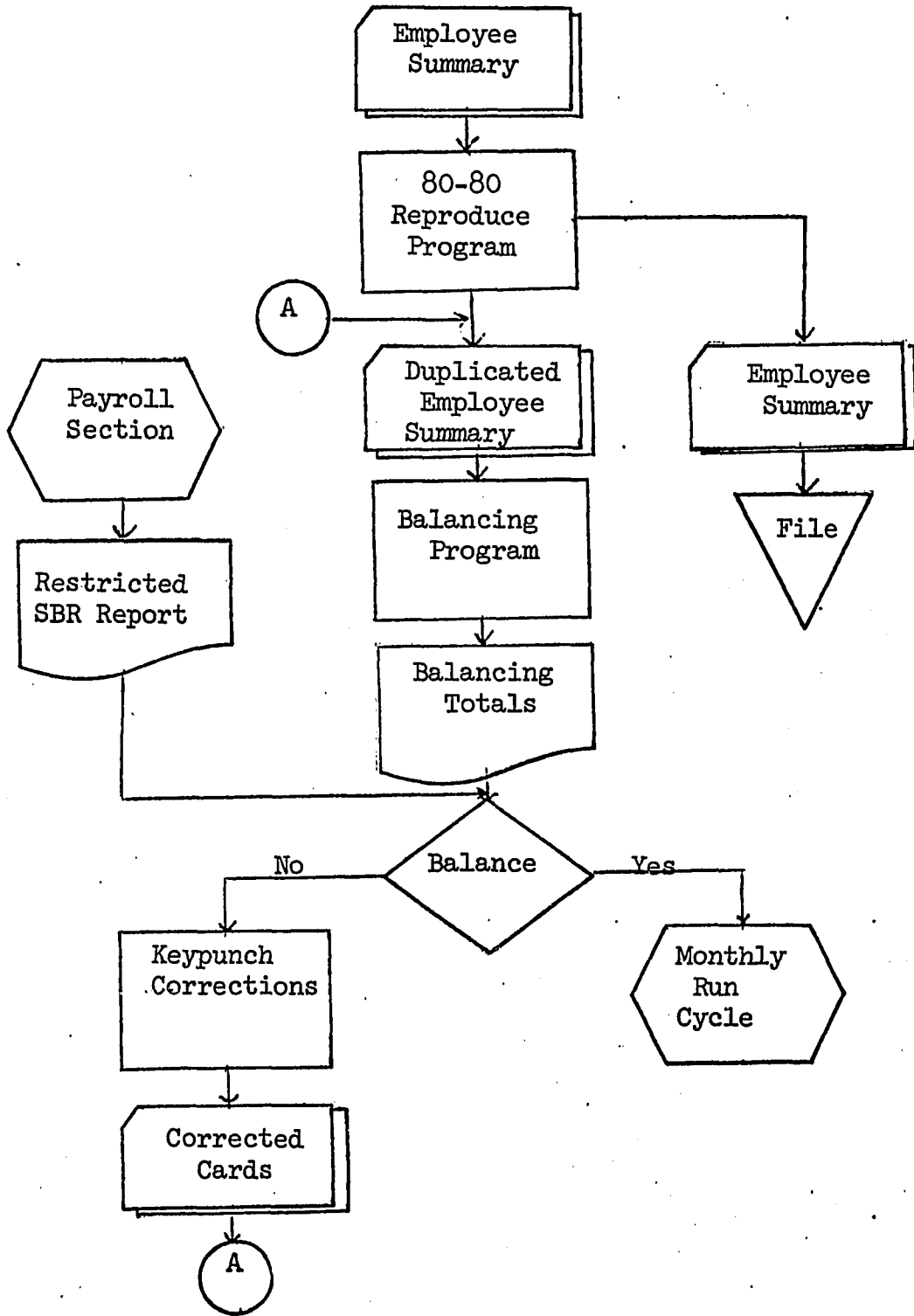
November 21, 1968



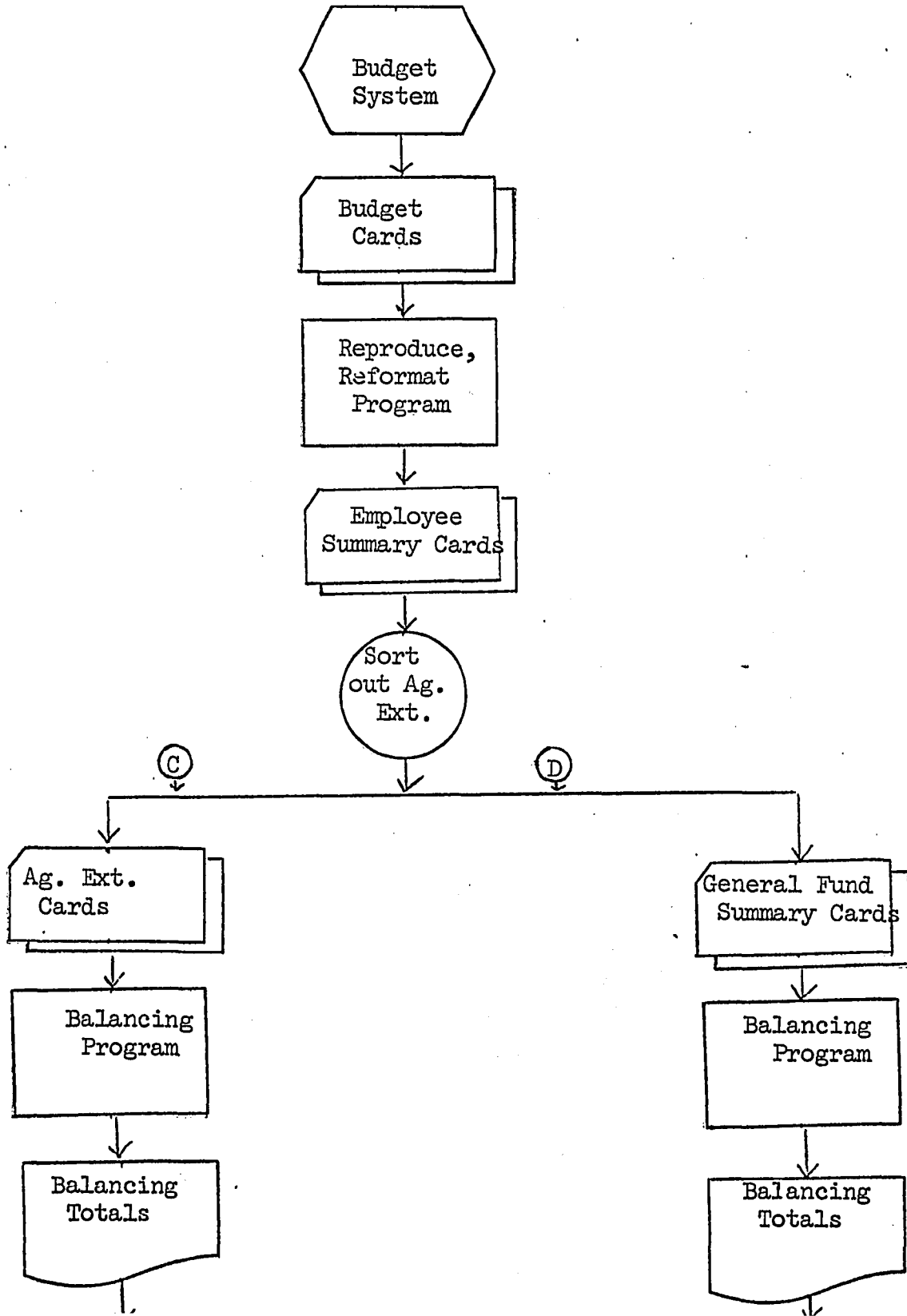
Appendix B: LSU Master Payroll and
Changes to Master Payroll Forms

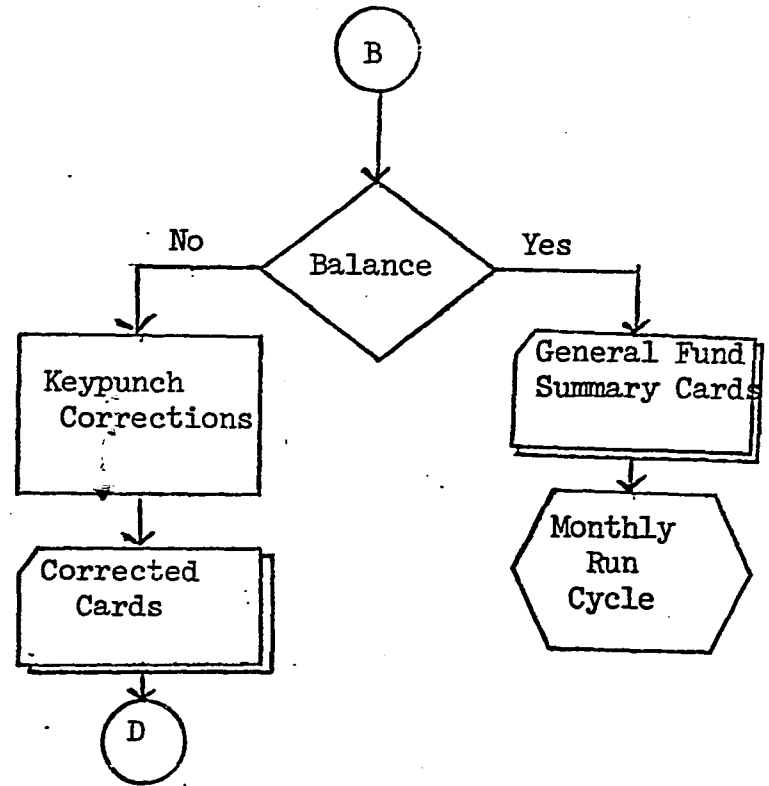
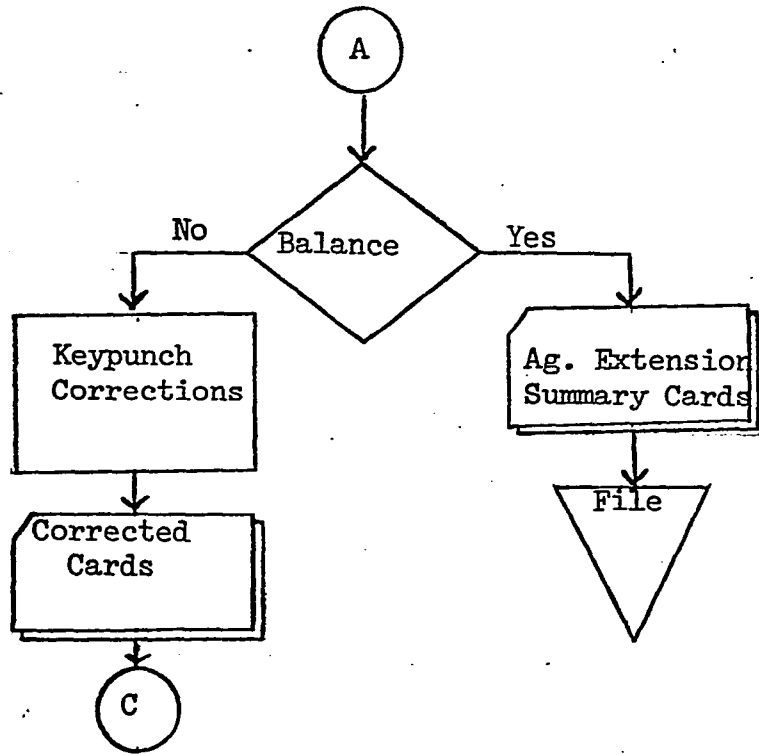
Appendix C: Creation of Employee Summary Cards

Restricted Fund File Creation of Employee Summary Cards



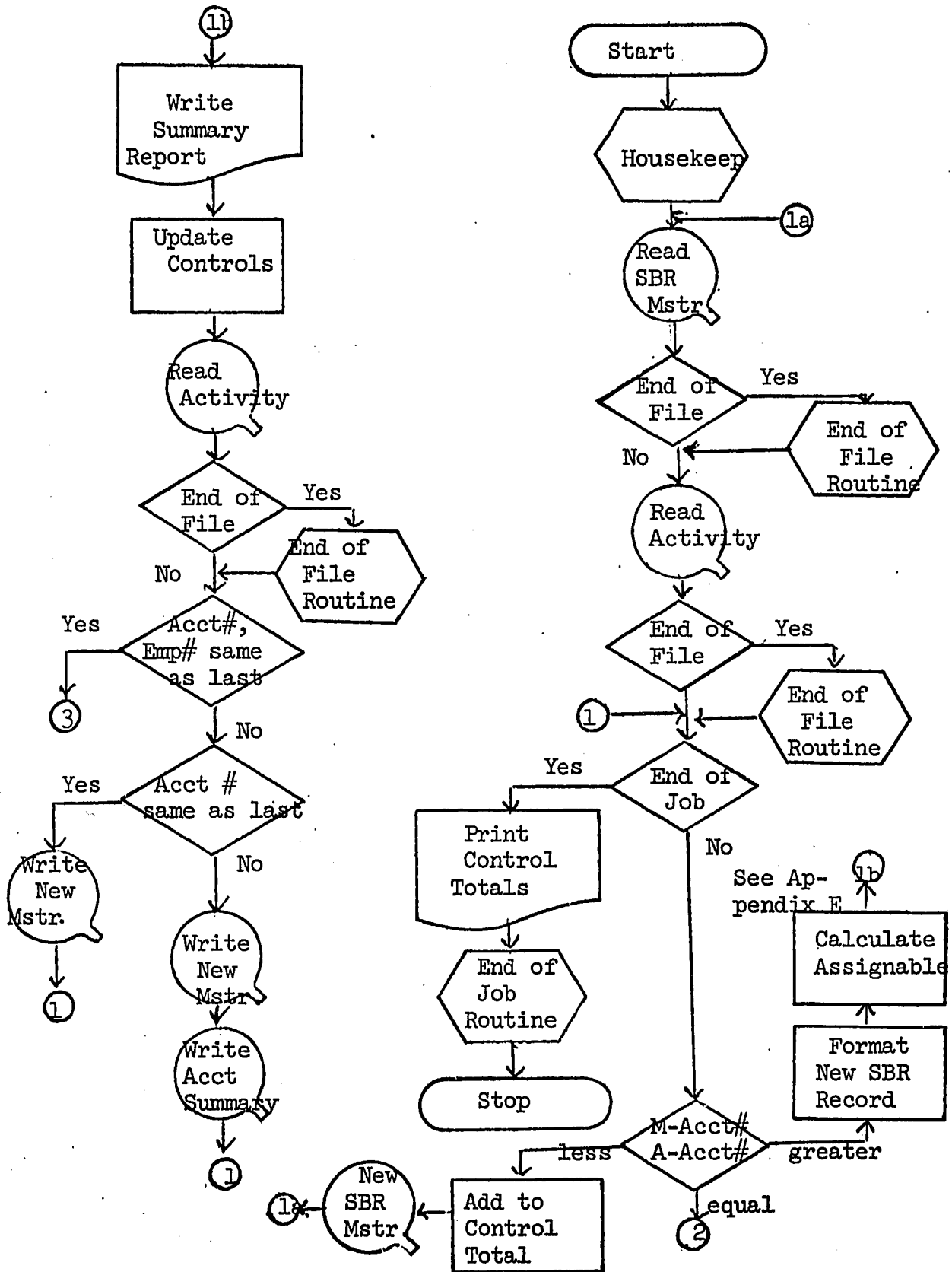
General Fund File Creation of Employee Summary Cards

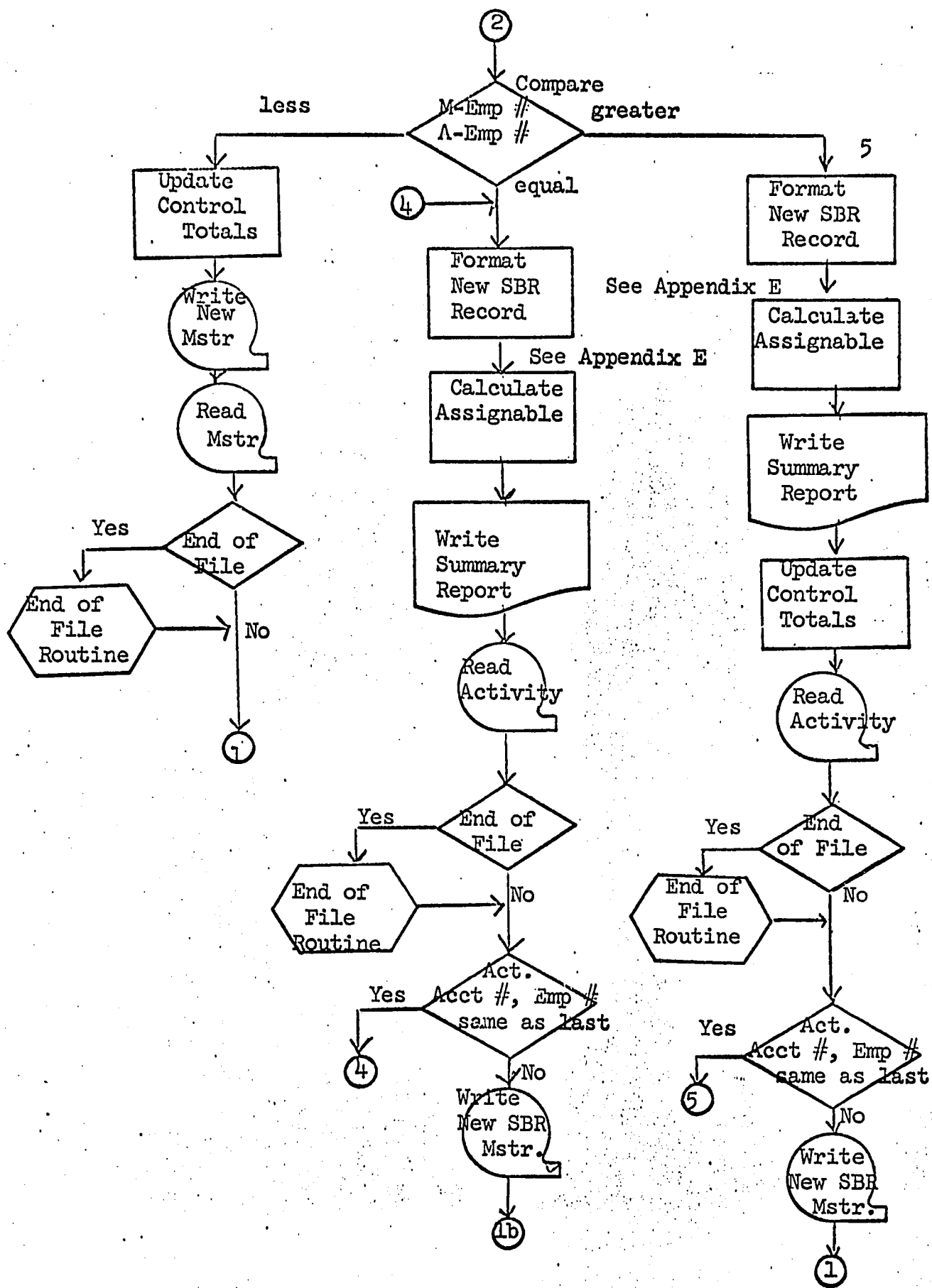




Appendix D: Flowchart of SBR Assignable
Calculations Program

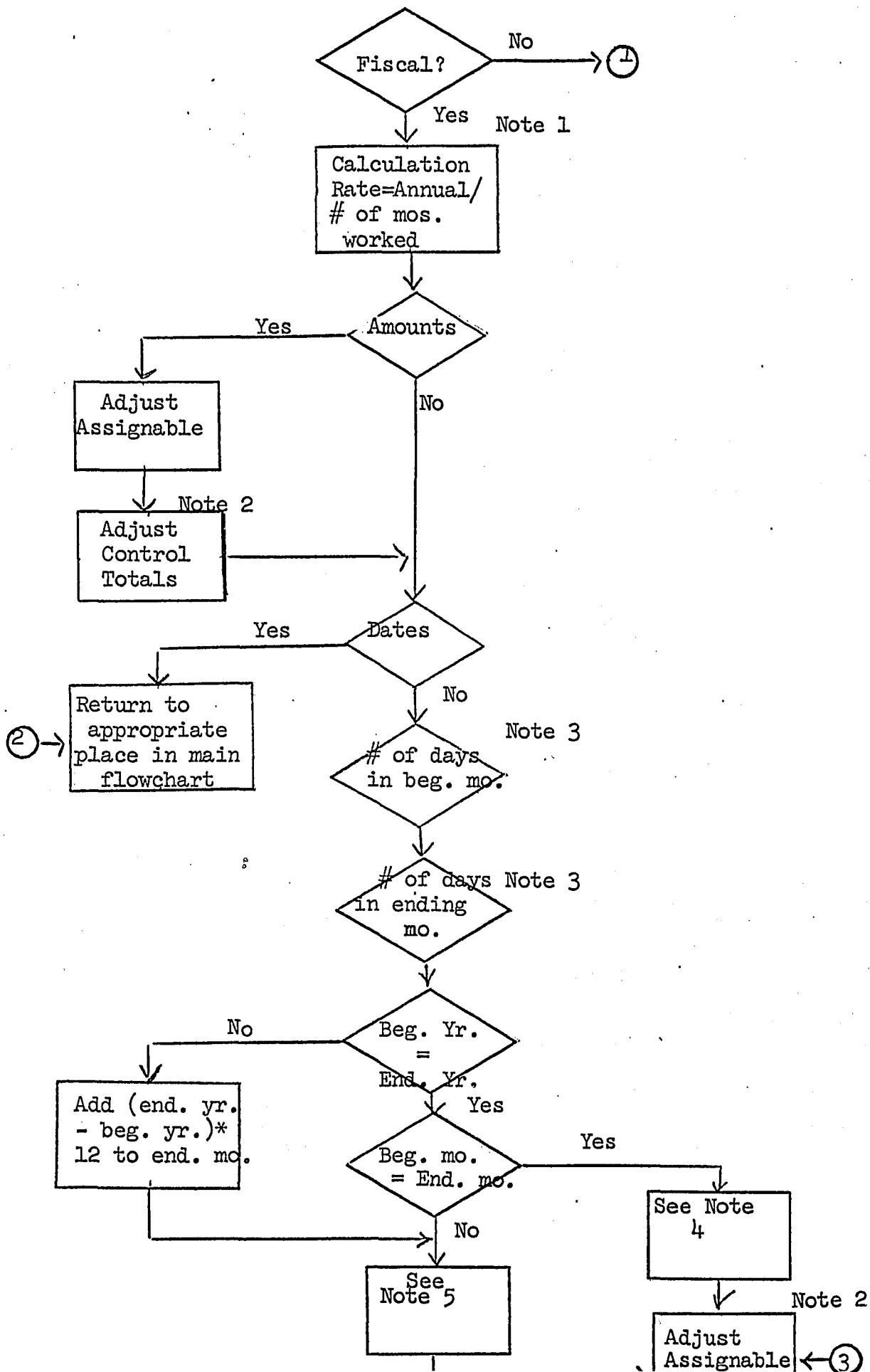
Flowchart of SBR Assignable Calculations Program

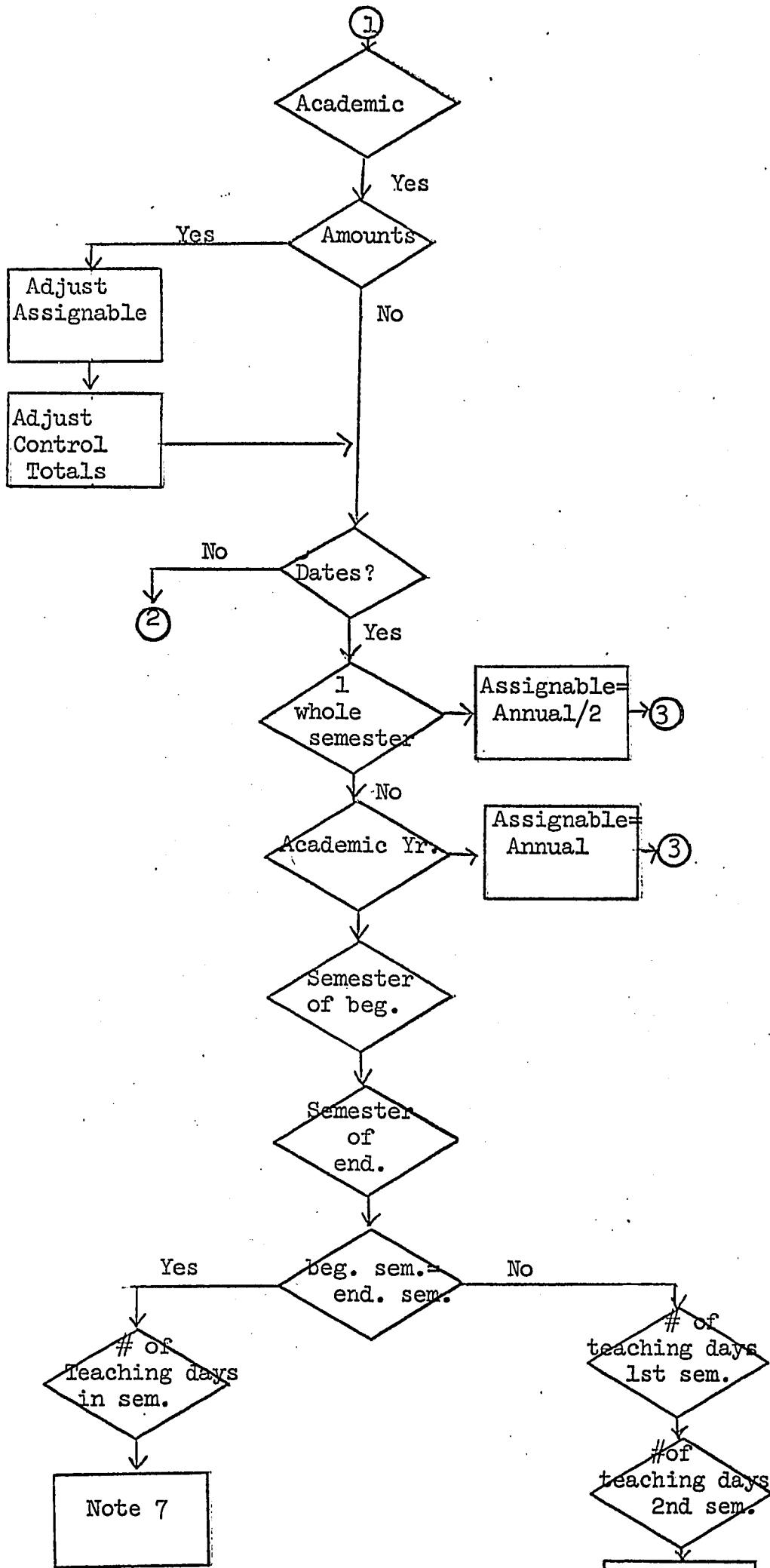




Appendix E: Detailed Flowchart of
Assignable Calculations

Exhibit 4. Detailed Flowchart of Assignable Calculations





Appendix E Diagram Notes

1. This is opposed to the rate used by payroll which is equal to annual divided by the number of pay periods. The number of pay periods is not always equal to the number of months worked.
2. There are two control totals for General Fund accounts (one for additions and one for deductions) and two control totals for Restricted Fund accounts (one for additions and one for deductions).
3. A table is to be stored in memory giving the number of days in each month.
4. Assignable = $(\text{Rate} / \# \text{ of days in beginning month}) * (\# \text{ of days in beginning month} - \text{beginning day} + 1)$
5. Assignable = $\text{Note 4} + (\text{Ending month} - \text{beginning month} - 1) * \text{Rate} + (\text{Rate} / \# \text{ of days in ending month}) * \text{ending day}$
6. Each year an academic calendar will be loaded into memory. This table will contain the following:

<u>Date</u>	<u>Number of Days Taught</u>	<u>Number of Days Left</u>	<u>Semester</u>
-------------	------------------------------	----------------------------	-----------------

In addition, the total number of teaching days in each semester will be loaded into memory.

7. Assignable = $(\text{Annual}/2) / \# \text{ of teaching days} * (\# \text{ of days left as of beginning date} - \# \text{ of days left as of ending date} + 1)$
8. Assignable = $((\text{Annual}/2) / \# \text{ of teaching days in first semester} * \# \text{ of days left as of beginning date}) + ((\text{Annual}/2) / \# \text{ of teaching days in second semester} * \# \text{ of days taught as of ending date})$

VITA

Joan Dowty Bruno, daughter of Mr. and Mrs. John A. Dowty, was born in San Antonio, Texas, on November 26, 1942.

After graduating from John McDonogh Senior High School, New Orleans, Louisiana in 1960, she entered Louisiana State University in New Orleans, and completed the requirements for the degree of Bachelor of Science in accounting in January, 1964.

In February, 1964, she began graduate work at Louisiana State University and earned a Master of Science degree in accounting in May, 1965. Continuing to pursue graduate studies, she is now a candidate for the Doctor of Philosophy degree in accounting at Louisiana State University.

She is married to Sam J. Bruno, of Port Arthur, Texas.

EXAMINATION AND THESIS REPORT

Candidate: Joan Dowty Bruno

Major Field: Accounting

Title of Thesis: Auditing On-Line Real-Time Electronic Data Processing Systems

Approved:

Fred U. McComison
Major Professor and Chairman

R D Anderson
Dean of the Graduate School

EXAMINING COMMITTEE:

B. Preston

W. E. Sawyer

Glenn Walter

George W. Fair

Date of Examination:

May 15, 1969