1956

Electronics in Business: Effects on Accounting.

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ELECTRONICS IN BUSINESS: EFFECTS ON ACCOUNTING

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

Gardner Monroe Jones
B. B. A., University of Michigan, 1949
M. B. A., University of Michigan, 1950
A. J. A., 1956
ACKNOWLEDGMENT

Appreciation is expressed to Dr. Lloyd F. Morrison, Professor and Head of the Department of Accounting, for the initial stimulation of the writer's interest in the field which eventually became the subject matter of this dissertation, and for his encouragement and guidance during its writing. Thanks are due also to Dr. P. F. Boyer, Professor of Business Administration, Dr. Harlan L. McCracken, Professor and Head of the Department of Economics, Dr. Loon C. Haggins, Associate Professor of Business Administration, Dr. Stanley W. Preston, Professor of Business Administration, and Dr. William D. Ross, Professor of Economics.
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ABSTRACT

For accountants in industry, the pressures of the immediate problems of converting accounting systems to electronics impede calm consideration of the future; however, now is the appropriate time to look forward to the future of accounting under electronics. One approach to such a study is to seek answers to a series of questions: what are the services that accounting provides? what is electronic data processing? what effect will electronic data processing have on the performance of accounting services, on accounting organization, and on accountancy?

Accounting is defined as a function, an approach, and least importantly, an organization. The function of accounting within the business firm is to collect, analyze, and report information for policy planning, control of costs and revenues, conservation of assets, and assistance in routine operations. Outwardly directed accounting services include reporting to society and aid in meeting legal requirements; an outside accounting service directed inwardly is external review for internal control, by independent accountants.

Electronic data processing encompasses maintenance of volume magnetic files and electronic manipulation of data therefrom according to instructions to the manipulating device.

Electronic data processing may affect the performance of accounting
services through organizational realignment to fit the concept of an integrated company-wide accounting system, the use of mathematical analysis of accounting and production records to aid in decision-making, and the acceleration of reporting processes. There is increased emphasis on managerial control by exception, little effect on published reports, and some changes in audit procedure to make use of electronic capabilities. Audit emphasis is on testing the working of the system rather than on verification of detail, but standard confirmation procedures are still used. The systems experience of the controller's staff should place the controller in a position of leadership in planning and coordination of the electronic business system; but the business system requires a team effort from all functional divisions, making use of engineering and mathematical skills along with accounting experience.

Accounting organizations and accounting literature are giving increasing attention to business systems; accounting education must emphasize basic conditioning in logical thinking, in understanding people, and in the flows of business information. Curricula for prospective accountants should be compartmentalized to include mathematical discipline, industrial engineering, and human nature studies.

The universities' training obligations in the area of electronic data processing are not to large concerns able to provide employee training programs but to smaller organizations and individuals who
cannot obtain appropriate training by other means. The universities will meet the need largely through graduate programs, adult education courses, conferences, and seminars for business men.
INTRODUCTION.

Since 1946, when the basic pattern of present-day electronic digital computing machines was outlined, an almost fantastic growth has taken place in the completely new computer industry. For ten years, almost every month has seen some new development in this young but vigorous industry. During the early years of computer development, accountants were little concerned with computers, as the machines were operated by governmental laboratories, military installations, or universities, and were used only for involved logistical, engineering, and scientific calculations. Some commercial uses were made of small electronic calculators but these usually were an adjunct to punched-card installations, speeding up specific arithmetic steps in otherwise unchanged methods of handling business data.

By 1951, the technique of using magnetic tapes for record-keeping and the enormously increased machine speeds and capacities made possible the economic application of electronic computational devices to processing repetitive accounting, inventory and production situations.


The necessity for businesses to take advantage of any cost-saver in an "overhead" activity, the aura of glamor surrounding a certainly fascinating new toy, the stirring of imagination by new words like "automation" and "electronic brain," have pressured business firms, most of them on economic bases but some on emotional ones, to join the rush to high-speed digital computing equipment. Caught in the rush, clerks, production men, accountants, personnel directors, auditors, and executives have found themselves using a strange new jargon which they don't quite understand, through its very newness.

STATEMENT OF PURPOSE

The involuntary preoccupation of accountants with the mechanics of adapting business systems to make use of electronics has allowed little opportunity for them to view their own future position in perspective. Accountants are at the very center of systems revisions, and are likely to be most directly affected by the commercial use of electronic data processing. The composition of accounting staffs, the way they perform their work, their relationships to the equipment they use, the sources and extent of their authority, the internal control devices they employ, their auditing procedures, and their education and training, may be altered in some degree by putting these minute pulses of electricity to work in providing business information.

It is the purpose of this dissertation to analyze the accounting function and what it does and to anticipate how the accounting function is likely to be changed as electronic technology comes into wider use in accounting situations. Evolution, not revolution, is characteristic of developments in accounting, and even in a period of rapid technological
change in handling accounting data, changes in what accounting is and does will evolve, not erupt.

METHOD OF APPROACH

The method of approach used here will be (1) to examine, one by one, some of the characteristics of the accounting function, (2) to attempt to appraise the impact of electronic data-processing methods on each characteristic, and (3) to look into the ways that the procedures, preparation for, and practice of accountancy may be changed by the application of electronics. An intensive examination of this nature should permit a view of accountancy in its conditions of several years ahead.

LIMITATIONS

Descriptions of computers and electronic devices and their technical applications purposely are limited in this paper. A general non-technical outline of the nature of electronic data-processing is given. A considerable number of introductory papers have been presented at conferences and published in trade journals, outlining the basic elements of computer logic and number systems although few books on the subject are available as yet. The more technical aspects of construction and components are available from the several manufacturers and in electrical engineering trade papers and proceedings. As to computer applications, technique is fluid; in such a new field, situations are not standardized and new ways of making use of electronic

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DEFINITIONS

The term "computer" is narrow in meaning, as used here. While a slide rule, an abacus, or an adding machine is a computer of sorts, it is basically an aid (as are paper and pencil) to a mental process carried on in the mind of its operator. It performs a single arithmetic step and that one step only when immediately and specifically instructed to do so. Some punched-card machines have an ability going a little further toward automaticity; the ability to make simple choices and to execute very limited instructions without the necessity of manual intervention. That ability is provided by externally wired plugboards embodying fixed instructions to the machine. However, the sequence of instructions (known as a program) which can be wired is limited, and the machine cannot "remember" the instructions which have been given it, but must return repeatedly to the external program—the plugboard—each time an instruction has been informed. Further, a punched-card machine usually can perform only one step in computation: it can classify or add or multiply or collate or write out an answer, but only one such step at a time.

An electronic digital computer, on the other hand, has distinct features not possessed by less sophisticated machines. First, it has an internal "memory" where instructions and data and intermediate
results and final answers can be stored. Second, the length of the sequence of instructions it can be given to follow without manual intervention is limited only by its storage capacity. Third, a computer can perform any arithmetic operation, it can sort figures or group data together, or it can perform a sequence of unlike operations, modifying its own instructions if necessary. Fourth, it operates at electronic, not mechanical, speeds.

Business applications ordinarily are limited to the digital computer, which uses discrete units of information. The digital computer recognizes only two states: oneness or noneness, on or off, pulse or no pulse. An analog computer also operates electronically, but its values are expressed continuously by variations in the level of voltage or in some other continuous form of output. An analog computer is used to perform computations where problems can be stated in terms of relationships; the digital computer is ideally suited to the physical units and dollar values found in business data.

In brief, the digital computer, as used here, includes only those electronic devices capable of performing complex arithmetical problems at high speeds, operating entirely from an internally-stored sequence of instructions, using data which may be internally stored and providing intermediate or final results which may likewise be stored internally, all without the necessity of human assistance from the time data is inserted to the time the answers or results are punched out or printed out for reading or further machine use.

Technically defined, a computer would be distinguished from a computer system by the inclusion of peripheral equipment in the latter.
applicability of electronics to all institutions would be far too inclusive for a study of this size and nature.
Chapter I

SERVICES PERFORMED BY THE ACCOUNTING FUNCTION

Accounting is a service function designed to be of use both within and outside of the business firm. The services provided are far-reaching and significant to society as well as to business management.

ACCOUNTING SERVICES WITHIN THE FIRM

The services of accounting within a business firm can be summarized as comprising five categories of information activities:

- Providing information for policy determination
- Operational planning
- Control of costs and revenues
- Conservation of assets
- Routine information services for day-to-day operations.

In performance of these service activities, not only assembling of information itself is required, but interpretation of goals and of results, making reporting meaningful by pointing up exceptions, weaknesses, points of strength, cost-savers, revenue-boosters—any feature which will make the business more productive, more efficient, more useful, or more profitable.

REPORTING FOR POLICY PLANNING

In every segment of firm activity, policies are being established, revised, restated constantly. "Policies are... plans. They are general statements, or understandings, which guide or channel the
thinking and action of subordinates in an enterprise or one of its departments. ¹

The larger the business, the more far-reaching are the consequences of any setting of policy and the more levels of management through which a policy determination must be interpreted and refined into operating instructions. Total financial information, not only recorded but prospective, is essential to top-level planning. Operating and financial policies are not cast in haste, and the maximum of information is called for before major policy decisions are promulgated.

In policy determination, the service of accounting is to provide information, reasonably factual as to the past, reasonably reliable as to the future; "reasonably" factual because no one can state with finality the exact cost of an item or an operation, the exact net profit for a year, the exact loss involved in a calamity or even in ordinary deterioration of merchandise; "reasonably" reliable because of the elements in forecasting the future over which corporate forecasters have no control. Nature behaves erratically. ² A material once scarce (grindatone) soon is found in abundance (carborundum); or a material once considered adequate for perpetuity (lumber) is depleted by the unbelievable demands of a growing population. Government, less sudden in its impact than Nature, can turn into


disappointment the most clever plans for profit or for industry control. Antitrust action, hostile labor legislations, or changes in tax rates or in fiscal policy, can make obsolete well-based financial plans. Style fads, taste in housing, in cars, in clothes, in recreation, change in the face of business attempts to influence public acceptance.

In spite of the relative inexactness of historical accounting figures and of estimates of the future supplied by the accounting function, people in decision-making positions ask for these guiding figures because they are the only tangible bases on which to predicate action.

The enormous geographical dispersion within individual firms demands that some means be employed whereby total information concerning the whole of the enterprise be made available to corporate executives. According to Heckert and Willson,

> The use of modern accounting and statistical data is the means by which the executive is able to direct and control operations which reach beyond the range of his own personal observation and supervision. ³

**Policy in employee administration**

In establishing policy in employee administration, dollars-and-cents considerations as well as social pressures are important; more than employee work satisfaction or employer dignity or face-saving for either side is at stake. In deciding whether to hold the line on wages, the profit and price effect is immediately relevant. In dealing with coffee breaks, reassignment of employees, approval of absence, sick leaves, or timing of vacations, the prospective consequences in terms

of physical production and of cost of production are important. The provision of figures on which personnel policy decisions are in part based is a service provided by the accounting function.

**Policy in sales administration**

In sales planning, accounting records of the past and present and an accounting approach to the future are basic. No matter by whom sales projections and plans are made, the approach is in terms of volumes and prices and revenues and related costs. Order sizes, customer selection, means of shipment, salesman performance measures, prices, discount policy, adoption or abandonment of lines, are based on dollars-and-cents considerations.

**Policy in purchasing administration**

In policy-setting with regard to the purchasing function, an accounting approach is again basic. Make-or-buy decisions, selection of suppliers, routing of inbound shipments, and lot sizes involve dollar decisions. Determination of optimum lot sizes for purchasing, for instance, involves not only price per unit, but cost of carrying inventory of large lots from the investment point of view, and cost of maximizing productive use of physical facilities, from the storage point of view. Is it necessary to borrow to finance economical lot sizes? Is it necessary to rent storage space? Is there deterioration in quality while the material is standing, that will result in scrap or wastage? The careful balancing of these dollar factors requires an accounting approach.
Policy in capital administration

Investment decisions rely, too, upon accounting reporting services. The direction of corporate growth in our time is deliberate, following economic compulsion to diversify. Calculations of future profitability of specific proposed activities and of prices to be spent for acquiring business or for development of new products or processes are an accounting-based function; no matter by whom performed.

The organization of business capital is based to a considerable extent on determinations of an accounting nature. In some few cases maintenance of control outweighs dollar considerations, but these are exceptions to the usual situation. Whether to employ equity financing or to borrow, whether to incline toward retained-earnings financing, how to finance working capital needs, these are all decisions requiring an accounting approach.

It is not suggested that accounting determinations are the only bases for policy decisions. "The accountant does not pretend to be an executive and is not concerned with making executive decisions; he is chiefly concerned with providing the executive with the kind of factual information he needs, recognizing that 'intangibles' and other non-accounting types of information are also essential for executive decisions." Industry's citizenship responsibilities, employee work-satisfaction questions, matters affecting the public good, industry leadership, personal relationships among executives, personal talents, and other intangibles are important, too. However, there are few well

considered policy situations where company planners do not call for the services of information, analysis, and interpretation on the part of the people performing the accounting function.

OPERATIONAL PLANNING

Another area in which accounting services are rendered is operational planning. An immense amount of detailed record-keeping, translation of production goals into man-hours, machine time, and materials requirements, is inherent in the job of maintaining efficient, low-cost production. Today's highly systematized industry is full of potential material, machine, or man-power bottlenecks which can be averted only by extremely careful planning based on facts and figures. Provision of these facts and figures and much of the planning itself is a service of the accounting function.

A sensitive area of planning is the management of cash. The line between having too little cash and too much cash is a narrow one that can be walked only by constant current reference to present and future transactions. Here the reporting service of accounting is indispensable, and it must be a prompt service.

A necessary part of production planning is scheduling of purchases. Establishment of re-order points, automatic reporting of low stock levels, scheduling of release dates on portions of large purchase orders, maintenance of balance between sufficiency for production needs and cost of carrying inventories, all are situations that call for an analytical approach. The accounting function provides that analytical approach and provides practical working answers to purchasing problems.
CONTROL OF COSTS AND REVENUES

The most obvious accounting service in many organizations is the determination of costs. Any particular cost is not significant per se, but is significant in relation to something else: in relation to price, to cost of alternative products, to competition, to net profit, to budgets or funds provided, to other types of cost, or in relation to some measure of operating efficiency.

Parallel to the question of what costs are (or should be) is the question of what revenues are (or should be). A concrete statement of both income goals and cost goals is expressed through preparation of budgets. Knowledge of both revenues as they are and costs as they are is obtained through recording and analysis of transactions. Control over costs and revenues is obtained not only by establishing what the differences are between what is desired and what is actual, but by attaching those differences to responsible persons or functions or departments for attention and correction.

This whole field of accounting service could be described as "responsibility accounting." The usefulness of the service is predicated on the one hand, upon the definition of lines of authority and responsibility, and on the other hand, on the susceptibility to management of particular costs or revenues with which specific persons or departments are charged. The principle is recognized in standard cost systems where production departments are charged with effective usage of materials but not with purchase price variations which are outside their control. The principle is ignored in practice when
home office expenses are allocated to each of branches or operating divisions on some basis not consistent with services rendered for the particular branches.

Responsibility accounting operates in many forms. Standard cost systems are one form. Budgets are another. In either case some form of operating report points out the locations where attention is needed. Budgets, standards, cost records, and operating reports together form the structure of cost and revenue control.

It is important to note that seldom does an operating report include instructions on what to do to correct an exception situation. Like statistical quality control, responsibility accounting isolates and calls for the investigation of some variation from desired (or expected) performance. No one has found any machine—including the new "electronic brains"—that can do more than that.

CONSERVATION OF ASSETS

A fourth internal accounting service consists of the conservation of assets. The assets of a business include not only the physical properties of production and its inventories but include, as well, the skills and talents of its people. As in control of costs and revenues, the basis for control of assets is responsibility, or accountability. As before, the requisites for effective control are (1) definite placement of responsibility and (2) susceptibility of the asset to management. The service provided by the accounting function in conservation of properties is in detailed record maintenance as to who has custody of what properties and personnel and in reporting on what they have done with them; in reporting on the profitable employment of facilities
and efficiency in use, in budgeting, and in planning for funds to maintain facilities adequately.

As far as inventories are concerned, accounting operates on an accountability basis, not only in regard to physical existence of inventories, but as to spoilage and wastage factors, and as to minimizing investment in inventories consistent with maintaining uninterrupted production.

DAY-TO-DAY ASSISTANCE IN OPERATIONS

Accounting performs many unspectacular routine services to industry to keep internal affairs running smoothly from day to day. Questions that are meaningful to individual employees doing particular jobs have to be answered. How much of Item X is in the warehouse? By what route did Material A reach our plant? Was employee Z at work on Tuesday the fifteenth? What is the balance of customer H's account? How many men will have to work overtime to handle job H2? In what storeroom is supply item B carried? Day after day, someone has to look up answers, somewhere in the organization. This duty of providing little pieces of information falls to those who keep records, and is probably the least glamorous but most immediately useful of all accounting services.

ACCOUNTING SERVICES: OUTSIDE THE FIRM

Accounting activities, broadly seen, render three services either outside the business or internally but directed outwardly. The three services are: external review for internal control, reporting to society, and meeting legal requirements.
EXTERNAL REVIEW FOR INTERNAL CONTROL

The certified public accountant, looking in from the outside, is peculiarly situated to render a unique advisory service to the business firm. His periodical review of the records and accounts, while in most cases designed to assure outsiders of the integrity of corporate reports, also provides opportunities for objective examinations of procedures and operating controls, leading to more efficient internal operations or to better accountability. In the exercise of the audit of large-volume activities, he examines large numbers of documents or transactions, thereby becoming a data processor of sorts, as, for instance, in reviewing inventory extensions or in preparation of confirmation requests on receivables. His observation of clients' procedures in a multiplicity of firms places him in a position to criticize constructively the procedures used in processing business information in the firm under audit.

REPORTING TO SOCIETY

While reports to society usually are prepared by persons inside the firm, such reporting is an accounting function directed toward the outside, toward stockholders, employees, government commissions, investors, and the general public. Again, one central idea in reporting to society is accountability. The corporation, through its officers and executives, is entrusted with society's assets: people and goods. It is essential that the corporation report on its stewardship of these assets. Investors and governments must be able to make factually-based investment and regulatory decisions. Those who contribute to corporate existence are entitled to a revelation of performance
of corporate administration. The internal affairs of a corporation become vested with a public interest when the firm is owned by thousands and when the livelihood of thousands more rests on successful corporate management. The public—which is society—cares to have a right to know of corporate conduct.

**Tax determinations**

Reporting to society has its very practical aspects, too; determination of the share which a business must bear of the cost of government operation through taxes is a reporting matter. A business, though not a real person, receives the same protective services, exists in the same atmosphere of law and order, as individual citizens; it is equitable that a business citizen should share in the cost of maintaining collective social services and the favorable social and economic climate. Providing the factual basis for the corporate contribution to public services is an accounting function, even when nicely knotted with legal complexities.

**MEETING LEGAL REQUIREMENTS**

Some agencies of government set up legal reporting requirements for the protection of potential investors or for regulatory purposes. Examples of these are the Securities and Exchange Commission, the Interstate Commerce Commission, the Federal Power Commission, the Federal Trade Commission, and state regulatory commissions. In each of these cases, while the basic reporting requirements are legal in nature, the technique for providing wanted information is an accounting technique.
On the state and local level, the accumulation of accounting data for reporting purposes is called for in levying taxes. Some taxes are based on reported expenses; unemployment insurance contributions, for instance, are based on one expense: payrolls. Other taxes are revenue-based: sales and use taxes, state income taxes. In each case the contribution to society by the corporate accounting function is substantial.

**HOW ACCOUNTING PERFORMS ITS SERVICES**

Behind all reportorial activities, whether directed inwardly or outwardly, there is a logical system of organizing business data. The business whose records consist of pen-kept ledgers, or the business whose records are an invisible pattern of flux chart, as on the surface of yards and reels of magnetic tape, performs the same basic steps in providing information: plan, record, analyze, report.

**Planning**

Planning involves thinking out the solutions to countless questions in reporting information. What is the end product desired? Control? Compliance? Unit cost information? Net profit? What kind of report will reveal the story we want to tell? When and where is the report needed? How can it be assembled? From where are the raw materials (facts and figures) to come? What processing is necessary to get the raw materials into usable form? How is the raw information to be stored? How to store semi-finished information? What tools are available for processing the material? What is the cost of getting the desired end product? Does the end justify the means? Devising methods for getting answers to these and related questions has come to be known as systems.
work—in many large organizations a step in accounting that is placed in the hands of a specific group, the Systems and Procedures staff or Methods Analysis staff.

A recent study by the American Management Association revealed the importance attached to systems work.

A majority of the companies included...consider office methods, systems, and procedures important enough to assign this function as the chief responsibility of at least one employee. Methods, systems, and procedures in the office are the chief concern of at least one employee in 67 percent of the responding companies.

"Systems and procedures" is the departmental title that appears most frequently in the replies of the 90 companies that have such a staff; 40 respondents use it.

Other titles mentioned by a number of firms are "method," "methods and procedures," "procedures," "management services," "methods and standards," and "systems."

In some companies no one specific individual or group specializes in system work; all departments or divisions work out procedures, somewhat on their own, and by trial and error dovetail their paperwork in with others. Such independence makes for flexibility—and also for duplication of paperwork, lack of coordination, and friction between departments and groups of employees. A records methods planning group is almost essential for smooth functional operation.

Scheduling and budgeting

Planning involves, too, all the work that comes under scheduling and budgeting. Systems work is concerned with procedures; scheduling is concerned with times and physical quantities; budgeting is concerned

with dollar goals. All are concerned with the future, in contrast with the popular attitude that accounting only records what has happened.

Recording

Recording, as the term implies, concerns the actual collection of information from varied sources and in diverse forms. Cash register tapes, invoices, freight bills, memoranda, insurance policies, sales slips, correspondence, sales orders, clock cards, time tickets, receipts, checks, meeting minutes; these are all original recordings of accounting information. Once collected, all this information must be analyzed.

Analysis

Analysis includes summarization and rearrangement of information. In a traditional system of accounts, summarization takes place in special journals and in ledgers. In a system of accounts kept electronically, summarization might occur simultaneously with recording; as soon as a transaction is recorded, the amount involved is added to the respective accounts to provide cumulative balances.

Reporting

Finally, accounts are rearranged into functional groupings or into other desired forms for presentation in reports, to provide information, which is the end-product of the accounting function.
Chapter II

THE NATURE OF ELECTRONIC DATA-PROCESSING

Technological improvements in accounting devices have grown out of the need of accounting services to be performed more rapidly, in broader scope and in greater detail in the face of an ever increasing flood of business papers. The increasing demand from all sides for information and the growing complexity of business organization have compelled people dealing in business figures to find means of digesting details and putting out more answers more quickly. In the years since Felt devised the Comptometer (1861) and Burroughs the adding machine (1886), the services offered by accounting have expanded from an historical recording of transactions as they occur to machine-assisted complex determinations in operational planning, tax policy, efficiency analysis—anywhere in business life where past, present, or future values are involved. The green-visored bookkeeper of 1890 with his pen-and-ink records is replaced now by a system and procedures specialist, who is a member of a group of planners, organizing whole groups of people and machines to perform informational services to industry beyond the imagination of the accountants of that day.
Up until the end of World War II, calculating equipment was designed specifically to solve the paperwork bottleneck in business. Posting machines, Scheed-a-graphs, pegboards, notched cards, and tabulating equipment all were designed to facilitate the handling of volumes of paperwork. In contrast, electronic equipment was not designed initially for business use but for entirely different kinds of data manipulation. It was not until the equipment had been devoted to ordnance and mathematical problems for about two years (a relatively long time in such a rapidly evolving field) that its adaptability to the arithmetic problems of payrolls and inventories began to be appreciated. Four more years of exploration and experimentation went by before field accounting processes were turned over to electronic computer systems. In the meantime, nearly a dozen "scientific" computers were build and used for problems involving ballistics, missile trajectories, wing design, astronomy, nuclear physics, and many other mathematical and engineering situations. Usually these situations involved a small amount of input of data, a large amount of computation, and a small amount of output. For example, a rocket trajectory problem might call for the input of (a) basic factors, such as temperature, air pressure, wind velocity, design features, weight, fuel consumption, atmospheric density, and other factors, and (b) formulas expressing

1. The typical business problems to which computer systems have been adapted are essentially file maintenance problems, involving processing of items and amounts rather than computation as such; hence the name Electronic Data Processing Machine has been given to such a system and will be so used throughout this dissertation, with the popular abbreviation of EDP.
relationships between the factors. Thousands of computations would follow, but only at selected points along the rocket's theoretical path would answers be obtained describing the rocket's behavior.

The nature of most business problems is entirely different. Ordinarily, business problems involve (1) the assembly of information from one or more files, (2) the sorting or re-classification of data, and (3) the posting of re-arranged or supplemented information to one or more files. There is a small amount of computation, such as extension of earnings for payroll or extensions and summarization of amounts and figuring of discounts in handling invoices. Ready accessibility of stored numerical information, high-speed arithmetic handling and arrangement of data, and automaticity of operation of electronic computing equipment have brought rapid conversion of the equipment to business record-keeping. That adaptation is another step in improving the services that the accounting function performs for business and for society.

LOGICAL STEPS IN ACCOUNTING

In any method of keeping business records, a certain few basic operations are necessary:

- transportation
- reference to files
- transcription
- manipulation
- storage.

The separate steps are seen clearly in the manual processing of a payment on account by a customer. On receipt of payment, a document showing amount and source is carried or sent (transportation) to an accounts receivable clerk who looks up the customer's account in the
files (reference), copies amounts into a keyboard or on paper (transcription), subtracts the payment (manipulation), enters the new balance into the account (transcription) and replaces the account card in the file (storage).

The same clerical steps are as essential in an electronic recording-keeping system as in any other, but are carried out entirely within the mechanism. In terms of physical handling, the five steps above can be regarded as only one step.

The extremely desirable combination in one instrument of facilities for transfer, transcription, storage, file search, and arithmetic, makes possible the elimination of many human errors in handling business figures. Assuming the mechanism to be in proper operating condition? the machine cannot commit the errors of judgment or the inconsistencies of decision of a human clerk; nor is the machine subject to fatigue or emotional stress. A possible disadvantage of a computer system as compared with a person is that a computer does not know what to do and cannot imagine what to do when faced with an unexpected situation. Presumably a human clerk, encountering an exception to routine, would reason out a way to handle the exception, while the machine can only pursue its normal course of action, or stop and wait for instructions—but it could stop only if instructed to stop.

On the other hand, a human clerk possessing abilities suitable to routine paper-handling (an exercise not itself conducive to the development of originality) is little more likely than the machine to proceed correctly and is less likely to proceed consistently.

2. Error detection and preventive maintenance are discussed at page 36.
The advantage of speed and the ability to operate tirelessly for long periods are obvious. In fact, electronic equipment operates most reliably when kept in continuous operation. The controller of a large life insurance company says:

"By studies have indicated that a one-shift operation on digital computers is not an economical approach to the problem. Machines that are operated "around the clock" will probably give better service and less breakdown time than equipment used for normal one-shift operation."

The inability of digital computing equipment to form judgments may be considered an asset, in the sense that, unlike people, logical devices cannot deviate from instructions once given, thereby assuring consistency of performance throughout the processing of large masses of information. While the machine cannot exercise judgment, it can select one of two courses of action if it has been given criteria for selection. For instance, it is not difficult to prepare an instruction program that will tell the computer to test the result of some computation for positiveness or negativeness; if the result is positive, to follow one course of action; if negative, to follow another. Such a decision point is called a branch. The extent of branching is limited only by the ability of programmers to visualize the network of divergences that might arise in following any logical course of action. A chart of such decisions might resemble an inverted family tree, with any path from a decision point leading to another decision point, and from that to another. Figure 1 presents graphically the process of decision-making by an electronic computer.

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Figure 1. An example of decision-making by a computer.

Problem: if data ($X_n$) in register is positive and larger than zero but smaller than $(y / z)$, process it according to course of action "A." If it fails to meet any of the three necessary tests, discard and go to the next piece of data.

START

BRING $X_n$ INTO REGISTER

GO TO NEXT DATA $X_{n+1}$

TEST #1
SIGN OF $X_n$ = +?

TEST #2
$X_n$>0?

TEST #3
$X_n$<(Y+Z)?

PROCESS $X_n$ ACCORDING TO COURSE OF ACTION "A"
The ability of an electronic data processing system to perform a series of clerical operations rapidly and in correct sequence without human intervention necessarily makes the device complex. An EDPI is a battery of integrated machines built around a central computing mechanism and includes equipment for input of data, temporary and permanent storage, manipulation, output of results, and control of the operations of the system.

COMPARISON WITH PREVIOUS PROCESSING METHODS

While an electronic accounting system is handicapped at present by the necessity of converting printed documentary information to machine language, the system has substantial advantages over previous methods of handling accounts. Existing punched-card systems have reduced enormously the problem of processing large quantities of paperwork by means of mechanical sorting, file searching, transcription, and reproduction of records. Systems employing punched cards have been limited by the comparatively slow speed of the machines and by the large amount of transportation involved in shifting the cards about from specialized machine to specialized machine. The machines could not handle complex procedural situations except by numerous rearrangements of the cards, nor could they handle exceptions to routine. While the use of cards alleviated for a period of years the difficulties that have been encountered by insurance companies and others with great quantities of occasional-reference papers to handle, the growth of commerce within recent years has made the load of paperwork more than even punched-card systems could handle effectively. For example, one large life insurance company reports their usage of punched cards at 25 million cards a year.
In the case of this highly mechanized company

.....the amount of information required to be maintained in punched cards is such that it requires in some instances as many as 25 cards per ordinary policy. If you take into consideration the largest amount of information that must be used for identification purposes so that the cards can be brought together for any one policy, approximately one-third of all information is plain ordinary duplication.

The further one studies the problem the more one is convinced that some means must be devised so that all duplication of records can be eliminated, and the means for processing the remaining data speeded up. Is it necessary to get a new medium in place of punched cards for the storage of accounting and statistical data? The answer is definitely "yes."

PREPARATION OF DATA FOR THE COMPUTER SYSTEM

Not part of the system itself but essential to its operation is data preparation equipment which may consist of electric-typewriter-actuated paper tape punches, adding-machine-actuated paper tape punches, magnetic tape writers, card-to-tape converters, or teletypewriter connections to leased wire networks.\(^1\)

From the point of view of preparing data for most electronic systems versus most mechanical systems, there is little difference in the amount of work required. Most business information is printed or written and must be converted to cards, paper tape, or magnetic tape before it can be used in either system. In some few commercial applications of electronics, devices have been developed for the input of information directly from the point of origination of the transactions; these have been specialized types of equipment for particular situations and are not in general use. One such application, recently announced,

\(^1\) Ibid.
in a point-of-sale recorder for use in department stores. A special cash register is equipped to read electronically punched permanent tags at time of sale, and to punch information into a paper tape within the machine. The cash register will read customers' identification tokens and has a keyboard for insertion of other information, such as clerk's number, price markdowns, and for non-tagged items. From the inserted information the machine will prepare automatically sales receipts and punched paper tape which is used later in an electronic accounting system to prepare sales commission statements, stock record changes, customer account charges, and sales analyses. The logical extension of point-of-transaction recording is to the linking of employee time clocks to a magnetic drum or tape system. Each employee would insert into the time clock an electronically-readable token at his entrance and departure daily, with employee number and time automatically recorded magnetically. Elapsed time would be computed by the electronic equipment and posted to a magnetic record daily and would be merged with permanent employee information weekly to prepare the payroll and write the checks. In industrial plants using job tickets for cost distribution, point-of-work recorders would collect job time information in the same way, for electronic computation of costs for particular jobs or operations.

Such advanced devices are not in general use. Data preparation still requires a large amount of manual work; progress in automatic

recording of transactions has not kept pace with computer development. Input preparation equipment handles a broad range of physical operations, in order to convert information in its usual form to a medium which can be operated on by the data processing unit. The differences between business language and computer language are significant in two ways:

...first, to perform these input preparation operations may require the services of many people, operating a large battery of the same types of equipment, such as card and tape punches, as are used in mechanical systems; and second, the speed of performing the operations is still bound by human mechanical limitations.

To overcome human limitations, increasing use is being made of automatic preparation of paper tapes as a byproduct of forms preparation on electric typewriters with punch attached.

INPUT

Equipment for injecting instructions and data into an EDPM system includes a variety of devices. Since the volume of items that must be recorded is very large and the amount of handling of each item is small, high speed of input and output is important in most commercial applications.

KEYBOARD

The slowest means of input would be by manual insertion through a keyboard. Of the many computers offered for business use, only three use a keyboard as the normal means of input, although they can

be equipped with paper or magnetic tape readers. Present computer systems have keyboards for occasional use in inserting corrections or for making minor program alterations.

**Punched Cards**

A more rapid means of input is the punched card. Where cards are used, usually a separate piece of equipment, a card reader, is connected by cable to the central computer. The rate of input in several computers is 100 cards per minute \(^8\), or 800 “words” of ten decimal digits plus sign.

**Paper Tape**

A third means of input is punched paper tape, which can be read by a mechanical reader at low speeds, or by a photo-electric reader at speeds of the order of 2500 10-digit “words” per minute. Groups of characters are arranged serially along the tape and are coded to represent instructions and data. In some installations, special electric typewriters produce punched paper tape as a by-product in preparation of standard business documents, such as sales orders and invoices. The tape is used later in a computer system for electronic posting to customers’ accounts and to inventory records, or may be

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7. **ELCOM950**, **BURROUGHS 101**, and **Hollerith III**. **READIX** and **HINHAC** normally use Flexowriter keyboards as input but are adaptable to paper or magnetic tape devices.

8. **READIX**, **HINHAC**, **DATA TRON**, **IBM 650**. **IBM 705** employs a card reader at 250 cards per minute.

9. Among computer systems adaptable to use of by-product tapes are **DATA TRON**, **HINHAC**, **ELCOM 125** System, and **RCA BIZMAC** System.
used in standard communication systems to transmit sales, customer, or stock information to a central data processing center. Paper tape finds its best application in situations where the data to be processed can be obtained as a by-product of some usual business operation, although it can be produced by card-to-tape conversion, or punched directly specifically for computer use. Paper tape combines the advantages of semi-automatic preparation (in some instances) with fairly high read-in speed. Straight-forward decimal numbers (binary-coded) are used in most of the systems using paper tape, making visual verification of particular tape segments possible. Paper tape is sometimes less convenient to handle than punched cards, since data cannot be rearranged easily and paper tape is more difficult to reproduce when damaged.

MAGNETIC TAPE

The most rapid input device is magnetic tape, but it is used more widely for permanent internal storage than for input. Remington Rand’s UNIVAC uses for input reels of magnetic tape which are prepared on a modified electric typewriter, the Unityper, from original documents. Reels are placed on a Uniservo reading mechanism which will pass the tape under reading heads at speeds of the order of nine feet per second. Marchant’s MINIAC is designed to read from magnetic


tape "capsules" which are by-products of regular paperwork operations through attachment of magnetic tape recording devices to standard typing or billing machines. In the RAYCC systems, magnetic tape is prepared by a card-to-tape converter; this may also be done in the UNIVAC system when an existing punched card system is being converted to an electronic system or when available records are on punched cards. In magnetization, opposite states of polarity are induced in the metallic surfacing of plastic, rayon, or metal tape by the windings of reading/writing heads under which the tape passes. One direction of flux is assigned a value of 1; the other of 0. A pattern of 1's and 0's comprises a coded digit; a series of coded digits is a "word" or group of letters or figures.

BUFFERING

Because the speed of computer systems in data manipulation far exceeds their speed in input, a "buffer" is provided in most of the machines, so that input of a second group of information can proceed while processing of the first group takes place. While the first data is being manipulated internally, the second is being read into the "buffer." Use of a buffer reduces the delay between completion of one computation and beginning of the next. Likewise, output is transferred to a buffer, to clear the arithmetic unit immediately for the next problem to be solved, while the result of the first problem is being printed out.

STORAGE OF DATA

EDRF systems employ both a "slow-access" large volume permanent
or semi-permanent storage medium and a high-speed, quick-access storage for use in manipulation of data. As most commercial situations are file maintenance problems, a large amount of storage space is needed for permanent information. A great many references are made to the file, but only occasional use is made of any one item in the file. It would be extremely costly to provide rapid-access storage for all items, hence magnetic tape is used to file information permanently, with reading-writing equipment developed to search the file rapidly and to extract information therefrom or insert information where desired.

Unfortunately the files of most commercial applications are of very large size. The Master Employee Record File for a 10,000 man payroll might contain 12,000,000 bits of information and this is a relatively small file compared to the million accounts in the master file of a public utility company. Yet the largest fast internal memory system built stores only 2,750,000 bits at present. In contrast to the above memory devices, the cost of storing large files on magnetic tape is well within the realm of economic feasibility.

TEMPORARY STORAGE

Temporary internal storage for instructions and for use during manipulation of data may consist of magnetic core matrices, electrostatic storage in cathode-ray tubes, a magnetic drum, acoustic delay lines, or a combination of these devices.

Magnetic Cores

A high-speed storage device coming into wide use is the magnetic core memory. Tiny doughnut-shaped ferrous cores are strung in a rectangular array on insulated wires in such a manner that the

intersection of a horizontally-numbered wire and a vertically-numbered wire forms the location for the storage of one magnetic charge. A pattern of such charges forms a character, or coded digit, and a group of characters forms a "word" or piece of information. The magnetic state of an individual core represents a 1 or an 0, depending on the direction of flux within the core. The passing of a small current from one direction only to a core will not magnetize the core, but the summation of simultaneous charges from both vertical and horizontal wires will cause a change in flux. The contents of the core may be read by passing another current in reverse direction; if a change in flux takes place at this time, a pulse is induced in a third wire strung through the core, thereby indicating the presence of a 1. The pulse is then amplified and carried to a register or elsewhere in the system as part of a piece of information.

Magnetic cores permit rapid availability of stored material, and with recent improvements in manufacture of cores and in their insulation, their reliability is reported to be high. Access time is slightly longer than in electrostatic storage and circuitry is necessarily complex; however, preservation of stored material is not dependent upon maintenance of power. Reading of stored information, since reading changes the flux, destroys whatever is stored; to be retained, the information must be re-recorded.13

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13. Commercial EDF2's now using magnetic core storage include IBM models 701 and 705, RCA BIZMAG, and UNIVAC II.
**Magnetic Drum**

The magnetic drum is the usual high-speed storage device among smaller and intermediate-size computers. The drum is a metallic coated cylinder revolving at high speed, with the magnetizable surface of the drum divided into bands and sectors designating "memory" locations. A combination of a band and a sector designation indicates one location, or "cell," where a word or group of characters may be stored in the form of a pattern of magnetized spots. The revolution of the drum under reading and writing heads is synchronized with the timing of trains of pulses carrying coded numbers or letters, making possible the entry or extraction of information to or from desired locations on the drum.

**Electrostatic Storage**

Computer systems are no longer being made with electrostatic storage, which earlier machines used extensively. The Ferranti Computer used cathode-ray tubes as storage; the IBM 701 is the principal American user of electrostatic storage, although the "Princeton" nodes computers including the scientific computers Illiac, Oracle, Johnniac, Ordvac, Maniac, and IAS Computer, were designed with electrostatic storage.

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1. Among computer systems using magnetic drums as the principal rapid-access storage are DATATRON, IBM 650, HECIAC, READIX, MIRRODOT, ELECOM 50, Bendix G-15, ELECOM 125 Computer (but not ELECOM 125 File Processor, which has an acoustic internal memory). RCA's HECIAC uses magnetic cores as its main memory, supplemented by a large-volume magnetic drum.

storage. In the electrostatic type of memory, figures are represented by patterns of charged spots on the face of a cathode-ray tube similar to the familiar television picture tube. To store a charge at a particular spot on the face, a stream of electrons emitted by a cathode is directed toward a pair of deflection plates to which varying voltages are applied according to a scale governed by where the item is to be stored on the face. The voltage level at the plates determines the angle of deflection of the electrons, which are directed to the desired location.

Because of dissipation of the stored charges, they must constantly be read and regenerated; likewise, reading of the spots destroys the information which must be regenerated and restored, in order to be used again. Erosion of the phosphor surface of the face through constant bombardment by the electron stream leads to relatively short life of the storage medium, as compared with magnetic storage devices; the problem of frequent tube replacement and the impracticality of charges dependent on continuity of electric current, have led to the substitution of magnetic core memories in later models, and to the conversion of at least one older machine (Johnniac) to core memory. One machine (SINAC) uses electrostatic tubes as quick-access memory, with a large magnetic drum as secondary slower-access memory.

**Acoustic Internal Storage**

Acoustic delay lines, or "mercury-tank" storage systems have been

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16. "Princeton" model computers are so called because they are based on Von Neumann's *Logical Design of A Computing Instrument* (referred to in footnote 1, Page ix) which was released by the Institute for Advanced Study at Princeton in 1945.
used in few commercial machines, although early UNIVAC models were so equipped.\textsuperscript{17} Trains of pulses representing coded figures are converted to extremely high frequency physical vibrations through a quartz crystal; the vibrations move in successive order through a tube or column of mercury, are read by another crystal at the opposite end, and are regenerated and recirculated. The timing of pulses is synchronized with the frequency of vibrations within the cycle; the location of a particular bit of a particular digit of information is specified by its time-location in the cycle. The presence of a "one" (representing a binary bit) is sensed by opening a channel for the release of the impulse at the exact time the particular time-location emerges from the storage medium. An impulse so released is carried through other circuits to be used elsewhere in the machine.

**Magnetic Tape**

Magnetic tape is used not only for permanent filing of data but for some manipulations of numbers, particularly sorting. In sorting into desired sequence long groups of numbered items (as, for instance, employee numbers with current earnings data), more space is needed for the several arrangements and rearrangements of data that are involved in reaching a final order than is available in quick-access storage. Several tape reading-writing units are employed

\textsuperscript{17} Of commercial data processing equipment now being made, the BŁECON File Processor is equipped with acoustic memory. Raydac, a scientific computer built by Raytheon Manufacturing Company for the U. S. Navy, employs a mercury-tank memory.
for holding intermediate arrangements of the series. Figure 2 illustrates the arrangement of data on magnetic tape.

ARITHMETIC DEVICES

All computing systems have one or more central arithmetic units in which addition, subtraction, multiplication (plus certain other comparing and checking functions) take place. The arithmetic unit consists primarily of a main register, plus supplementary registers to handle overflows, to count shifts in multiplication and division, to count numbers of iterations, and to keep track of program stops being carried out. The registers are variously called adders, accumulators, or counters. The main register functions as a comparator as well as a counter, and also is used for triggering alternative program routines, by recognizing changes in sign or the presence of zeros in the register.

The registers themselves consist of assemblies of bi-stable electronic circuits, each circuit corresponding to a two-position switch capable of being either ON or OFF. The presence of voltage represents an ON state of a particular bit position, a pattern of bits making up each character representing a digit.

NUMBER SYSTEMS

In binary-coded decimal numbering, four bit positions comprise a digit. The presence of an ON state in the first bit position indicates a 1, an ON state in the second bit position indicates a

Figure 2a. Magnetic tape coding pattern for IBM Model 705 EDPM.

Figure 2b. Magnetic tape coding pattern for MAYCOM system.
2, in the third position a 1, in the fourth position an 8. Numbers from 3 to 15 may be represented by combinations of 1, 2, 4, and 8; that is, by combinations of ON states of two or more bit positions. Numbers above 9 are not needed to represent any single digit, and in decimal notation are by design not recognized by the computer. In fact, a number larger than 9 appearing in a digit position is a "forbidden combination" and the appearance of such a number will cause the machine to stop and signal an error.

Number systems other than decimal notation are employed in some computers. Both hexadecimal and octal notation permit handling of much larger numbers within the same size register. In the hexadecimal system all possible states of each digit position (consisting of four toggles) are used to represent numbers up to 15. On the number 16, the digit position would overflow to 0000 and would carry a bit to the higher order digit position, i.e., to the left. In octal notation, numbers through 7 are representable by one digit position. Figure 3 presents a typical set of number system equivalents.

As an example of the larger number capacity of the hexadecimal system, consider the magnitude of number which can be shown in a 10-digit register. In decimal notation, the largest possible number would be 9,999,999,999, the state of the toggles comprising the register appearing as follows:

```
1001 1001 1001 1001 1001 1001 1001 1001 1001 1001
```

Using hexadecimal symbols shown in Figure 3, the largest possible number that can be accommodated in the same register is 15,151,515,151,515,151,515 (a 20-digit decimal figure), or in the hexadecimal notation:
The state of the toggles comprising the register would be

```
1111 1111 1111 1111 1111 1111 1111 1111 1111 1111
```

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<th>B</th>
<th>C</th>
<th>D</th>
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<tr>
<td>16</td>
<td>10000</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

**Figure 3**

Number System(203,885),(570,913)

In octal notation, an even larger number could be entered, as each digit position can represent any number up to 17. Therefore, 17,171,717,171,717,171,717 could be shown in a 10-digit register, utilizing every toggle of every digit position.

There are machine capacity advantages in using hexadecimal or octal notation in dealing with large numbers, as in many scientific

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calculations. However, the problem of converting ordinary decimal numbers in business to a more complex system of number rules against the use of non-decimal number systems in those computers which are designed for business use.

Operation of a register may be parallel, serial, or in a combination of serial and parallel. In completely parallel operation, the entrance of all bits of all ten digits simultaneously would require forty circuits carrying pulses to the register, as in Figure 1a. To reduce the amount of circuitry, digits might be entered in completely serial fashion, requiring only one circuit for entrance, as in Figure 1b. Because serial entrance is unnecessarily time-consuming, a combination series-parallel arrangement is provided, as in Figure 1c. The ten digits are entered serially from right to left, each new entrant replacing the preceding figure, which moves one place to the left. The four bits of each figure enter in parallel, providing a much faster entrance to the register than in completely serial entrance but with much less circuitry than in completely parallel operation.

THE PROBLEM OF MACHINE RELIABILITY

Before businessmen can place reliance for day-to-day operations on electronic machinery, they have to be satisfied that unexpected breakdowns will not throw the entire office organization into chaos at deadline times, as on payday. They have to be sure that the machine system will make few errors—at least no more errors and no more serious errors than people do. To assure machine reliability in operation, computer designers have, in some cases, incorporated partial.

20. Remington Rand, Univac Electronic System (New York, undated); Raytheon Manufacturing Company, Raydec (Waltham, undated).
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or complete duplicate circuits to perform operations in parallel and
to compare results of the two simultaneous computations. The cost of
complete duplication of facilities is substantial; low-priced check-
ing of reliability is provided by preventive service routines applied
daily, or at least frequently, to locate potential machine difficulties
before they occur. Problems incorporating the use of all machine com-
ponents and circuits are performed at voltage levels considerably
above rated capacity to force break-down of components which are in
inferior condition. Package construction makes replacement of defec-
tive parts easy at the time of preventive checking. Test problems are
run repeatedly during maintenance time to assure that all parts are
working properly. One computer manufacturer says

Diagnostic test problems are used to facilitate locating the cause of machine mal-function. The use of marginal
checking procedures while operating on test problems during
regular periods of routine maintenance will detect most of
the incipient failures, so that much of the mal-function that
otherwise might occur may thereby be eliminated.21

Errors sometimes occur in transportation of data through the
system. Detection of transport or storage errors may be made by
attaching to each group of bits, at the time of entry into the system,
an extra bit when appropriate so that the number of active bits in each
character always will be even. As each character is moved past certain
check points, it is examined to see that the number of bits is even.
As long as none of the bits was lost in moving, the number of bits
always should be even. On the sensing of an odd number of bits in a
character, the machine signals an error.

21. UNIVAC Electronic Digital Computer (Oakland: Marchant Calculators,
In spite of built-in and programmed error detection, some unpredictable errors in operation are bound to occur through technical deficiencies, such as invisible damage to cathodes through jarring or minute flaws in some component, which errors only sporadically give trouble. Improved engineering of components has reduced the frequency of parts failures. Maintenance engineers still have to pursue elusive transient errors by whatever searching methods they can devise. On the whole, reliability of equipment is no longer a formidable problem, once the check-out period is completed on a computer system. Numerous instances are available of computers performing hundreds of hours work without internal error, including full work shifts without human attendance. Careful cataloguing of down time and causes of failure have enabled design engineers to improve remarkably the percentage of "good" operating time.

CONTROL OF OPERATIONS

The term "system" implies an orderly carrying out of steps in a process by different units of equipment, in a particular uniform order at specific times. To serve as a coordinating device each electronic data processing system has a control unit interpreting designated information as instructions, relaying the instructions to particular


functional units within the system, and keeping track of the program being executed.

One of the useful characteristics of commercial computers is that instructions ("commands") can be stored in the same coded form as data itself. Only the addition of a unique digit to a computer word, or the designation of particular digits within a word to cause it to be interpreted as a command, distinguishes commands from data. Since locations in memory also are representable by digits, the same form of computer word can represent an order, an address, or information, depending on the identification of the word contents by the control unit. Common representation makes convenient the alteration of stored instructions by creating particular instructions as data, and modifying them by addition or subtraction.

HOW THE CONTROL UNIT WORKS

When instructions and data are read into the computer system, a coded signal indicates that read-in has been completed and execution of instructions is to begin. At this point, the control unit assumes command of operations in carrying out the program. The instruction stored in the first designated memory location is brought into the control unit, which reads and interprets the digits representing a command and reads also the digits representing the location of the data to be used. Control is transferred from the control unit to the functional unit responsible for carrying out the particular operation called for; upon completion of execution of one instruction, the next consecutive instruction is read and carried out. Automatic sequencing is interrupted only if the operating program includes
provision for transferring control to a different step in the program, from which point sequencing would continue.

Computers are designated as single-address, two-address, three-address, or four-address, depending on the number of instructions that can be brought into the control counter at one time. The control counter keeps a record of what order is being executed as well as what order is to be executed next. The control counter of a single-address machine would show the command symbol and a memory location, as for example:

```
ad 1012
```

meaning: add to the register the contents of memory location 1012.

A three-address machine would show three consecutive instructions as one unit or program step:

```
ad 1012  su 1024  tr 1040
```

meaning: add to the register the contents of memory location 1012. Subtract the contents of memory location 1024. Transfer the result \(a-b\) to memory location 1040.

While the single-address or three-address characteristic is of importance to coders, in terms of length of program and techniques for organizing the computer solution, the address feature need be of little concern to the accountant or businessman. The form of address has little bearing on the machine's ability to solve his particular problem.

**Programming**

In order to put any problem into a computer system, it is necessary to dissect the problem situation and to convert each individual step in the problem to language acceptable to the processing unit. The process of problem analysis and conversion to machine procedure is broadly
labelled "programming" although in a narrow sense programming is an intermediate step between analysis of the problem and actual conversion to machine language, or coding.

**ANALYSIS**

Many business problems are reducible to mathematical expression, while others are strictly procedural situations of no mathematical complexity but simply occur in enormous volume. One possible classification of business problems for computer solution is

1. Payroll, inventory control, and other repetitive types of volume operations;
2. Research problems, of engineering or scientific nature which involve advanced mathematics; a permanent analytical staff is required;
3. Advanced business data processing; an intermediate area which includes operations research and a "management science" approach and which requires both mathematical abilities and knowledge of business procedures.

Updating of payroll records, billing, cost tabulations, and posting inventory items are everyday mathematically uncomplicated procedures which need electronic speed to keep up with the volume of work. The bulk of commercial applications are procedural. Other situations involving large numbers of variables are best solved by mathematical methods. Production scheduling, determination of most desirable inventory levels, merchandise distribution patterns, even establishment of depreciation rates, represent types of situations reducible to formulae. Analysis of the particular problem by competent personnel is necessary, in order to establish an appropriate problem description, whether mathematical or procedural.

Diagrams and flow charts are particularly useful techniques for problem analysis. An overall flow chart outlining the basic structure of the processing situation is a useful first step in analysis of procedural type problems. More detailed flow charts follow, covering segments of the procedure. Fairly uniform symbols have been developed and are used in applying flow-chart techniques. It is at this point, according to some authorities, that electronic data processing becomes of value; the necessity for painstaking, minute examination of present procedures often brings to light previously unseen possible efficiencies in the organization of work. It is quite possible that a great portion of the savings that are attributed to machine installation really arise out of the systems improvements made in preparation for the machines. Estimates of the savings through automation run as high as eighty per cent of former costs, but much of the savings could be obtained by systems improvement and work simplification without the new machines at all. 26

Programming follows analysis of the problem. In practice, the line between analysis and programming is indefinite, as is the line between programming and coding, the next step. Description of the problem shades into description of basic procedures for its solution. Flow-charts are drawn to describe machine handling of the procedures. The completed program is coded into machine language, making maximum use of the design of the particular computer to facilitate rapid processing of the case. The programmer, knowing the capabilities of the

particular machine, shapes the problem solution to employ the machine's built-in talents or to avoid the price of its particular inabilities and so that the coder can have some flexibility in fitting the program to the machine. Often one person carries the problem through from analysis to coding.

AUTOMATIC CODING

The art of programming has advanced to the point where much of the work of assembling machine routines can be turned over to the computer itself. One pioneer in the development of automatic coding techniques states that although preparatory work (analysis and flow charting) takes up about 85 percent of total problem solution time, 27 the use of automatic machine techniques permits reduction of the 15 percent of the time devoted to coding. As coding is largely a matter of translating the detailed outline of the problem to machine language, the coding can be done as well mechanically as by a coding clerk. It is necessary, of course, to provide the building blocks from which the program is to be constructed and to provide instructions for the assembly.

Each computer has a list of command symbols which, by design, the computer recognizes as instructions to perform certain functions. A group of command symbols can be set up to use as a unit of instruction, with the group itself identified by one symbol. Any time that the set of operating steps contained in the group of instructions is to be performed, the code would call for the group of instructions by

designating the code symbol for the group rather than to call for each of the individual steps.

Any frequently-used series of steps can be identified by a group symbol. For example, the operation

bring item \( x \) into the register
multiply by item \( y \)
transfer the product \( xy \) to storage

can be described by one symbol \( \text{ABS} \) (multiply \( A \times B \) and store) rather than by three separate symbols for operations:

\( \text{CL} x \) (clear and add item \( x \))
\( \text{MU} y \) (multiply by item \( y \))
\( \text{TS} p \) (transfer product to storage).

It would be possible to catalogue all common sequences of steps under a shorthand code system, in such a way that a long program sub-routine could be identified by one symbol. For instance, a common sub-routine is one for deriving square roots. A coder desiring to incorporate square root derivation into a larger program need only designate this sub-routine by its appropriate code (and make provision for entrance into and exit from the sub-routine at appropriate points in the main program.)

Where a library of sub-routines is stored on magnetic tape, insertions may be made therefrom into a main program assembly when needed. Most sub-routines do not specify that they be stored in particular memory locations, but are so arranged that they will be placed in position by the main program. This approach is known as relative coding; in a program adaptation of relative coded sub-routines, the program will include a routine for converting the relative locations of the sub-routine to fixed locations fitting into the locational pattern of the main program.
Programs are so written that where one kind of operation is repetitive, the computer, on recognizing the pseudo-code symbolizing the operation, will go to the sub-routine indicated and execute it, then return to the main program. One example of the operation of an automatic-coded program is in a payroll situation where F. I. C. A. tax is computed. A sub-routine for computing the tax is stored in memory; when the main pay computation reaches the F. I. C. A. tax computation, control is shifted to the sub-routine by the control unit's recognition of the code symbol representing this particular operation. The sub-routine is acted upon, including tests of whether the current pay is fully taxable, partly taxable, or fully exempt. Upon completion and storing of the amount of tax, control is returned to the main program by a code at the end of the sub-routine identifying the end and the next step to be carried out, which would be the next step in the main program.

Program Compiling Techniques

A computer program can be seen structurally as an assembly of sub-procedures; in that case, a programmer or coder need only designate the sub-codes to be assembled and the order of assembly and instructions to the computer for carrying out the assembly. Assuming the availability to the computer of stored sub-codes, the machine itself can assemble the necessary sub-codes to accomplish a desired program. Much progress has been made recently in developing techniques for compiling routines

20. Federal Insurance Contributions Act, also commonly known as "social security tax" or "OASST TAX".
from stored sub-routines. By use of compiler techniques, a programmer who has analyzed the problem into a set of sequences can easily assemble, in a few lines of programming, instructions for getting together rather long and detailed programs, rather than having to build the program directly detail by detail.

PREPARATION AND ERROR ELIMINATION

The coded instructions are punched into cards, paper tape, or magnetic tape, along with sample problems the answers to which have been previously determined. Every program will have flaws, which must be located and corrected before the program can be used. The "do-it-bugging" operation is frequently very time-consuming; the common, more obvious errors are quickly spotted and corrected but the really troublesome program errors are elusive.

EXTENSIONS TO NON-PROCEDURAL PROBLEMS

The applicability of electronics to numerous routine figure-handling situations would seem apparent to most accounts. Inventories, billing, customer records, premium files, and subscription files, are natural situations for use of this new technology.

Beyond these immediately visible basic applications are more complex business situations which, though familiar to accountants,

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production, and sales planning executives, are difficult of solution through procedural methods. Typical examples are production scheduling, warehousing, and transportation problems. Characteristically, business people, while they see the potential application, are hindered by backgrounds, training, and experience oriented toward procedural solutions rather than formulative solutions. At this point the services of mathematically oriented analysts become particularly useful to business. Frequently, the business situation, with many ramifications can be seen by the mathematician as essentially reducible to formula, thereby permitting a practical-theoretical solution to its understanding.

LINEAR PROGRAMMING

The name "linear programming" is given to one group of quasi-mathematical approaches to these problems. The problem is seen not from the point of view of what result would be achieved by particular combinations of resources and activities, but from the point of view of what combinations are necessary in order to attain a desired objective. In production, the objective would be stated in terms of so many units of product in a given period of time at the lowest practicable cost. When the number of men, machines, parts, and processes becomes large, the working out of even a few complete production planning alternatives requires so much time that production management is not able to know if it has found the most efficient or lowest-cost production. Linear programming follows essentially the same line of approach as previous production scheduling methods but
in contrast to previous methods uses high speed computation to try out all possible combinations of resources until the one lowest-cost method is found. The cost of less-than-best-use of facilities includes more than directly measurable factors. For instance, experienced men in a productive organization often can by a little calculation and much intuition arrive at a solution nearly as satisfactory as the computed solution. However, men of such experience are the busiest and most needed production supervisors and executives, and time spent in production scheduling detracts from the valuable time they can spend on their job of production itself. 31

The solution of a problem with many internal interdependencies starts with the formulation of a program that will accomplish the objective. 32 It need not initially be the "best" program, but serves as the starting point for trying out each of various alterations, either in program components or in figures to which the program is applied. Eventually, (if sufficient time is available) the program describing the lowest-cost combination of resources will be obtained. The high speed of digital computation permits repeated experimentation with program content, leading toward the one best solution, probably not obtainable previously, in production scheduling and similar planning operations. In industry, some of the people familiar with electronic computers feel that the machines' greatest potential lies in more scientifically and accurately planned production. 33

32. Ibid., p. 75.
Linear programming is best used in those situations where input of all productive factors is proportional to production or to volume of activity; that is, truly linear. It would be unreasonable to assume, however, that all production or sales situations contain fully variable use of materials, plant, or manpower; on the contrary, in the typical situation costs do not rise in a fully variable manner nor are they fully fixed. Each individual resource is used in its own unique pattern of semi-variability. Linear programming in production planning is still possible, however, through mathematical expression of non-linear relationships within the basically linear production situation.

THE TRANSPORTATION PROBLEM

Another form of business situation which is often soluble by mathematical methods is the "transportation problem" or "warehousing problem." Essentially the problem consists of finding the lowest-cost combination of shipments from a large number of sources to a large number of destinations. The method of solution can be described mathematically although basically the approach consists of repetitively assembling costs of using combinations of sources-and-destinations until the lowest-cost combination is reached. The "transportation problem" can be solved by pencil and paper, but at great expense of time. The coming of digital computers has made feasible the examination of all possible patterns of transportation combinations, for the first time.

OPERATIONS RESEARCH

Recent applications of scientific method in analyzing business
operations have been classified under the heading of operations research, wherein teams consisting of business specialists, industrial engineers, and mathematicians convert operating figures into mathematical models of a business in the same way that chemists convert their understanding of molecular structure into three-dimensional physical models.34

Models...reduce to a set of one or more equations which represent the basic factors in the problem which are relevant, and it is so constructed as to make it possible to predict the effects of a given course of action.

Models...are generally considered to fall into six classes: (1) planning, (2) allocation, (3) scheduling or sequencing, (4) replacement or maintenance, (5) competitive, and (6) search of information.35

While the methods of operations research are basically statistical, operations research analysts call upon every available technique—accounting, statistical, computational, scientific, engineering—that will help in defining the operation under study.

The understanding of internal relationships and of the logical structure of a business, impassionately dissected, leads to new approaches toward methods of production, inspection, promotion, employment, and sales. Frequently, electronic computation is a substantial aid in performing the necessary re-shaping of business figures for operations research purposes.

EVALUATION OF MACHINE POTENTIAL

One of the most difficult problems in studies leading toward


EDP installation is evaluation of potential savings, not only directly through clerical force reduction, but through improved control of inventory, better interdepartmental and customer service, more timely information, and in other indirect ways. Direct costs expected to be saved may, in one case, be overshadowed by the indirect benefits obtained, and in another case be offset by unforeseen indirect costs.

Authorities in the field of automatic paperwork processing are not in agreement on what criteria should be used in evaluating the profitability of proposed applications. Dr. James W. Forrester has outlined three main categories of benefit to business:

1. Simple cost reduction.
2. Indirect assistance to management by more comprehensive or quicker information.
3. Direct use of machines in evaluation of mathematical probabilities, including operations research problems, linear programming, and forecasts and projections.36

Cost reduction, according to Dr. Forrester, may or may not be a valid basis for economic justification of the computing equipment. The second category is likely to be the real source of value.37 In the past, additions of new types of machines, even when absorbing relatively great amounts of clerical workload, have not resulted in spending less total money on information gathering and interpretation and dissemination. The same occurrence will be likely with the

37. Ibid.
application of electronics. Instead of reducing total informational spending, businesses will expand the amount of processing of data, for expanded uses of data.  

On the other hand, others feel that installations must be justified on the basis of foreseeable cost savings. One suggested rule, stated as an equation, is: if the costs of mechanical performance of a clerical procedure is smaller than the manual cost of the procedure, the machine system is justified. Another suggested approach is to make a quick study to obtain approximate estimates of savings between computer methods and previous methods of operation. In a third company, important emphasis was placed on demonstrable cost reductions; however, if cost reduction through electronics would result in a decline of quality of service to the customers, the change would not be made.

The Experimental Approach

The two almost contradictory points of view suggest that in different companies there are two diverse philosophies underlying the arguments for acquisition of electronic hardware. One philosophy is


that the initial application is an experiment, an exploration undertaken to find out on a trial basis whether electronic equipment can handle satisfactorily particular operations. The experiment would serve as the basis for extension to further applications or for rejection as an unsuitable solution to paperwork handling problems. The experimental approach is likely to be taken in organizations where top officials become interested in the possibilities of electronic applications, and are willing to risk some few thousands of dollars (perhaps up to hundreds of thousands in large firms) in an experiment which may or may not provide a return.

**The Cost Approach**

The second philosophy is that any new approach must be justified on a dollars-and-cents basis. It is likely that in organizations where the impetus for applications of electronics comes from operating levels, the dollar justification argument would be used.

In many companies (even among the largest corporations) the argument of direct cost saving presented as justification for EDPL installation may not be the real reason behind installation. One of two possible underlying motives is a belief that the real source of machine value lies in benefits which are not measurable immediately in dollars and certainly not measurable in advance. Such benefits include the savings obtainable through improved inventory control, closer scheduling, and other indirect managerial improvements; they would be extremely

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difficult to measure and any estimates of such savings necessarily would be crude. Operating personnel could hardly present to financial management their proposals for EDI installation with such indefinite dollar support, even when they themselves are convinced that the indirect benefits are the benefits that will count in the long run. The only arguable basis, then, is cost reduction; the argument is used repeatedly.

A second underlying motive is the desire for prestige, to be known as "the first with the first," a human frailty to which even hard-headed businessmen are subject. If charged with rationalization of this desire by exercising the cost-savings argument, the business executive would deny rationalization; one seldom recognizes his own arguments as rationalization. Man is conditioned to justify his actions by having a reason for acting; the cost savings argument justifies acquisition of electronic equipment where desire for prestige is the underlying motive. Again, cost reduction serves as the apparent reason for purchase. One of the selling points in "selling" computer applications to the financial management group is "explaining how computers can effect clerical savings."

Whether estimates of expected cost savings can be accurate is another question on which opinions differ. On the one hand,

...no projection of savings can be completely accurate down to the last decimal point, the speaker said, and therefore

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trying to establish precise figures in advance is a process that serves no purpose.45

But in the case of several special-purpose computers:

For practical purposes, the cost savings themselves are quite insufficient to justify the machine in most cases. On the other hand, many intangible benefits are claimed, such as better customer service.46

Other experienced analysts point to what they feel are concrete methods of estimating savings. R. F. Clippinger has worked out a rather detailed approach to determination of costs of computer operation in terms of manpower required to perform the same computing job by manual (i.e., desk calculator) methods. He emphasizes, however, that the total cost of computer capacity, staff, peripheral equipment, and problem preparation must be determined as proximately as possible before any final estimate can be made of savings. As examples, he has prepared rather thorough estimates for costs of handling given volumes of data by punched-card versus electronic equipment, for two large companies.47

Other writers with considerable experience in developing computer applications in industry point to rough measures for estimating savings. Potential savings can be evaluated


46. Leubach and Thompson, op. cit., p. 124.

in terms of
(a) salaries
(b) "fringe benefits" of clerical workers to be displaced and
(c) the related costs, if recoverable, of occupancy and
furniture and equipment depreciation.\footnote{48}

Or, stated in terms of personnel,

....if a computer can replace 125 or 150 clerks or the
equivalent of their salaries in machine rentals, depreciation,
and so on, the equipment's cost will be economically justi-
fied. It is difficult, however, to generalize about the
characteristics of the companies in which such a situation is
likely to prevail.\footnote{49}

There is likely good reason for their being no well-defined
rules for evaluation of savings. The use of electronics is new in
business although fairly old in ordnance and mathematics; it was
only two years ago (the summer of 1954) when the first UNIVAC was
installed at General Electric Corporation's Appliance Park as the
first all-commercial installation of any large-scale EDPM system.
Although at least six other UNIVACS and about the same number of
IBM 700 Series EDPMs have been put into commercial operation since
then, experience with all of them is limited, and the companies
involved are still experimenting with new programs and program
revisions. The detailed experiences of few of these companies are
available as yet; only after businessmen have passed through the
period of tryout on their particular problems will we have sufficient
empirical evidence on which to base valuation judgments.

\footnote{48} Osburn, op. cit., p. 101.

\footnote{49} J. A. Higgins and Joseph Glickauf, "Electronics Down to Earth,"

\footnote{50} Paul Burnham, "The Audit of Machine Records," Journal of
Accountancy, March, 1956, p. 58.
In addition to the factors of newness and limited experience, there is another which may account for the lack of development of generally disseminated procedures for evaluating potential: those corporations which, in their own view, have obtained a competitive advantage by making use of a new cost-saver, and have worked out their own electronic installation plans and short-cuts, are unlikely to be over-generous in sharing their findings with others in the same industry.

In spite of the lack of long operating experience of companies using the equipment and the unavailability of precise measures of estimating profit potential from its use, current literature carries few warnings against employing electronics. 51 (possibly not because there have not been mis-applications but because those involved in mis-applications have the good sense not to advertise their own mistakes) and many articles advise positively to go ahead with electronics studies and plans. 52

Whether or not the studies made lead to the installation of a computer, the studies themselves will lead to new ideas for cost reduction through more thorough understanding of how information is handled under present procedures. 53

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51. George Hudson comments: Let small and medium-sized companies approach computer installations cautiously, leaving the risks of experimentation and initial high costs to be assumed by large and well financed organizations. Office Management, December, 1955, p. 47.

52. Laubach and Thompson, op. cit., p. 121.

Out of the varying viewpoints expressed by the various writers and speakers, each of whom has had experience in at least one large electronics study program, one conclusion may be drawn: no company can make its decision to electronize or not to electronize on the basis of someone else's experience; each firm situation (and even each situation within the firm) is sufficiently different from others that a study directed toward that particular company or that particular operation is the only way to find out if electronics is the answer to the problem at hand.
Chapter III

THE EFFECTS OF ELECTRONICS ON THE ACCOUNTING FUNCTION WITHIN THE F.L.I.

Micro electronics are being applied to accounting situations, the future consequences of such applications within the business organization may be seen from three points of view:

changes in services performed by the accounting function
changes in accounting organization
changes in emphasis in accounting.

CHANGES IN SERVICES PERFORMED

Under EDH methods the list of activities performed by the accounting function does not change. However, the ways in which these activities are performed may be altered considerably over the next decade. Predictions of changes in some are predicated on two assumptions: (1) most of the large American corporations will adopt electronics for business use, either on a company-wide basis or for particular operations in record-keeping and (2) computers and EDH systems will be developed for smaller concerns at prices which will yield savings for many medium-sized companies in broad areas and even for small concerns in particular operations. Present progress in new circuit designs, assembly methods, and miniaturization of components points toward reduction in size and cost of computing.

1. P. 1, supra.
systems substantially over the next few years. Already, conservative estimates place at 500 the number of digital computers which will be in use by 1957, in a cross section of American businesses. 2

REPORTING FOR POLICY-PLANNING

The increased speed of record-keeping and the ultimate availability of quick access to enormous files of detailed information is likely to lead to much more detailed reporting on particular matters affecting the setting of policies at all levels. For instance, important information about sales performance in some price lines would, as now, be called to executive attention in summary reports. Under manual methods of recording, a further investigation would require, at most, physical assembly of large numbers of orders, invoices, credit memoranda and other sales reports. Manual copying of information into appropriate categories for analytical purposes and writing up the analysis of the situation would be necessary. Where records are kept on magnetic tape, the same information may be assembled in any desired order or arrangement by preparation and execution of a program of instructions. Certainly the EDP cannot provide interpretation of the figures but can facilitate the assembly and analysis of the figures for special reports on exceptional situations as well as for routine reports under normal conditions.

The new techniques of operations research, in which electronic computation is likely to play an increasing role, are receiving increasing attention as a tool for use in policy-setting. Definitions of operations research imply its connection with policy rather than with departmental operations. Operations research can be defined as

...the application of scientific methods to the study of typical problems confronting executives. In order to differentiate "Oh" from other scientific activities in a company, it is essential to point out that the typical executive problem to which we refer deals with over-all company policy, not specifically with activities of any one department.1

The inventory level problem, to which mathematical methods are now being applied, is an example of a situation having company-wide significance. Determination of appropriate inventory levels is of concern to production departments, to procurement personnel, to financial executives, to sales management, and to personnel administration. Physical space requirements, money committed to inventories, transportation methods, discount policy, availability of goods, lay-off and overtime problems, and investment in sales programs are related to inventory levels and are matters of concern to policy-making executives at high levels.2

While high-speed computer systems are not essential to performance of the necessary mathematical problem-solving in operations research, the availability of computing systems as a ready and versatile tool should lead to the presentation of more trend projections under varying conditions, more detailed reporting to policy-makers in


1. Ibid.

2. Ibid.
particular situations, and more comprehensive predictions of results of alternative courses of action. With electronic speeds available, the promptness of supplying information for policy-making is limited only by the ingenuity of accountants, engineers, and mathematicians, rather than by the physical effort of digesting voluminous detailed data.

REPORTING FOR OPERATIONAL PLANNING

The comments above concerning operations research problems are valid also for operational planning. Linear programing methods are especially applicable in production planning situations. Pre-recorded bills of materials can be extracted easily from tape files and expanded quickly and automatically to prepare requisition and purchasing information. The same records contain machine and manpower needs which can be "blown up" to meet any scheduled volume of production. The basic approach is not necessarily different than under older methods but the time for developing complete requirements schedules for any production level is reduced, along with the clerical work of copying such data from and to numerous shop documents. An even more promising feature of EDPI production scheduling is the ability to revise entire schedules rather quickly in response to market changes, strikes, acts of God and supplier difficulties.

Already, the keeping of inventories on magnetic drums has

demonstrated advantages (it is claimed) in levelling out work loads for procurement personnel and has permitted daily concentration on those stock items which are exceptional, i.e., too low or too high. Daily reporting to procurement auditors of re-order items permits maintenance of lower stock levels, thereby requiring a smaller investment in stock items. Another desirable consequence of daily attention to exceptional inventory items is the near-elimination of production bottlenecks due to sudden shortages of parts. The same advantages are reported through the use of the Distributon (Speed Tally System) at John Plain Company, where stock level records are kept on a magnetic drum and a stock status report is available daily for procurement planning.

The next decade should see electronic experimentation in many more companies and in many areas of operational planning which at the present time have been explored only slightly. Balancing of production in refining, plastics, and other process industries is already a reality through computer manipulation of market factors on the one side and raw material characteristics on the other. The same techniques for planning production will receive increasing acceptance in other manufacturing industries. Tighter scheduling

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and more efficient use of materials and manpower should produce such effects on areas outside of production as reduced cash requirements for a given level of operations, and improved pay scales through increased production per employee.

CONTROL OF COSTS AND REVENUES

A most important area susceptible to electronic recording and reporting is the broad field of control of costs and revenues, embracing almost every activity of the business firm.

Budgeting

The ability of high-speed computing machines to develop rapidly alternative budgets in advance to meet varying operating and market conditions indicates the possibility of closer planning to meet cash needs, parallel to closer planning for materials and manpower in production. The use of the equipment for performing investigative computations leads to more detailed knowledge of relationships between sets of operating and financial conditions. If production can be planned scientifically, then it should be possible to plan scientifically for the financing of that production.

The skills of accountants alone may not suffice in complex planning situations. The science of mathematics implies a structure of thought based to a considerable extent on relationships between things or symbols or ideas. The assistance of mathematicians may be
required to help procedure-oriented accountants and financial personnel solidify into usable formulas previously intangible relationships. In multi-product companies, the computation of profitability of various product mixes is of forbidding complexity; mathematical methods coupled with high-speed computation should be an aid in finding answers to production questions and to the budget questions that go with them. Accountants must still provide the service of setting up financial guides to business, but they may need to reach out to the sciences to find the most effective methods of providing budgetary and planning services.

Control of labor hours in production

The use of central electronic equipment leads, in some cases, to expanded use of advance work schedules, complete to the listing of employees and hours each one is to work, prepared for levels of production determined in advance. Pre-determined work schedules within departments serve as informal budgets for supervisors, thus aiding in the control of costs. On the basis of expected volume of production, the EDP system with high-speed printer can supply each supervisor with an advance time schedule for the week, listing his employees and job categories and the expected hours for each to work each day if the expected production is to be maintained. The principle of accounting by exception is put to work; only where hours worked by an employee vary from the hours scheduled does the supervisor make notations. Foremen in most organizations are not enthusiastic about
the amount of paperwork they have to do; clerical work is an inefficient use of their time as well as an annoyance. A reduction in the amount of writing they must do in the work reports should have a double effect: to improve the use of their time and to reduce somewhat one of the annoying details of their job, that of preparing employee time reports.

The use of pre-determined departmental work schedules is not new in industry, but under manual methods (and even with punched cards) preparation of the schedules is in many cases too time-consuming for practicability. Electronic preparation of the schedules should facilitate their use.

Standards

It is doubtful that computers or computer systems will develop ability to establish time and performance standards for individual production operations. True, computers are useful in analyzing series of observations to set standards; but actual observation of how the job is done is as essential as ever and will continue to be essential. The methods engineer with a knowledge of time and motion study techniques will not become obsolete, but his work may be made easier through the medium of electronics. For instance, industrial television can carry to a centrally located film room an automatic record of the actual doing of the job; the time study man need not be at the place of work. There is a question of employee reaction to having a camera looking over one's shoulder; the same question arises with a time
study can present at the job. In another connection, filmed television record of how individual employees work when beginning employment and after varying lengths of employment could give clues to training methods to speed up the learning process.

**Work studies**

It is possible that electronics may play a part in measuring the physical efforts of individuals to help in finding the most effortless way to do a particular job. Pressures and strains of a plane or of any other physical structure are measured by attaching transducers (minute devices sensitive to pressure, bending, strain, or other physical movement) to the structure at many points. Each transducer is connected by wire to a galvanometer or to some type of sensitive recording instrument which creates a moving line on a recording oscillograph or on a chart. Why could not the same techniques be applied in evaluating human effort on jobs in industry, the readings digitized and machine-analyzed?

These possibilities of electronics may be outside the realm of business data gathering and reporting, but the knowledge they uncover may contribute to worker efficiency and may help in the setting of standards for employee performance. Standards once developed can be used by EDRM systems in developing standard cost figures, in estimating costs of jobs, in preparing control reports for managerial use, and in alignment of labor as production rates change. As production line speeds change, for instance, individuals can do varying combinations
of stops in assembly. Determining the necessary assignment of workers along the line at various line speeds is a rather complex problem, known as assembly line balancing. This is the kind of problem at which the electronic computer excels.

Allocation of costs

The usefulness of computing mechanisms in allocations of costs has already been demonstrated at National City Bank. For statement preparation, allocation of overhead expenses does not need to be made daily; but even when made only monthly, the process entails a tremendous amount of work in any departmentalized business. The process of allocation of primary expenses, reallocation of derived service department costs, and cross-allocations between departments, can be stated mathematically. The problem is not unlike the study of traffic flows which has been simulated on computing equipment.

When stated as a formula, the problem can be turned over to a computing system for quick preparation of departmental cost reports. It can be argued with good logic that a cost report resulting from such allocations and re-allocations is meaningless from the point of view of cost control; the principle of accountability for cost is violated. A department head cannot effectively be held accountable for allocated costs charged to his department. Regardless of the real value or lack of value of such reports, the fact remains that where there is a large

9. Ibid.


cost allocation job to be done, computing equipment can perform the allocation rapidly according to a formula provided. As accountants come to understand better how to use computers, more periodic allocation problems probably will be performed electronically. Primary expenses can be accumulated on magnetic tapes, carrying totals forward daily; at the end of each accounting period (or as ordered) analyses, including allocations, can be made quickly without physical transcription from written records.

Consistency of classification

As pointed out in Chapter II, automatic classification of record items by machine according to previously defined criteria is likely to be more consistent than human classification. The result should be increased reliability of accounting figures, even when shown in considerably more detail than has been possible with previous manual or machine systems.

Quicker reports

In those situations where the time required to process physically masses of operating information has caused delay in reporting idle time and materials usage, for instance, back to department heads and foremen, electronic record-keeping should provide quicker reports. One of the criticisms of punched-card systems has been the length of time between recording and reporting, because of the punching, verifying, sorting, collating, and other time-using operations. In those cases

12. P. 19, supra.
where immediate electronic recording can take place, electronic
equipment can provide quick reporting; where manual preparation of
input information cannot be avoided, promise of quicker reports
through electronics may be an illusion.

Present developments in automatic recording suggest that many
devices for on-the-spot recording will come into use to bypass the
manual punching step. When that happens, many firms will find it
possible to feed back to supervisors and to their superiors detailed
reports on departmental and individual performance for each day
before the day is over. Stored programs for interpretation of time
reports and production records can provide indices of efficiency and
can indicate promptly points of exceptional performance for immediate
managerial attention.

While the reporting process for help in operations may be
accelerated, there is little prospect of real-time computation,
feedback, and control, where people are doing the work. Performance
of what they do cannot be measured until after they have done it;
hence there will always be some delay in recording human activity and
in analyzing it.

For the near future, it is probable that such gain in operating
report preparation time (as compared with punched-card systems) will
not be obtained except in those situations where transactions or
activities are recorded automatically at the point of occurrence and
do not have to pass through a data preparation phase before being
recorded magnetically. However, the number of adaptations of immediate magnetic recording probably will increase very rapidly over the next two or three years, making increasing numbers of situations suitable for prompt reporting of current activities.

Electronic equipment does offer considerable promise in the preparation of summary reports. Once records are accumulated day by day on magnetic tape, the assembly of totals and cumulative information at the end of each week, month, or other period, can take place more rapidly through computer control of assembly than through the handling of masses of punched cards. Examples of great time savings are already available in the preparation of summary reports through electronics. At Monsanto Chemical Company, preparation of summary cost reports electronically was expected to reduce actual preparation time from weeks to days, with reports ready to go out on the second day after the end of each month. 13

The ability to turn out summary reports quickly depends on the maintenance of up-to-date cumulative files, from which information can be assembled immediately. The problem troubling systems designers has been that of achieving a balance between maximum storage capacity and minimum access time. Although equipment manufacturers are somewhat secretive about developmental projects, persistent rumors point to the probable announcement of colossal-capacity magnetic files in

the reasonably near future.

When such enormous magnetic files and appropriate file searching equipment becomes a reality, very large concerns will be able to have high-level reports on production, profit, investment, personnel, and so on, within one or two days after the end of each month. The contrast with the present one to three weeks (or longer) for divisions of large companies and three to eight weeks for a company's overall results, is obvious.

Smaller concerns probably will have available similar large capacity magnetic files from which important reports will be assembled much more promptly than now. Already, Underwood Corporation offers a device to achieve this very purpose: the File Processor. There are rumors of similar devices under development by other manufacturers to meet the file maintenance problems of medium-sized businesses, and 1957 and 1958 should see the new devices appearing on the equipment market. Printers of sufficiently high speed (600 to 1000 lines a minute) are a reality and even faster printers may appear within a few years. Even with the best of present computing, file maintenance, and print-out equipment, the time barrier of data preparation still exists and will have to be solved if all reporting services are to be provided promptly.

One change in overall company reports that must be accepted by accountants and all those who impute an unnatural degree of accuracy.

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to reported figures is the use of estimates in preparing statements at the end of accounting periods. It has often been the practice of accountants to delay attempting to prepare statements of operating results or of income until all the information was in. Under old methods of record-keeping, assembly of information was a process sufficiently slow that all the information was in by the time the accountants were ready to prepare and present their summaries of affairs. If electronic means should accelerate the entire report preparation process, the stray transactions and unsettled bits of business at year-end will have to be forgotten or estimated in order to avoid holding up report preparation. The acceptance by accountants generally of the idea of omission of information in order to gain time will require a long time; inclusion of estimates of unsettled items will seem loss of a break with the worthy tradition of "full disclosure."

CONSERVATION OF ASSETS

The employment of electronic devices for handling record-keeping does not necessarily affect the control of cash. Some writers have expressed fear of loss of control when some one or a few operators have complete custody of cash records maintained in magnetic tape files. The opportunity is great for the operator at the console to introduce changes in data itself, or even in programs which will alter the records by error or design. The danger to cash control is probably more apparent

than real; cash transactions invariably involve "outsiders" and therefore require pieces of paper which are preserved as documentary evidence. Authorization of expenditures continues to be necessary prior to payment for purchases and for intra-company transfers. In the case of payroll, genuineness of employment and proof of employee identity have to be ascertained through identification methods now in use and probably through new devices for monitoring clock-punching and check issuance. For instance, television monitoring of employees as they enter to be sure that each employee enters only one token in the time recorder may replace watchmen. Automatic photographing of employees as they receive their checks at pay windows is another device for discouraging payroll abuses, and probably will be used in the future.

Adoption of electronic methods for cash record-keeping does not mean the abandonment of controls now in use.

One new development in cash payments is the use of character-sensing devices for check identification. By 1960 some check systems may be converted to character-sensing devices for reading printed numbers and amounts rather than holes punched in the checks. The necessary character-sensing equipment has been devised, but its use is at present limited to the processing of travelers' cheques. The entire process of accounting for money may take less time in the future but will require the same control techniques that are in use today.

Control of receivables is closely allied with control of cash.

In each case an "outsider" is a party to the transaction, with the transaction evidenced by customary printed documents. Standard confirmation procedures are employed to ascertain the genuineness and size of receivables, in all kinds of businesses. One possible new development in confirmation procedures is the use of the electronic data-processing system itself to help select the sample of accounts for confirmation according to a predetermined sampling plan. The program for selecting confirmation samples is discussed in Chapter IV.

Electronic inventory-keeping cannot eliminate the need for physical verification of stocks at regular intervals. The maintenance of minimum inventory levels may mean more frequent inventory-taking; the smaller the stock of any item, the more serious is a misstatement of the inventory balance of that item. An error of 50 units in an average inventory of 50 units ordinarily is more critical than an error of 50 units in an inventory of 500 units. Accountability is still the basis for physical inventory control; independent reporting on custodianship is not made obsolete by electronic gadgetry.

The principle of accountability applies to control of fixed assets as well as to inventories. The major change in accounting for fixed assets will not be in the area of control but in the mechanics of record-keeping, depreciation computation, and report preparation, although the maintenance of more detailed records may lead to some closer control.

17. P. 102.
Coaaeification of human resources

The immense analytical ability of computing systems (when coupled with men who know how to use them) is being put to use in helping to match the abilities of men to particular types of jobs. On the basis of statistical treatment of many, many observations, descriptive profiles of appropriate personal characteristics can be developed for each of thousands of jobs. Industry and the colleges have gone a long way in developing job profiles for many vocations, using manual and mechanical classification systems. The mass of detail from millions of successful (and unsuccessful) jobholders can be digested easily by computing mechanisms to provide much more precise pictures of personal suitability than has ever been possible before.

The benefits of improved placement guidance should be made available not only to large industry but to much of the business world through the schools and colleges sharing in vocational information.

Another way in which more efficient use of human effort might be achieved through electronics is through group dynamics analysis in considerable detail; studies of productivity of individuals and groups involving complex inter-relationships can be carried out by machines, coldly and logically, given the ability of social scientists to reduce the nuances of personal feeling to measurement. In many complex, intangible situations, it is not the matter of relationships alone which causes difficulty in visualizing the delicate interpersonal structure of work groups; the added burden of attempting to grasp at one time too
many details obscures the framework of logic. If electronic machines will carry some of the burden of detail, social scientists may be able to lead managers of people in business to a better understanding of how people work and why.

On the other hand, machines cannot make final decisions on where or how a man should be used, and they can lead to understanding only of those characteristics which are measurable. Engineers' arithmetic equipment and statisticians' formulas have anticipated by years the psychologists' ability to reduce the human puzzle to measurement. Business is people; the conservation and best use of people in business will continue to depend on what the users (and the used) feel and think and want. Managing people is an art beyond the present or future capabilities of the most advanced machine.

INTERPRETATION IS STILL THE ACCOUNTANT'S BUSINESS

Regardless of coming technological developments in the devices to aid in the performance of accounting services to business, accountants will still be needed. The accountant may go under the title of methods analyst, or controller, or financial analyst, or internal auditor, or reports supervisor, or even accountant. Whatever his title, he will perform informative and interpretive services to company administration at all levels. His primary tool will be reports, but his usefulness will not be measured alone by his production of reports. Large volumes of report information alone is not necessarily a desirable objective. Rather, "instead of printing masses of data...we will print out and
provide management only those items whose performance was very
good or very bad and deserving of attention. 18

He will stand ready to interpret his product in terms of the
intangibles that figures cannot show. Electronic machines can take
over the assembly of information and its presentation, but inter-
pretation is still the accountant's business.

CHANGES IN ACCOUNTING ORGANIZATION

In many businesses the most conspicuous result of conversion to
electronics is a change in location of some accounting work. Changes
are in the form of (a) geographical centralization and (b) depart­
mental centralization. Some large organizations remove a major
portion of business data handling from their outlying offices, cen­
tralize records and analysis at one location, and send reports back
to the branches or district offices. Centralization is not depend­
ent on the use of computers; punched card systems without computers
also offer a basis for centralization of the record-keeping with
considerable savings in clerical cost through full-time use of equip­
ment at one place rather than part-time use at scattered points.
Even under manual methods, records are often kept centrally, but the
potential clerical saving in geographical centralization are much more
dramatic when high-speed computing and filing equipment is used in a
central location.

18 W. W. Smith, op. cit., p. 16.
In very large organizations, the centralization of record-keeping might very well not result in substantial efficiencies if data processing is non-electronic. The sheer problem of administering a large clerical force could cause centralization to reach a state of progressively diminishing returns. However, if integrated record-keeping is coupled with electronics, large businesses can tie together entire record-keeping, scheduling, and reporting systems to get more done with fewer people at less cost. Much work of information gathering and reporting need not be done in accounting departments as presently constituted nor in purchasing, production planning, or sales. Many information processing activities which traditionally have been done in these functional departments can be done in a data processing center.

Mechanical equipment for automatic punching of data into cards or tape from telephone or telegraph networks has been developed to the point where linking of scattered offices and plants for data accumulation and dissemination purposes has become a reality in several multi-location businesses. By drawing volume paperwork operations into a central location, these firms have been able to employ economically the abilities of large computers and expert analysis and programming staffs. Even before the installation of Univac and IBM 700 series EDW systems, some companies were centralizing report summarization and payrolls in central locations with smaller machines.

19. Up to 1956, the leading integrated data processing systems were those installed by Chesapeake and Ohio Railway, Aluminum Company of America, Sylvania Electric Products, Inc., and National Tube Division of United States Steel Corporation.
for processing of information from widely scattered points.

ORGANIZATIONAL STRUCTURE

The enormous digestive capacity of central EDP equipment (plus its high cost) means that often a re-structuring of organization must take place to accomplish the great potential of the equipment.

Even where electro-mechanical systems are in use, the accounting organization continues to be divided and sub-divided by operative functions. Payroll, time studies, sales accounting, and production planning, tend to serve as semi-independent groups, each attached to some functional unit of the business. Each such group assembles and analyzes its own information and exchanges portions of that information with other groups to meet particular departmental needs. The adaptation of data from other departments to meet the needs of each area requires considerable time-consuming transcription and rearrangement of figures. Where punched cards are used, much of the work of adaptation is mechanical, but there is still a great amount of manual handling of cards between the many machine steps.

Electronic data processing equipment does not solve the problem of re-processing of information by each group for its needs, unless the organization for assembling and handling information is re-shaped to conform to the concept that all paperwork is inter-related.

20. Monsanto Chemical Company prepared payrolls and reports at St. Louis for plants as far away as Houston; Allstate Insurance Company centralized much analysis at Skokie, Illinois, which analysis had been done previously at regional offices.
each functional section retains its own peculiar forms and procedures along strictly compartmentalized lines, much of the value of centralized data processing equipment is lost. Multiple-purpose centralized record-keeping means the surrender of some independence by cost accounting, payroll, production planning, and other accounting or paperwork groups, and entails a shift of duties, prerogatives, and personnel from them to the data center. "....a fluidity of information throughout the company....can only be achieved by a breaking down of the strict departmental lines that have existed in the past, a general pooling of clerical effort rather than concentration of clerical strength within strictly partitioned work fields." 21

There is a likelihood that rearrangement of the clerical work force will encounter resistance among those supervisors and department heads whose scope of authority, as evidenced by departmental size, is reduced. Experience in one large insurance company indicates that a transition can be made smoothly and without serious internal repercussions if a planned program of assuring security to old employees is carried out and if compensation is provided to supervisors sufficient to offset the loss of status inherent in cutting down their staffs. Such compensation might include opportunities to join the data processing group after retraining, transfers with status-gaining promotions, more elaborate job titles, or any other disposition which would offer a gain

in status within the organization, preferably with a gain in pay also. 22

CENTRALIZED EDP SYSTEMS DO NOT MEAN CENTRALIZED MANAGEMENT

Centralization of the physical process of data handling does not mean surrender of decentralized management in any sense. Branches, plants, or operating units supply basic information to the central processing group and use the information that comes back to them. The one change that does take place is the substitution of a few record-keepers and planners (with more efficient equipment) in one place for many record-keepers in many places. Centralized management is a reflection of company managerial philosophy, rather than of any particular method of record-keeping.

It is possible that centralized data processing could contribute to, rather than detract from, effective decentralized management. Reduction of administrative details in the branches should release some branch executive time to be devoted to actual production or sales, which is the primary objective of the particular company unit. Central planning of what a particular factory branch is to produce is not a departure from present practice; present multi-plant concerns with decentralized management specify what is to be produced by each unit and leave the production of the good to the administration of the unit. The same practice would be followed when data is processed

22. Harold F. Craig, Administering a Conversion to Electronic Accounting (Boston: Harvard University, Graduate School of Business Administration, 1955), 224 pp.
centrally, but with probably quicker information on market changes and overall company production goals than is available now.

THE POSITION OF THE CONTROLLER IN DATA-PROCESSING

EDP systems ultimately may lead to increased importance of the controller in the corporate organization. While the controller certainly should not be and cannot be the final authority on all corporate financial and production matters, the systems-and-procedures nature of EDP applications brings to the forefront the systems experience of the controller's staff. Development of a complete electronic data system is a long-term process requiring close collaboration between departments throughout the business. The controller's staff probably has more experience than any other group in getting and distributing information across departmental lines. The service nature of the data-processing activity suggests that its administration should be under the controller rather than under any operating division. It is doubtful that the center is of sufficient administrative importance to justify its standing as an autonomous agency or on a par with the treasurer, controller, head of production, or head of sales.

Restructure of controller's staff

In keeping with the broadening of responsibilities of the controller's staff, some rearrangement of his division may take place. A likely realignment of duties might result in an organization consisting
of five groups:

1. A systems and procedures group, charged with development of methods for accomplishing information-gathering, processing, and reporting throughout the firm.

2. A budget and planning group, charged with preparation of plans for prospective activities, in regard to both production and finance.

3. A reports group, charged with presentation of reports and all outgoing information services; included would be general accounting, production analyses, payroll, cost reports, and statistical studies.

4. An audit group, charged with determination of existence of adequate controls and their effectiveness in use.

5. An operating group, charged with performing the actual data processing.

All groups would work closely with one another and with production, sales, and treasury departments. Particular firms may require other arrangements of duties to meet the peculiarities of their product or personnel.

The Operations group

The operations group includes analysts, programmers, coders and machine operators for the EDPM and for data preparation equipment. Some clerical personnel are necessary, of course. The operations group might include, also, individual information-supplying clerks in various locations. For instance, a clerk in the receiving department of a manufacturing plant might be a part of the operations group
but be stationed in the receiving department to record by machine the original transactions occurring there. Whether it would be better for the clerk to be an employee of the receiving department (under plant supervision) or of the operations group (under controller's supervision) is an administrative problem for the particular organization. Branch plants might include a very small data staff to collect and transmit information and to receive information back from the central processing unit for distribution locally. There would be no cost accounting department, payroll department, or books of account at the branches.

Staff changes

As is evident in most situations where work has been turned over to machines, upgrading of personnel takes place among accounting staffs as electronics is applied to accounting areas. The skills necessary for systems work, budgeting, schedule-making, and analysis, command prices higher than are customary in routine accounting. Almost every man outside of the clerical workers and machine operators in the operations group, becomes a specialist of some sort, and earns the reward of a specialist.

Problems relating to accounting occupy the increasing attention of mathematicians and engineers. The abilities which they exercise are in appearance not related to the accounting profession, but "these specialized skills... are being combined with those of the accountant
and industrial engineer to form a team to study accounting systems and a wide variety of business problems."

Aside from imported mathematicians and engineers, where will the accounting specialists come from? Mostly from existing accounting, production, finance, sales, and personnel divisions. Men with company experience of several years in departmental jobs, and with the capacity to absorb new ideas and put them to work, are being drawn into data processing groups. There is and always will be a need for systematic, bright young men who

...can see the simple pattern in a mass of detail, who can see the possibility of order in apparent chaos, and who know how to make modern machines and methods serve the needs of modern men."

A spokesman for a large life insurance company using UNIVAC for data processing states that the company looks for some mathematical background in its data processing employees but that it is not entirely essential. More important is "familiarity with aspects of the business.";

The possibility of clerical unemployment...

The prospect of mass clerical unemployment as the result of introduction of EDI systems might appear to be a serious problem. However, the period for planning installation and for conversion of


particular operations extends over 12 to 24 months, and a not unappreciable amount of attrition normally takes place in that length of time. The experience of companies thus far has indicated that the fear of employee layoffs is not well founded. Of those employees not shifted to the data processing group or absorbed by the demands of other departments, the remainder almost without exception are taken care of by natural attrition. In setting up the Chesapeake and Ohio Railway's integrated data processing system, the company repeatedly "emphasized the fact that no one will lose his job because of electronics." It is not practicable to turn over all clerical operations to the EDI system immediately upon installation. Because of the complexity of each application, the most probable approach to conversion is to work out the difficulties of one application at a time before becoming too involved in a new application. Thus, the conversion is spread over a considerable period of time and the employee dislocations which might otherwise be felt actually do not materialize.

CHANGES IN EM phasis IN ACCOUNTING

Over the years accounting has evolved gradually from a descriptive device for showing how the business stands financially to a useful tool for control of assets, revenues, and expenses and for

managerial planning. The evolution will continue under electronic accounting. For control purposes, accounting is not based on the recital of figures as such, but on the reporting of significant deviations from planned performance. The larger the sphere of activity of managers, the more important it is that their report-reading time be devoted to significant variances and changes, and primarily to those variances and changes on which they can act.

THE PROBLEM OF ACCOUNTING CONTROLS

One of the apparent dangers in getting away from manual or mechanical accounting is the loss of proofs of accounting accuracy. When records are kept invisibly and recording of transactions is electronic, a very real possibility exists of accidental (or deliberate) destruction of records. Auditors, especially, have expressed concern over the expected difficulty of evaluating the accuracy and validity of reported information when the records are erasable. In addition, electronic point-of-transaction recording may eliminate some papers which serve at present as original documents for reference purposes. One suggested solution to the possibility of loss of data in magnetic form is that of duplicate recording of all transactions. Another would be to retain all the original documents (if there are any original documents) so that the information which is lost can be ferreted out and restored.


There are several factors providing reassurance. One is that presumably competent, experienced people are to be entrusted with the operation of the electronic equipment, where serious record-keeping is to take place. Their competence should reduce the likelihood of accidental error. Another factor is that in order to prevent mistakes being made through unauthorized use of equipment, only certain immediately concerned personnel should be allowed to work with the equipment or to handle the tape files. A third factor is that experience in previously mechanized installations indicates only extremely rare cases of deliberate mischief by disgruntled employees; the likelihood of such an occurrence in an EDPM room probably is even more remote. A fourth factor is that even under electronic methods of data handling, most transactions are evidenced by documents which are available in case of loss of recorded data.

Where initial recordings are electronic, a more serious problem of ascertaining genuineness is likely to arise. In older systems, signatures on visible documents testify as to who received what items and how many, who approved overtime for an employee, where a tool went, and so on. If receipts, issuances, times worked, and amounts are recorded electronically, are there opportunities for anonymous abuses of materials and time? Clearly, positive means must be established to control the use of electronically-read tokens and recording keyboards. In these cases, both limited access to recording devices and tight control over identification tokens or keys must be enforced. For most transactions involving outsiders, electronic recording
probably in a byproduct of preparing "outside" documents; there are, then, visible records to support magnetic records, if support should be needed. 30

One function which electronic equipment cannot take over is the review by experienced clerical personnel in handling business papers. Long exposure to particular papers makes such persons sensitive to errors or inconsistencies in the documents they process. The inferior ability of machines in this regard probably is more than offset by the superior ability of electronic equipment in handling the figures, once they are entered in the computing system.

**Self-checks**

The electronic computer, in manipulating information, can do a great amount of self-checking, not only of its own manipulations, but of the validity of information presented to it. The computer can be programmed to test data for particular types of figure errors. For instance, numbers, quantities, or prices of an obviously impossible magnitude (83 hours instead of 38, £2.20 per hour instead of £2.50, -12 units issued, pay of £.1725 per hour) can be subject to test and rejection through programmed comparisons.

Proof totals are generated within the machine itself. For example, in a payroll computation, the computer itself will determine the total earnings for the payroll and in distributing the wages to jobs or departments will accumulate other sets of totals to be proved.

30. Ibid.
to the total earnings. Specifically, the computer can ascertain that

1. gross pay equals the sum of departmental charges
2. gross pay equals the sum of charges to production orders
   and overhead accounts
3. net pay plus the totals of all classes of deductions equals gross pay.

Other sets of proof totals can be generated, similarly. The machine can test the accuracy of read-in of information by having data read in twice, into two separate series of memory locations, then adding up the numerical values of one series (treating the stored data as numbers without meaning), then adding up the numerical value of the other series, and comparing the two totals. If the totals from both read-in runs agree, the machine has read in consistently, and probably correctly.

Of course, the computer cannot determine that employees have submitted to it all of a given class of transactions, nor that they have not inserted into it extra unauthorized transactions. Reliance must be placed, in many accounting situations, on predetermined proof totals, on establishment of the number of items to be processed in a "batch," or on identification of each transaction by a distinguishing number in a series of transactions. All these control measures are in use now and will have to be carried over into electronic accounting where appropriate.
Corporate accountants never have been, are not now, and probably will not be line executives. They have (and should have) administrative authority only within the accounting department. It is their function to provide information and counsel, and where appropriate, to make useful recommendations. The strength of the corporate accountants' position within the organization stems from their ability to carry out their function promptly, completely, and reliably. Increasingly, their importance as reporters and advisors is a direct reflection of the extent of their ability as designers of smooth-working, rapid-flow information handling systems. Under electronic accounting, the importance of the systems and procedures design assignment is heightened considerably; for when the entire paperwork area is viewed as one work area (which it must be, for greatest effectiveness), the smooth blending of data from multiple sources for multiple uses becomes extremely important.

Under electronic data processing, then, organizational recognition of the accountant comes in part from his performance as a systems designer.

Secondly, his reportorial and advisory authority arises out of the accountant's position of independence. It is most desirable that accounting not be subject to control by any one department or function, while working with all departments. In no other way can independence, and therefore objectivity, be assured. This source of his authority
is not new; in organizations attaching more than perfunctory significance to accounting activity, the independence of accounting is guarded carefully, whether records are electronic or manual.

Third, the accountant is recognized as the interpreter of a mass of details. No manager has the time nor the capacity to classify and organize and summarize all that happens. That task has been charged to accounting personnel. Accounting has been the one source of figure information; perhaps accountants will be replaced by machines as "the only one with the figures," but accountants will be needed to interpret and arrange those figures meaningfully. Again, no change in emphasis is inherent in conversion to electronics.

**Emphasis on System**

In electronic data processing, automatic handling of unusual situations is attempted wherever possible. In punched card accounting, handling of exceptional situations is an inconvenience; cards must be extracted from the normal processing routine for special handling. In electronic accounting, manual handling of exceptional situations is not only inconvenient; it is downright inefficient if high-priced machinery employing complex processing routines is held up often in order to find and extract pieces of information and problems that do not fit the machine routine. It is more efficient and effective to build into the processing routine ways of handling all foreseeable exceptions. Such inclusiveness means that the entire processing procedure must be as nearly self-managing as the designers' ingenuity
in initial programming can make it. Every possible situation must be catalogued for disposition, either by having the equipment process it or by having the equipment automatically provide, probably through print-out, all the salient facts so that the matter can be handled by people.

Does emphasis on the system for doing things threaten the mechanization of people? The requirement that there be only one way to process a given transaction or document (because the computer is equipped to handle transactions in only one way) limits the area of discretion of employees recording and handling the paper in any transaction. There is a danger of creating a feeling among employees that they are hired only to minister to the needs of the machine.

Yet the danger in extreme systematization, from the viewpoint of human relations, is no greater (and probably no less) in electronic data processing than has been experienced in the past in any mechanized or manual volume clerical operation. Experience indicates that employees welcome relief from the type of systematization that has been prevalent in office work, i.e., monotonous posting, reviewing, or checking of masses of almost identical papers. 31

If the drudgery snares of these jobs can be performed by machines, releasing employees for more varied and imaginative work, then the systematization that goes with EDP's should be regarded as a step away from the mechanization of people.

Automatic control devices that work, whether in plant or office,

31. Craig, op. cit.
reduce the number of small urises that require executive judgment. The fewer minor decisions that have to be made, the more time managerial personnel — from foreman to superintendent — have for the exercise of imagination and the trying out of new ideas. Built-in procedures which act like automatic control devices reduce the number of people who are concerned with expediting, either in production or in paperwork functions. A case in point is the probable reduction in long distance telephone bills and in the staff expediting inbound shipments when purchase orders, commitments for delivery, receipts and inventory information are recorded promptly in detail; the status of exceptional items (those calling for action) is available daily, without need of reviewing non-exceptional items. The personnel responsible for seeing that materials arrive on time can concentrate systematically on actionable items. The automaticity of procurement follow-up yields other benefits through the reduction of the number of stock-closers in production departments. If availability of materials is taken from a "crash" or emergency basis, there need no longer be groups of personnel who devote their time to personal attendance on crucial items, to get them where they are needed in a hurry.

In summary, the application of electronics leads to new emphasis on systematizing all possible procedures, not only because mass data processing devices cannot handle affairs on an individual basis, but because automatic control in place of many minor decisions releases managerial talent for more creative activity.
Chapter IV

EFFECTS OF ELECTRONICS ON ACCOUNTING
RELATIONSHIPS OUTSIDE THE FIRM

The consequences of conversion of accounting systems to
electronics are important to public accountants as well as to
company accounting employees. The nature of audit engagements
and some of the auditing tools of the Certified Public Accountant
are undergoing some change in those situations where records are
kept electronically. Society's interest in electronic accounting
is in the possibility of having earnings information more quickly,
an interest which properly might be shared by government, for
reasons of economic measurement and forecasting as well as for
taxation.

EXTERNAL REVIEW FOR INTERNAL CONTROL

The nature of audit engagements among business enterprises has
been undergoing evolution for some years, away from the detailed
checking of individual transactions toward the determination of
existence of built-in controls over assets, obligations, revenues,
and expenses. Especially in audits of companies which maintain records
electronically, the trend toward a management-controls approach is

1. Donald J. Bevis, "Audit Programs and Internal Control," Journal of
Accountancy, June 1955, p. 46.
likely to continue. The majority of electronic-record situations are large-volume operations, where it is impossible (because of cost considerations) to trace physically more than a limited sample of individual transactions. The integrity of corporate records must then be ascertained by a study of the system of recording transactions, with a view to determining whether automatic checks and balances are built into the system, and whether the planned controls are in fact effective.

Because of the complex nature of a comprehensive, centralized accounting system, as is probable when an EDRM is in use, increasing reliance for audit and review would be placed on the firm of public accountants who helped to plan the system. Orientation of audit teams is a time-consuming matter; efficient handling of the audit engagement is enhanced by periodical return of the systems-planning staff to review the operation of the system and to determine its effectiveness. There may, of course, be companies where no public accounting firm has participated in setting up the accounting system for electronic data processing; in that case, the external auditors have a considerable task to familiarize themselves with the new system. In most cases of computer planning and installation for accounting purposes up to this time, public accountants have been involved in the planning from the very start. The large public accounting firms now maintain staffs of specialists who engage only in systems work involving electronics.2

2. For example, Arthur Andersen Company has an Electronics Division within the Management Advisory Services group; Ernst & Ernst's Management Services Division includes a Director of Electronic Research; Peat, Marwick, Mitchell's Management Controls Department includes electronics applications specialists.
An adequate review under complex conditions requires a level of skill considerably above that of mere figure-checking. A thorough understanding of EDP systems in general and of the particular firm's procedures specifically is a prerequisite to satisfactory audit of the firm with an electronic data handling system.

The auditor is concerned with the functioning of the system as a whole, and also with specific details of its operation. Some of the sensitive details which particularly important to him are the extent to which operators are allowed to alter the data or instruction programs, the existence of visible records to meet legal requirements, and the accessibility of machines to personnel who might have an interest in record alterations. The auditor is concerned with the kinds of reports prepared, as to whether they accomplish a useful purpose, whether they are timely, and whether they contain information in the form most useful to the designated users of the report.

The auditor's necessary understanding of computer system operations does not mean that he need be a skilled operator or programmer himself, although these would be useful skills. He does need to cause to be processed through the system, under his supervision, selected transactions sufficient to assure him that the results of transactions in general are as represented. The extent of such testing varies with his impressions of the basic soundness of the procedures and with his findings of errors or weaknesses. The American Institute of Accountants
has established a general measure for the adequacy of testing:

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

The system of testing is not designed to discover each and every irregularity or mistake in recording, but to establish that the probable overall amount of error in the accounts is not significant in amount or nature. Auditors cannot reasonably be expected to find all irregularities (either intentional or unintentional) without prohibitively costly tracing of all transactions. On the other hand, the possible charge of negligence is serious; auditors must exercise care to see that their testing of records and transactions actually reflects the state of the client's accounting system. 4

There appears to be nothing in electronic data processing that would do away with examination of assets and with standard verification techniques now in use, including confirmation of bank balances and of receivables and payables. Existence and valuation of assets must be established; examination of documents and memoranda are necessary, to ascertain propriety of classifications of transactions. The accountant reviews policies, either directly or as a byproducts, and is alert to recommend policy changes leading to improvements in internal control or elsewhere. In some of the preceding activities,

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changes in present audit methods are indicated, to make use of
machine capabilities in selection of transactions and record items
to be studied in detail. The machines can at the same time be used
in preparation of audit confirmation forms, inventory lists, and other
documents for audit purposes.

SCIENTIFIC SAMPLING IN AUDITING, WITH MACHINE HELP

In recent years, some accountants have advocated the use of
statistically selected samples in auditing to obtain a definite level
of assurance before expressing opinions on the financial statements.\(^5\)
The review of invoices, receivables, inventories, payrolls, and
payments, covers classes of transactions occurring in large volume.
Auditors do not in fact make complete examinations of all transactions,
but select a sample of items for detailed examination. The argument
for use of a scientific (i.e., statistically selected) sample rests
on the ability to determine in advance a definite degree of assurance
that correct conclusions are being drawn from the characteristics of
a sample. One objection to the use of statistical samples is the
clerical work involved in determining precisely how many items are to
be chosen from each price or amount or size group and which specific
items are to be investigated. Rather than to work out a plan that is
statistically appropriate, it is easier to choose arbitrarily a sample

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\(^5\) R. W. Johnson, "Statistical Techniques for Auditing Need Deeper
Study," *Journal of Accountancy*, September 1953, pp. 336-337, and
Aging of Accounts Receivable," *Journal of Accountancy*, March 1951,
pp. 293-296.
size, and in selecting specific items, to take every nth item rather than those items indicated by a random sampling scheme.

The capabilities of computer systems are such that the selection of audit items can be turned over to the computer, provided that criteria for selection are set up for the machine to follow. Tables of random numbers may be stored conveniently on magnetic tape or drum, and are available for specification of transaction numbers to be chosen for study. Alternatively, the machine itself can generate its own table of pseudo-random numbers, which serve the same purpose. The advantage of machine selection is that entire files can be searched in a relatively short time. The accounts receivable file in its entirety can be inspected in a fraction of the time that visual inspection would require, with examination of each account for age, amount, and whatever other factors are important. As each account is inspected, it is disposed of for aging purposes and for selection (or non-selection) for further investigation.

An audit program using electronic equipment

An EDMS program for selection of receivables might contain the following instructions (presented here in simplified form):

To inspect account number mmm:
1. Ascertain date of origin of account
2. Place account in proper age category and store on auxiliary tape for subsequent aging schedule
3. Ascertain size of account
4. Place account in proper size category
5. Refer to stored sampling plan for items of this size. Is this account to be selected for examination, according to number designated by sampling plan?
6. If account is not to be examined, drop it and inspect next account
7. If account is to be examined, store account information on auxiliary tape for subsequent preparation of list of accounts
8. Store account information on auxiliary tape for subsequent preparation of confirmation request

When entire file has been inspected:
1. Compare total of receivables file with control account
2. Print out visual record of accounts to be studied, from tape
3. Print out aging schedule, from tape; list all non-current items but show only total amount for current items
4. Print out confirmation request; from tape;

Whether or not audit samples are selected statistically, the advantages of machine preparation of aging schedules and of confirmation requests can be seen. The most immediate advantage is the elimination of an immense amount of transcription by hand or by typewriter, or posting machine, saving hours of clerical time. Another advantage is the probable reduction of errors by elimination of the human element in transcription.

The absence (as far as the accounting profession is concerned) of precise criteria for the statistical selection of audit samples should not be a bar to employment of statistical techniques by competent auditors, especially when suitable equipment is available to perform much of the clerical detail. Both the general standard which serves as an informal rule and the spirit of the rule call for "sufficiency" in testing, but leave the means of obtaining that sufficiency of objective evidence to the auditor. 6

Audit of inventories

Use of the EDRI is practical also in preparation of inventory

6. Page 100, supra.
lists for verification of stock records. An especially useful aid to inventory-taking is machine preparation of a prepunched, pre-printed, mark-sense card for each inventory item, which after inventory-taking can be read entirely by electronic or electro-mechanical means. From the card, the recorded inventory count is fed back into the system in order to prepare reports of inventory discrepancies. The clerical work in inventorying is thereby almost eliminated.

REPORTING TO SOCIETY

The effects of electronics are less pronounced in reporting to investors and to government than they are internally or in relation to the firm's public accountants. Certainly the ability to provide earnings information more quickly is of interest to stockholders and the Treasury, but the form of published reports, their content and purpose are unlikely to exhibit change as a result of conversion of accounting systems to electronics.

ANNUAL REPORTS

The desire on the part of investors to have net profit information more quickly than the two to five months now required for large firms is likely to lead to pressure to accelerate preparation of annual reports. The necessity of such a long period to assemble earnings information is weak testimony to the effectiveness of accounting planning. Of course, in many cases the delay is occasioned not by the business's own inability to complete the reports, but by the
time required to perform the annual audit. In either case, investors and directors are entitled to demand that accountants find ways of reporting the results of operations more quickly.

One factor delaying the release of net earnings figures has been the feeling of accountants that all pertinent information concerning a year's operations or concerning financial status at a year-end date must be included in the reports. Serious consideration should be given to abandoning the idea of reflecting every invoice and minor adjustment in preparation of annual statements. Unsettled items can be reflected by estimation without incurring delay and with probably slight loss of accuracy. Estimation must be tempered with judgment; certainly items of significance should be presented precisely, but it is realistic to observe that the estimating of undetermined expenses and liabilities would distort net earnings no more than do many of the generally accepted estimates universally used by accountants. Bad debts allowances, income tax liability, reserve for product warranties, depreciation allowances, and many other income statement and balance sheet items are only approximations; yet there is no objection to showing estimates of these items in the statements.

The generous use of estimating procedures at cut-off date plus high-speed electronic assembly of data can facilitate the appearance of annual reports at much earlier dates than is now possible—if one factor does not interfere: time to complete the annual audit.

There are ways already in use to reduce the time lag between year-end and release of the audit report. One method is to spread the
audit out over a longer period, by having auditing personnel examine clients' records throughout the year or at intervals, as well as immediately after the closing date. In this way, much of the verification of clerical accuracy and the evaluation of internal control is established at an early date. Another method is to change the fiscal year of the firm to take advantage of the slow season in public accounting in summer and early fall. Public accountants have met with only moderate success in getting businesses, especially large businesses, to change their fiscal year basis. Corporate executives are not unlike other persons in being convinced that the year ends on December 31.

Whether the coming of electronics will accelerate substantially the issuance of corporate reports in a majority of businesses is a question which can be answered only in the future; in some firms report preparation will be more prompt.

THE FORM OF REPORTS

The evolution of published reports is not dependent on the technology of record-keeping. Published corporate reports are shaped primarily to meet the information demands of the investing public and legal agencies. Any changes that come in corporate reports are due primarily to changes in what the public wants to know. At the time that major companies were moving from hand posting to machine posting to punched-card records, changes were taking place in the published reports of those companies; but the changes were coincidental, not
related to the record-keeping mechanisms. There is no reason to believe that the change to electronics will have much influence on the development of report form or content, except that some of the figures may be more accurate because of more precise and detailed record-keeping.

THE USE OF EARNINGS INFORMATION FOR ECONOMIC FORECASTING

Aside from the particular concern of the Treasury in corporate earnings, governmental agencies and some private economic research groups are concerned with the important segment of the economy represented by business corporations. The gross output of goods and services and the extent of changes in business inventories are significant in predicting the future course of the economy and hence in planning governmental action toward maintenance of stability. 7 Quarterly and annual operating reports of corporations are a source of key information to forecasters. If, through electronic data processing or by any other means, the results of business effort can be made available more quickly, knowledge of what is happening in the economy can be brought closer and closer to the moment it is happening. More current knowledge should lend greater sensitivity to the Federal Reserve Board's study programs and to other instruments of national economic measurement and management.

MEETING LEGAL REQUIREMENTS

The possibility of determining new earnings more quickly should

7. Among the federal agencies using business earnings and inventory figures is the Office of Business Economics of the Department of Commerce, whose Survey of Current Business (monthly) is an extensive record of changes in the economy.
be of interest to taxing agencies, particularly the Treasury. There is some question, though, as to the usefulness of electronics in arriving at taxable income, even if the net earnings figure were available more quickly than formerly. Net income determined through normal accounting procedures is only the starting point for a series of technical adjustments to arrive at taxable net income. At every step in the tax determination process, there are matters of interpretation which are not adaptable to machine treatment. Even if the entire process from reported net income to tax amount could be codified, the one-time nature of the problem would not justify the time and expense of programming the problem for machine solution.

**Asset-based taxes**

The use of electronics in the accumulation of information for determination of asset-based taxes shows more promise. Carrying of property records in magnetic tape files facilitates the preparation of property lists as a useful guide for valuation purposes. There is no physical reason (i.e., by way of equipment) why governmental records of real property could not be on magnetic tape, from which voting lists (for bond issues), assessment rolls, and tax bills could be prepared. It is unlikely that the next decade will find magnetic recording used for this purpose, however, because of legal restrictions as to the form and availability of records and because of the traditional lag in adoption of new ideas and methods by governmental bodies. While it is true that the infrequent use of the
individual records probably would not justify the cost of magnetic recording equipment, the same argument holds for punched-card, typewritten, or hand-written records. Studies in individual assessors' offices would indicate the system giving the lowest per-record-unit cost, which in some large situations could be provided by magnetic recording. The possibilities in electronic record-keeping extend far beyond the boundaries of private business, to file maintenance situations such as property records, special assessment rolls, and voters' registrations.

Rate-basing by regulatory commissions

Electronic accounting systems probably have little to contribute to assembly of information for rate-basing by regulatory commissions. While the approach to rate cases is an accounting (analytical) approach, the figures developed from accounting records are subjected to slanted interpretations. Where the purpose of presentation is the winning of favorable concessions, objectivity and consistency of classification are subordinated. The inability of logical equipment to inject the element of viewpoint into dollar information and the one-time nature of the information assembly problem make the use of electronic equipment for this particular purpose unlikely.

Calculation of depreciation rates

Electronic computers offer a new advantage to corporations having
to determine appropriate depreciation rates for maximum tax advantage. Current income tax laws permit business use of a choice of depreciation methods, including straight-line, declining-balance, and sum of the years-digits method. 8 In deciding which depreciation method to use for any given asset, tax rates (present and future), estimated replacement cost, physical life of the asset, salvage value, the pattern of maintenance costs, and the expectation of supersedeance by newer models, must be considered. Not all of these factors can be reduced to measurement, but to the extent that they can be expressed in value terms, computation of the most advantageous depreciation pattern is made feasible by the use of a high-speed computer. Where large numbers of assets are to be depreciated, each at its optimum rate, a one-time preparation of depreciation tables is in order, embodying the various combinations of considerations.

Chapter V

EFFECTS OF ELECTRONICS ON ACCOUNTING ORGANIZATIONS AND ON PREPARATION FOR ACCOUNTANCY

Among the likely eventual consequences of electronic applications in business are:

1. the rise of new organizations centered around electronic business activities
2. the diversion of attention of older organizations toward electronic procedures and problems
3. the growth of a fund of literature regarding computers and data processing systems for accounting use
4. changes in educational programs for accountancy
5. some change in professional accounting examinations
6. extensive educational (retraining) programs for employees affected

ACCOUNTING ORGANIZATIONS

Business associations which include accountants and controllers in their membership have not been unobservant of the movement toward electronics in business. Most of the older (pre-World War II) business organizations have turned toward electronics at least part of their attention at annual meetings and in their literature. Some
never organizations have been formed whose early emphasis was on accounting systems or punched card procedures but who are now moving toward business electronics as the center of interest; and one organization is based specifically on computing machines.

RECENT ORGANIZATIONS

**Systems and Procedures Association**

The Systems and Procedures Association was formed in 1946 to improve business systems engineering. The organization has from the early days of electronics given increasing attention to computer applications in business and in 1951 devoted a considerable portion of the International Systems Meeting to EDI systems and operations research. As systems engineering comes more and more to be identified with electronic data processing, it is probable that the Association's publication, the SPA Quarterly, will give more space to electronic office equipment. As accounting becomes less compartmentalized through company-wide data organization, accountants will be more system specialists than bookkeepers, and will tend to occupy a more active part in systems organizations, such as SPA, which they now share with a heavy representation of industrial engineers.

**National Machine Accountants Association**

In 1951 some 17 local organizations of tabulating department supervisors and administrators formed the National Machine Accountants

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Association. The Association has dealt chiefly with tabulating systems, but fairly recently has turned from emphasis on punched card methods to electronic machinery to accomplish the same types of work. At the 1955 Annual Meeting "electronic data processors" were the center of attention in the papers presented. It is inevitable that the membership should become concerned with electronics, for many of the members are employed in concerns where conversion to electronics is under way or contemplated. The Association's membership now includes supervisors of both tabulating departments and computing centers, but probably the Association will remain primarily an organization representing machine operations groups.

Association for Computing Machinery

The Association for Computing Machinery, although young in years, has had great influence on the development of applications for electronics in business and on the dissemination of information about computers. Initially composed primarily of electrical engineers and mathematicians (the early users of computers), the Association now includes many accountants, controllers, and financial personnel. Through the Journal of the Association and through the Proceedings of its periodic meetings, the ACM has stimulated the application of mathematical methods to the solution of business problems and has served as a common meeting ground for business and scientific people, with a

resulting fruitful exchange of ideas. The programs of the meetings of the Association reflect the growing interest of business people in new, more efficient ways to get paperwork done; they reflect also the gradual realization on the part of technical and scientific personnel that they have the means to help business people with the surprisingly complex problems of business planning. The AGU has formed a bridge between the technical interest in computers on the part of electrical engineers (represented by a section of the American Institute of Electrical Engineers) and the users' interest on the part of businessmen. A continuation of the very useful communication services of the AGU should be of benefit to both fields of activity.

OLDER ACCOUNTING ORGANIZATIONS

A number of groups which have been studying for many years questions of personnel administration, accounting theory, auditing procedures, production planning, and organizational structure, are now interested in computer potentialities and problems.

American Management Association

One of the groups which has been very active in studies of business applications of electronics is the American Management Association, an organization of business executives and supervisory personnel. The AHA has released a number of reports dealing with installations and planning installations, and to some extent with

3. AHA publications are listed in the Bibliography, pp. 
actual EDPM experience. Now that some large installations have
been in operation for a year or more, further reports may be
expected on experiences in some of the established installations. 4
The years up through 1954 are said to have been years of hysteria,
then negativism or do-nothingness, then of following the leader;
1955 was a year of critical evaluation, and 1956 and 1957 are the
"prove-out" period after which is to come the "bandwagon" era
when computers will be adopted widely. 5 The passing of these years
of experimentation and testing should bring some serious reporting
of results, free of the glowing expectations which crowded into
earlier years' discussions of business electronics. Judging by its
studies released to date, the AHA will be among the leaders in
reporting actual electronics experience in business. 6

Controllers Institute of America

The important position of the corporate controller in planning,
installation, and operation of EDPM's is reflected in the efforts of
the Controllers' Institute of America to keep its members up to date
on what is happening in the field. The research branch of the
Institute released in 1954 and again in 1955 compilations of sources
of information on electronics in business. 6 The official organ of
the Institute, The Controller, has carried numerous articles on the

4. P. 80, supra.
5. "Major office automation meeting held in Chicago," Office Management,
December 1955, p. 20.
1955).
subject. Controllers, who are at the very center of accounting systems work, will be connected closely with virtually all of the new commercial EDPI installations; industry and education should expect contributions of much useful experience from them.

National Association of Cost Accountants

Many members of the National Association of Cost Accountants are employed in firms where conversion to electronics is taking place, and many of them have recorded their plans and early electronic applications experiences in the N.A.C.A. Bulletin, the journal of the organization. Members are close to the work of converting existing accounting systems to electronics; over the next several years a considerable number of reports from members should be appearing in the Bulletin, covering newly developed uses in accounting and production control.

National Office Management Association

The membership of NOMA, consisting to a considerable extent of accountants, controllers, treasurers and administrative personnel, has since 1954 been following the progress of computers rather closely, with increasing emphasis being placed on electronics in the 1953, 1955, and 1956 annual meetings. The Office Executive, publication of the Association, has since 1954 carried several articles on computers. In common with other business journals, the Office Executive probably will in the future reflect the importance of new data processing methods, with special emphasis on organizational
structure, office procedures, and human relations aspects of changes in accounting systems.

**Institute of Internal Auditors**

Up through 1955 the *Internal Auditor*, journal of the Institute of Internal Auditors, has demonstrated (by the papers presented therein) apparently little concern on the part of internal auditors with the audit implications of electronic accounting systems; interest seems more to be directed toward the auditing problems arising out of punched card systems. It seems reasonable to expect that when the "band-wagon" era arrives, internal auditors in many firms must develop new audit procedures, although the applicable principles of internal control remain the same as at present. Their literature then will show much more discussion of auditing problems in electronic systems.

**American Institute of Accountants**

The membership of the American Institute of Accountants, the national association of Certified Public Accountants, falls into two groups as far as electronic data processing is concerned:

1. National firms, with Management Services Divisions working with equipment manufacturers and with business firms in planning for electronisation. 8

2. Local firms and individual practitioners, who at the present time have little contact with punched card installations and no

7. P. 115, supra.

8. P. 98, supra.
connection with electronic business systems.

The first group has been very active in contributing to electronic accounting experience and to literature in this area, through the *Journal of Accountancy* and other publications. The Institute itself has appointed a Committee on Electronics, but up to 1956 has not released studies in outside auditing of EDP systems. Audit case studies based on such systems should be forthcoming soon from the Institute.

During the period when electronics was rising in importance, the attention of public accountants in both groups was diverted in another direction. The controversy over rights to tax practice before the Treasury has absorbed energies which otherwise might have been used in developing audit standards and procedures to meet the new technology in accounting.

Within a few years, the use of computers in smaller business firms will require further education for the staffs of many smaller public accounting firms; when that happens, the work of the Institute may incline more toward solution of auditing problems in electronic accounting in both large and small businesses.

American Accounting Association

It is unfortunate that some of the teachers of accounting, who make up much of the membership of the Association, have not kept pace with system developments, but have been content to relay to their
students only bookkeeping techniques. However, others have taken commendable forward steps in another area. The interest of leading accounting teachers in refining accounting theory is not unnatural; they are concerned more with cultivating logical and consistent thinking in students (and in practitioners) than with the mechanics of accounting.

American business, however, is technical, and demands technical men as well as logical men. Basic as accounting logic is, an understanding of how the accounting function is performed is basic too. The company-wide interrelation of accounting records under electronics requires more emphasis on teaching principles of internal control and design of information assembly systems. Accounting teachers must become better informed on these matters themselves; more arrangements should be made for teachers to spend time in industry to maintain contact with business reality.

Lest it appear that the teaching profession has remained completely apart from the study of accounting systems and computer applications, it should be observed that many teachers are active members of the several organizations interested in business electronics, and a few individual accounting teachers have specialized in accounting systems and more recently in electronic systems. It is to be hoped that the next several years will see the rise of some outstanding teachers in this developing field and the active participation of the American Accounting Association in the literature of this field, and that the
Accounting Review of the Association will become, in part, an instrument for the exchange of information in the educational phase of electronic accounting.

THE LITERATURE OF ACCOUNTANCY

Available literature, of which there is a considerable amount, gives fragmentary coverage of electronics applied to business. The literature is largely descriptive rather than analytical. Though the reader must treasure a little information here, a little there, the supply of fragments of information is growing; each of the above professional organizations has contributed to the growing store. In addition, periodicals in all fields of business keep bringing out new writings on computers, operations research, and automation.

Prior to 1956, the few books which have touched on the business applications of electronics have given limited coverage to the subject. Until early 1956, no volume aimed specifically at the business uses of computer systems had appeared; but early in 1956 some textbooks in the area appeared, and it is likely that the extensive demand for training will lead to the publication of others. Formerly the equipment manufacturers were the primary source of specific applications information, but regular college textbook publishers are now entering the field. The years of prove-out of equipment should bring a reduction in the number of glowing half-informed bits and pieces appearing in the popular press, and a
substitution of practical, useful, better organized literature for
the miscellaneous that has accumulated to date.

EDUCATION FOR ACCOUNTANCY

Among the educational fundamentals for future accountants in
EDP systems are:

1. training in logical thinking
2. acquaintance with accounting devices
3. ability to apply flow chart techniques
4. understanding of organizational structures and their
   relation to internal control of assets, revenues, and expenses
5. practice in design of accounting systems
6. conditioning for dealing with people.

Students in serious preparation for electronic accounting cannot
ignore the importance of systematic approach to accounting situations.
The accountant of the future needs to know much more than procedures;
his sphere of activity is an entire system rather than a restricted
area like accounts payable or property records. He must cultivate
a point of view that is at once broad and detailed, general and specific,
policy-oriented and operations-minded.

TRAINING IN LOGICAL PROCESSES

Probably the most basic requirement for the future accountant
in industry or in public accounting is a background of conditioning
in systematic thinking. Mathematical training is one appropriate
means of acquiring such a background. The type of mathematics
encountered in a typical "Business Mathematics" course usually taken by accounting students probably does less toward providing practice in logical thinking than does basic general mathematics. College algebra, geometry, and calculus are decried by students as being too abstract and by some accounting teachers as being impractical. Nevertheless the practice in systematic reasoning processes and in visualizing and symbolizing intricate relationships between ideas is the same type of thinking organization that is needed in grasping the complexities of full-fledged, integrated accounting systems.

Training in applied statistics

A useful bridge between mathematical fundamentals and practical business problems is the study of statistics. The educational background of the accountant should provide a working acquaintance with regression and correlation techniques, sampling methods and sample analysis, the use of statistical methods in control of production and of clerical output, and with other standard statistical devices for analysis of accounting, production, and marketing problems.

The use of accounting tools

In addition to conditioning in logical thinking, the student needs to become acquainted with the tools of accounting. The uses of various accounting devices, such as special journals, voucher systems, subsidiary ledgers, and machine methods should be taught, from the point of view of controls being built into accounting records.
Too, it is necessary to understand traditional and mechanical systems in order to understand the process of conversion to electronic systems.

FLOW-CHART TECHNIQUES

The use of flow-charting techniques to describe processes should begin with the first courses where accounting processes are described. The determination of net income, the position of a company, or movements of inventory can be described graphically as well as by schedules. The chart gradually will develop through flow-charting practice an ability to materialize in his mind as well as on paper even rather complicated accounting processes.

ORGANIZATIONAL STRUCTURE AND INTERNAL CONTROLS

An accountant's education should include the principles of effective organization, especially in relation to maintenance of internal control. He should have practice in setting up organizational charts for all kinds of businesses under various conditions, with the aim of developing workable administrative arrangements while at the same time maintaining accountability. The accounting student's prospective work with EDPM systems involves rearrangements of departmental authority and responsibility in many areas of the business. Creation of new organizational structures for electronic data processing must not weaken internal control; the education of the future accountant should prepare him, as far as possible, to meet shifting organizational situations.
Design of systems

Throughout his accounting education the student should receive practice in design of systems. In connection with the study of receivables, for instance, the organization of records for receivables and the possible alternative arrangements for processing charges and payments, and all other aspects of handling receivables might be considered as a unit for systems design practice. The student could tie the receivables system into a larger system of accounts and of organization by its position in data-flow charts and organizational charts. Study of how to organize the flow of accounting information can be integrated with other accounting instruction. Considerable experimentation could be and should be done along this line.

CONDITIONING FOR DEALING WITH PEOPLE

Accounting students destined for either conventional or electronic accounting fields should receive as a regular part of their college training instruction in courses which help to understand human nature. The accountant who is concerned with company-wide accounting systems, who is working with budgets, production and financing plans, who must report both favorable and unfavorable performance, spends most of his time with people from all departments. He needs an understanding of the motivations that impel people to cooperate. Early in his college work, his studies should include psychology and sociology, to help him understand individual and group behavior.
UNDERSTANDING OF ECONOMIC FORCES

Accounting education already is generally understood to include an essential, basic training in economic principles. Accountants, engineers, and all other business and technical people cannot divorce their occupational activities from their performance as informed citizens. Knowledge of the roles of government and of business in the economy should be expected of every accountant.

USE OF CASES FROM INDUSTRY

Generous use of cases from industry should be made in the study of accounting systems. Materials like the American Institute of Accountants' Case Studies in Internal Control should be used generously. Wherever possible, instructors should assemble case materials locally, for student analysis and practice in criticism and construction of systems with an element of realism.

In the study of electronic accounting systems, the analysis of actual cases is especially useful, to present in concrete form the possibilities and difficulties in developing and using electronics for accounting work.

BASIC versus TECHNICAL TRAINING

Whether students' vocational aim is public or industrial accounting, a thorough background in logical thinking, systems analysis and accounting theory, with secondary emphasis on clerical tools, will go a long way toward giving students a proper educational
background for the eventual assumption of top-level accounting responsibility.

Few universities have (up to 1956) provided specific instruction in computer systems for business students, although industry is increasingly interested in hiring young men with some acquaintance with the subject. Computer training, while economically valuable to the student, is an adjunct to, not a substitute for, regular accounting instruction. There is no substitute for fundamentals. Colleges could conceivably do a disservice to students by allowing substitution of technical specialties for a fundamental understanding of how business—not just accounting—is carried on.

GRADUATE INSTRUCTION FOR THE BUSINESS ELECTRONICS SPECIALTY

If the undergraduate curriculum is occupied mostly with accounting fundamentals, the technical specialties must of necessity be acquired either on the job or in further study beyond the baccalaureate degree. Which is the better approach to training in computer systems? On-the-job work will equip the ex-student to handle particular phases of work well, but with probably inadequate or distorted views of the relationship of familiar areas of work to the entire organization. Further classroom work will not equip the student to produce an immediate return for his employer, but will provide him with a reasonable acquaintance with computer technique
and with proper perspective in regard to all the parts of the entire electronic data processing system.

For the student who proposes to specialise in EDH systems, the graduate curriculum should cut across departmental lines and college lines to include a considerable portion of studies complementary to his business background. To be fully proficient in his chosen field, the student should acquire some training in the application of methods of numerical analysis and some practice in visualising problems posed by engineering situations, and should be familiar with (though not necessarily an expert in) mathematical model building. Only by mastery of his own field and a working appreciation of related fields can he be most useful as a business electronics specialist. The more complex industrial organization becomes, the more important are men who are not narrowly specialised but who are broadly specialised; that is, they can work as a team with other specialists with mutual understanding of methods.

INTERNSHIPS

Accounting and industrial firms in some parts of the country offer periods of practice in accounting to students. Industry can provide a useful service to education (and indirectly to industry itself) by providing similar internships within commercial data processing systems. As has been demonstrated repeatedly, internship experience in industry complements "book learning," giving to students a sense of reality in their studies. The growth of internship
programs in industry for students has been slow and even today is not really extensive; until electronic accounting procedures and organizations become more mature, there probably will be little use of internships in electronic data processing for students, although both industry and education would benefit.

**SHORT COURSES**

Industry is the chief beneficiary (aside from the employee) of an investment in technical education. The primary responsibility for the educational development of industrial employees along technical lines should fall on business itself. Almost all companies which are large enough to employ computer systems profitably are large enough to conduct computer training courses for their employees. The cost of employee training should be included in the expected costs of installing and operating a computer or computer system.

However, there are large numbers of business people who are not part of a large organization having a formal training program. Members of smaller public accounting firms, bank employees, and others, have vocational need for some training in business electronics; others desire merely to upgrade their own level of knowledge. Through the universities, courses in business electronics should be available to meet their needs. There enrollments will justify, adult education programs should include courses in the computer area to the extent the business community requires. The course offerings should include areas related to uses of computers: related mathematics courses,
principles of operations, accounting systems, audit of electronic systems, and other related subjects.

CONVERSION OF MATHEMATICIANS TO ACCOUNTANTS

From the point of view of abilities, a source of potential accountant material is the field of mathematics. The mathematician certainly has the background in logical reasoning and perception of relationships which is necessary in complex business record system. Given a substantial period of introduction to business procedures, the mathematician (or the engineer) might make a capable accountant, especially in EDP systems where accounting personnel may also be concerned with production scheduling, operations research, and other mathematics-using applications.

There are three effective reasons, however, why few mathematicians will be found converted into accountants.

First, the shortage of mathematicians to meet the demands of industry is as pressing as the demand for accountants.

Second, mathematicians (and engineers) generally look with disdain on business procedures as being a low form of clerical activity. The misconception ends only when they are drawn into situations requiring analysis of business problems, and especially of the requirements of accounting.

Third, accounting is an activity requiring close work with people throughout a business organization. The training of physical scientists typically is nearly devoid of preparation for dealing with people.
There is a possibility that physical scientists will expect other people to function logically and rationally; the expectation is not necessarily reasonable. Intuition is often more useful than logic in managing basically illogical people.

PROFESSIONAL EXAMINATIONS

The uniform certified public accountant examinations given to prospective Certified Public Accountants do not at present include questions directly involving accounting systems. No projection is ventured as to when the examinations will reflect the influence of electronic accounting systems; probably there will be no specific questions based on electronic systems until the devices come into such broad use that at least a little understanding of them is considered reasonably necessary as a prerequisite to certification. However, the increasing reliance being placed on the outside accountant as a consultant, not just as an auditor or tax specialist, seems to point toward the C.P.A.'s qualification as an authority on accounting systems. The uniform examinations (in either the Auditing or the Practice sections) probably will begin to include questions of a systems nature, to test candidates' qualification in this area.

RE-EDUCATION FOR EMPLOYEES

Installation of electronic data processing equipment is sure to produce some dislocation among clerical employees unless companies plan wisely. In companies now being converted, employees are being
retrained to perform new or different jobs in the organization. Employees are sent to manufacturers' schools and return to teach company courses to prepare employees for new jobs with the computer. Employees absorbed by other departments have to be re-trained to perform jobs new to them, either in classes or on the job.

Employees whose jobs are not eliminated have a considerable amount of re-learning to do, too. Since an EDPI system reaches into every phase of business operations, personnel from throughout the organization must be taught revised or entirely new procedures. The use of company courses is very wide in large organizations making conversion to electronics. Key employees take part in seminars to familiarize themselves with the requirements of the new system; many employees are sent to conferences at universities and to meetings of professional organizations to acquire general acquaintance with computer techniques.

The most effective method of re-training employees and the method which will probably be used most in well-planned installations, is training within the company through courses taught by the company's own people. Their approach is aimed specifically at the company's particular procedures, in contrast to the sales approach taken by equipment manufacturers' representatives or the generalized approach of the universities. Most companies installing computer systems will set up their own employee re-training program.

Public accounting firms already have been training some of their

staffs in electronic data processing, through special intensive schools which they conduct. In time, practically all large public accounting firms will have such schools, to meet the need for qualified consulting and auditing personnel in the electronic accounting area.
Chapter VI

SUMMARY AND CONCLUSIONS

The immediate mechanics of converting accounting systems to electronics occupy the attention of accountants to the extent that they have little time to consider the future effects of electronic data processing on accounting and accountancy. One way to evaluate the future effects is to analyze what accounting is and does, to examine electronic data processing, and then to try to visualize the effect of electronics on each aspect of accounting and to draw conclusions therefrom.

Accounting in industry encompasses a wide range of information collecting, processing, and reporting services. Accounting is at one time historical, current, and prospective. It is historical in recording and reporting past activities; it is current in the area of control of costs and production; it is prospective in the areas of budgeting, production planning, and finance. The services provided by accounting within the corporate organizational structure include (1) reporting for policy-planning, (2) reporting for operational planning, (3) control of costs and revenues, (4) conservation of assets, and (5) routine assistance in operations. Accounting services
performed outside the firm or performed inside and directed outwardly are (1) external review for internal control, (2) reporting to society, and (3) meeting legal requirements. In performance of these services, accounting is carried out through the logical steps of (1) planning, (2) recording, (3) analysis, and (4) reporting.

Electronic processing of accounting information involves the same clerical steps as do manual or mechanical systems of accounts, including the steps of (1) transportation, (2) manipulation, (3) reference, (4) transcription, and (5) storage. In contrast to earlier systems, all these steps are performed within the electronic mechanism without human intervention.

Electronic data processing systems consist of equipment for the magnetic storage of data, usually on tapes or drums, coupled with an arithmetic unit with a very fast magnetic, electrostatic, or acoustic storage for data and instructions. The system also includes equipment for inserting data and instructions through keyboards, paper tape, magnetic tape, or punched cards, and for output of results through any of the same media. Operations of the system are directed by a control unit which is governed by internally stored instructions. The term "computer system" is used interchangeably with electronic data processor, although technically the latter contains additional semi-permanent storage facilities. A computer is the central unit for control and manipulation. Electronic data processing systems operate with numbers or letters coded and expressed in binary form, with varying number systems. For commercial operations, binary-coded decimal numbers
Reliability of electronic performance has been brought to a high level and is assured through frequent test routines to indicate marginal components to be replaced prior to failure. In some systems duplicate circuits or monitoring devices inspect machine content and locate machine errors for immediate correction.

Computer systems are useful not only in routine clerical tasks, but in extensive mathematical solutions of managerial problems in market analysis, scheduling of men and materials, industrial logistics, and in the new science of operations research.

Evaluation of computer potential in economic terms is difficult. It is likely that the justification of cost saving offered in support of computer acquisition is more rationalization than reason, but that indirect benefits due to improved methods, organization, and scheduling will in the long run pay off more than the initially expected cost savings. Due to the newness of commercial uses, little electronic data processing experience is available upon which to base evaluation of electronic systems.

The effects of electronics on accounting services within the industrial firm are in organizational changes, changes in accounting emphasis, and in the way some services are performed. Much clerical work that has been done throughout the organization can be centered in a data processing center, with control of operations continuing to rest with company functional divisions. The corporate controller,
because of the accounting systems nature of the data processing system, may come to occupy an important place in the business. His division typically might consist of (1) a systems and procedures group, (2) a budget and planning group, (3) a reports group, (4) an audit group, and (5) an operations group. Staff changes involve much retraining and upgrading of retained employees; transfers and natural attrition absorb released clerical employees during the long planning, installation, and conversion period. In few cases are there likely to be serious layoff problems, provided the volume of business activity in the economy remains at a reasonably high level.

Accounting by exception is accentuated; reporting emphasis is on good and variations from normal or expected performance. Until point-of-transaction automatic recording becomes a reality in most firms, the danger of loss of records is not serious as original documents will be available for verification and auditing uses.

The authority of the accountant is derived from his performance as a systems designer and as an objective interpreter of a mass of details. Additional emphasis is placed on the overall record system as contrasted to detailed clerical operations.

The services performed by accounting do not change but include more trend projections under varying conditions, tighter scheduling for materials and labor, more detailed cost records with quicker reporting, and more flexibility in adjusting budgets and schedules to
The complexity of company-wide record systems leads to more reliance for audit and review on the public accounting firm which helped to plan the installation. More reliance in audits is placed on the working of the system and less on detailed review of transactions. Review of cash operations, use of confirmations, and inventory-taking continue as basic audit procedures. Scientific audit sampling and automatic preparation of confirmation requests, inventory lists, and schedules are facilitated by electronic equipment.

Corporate reports to the public now show and probably will show little change arising out of electronics applications, but may be available more quickly through estimating procedures at year-end. Electronic accounting equipment facilitates the assembly of information for tax purposes but has little effect on income tax determination because of the interpretative nature of tax finding. The same conclusion applies to preparation of data for rate-basing arguments before regulatory bodies. Computers are useful in determination of optimum depreciation rates for tax and managerial purposes.

Older accounting organizations are turning their attention toward electronic data processing; new organizations formed either around punched card equipment, systems engineering, or computers, are growing in size and influence. The organizations of auditors and accounting teachers are not as far along in the study of electronic accounting as are associations of executives and industrial accountants. The universities are beginning to enter the field and will be
very active in education for electronic accounting within a few years.

There is a considerable amount of literature available on electronics in business but it is largely descriptive and much of it is designed for popular consumption and filled with glowing expectations rather than fact. Until early 1956, books aimed specifically at business applications had not appeared; by 1958, however, a number of basic college textbooks should be available.

Preparation for accountancy under electronics need not vary substantially from present curricula but requires subsequent courses, probably at the graduate level. Technical education cannot be substituted for fundamentals. The early education of accountants should include mathematical logic and graduate programs for electronic accounting specialists should include some understanding of mathematical techniques for the solution of business problems and operations research methods. Prospective accountants should be trained in understanding people, for their work involves contact with the entire business organisation. Their training should include practice in flow charting of processes and accounting systems.

Although mathematicians and engineers have an excellent background for conversion to data processing accountants, probably few of them will turn to accounting because of (1) the shortage of physical scientists, (2) their disinterest in business procedures and (3) their orientation toward ideas rather than toward people.

Organisations employing electronic accounting should be responsible
for the technical retraining of their employees, and most large
firms do carry on their own training programs for electronic appli-
cations. The universities' responsibility (beyond basic accounting
education) is to educate those people who by personal interest or
vocational necessity must become familiar with business electronics
but who do not have access to industry's training programs. The
large public accounting firms have their own programs for staff
members to train as electronic business system consultants and
auditors, but smaller firms must obtain their electronics training
from educational institutions.
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VI: A

Gardner Monroe Jones, the son of Robert G. and Altha H. Jones, was born at Hesperia, Michigan, on December 1, 1913. He graduated from Hesperia High School in 1935 and attended Howell's School of Business in Muskegon, Michigan from 1938 to 1940. He was employed by Wisconsin-Michigan Steamship Company and Continental Motors Corporation until 1942, when he entered the United States Army. Upon his release in 1945, he entered the University of Michigan, where he received the B. B. A. degree in 1949 and the M. B. A. degree in 1950. From 1950 to 1956 he taught Accounting and related courses at Louisiana State University. His wife is the former Pauline Stenby of Michigan. They have four children and live in Baton Rouge, Louisiana.
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Candidate: Gardner Monroe Jones

Major Field: Accounting

Title of Thesis: Electronics in Business: Effects on Accounting

Approved:

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Dean of the Graduate School

EXAMINING COMMITTEE:

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Date of Examination: June 1, 1956