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THE APPLICATION OF LARGE SCALE ELECTRONIC DIGITAL COMPUTERS TO ACCOUNTING PROBLEMS

BY

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PREFACE

This is the first of a series of reports on the use of electronic computers for accounting that will be issued by Project M828. The overall aim of the project is logical research in the design of accounting systems. The present report will outline the general approach to be followed while subsequent reports will give the results of detailed researches.

I wish to acknowledge the benefit I have received from many helpful discussions of the material in this report with Raymond Bower, Raymond Abele, and Milton Mengel of the Burroughs Adding Machine Company, and Don Warren and Jessie Wright of this project. Mr. Mengel has been especially helpful in connection with Section 3. Of course, neither he nor the others are responsible for any of the assertions in the report.

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1. INTRODUCTION

1.1 Definition of "economic system".

The present study is based on a somewhat different concept of economic system than is usually employed, and hence we will begin by defining this concept: An economic system consists of (1) units of processing, distribution, and comsumption, coupled by (2) lines of transportation, all under the control of (3) units of accounting connected to each other and to the other elements of the system by (4) lines of communication.

This definition may be illustrated by considering a very simple article of consumption, e.g., a hammer. From the synoptic point of view the units of processing involved are mines, lumber camps, smelters, and hammer factories; the units of distribution are lumber yards and hardware wholesalers and retailers; the units of consumption are carpenters and householders. The lines of transportation are railroads, truck and steamship lines, and the streets on which the consumer walks to purchase the hammer. The accounting units are bookkeeping offices, tax offices, banks, and the minds of the consumers. And finally, communication is accomplished by telephone, mail, word of mouth, and the passage of money from hand to hand.

The definition just given and illustrated may sound so obvious as to be out of place in such a report as this. Nevertheless, it seems to us that it contains a point of view useful to the designer of accounting machinery. Perhaps the following supplementary remarks will make this clear.

First: The elements of an economic system may themselves be economic systems (similarly for accounting systems — see the next paragraph). Thus a factory is compounded out of units of processing (assembly lines, shops) and distribution (storage areas, warehouses), means of transportation (trucks, carts, aisles), and interrelated accounting units (shop offices, time clocks) connected by communication lines. Again, an assembly line consists of processing units (workers with tools) connected by transportation lines (conveyor belts) and controlled by accounting units (the people who regulate the speed of the line and make sure of a regular flow of materials).

Second: The elements (3) and (4) of an economic system constitute an accounting system. An accounting system, of course, is an integral part of some economic system. Its function is to receive information about the activities of the elements (1) and (2), transform this information, and then employ the result to direct the operations of (1) and (2). For example, a bookkeeping office compares the present rate of production of an item with current and expected demand and uses the result to regulate the speed of production. This phenomenon is the economic species of a well-known engineering process: that of feedback. In engineering terminology, the information coming from the assembly line is "fed back" (after combination with other information) to control the assembly line.

Third: The operation of an accounting system is similar to that of an economic system in a basic respect. For the function of an accounting system is to move (transmit) information from place to place and to process it, while the function of an economic system is to move (transport) <u>materials</u> from place to place and to process them. The situation is not completely parallel here in that the accounting system exists to serve the economic system and not vice-versa, so that the handling of information is not an end in itself but a means to the handling of materials. Nevertheless, the handling of information is such an important means to this end that it generates its own problems: problems of banking, interest, insurance, etc.

<u>Fourth</u>: Accounting computation and communication is not limited to what is traditionally called bookkeeping. Bookkeeping does involve the movement and transformation of information, but it is not the only kind of computational-communicative activity involved in accounting. Statistical studies and surveys of customer preferences are examples of somewhat different kinds of accounting activities.

<u>Fifth</u>: The operation of an economic system is a dynamic process in which speed is important. It follows that speed of operation is important in accounting. This consideration is reflected in the organization of an accounting system. Thus if an economic system (e.g., a manufacturing concern) is compounded out of other economic systems (e.g., branches), the speed factor may dictate a correlative organization of the accounting system (e.g., branch offices as well as a central office).

<u>Sixth</u>: Because of the great economic values symbolized by accounting information it is imperative that communication and computation in accounting be extremely accurate. From the point of view of the system designer this means that reliable checks must be kept on all the elements of the accounting system (human operators, machines). An attempt must be made to minimize errors and techniques must be devised for discovering and correcting those that do occur. Also, auditing and legal procedures must be incorporated into the accounting system.

Seventh: It is important to note the extreme generality of the concept of an economic system as we shall employ it. This is manifest in the inclusion of the consumer as an accounting unit (even though he may keep no written records of his economic activities) and the spoken word as a method of communication. Again, currency is regarded as a medium of communication and record keeping (it need hardly be pointed out that currency has mainly symbolic value). These elements are included because they come within the scope of the general definition, and because any complete attack on the problem of designing accounting systems must take them into consideration.

1.2 Aim of this investigation.

There are two phases to the design of an accounting system. The first consists in deciding what information is to be handled and what transformations are to be made on that information. That is, it must first be decided what questions are to be asked of the accounting system and what answers are required (from employee paychecks to the financial statements of the enterprise), on what original data the answers are to be based, and in what form they are to appear. This first phase of the design involves consideration of theoretical questions concerning how given items are to be treated (e.g., whether treasury stock is to be shown as an asset on the balance sheet, whether inventories are to be evaluated by a "weighted-average" method or some other method, etc.), and is what is traditionally regarded as accounting.

The second phase of the design of an accounting system is the planning of an installation of equipment and its use. This phase has traditionally been assigned a minor role, but recent developments in the field of accounting machines have steadily increased its importance, and this trend is certain to continue. At any rate, it is with this phase of design and not the first that we are concerned. The aim of our project is to study how large-scale electronic digital computer techniques may be employed for this purpose. The present report will outline the basic approach to be followed, and subsequent reports will investigate the problem in detail.

There are a number of alternative approaches to be considered. On the one hand, we could study how existing electronic computer techniques could be used to improve present accounting machines. This attack does not seem promising because it involves tying an intrinsically fast electronic technique to a considerably slower mechanical and human one. At the other extreme, we could investigate how presently projected electronic digital computers could be employed without modification to do accounting. We also reject this approach, because these machines have been designed to solve problems (scientific problems) which differ in a significant respect from accounting problems: namely, in their <u>communication-to-computation</u> ratio. The communication-to-computation ratio of a problem is the ratio of the quantity of information which is communicated to and from the computer to the amount of computation that is done on that information in solving the problem.* There is much less computation to do for each piece of data in an accounting problem than in a scientific problem, and hence a redesign of the equipment seems desirable.

Thus we are led to an approach lying between these two limits: that of making certain modifications in presently conceived electronic computers and supplementing them with auxiliary equipment specially designed for accounting

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* Though this is a very vague definition, it is satisfactory for our purposes. Indeed, it would be no simple matter to frame it precisely, for though a unit of communication exists (the bit, or binary digit) no precise unit of computation has yet been defined. But whatever the precise definition may be, it is clear that accounting and scientific problems differ in the respect mentioned.

systems. In the present report we will sketch a battery of machines which will answer this requirement and will show in a general way how they would be used.

One last point needs to be made before our problem is fully delineated. It is that this study will be a theoretical rather than a practical one (despite the intended practical utility of the results). As a consequence our analyses will not be limited by the practical requirements of existing equipment, practices, or laws. Thus in proposing a system of bank accounting (section 3.2) we ignore present laws. Again, the equipment installation described in section 3.1 would be too costly to be owned by small businesses, and hence they could make use of it only through centralized accounting agencies. To repeat: the actual adoption of the system herein proposed would require substantial changes in existing practices and laws. We ignore these consequences in our design, not because they are unimportant but because we believe that their consideration belongs to the developmental stage rather than to the research stage of an investigation.

2. PROPOSED ACCOUNTING EQUIPMENT

2.1 Media of communication.

It has already been made clear that the function of an accounting system is to transmit and transform information. Now for information to be either communicated or processed it must be expressed in some language, and that language recorded on some medium. We shall refer to this as the <u>medium of communication</u> and shall conceive it very broadly. Thus the air is the medium for communicating the spoken word, free space the medium for communicating radio messages, paper the basic medium employed in present-day accounting machines, and magnetic tape a medium for communicating from the outside world to the inside of an electronic computing machine.

The term "media of communication" even covers media whose function is exclusively storage: e.g., mercury delay lines and electrostatic tubes (which are used in electronic computers exclusively for internal storage) in contrast to magnetic tape (which is used for input-output as well as for machine-controlled storage). For if we conceive of communication as the transmission of information from one spatiotemporal location to another then storage is a species of communication, characterized by the fact that the spatial location of transmission is the same as that of reception, and by the relatively long and indefinite temporal period for which information can be stored.

In this subsection we will discuss the storage media to be employed in our accounting system. We begin with the media which are directly sensed by the electronic computer: the internal memory (consisting of mercury delay lines, electrostatic storage tubes, or perhaps magnetic drums) and the input-output medium (consisting of magnetic tape or wire, or perhaps paper tape). The choice of the particular media to be used in a computer is a complicated one, and one lying beyond the province of this project. Nevertheless, it is important that we plan our accounting system in terms of some choice so that our design work can be concrete in character. This does not mean that our results will be limited by the particular choice made, for they can easily be adapted to other types of computers. Accordingly, we will think in terms of electrostatic storage tubes for the internal memory and parallel-channel magnetic tape for the input-output medium. Efficient use of these media implies that the computer be a parallel one* in order that its communication and computation speeds for accounting problems will be comparable.

* I.e., one in which all digits of a number are handled simultaneously, in contrast to a series computer, in which the digits of a number are handled sequentially.

A parallel electronic computer employing magnetic tape and electrostatic storage has very high computation and communication speeds. On the basis of present designs we can estimate its addition time to be of the order of 50 microseconds (for twelve decimal digit numbers), its multiplication time of the order of 500 microseconds, and its input-output speed of the order of 1,000 twelve-digit numbers per second. To make use of these speeds we must supply it with information at a high rate. Now under present methods of accounting this information originates on such media as typewritten or handwritten pages. It is clear that a procedure is needed for transferring the information from such media to the machine media (magnetic tape) which will satisfy the speed requirement of the computer.

Let us look at the procedure employed in preparing problems for present electronic computers. As in accounting problems, the data originates on handwritten or typewritten sheets. It is transcribed onto magnetic tape by a typist. It should be noted, however, that this transcription involves more than the transfer of data from one medium to another. For before the raw data can be typed onto the magnetic tape it must be transformed in certain respects. Thus all numbers must be changed to a given range and all words made the same length. Similar transformations must be made on accounting data before it can be handled by the electronic computer. But while the method just described is satisfactory for scientific work, where the communication-to-computation ratio is low, it would not be satisfactory for accounting problems, because this ratio is high. Hence we must look for another -- and more automatic -- method.

It will be convenient to have a term for the storage media generally employed in accounting: typewritten or handwritten pages, government printed money, etc. Since these media are not under the control of the system designer we shall call them uncontrolled media. (Punched cards are clearly excluded from this category.) Now uncontrolled media have been designed primarily for human sensing. Thus they are inherently low-speed (relative to electronic speeds), for they must be inscribed and read by humans, and while they are readily sensed by humans it is very difficult to build a machine which will sense them reliably. In other words, these media are well-designed for accounting systems in which Homo sapiens is the computer, either alone or supplemented by keyboard machines.

It is obvious that the purpose of our proposed equipment is to displace the human as a computer, so it might seem that we could forget uncontrolled media. Such is not the case, however, for though the proposed equipment will largely displace human elements by machine elements, we must accept the fact that humans are the ultimate consumers and managers of an economic system, and hence must play an essential role in any accounting system. Thus an individual will still have his checkbook and his pocketbook and will still be a source and sink of information in the economic system, and account must be taken of this fact.

These considerations suggest that we need a new medium of communication which will share the characteristics of uncontrolled media (easily sensed by humans but not by the machine) and the adopted machine media (easily sensed by the machine but not by humans). We shall call this medium the coded page.* It is a paper page of any of various sizes inscribed in two parallel languages, one easily sensed by a human (called the conventional language and

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* The concept of the coded page comes from the research laboratories of the Burroughs Adding Machine Company. The name is borrowed from Adolph Matz and C. N. Weygandt, Jr., A Proposed Adaptation of Electronic Digital Computers to Machines for Accounting Processes, University of Pennsylvania, 1948, who used it in a quite different sense.

consisting of ordinary typed characters) and one easily sensed by a machine (called the coded language and consisting of special typed marks or magnetic marks).

2.2 Accounting machines.

Having chosen the storage media of our accounting system we can decide what machines are required. First, we need a machine which will prepare the coded page. Now when the coded page originates as an input medium the information on it comes from an uncontrolled medium or the mind of some person. In either case the translation of data is mediated by a human. Since the human operator is inherently slow an inexpensive piece of equipment is required. We suggest a coding typewriter, which is like a conventional typewriter except that stroking a key produces a character of the coded language as well as of the conventional language.

Because of the high speed with which the electronic computer can receive information from a magnetic tape it is not efficient for it to sense the slow-moving coded page directly. For this purpose we propose an automatic senser which will transfer the information character by character from the coded page to the magnetic tape. The automatic senser would scan a coded page line by line magnetically or photoelectrically, convert each character into electrical pulses, and use these pulses to magnetize the tape. To save scanning time a pre-scanner would simultaneously scan the next lines to ascertain whether they are blank and hence can be skipped.

The route of information is thus from human to coded page to magnetic tape to internal memory. After the computer has appropriately transformed the information the reverse route is followed. For this purpose a printer is needed to transfer the information from the magnetic tape to the coded page. This printer could consist of a mechanism which printed a line at a time, or of several automatic typewriters working from the same tape.

We have finally to discuss the electronic computer. Since it is specially designed for accounting work we will call it the electronic accounter. It need not, however, differ in any fundamental respect from the ordinary scientific electronic digital computer. Since accounting problems have a higher communication-to-computation ratio than scientific problems, a correspondingly higher input-output speed and capacity are needed. The speed is attained by using parallel channel magnetic tape (instead of wire), and the capacity by having a large number of tape feeds (e.g. ten) under the automatic control of the electronic accounter.* Moreover, since in accounting problems the emphasis is more on logical operations (sorting, matching, etc.) and less on arithmetic operations (addition, multiplication, etc.) than in scientific problems, the commands (code instructions) for the accounter may be somewhat different from those of a scientific computer. Only one further modification need be made to adapt the computer to accounting work, but in order to explain this we must first discuss the languages with which the various storage media are inscribed.

These languages are four in number: the conventional language, the coded language, the tape language and the internal language. All of these languages must accommodate alphabetical as well as numerical information, and also the instructions (sequences of commands) for the electronic accounter. The conventional language will contain most of the symbols usually put on a typewriter, and in addition special symbols for accounting purposes. Since its alphabet will be very close to the usual one no particular training will be required for using it or the coding typewriter.

In order that the coding typewriter be simple the coded language must have a character corresponding to each character of the conventional language, and the translation from one language to the other must be a

* It does not seem necessary to make the accounter capable of sensing or inscribing more than one tape at a time, however.

transliteration or character-by-character translation (in contrast to such a translation as that from German to English which is word by word or phrase by phrase). A similar requirement obtains for the automatic senser. Hence the structure or syntax of the conventional, coded, and tape languages will all be the same, and they will differ only in the characters chosen for the alphabet (e.g., "f" is represented in the conventional language as shown, but in the coded and tape language by a six-binary-digit aggregate).

Though the design of these languages is just beginning (it constitutes one of the main research problems of the project) it is fairly clear that the internal language will be somewhat different in structure and syntax from the others. For example, words in the conventional language will be their normal length, while words in the internal language should be all of the same length for ease of switching and computation. Now the electronic accounter should be designed so that it can sense and write the tape language, and so that it can make the translation from this language to the internal language. In this respect it will differ from presently conceived computers, which employ only one language, so that the operator must translate all information into this language (e.g., make all words of equal length) before the machine can understand it.

3. APPLICATIONS

3.1 An accounts receivable installation.

In this subsection we will sketch the design of a machine installation for the accounts receivable (and associated) bookkeeping of a mythical manufacturing concern.

We imagine a company whose products are distributed by twenty distinct branches, each with its own warehouse. Each branch has 10 salesmen, 2,000 customers (because of overlap the company has a total of only 32,000 customers), and receives 10,000 orders per month (or 500 per day -- assuming 20 working days per month), each order containing an average of 2.5 items. One half of the branches have inventories of 200 items, and the other half inventories of 1500 items; the complete inventory of the company consists of 2000 items.

The problem is this: to design a machine installation which will make the following transformations of information: given the orders and credit data, to prepare invoices and monthly statements. It is clear from a preliminary consideration of the problem that certain other accounting activities are so intimately associated with these that they should be incorporated into the problem: keeping the inventory and preparing sales statistics. Of these two we shall discuss only the first here, since it will be clear from our solution of the remainder of the problem how sales statistics could be handled.

Since the orders originate in the branches they should be typed on coded pages there. The remainder of the operations can best be handled by a central accounting unit which has a complete battery of the machines described in section 2. Thus the orders will be sent immediately to this unit (the branches retaining copies for reference) where the information will be transferred to magnetic tapes by the automatic senser. The central accounting unit will receive the payments and inventory information and will transfer it -- wherever necessary -- to coded pages. (If the machinery we are discussing is widely used much of this information will come in on coded pages.)

Thus the central accounting unit would prepare each day the following (magnetic) <u>input tapes</u>: (1) orders, (2) credit data, and (3) inventory data. These, together with the tapes containing the machine instructions (sequences of commands), would be the media from which the electronic accounter would receive its information. In turn, it would produce these output tapes: (1) invoices, (2) statements, and (3) inventory reports. These would go to the printer which would prepare coded pages for distribution.

It is of interest to discuss in more detail the operation of the electronic accounter in processing this information.* In order to do this we must be more specific concerning the amount of information processed, for since the electronic accounter has a limited internal memory (e.g., 4000 twelve-decimal-digit or forty-eight-binary-digit words) the method for best handling information depends on the amount of information relative to this internal capacity. It is convenient to measure information in terms of magnetic tape capacity as well as in terms of alphabetic (including digital) characters. For this purpose we assume a tape six channels wide (with perhaps an extra channel for markers) so that an alphabetic character can be represented by a row of magnetized areas across the tape. We assume further than 500 such characters may be stored per foot. Note that an internal memory of 4000 forty-eight-binary-digit words holds 32,000 characters, or the information on 64 feet of tape.

We can now estimate the information on the six input and output tapes involved in the problem. Assuming each order to contain 200 characters, there will be a total of 4000 feet of order tape for the company per day. The credit data tape will be much shorter -- say 500 feet --

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* A completely detailed discussion must await the preparation of the machine instructions (sequences of commands) for the problem, and will appear in later reports.

and the inventory data tape even shorter (since it includes only changes in the inventory: changes in stocks or prices, new forecasts, etc.) -- say 100 feet. If each invoice contains about 10% more information than the corresponding order, the invoice tape will be about 4500 feet long each day. A monthly statement will mention an average of 6-1/4 new invoices in addition to credit data and data from the previous month. Assuming that only the date of the invoice, the branch from which ordered, and the price are given (not a detailed list of the items), 300 characters seems a reasonable estimate for the length of average statement. If the statements are prepared on a cycle basis, 1,600 statements will be produced per day, and this will require approximately 1,000 feet of tape. The daily inventory report will be short, since it covers only significant changes in the inventory (e.g., items whose stock has fallen below a specified minimum) -- an allowance of 100 feet of tape per day will be ample for it.

As is generally the case in accounting, the computation is simplified by using certain reservoirs of information intermediate between the input and output tapes: namely, ledger tapes. These are (1) the inventory tape, arranged by branches, and (2) the customer ledger tape, arranged alphabetically. The inventory tape contains, in addition to the name of each item, such information as the price, the balance at the beginning of the period, the current balance, and certain maxima and minima (when these limits are exceeded the electronic accounter is to record this fact on the daily inventory report). Assuming a total of 70 characters per item, a 200 item inventory requires 25 feet of tape, a 1500 item inventory 175 feet, and hence the inventory tape is about 2000 feet long.

To estimate the length of the customer ledger tape we proceed as follows. At the beginning of its billing period a given ledger contains the name and address of the customer plus certain information carried over from the last period. At the end of the billing period it contains all this information plus the new order and credit data for the period. Estimating 200 characters for the former information and 600 characters for the latter,* we obtain an average of 400 characters per account and hence the 32,000 accounts require approximately 25,000 feet of tape.

It would be instructive if we could form some time estimates for the daily procedures of the accounter. In the light of contemporary engineering developments it seems reasonable to expect that the tape could be read (or inscribed) by the accounter at the rate of 20 feet per second.** Estimates can likewise be made for the time requirements of the elementary computations (addition, multiplication, etc.), but until we have programmed instructions for the complete computational processes (sorting, pricing, etc.)*** we cannot estimate the total computation times. In the meantime it seems worthwhile to make an order-of-magnitude guess at what these will be for our problem. This we will do by estimating the total computation time to be the same as the total communication time**** (cf. paragraph 2 of Section 2.1). It should be emphasized that we are merely guessing.

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* Note that this last figure is twice the quantity of information on the customer's statement. This is because the ledger should contain more detailed information about the orders than the statement, both for reference purposes and for gathering statistics. This information need not be carried over from month to month, however, provided that the old ledgers are kept on file. Consider, for example, a purchase made in one billing period and paid for in the next. All the information on the invoice should be added to the ledger at the time the purchase is made, but only an identification of the invoice and the value need be carried over to the new ledger at the end of the billing period.

** We assume that the accounter can sense or inscribe only one tape at a time; see footnote, page 11.

*** This will be done in subsequent reports.

****Not included is the time required for special checks to guarantee reliability or for maintaining the equipment.

We can now discuss the daily accounting procedures to be followed. There are five of these, as follows.

(I) Bringing the inventory up-to-date.

Input tapes: inventory data (100') and inventory ledger (2000').

Output tapes: inventory report (100') and revised inventory ledger (2000').

If the inventory data is properly arranged by branches it can be combined with the inventory ledger information in a straightforward fashion. A portion of the information on the data tape and a corresponding portion of the information on the inventory ledger will be communicated to the internal memory, combined to produce the corresponding portions of the inventory report and the revised inventory ledger, and then communicated to the output tapes. This process is repeated until the computation is complete. The total tape communicated to and from the machine is thus about 4200 feet* and the communication time approximately 4 minutes. Hence we estimate the total time (communication and computation) at 8 minutes.

(II) Preparing the invoices.

Input tapes: inventory ledger (2000') and order tape (4000').

Output tapes: revised inventory ledger (2000') and invoice tape (4500').

The procedure here is to take an order, look in the inventory for the items listed, find the price of each item in the inventory and extend it, register the changes in the inventory due to the withdrawal of the given items, and total the charges on the invoice, computing discounts, etc. Since not all of the inventory information is used in this problem the accounter would select a certain portion of it from the inventory ledger tape (name of article, price, and withdrawals during the month) and store it internally for use

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* The tape which holds the instructions (sequences of commands) is of negligible length.

in pricing the orders; after the items listed in that part of the inventory are priced, the new information as to withdrawals would be combined with the information on the inventory ledger to produce the revised inventory ledger. Even with this method of selection, however, it is impossible to store in the internal memory all the inventory information for a branch which has a 1500-item inventory. When the invoices for these branches are being prepared, only a fraction of the inventory (e.g., one-third) would be stored internally at one time and the order tape information then passed through the machine to produce a partially priced order tape (e.g., items in the first third of the inventory would be priced on the first such run, those in the last two-thirds unpriced). This process would then be repeated until all items on the orders for that branch were priced. The total tape communicated to and from the machine would thus be 23,000 feet, and the total time about 40 minutes.

(III) Alphabetically ordering invoices and payments.

Input tapes: credit data (500') and invoice tape (4500').

Output tape: ordered customer items: credit data, invoices (5000')

The credit data and invoice information can most easily be entered into the customer ledger if it is alphabetized by customer. This is done by a process known as <u>repeated meshing</u>. Each pair of items is examined in turn and arranged into an alphabetically ordered sequence of two terms. These sequences are then meshed into alphabetically ordered sequences of four terms. This process is repeated until it results in a single alphabetically ordered sequence containing all the items. Here again, it is impossible for the entire process to be carried out internally. Rather, blocks of information (e.g., that on 10 feet of tape) will be placed in the internal memory, ordered, and then temporarily stored on another tape. Then this tape is passed into the machine, and a new intermediate tape produced which has ordered blocks of information 20 feet long. This communication-computation process is repeated until a single sequence of alphabetized items results; a total of 10 runs is thus required. Hence a total of 100,000 feet of tape will be communicated to and from the accounter, and the total time will be approximately 2 hours, 40 minutes.

(IV) Posting the customer ledger.

Input tapes: ordered customer items (5000') and customer ledger (25,000').

Output tape: customer ledger* (30,000').

The process of posting the ledger is now simple. The ordered customer items and the customer ledger are passed through the accounter which combines them to produce a posted customer ledger. The total time will be about 1 hour, 40 minutes.

(V) Preparing the statements.

Input tape: part of the customer ledger (2000').

Output tapes: statement tape (1000') and new customer ledger tape (650').**

This process is likewise simple. Since we are preparing statements on the cycle basis, the ledger for only one-twentieth of the customers is put into the accounter.*** This information is transferred to the internal memory in blocks, portions of it are selected for the statements and the new ledger, and these are communicated to the output tapes. The old ledger tape would be kept on file for future reference. The total time taken is 6 minutes.

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* We neglect the fact that the output tape will be somewhat shorter than the combined input tapes because the customer addresses are on each.

** The new ledger tape is one-third as long as the old in accordance with the estimate made on page 16.

***This can conveniently be done since the tape reels will hold on the order of 1000 feet of tape.

This completes our description of the five computational-communication procedures needed. We note in conclusion that about 5-1/4 hours of electronic accounter operation is required daily. This includes no time allotment for special checks, for computing sales statistics, or for maintenance. A rough calculation indicates that two electronic accounters and their associated equipment working a 40 hour week, would be sufficient to do all the accounts receivable bookkeeping of this hypothetical company.

3.2 Bank accounting.

In this subsection we will indicate how the electronic accounter and its associated equipment can be used to do bank accounting.

The banking system of this country constitutes a single accounting system inasmuch as information originating in any one bank may move to any other bank (e.g., the information on a check). This accounting system uses chiefly uncontrolled media (cf. section 2.1): handwritten and typewritten checks, deposit slips, etc. Information is distributed from one place to another by physically moving these pieces of paper; thus checks are sorted in proof machines and transmitted by mail or carrier to different banks, clearing houses, and bookkeepers.

It is clear that to use the electronic accounter efficiently for bank accounting we must largely replace these uncontrolled media by the coded page and the magnetic tape. This can be done as follows. The information arriving at a bank on uncontrolled media would be immediately transferred to the coded page by means of the coding typewriter. (If the electronic accounter came into general use much of the information would be received in the form of coded pages, so that this transcription is not as large a task as it might otherwise seem.) This information would then be transferred to magnetic tapes by means of automatic sensers before any significant accounting computation is done on it.

When the information is on magnetic tapes it can be sorted, posted to accounts, etc., by the techniques described in section 3.1. Statements can be prepared and printed, also as in 3.1. Information can be communicated from bank to bank by transporting the magnetic tapes or by means of teletypewriter equipment which can sense coded pages or magnetic tapes. There are two significant respects in which this method of bank accounting would differ from the present methods. In the first place, the account holder would not receive his original checks along with his bank statement as he does now. He would, however, receive the information on these original checks along with a description of the receiving banks which hold them on file, so he could obtain any of these checks that he wished to see. Secondly, because of the large speed and capacity of the electronic accounter, bank accounting would be much more centralized than it is now. This is, of course, a natural outcome of the use of the equipment we have been proposing.