Elements of Financial Accounting

There are four essential elements in financial or dollar accounting. One of these elements is represented by the document of authorization. Another is a set of records for legal purposes. A third is a set of records for analysis, and a fourth is a set of records for control.

In any accounting system for management of money, documents of authorization are essential and these documents, bearing the signature of the authorizing agent, must be preserved for legal purposes and for control of the system. The set of records required for legal purposes must be available to settle questions of equity, since ownership of various portions of the money being handled must be clear at all times. The records for analysis must show the amount of money that is available at any time. They must also show the dollar amounts which are tied up by the processing method and which, hence, are not available for other uses. The records for control are needed for control of accuracy of the accounting procedure and as a basis for management decisions concerning funds.

This discussion will concentrate on bank accounting for commercial checks. It will not stress general principles, however the problems, conditions, and solutions for commercial check accounting do apply to many dollar accounting problems. Commercial check accounting involves all of the above elements of financial accounting systems, and it has been the subject of a five-year study by Stanford Research Institute for the Bank of America—a study that has resulted in an integrated system to handle commercial check accounting.

This discussion will attempt to point out the principal factors which affect design of a system to handle commercial checking, to show the consequences of these factors, and to describe, briefly, a system developed under their influence.

Before proceeding with a description of the problems, let us first examine the operations that take place in the handling of commercial checks.

Work Flow in National Banking

The actual work flow within the national banking system is very complex. It would be quite simple, although quite pointless, if each customer who wrote a check presented that check only at the window of the bank at which his account is held. This is far from the case. As a national average, only one out of five checks drawn on a given bank is charged immediately to an account in that bank. The other four must be returned through the national network of other banks.

To go into details of all possible means by which checks and deposit slips travel from bank to bank, would be an impossible task for this brief paper. However, certain concepts are important, and simplified diagrams can be used to establish these concepts. It is useful to define "clearing items," "transit items," "go-backs," "float," and the so-called "on us" items. It is also illuminating to note the volume of work and the pressure of time involved in the banking system.

Fig. 1 illustrates a clearing arrangement. This figure is very simplified and shows flow in only one direction, i.e., from Bank A to Banks B and C. In looking at this figure, bear in mind that two other flow arrangements should be superimposed upon it, i.e., from Bank B to Banks A and C, and from Bank C to Banks A and B.

The problem is this: Each bank receives over the teller's window, or through the mail, a mixture of items belonging to its own accounts and items belonging to other banks. These must be sorted out and exchanged. This commonly takes place through a clearing house which is financially supported by all the banks involved. These competitive banks agree to exchange items at a specified hour each day and each of them keeps a record of exchange in its so-called general ledger accounts. Bear in mind that clearing arrangements deal with banks located in the same geographical area. Also note the "on us" items which are charged to accounts in Bank A. This represents a great volume of work.

Fig. 2 illustrates some of the ways in which the same problem is handled when the banks are in different geographical areas. Three areas are shown, each having a group of banks with local clearing arrangements and
showing the flow of transit items, i.e., those which are presented at one bank but belong in another. In this case, many combinations are possible and Fig. 2 shows only three kinds of situations. In Area 1 is shown one bank of a system composed of many banks or branches controlled by a head office. Area 2 shows a single large bank with no other branches but with clearing arrangements with local competitors. Area 3 indicates two smaller banks, each with its own clearing agreements, but for which the Federal Reserve Bank performs the function, in some respects, of a head office. Again this figure shows flow in only one direction and there is actually flow in all directions. This is a very simplified picture—in actual practice there are many more arrangements.

Perhaps these comments on clearing and transit give a hint of the complex network which exists. Now add to this the figures on volume of work handled in the system. In 1939, approximately 3½ billion checks were written. During 1952, this rose to 8 billion and—if the trend continues—1960 will see 14 billion, and 1970, 22 billion checks written. Everybody hastens to point out that this trend may not continue at such a pace but no one argues with the fact that the volume is growing. Another factor of extreme importance has emerged from national studies. Each check is handled an average of 6 to 8 times during its progress through the banking system. By “handled” is meant the actual entry of the dollar amount of the check through a keyboard.

To the complexity of the work flow and the volume of data handled, one must add a time element. During the process of all this exchanging of checks, a certain number of “go-backs” occur. These are checks which cause overdraft or are drawn against uncollected funds, checks which are postdated, have stop payments against them or have irregular signatures, and checks which are missorted. These “go-backs” must be detected rapidly by the receiver and returned to the sending bank. The amount of time which can elapse before “go-backs” can be refused by the transmitting bank is rigidly fixed by agreements between banks and varies, depending upon geographical area, between approximately 3 hours and 48 hours.

The concept of “float” is also important. Brief mention was made, in the opening sentences of this discussion, to funds which were “tied-up” by the processing method: As an example, suppose Mr. Smith deposits in his bank in Boston, a check for $1,000 given to him by a man who has an account in San Francisco. Then suppose Mr. Smith immediately writes checks which use up half of that $1,000 deposit. If it takes three days for the Boston bank to collect from San Francisco, the Boston bank has loaned Mr. Smith $500 for those three days. There are many more ways in which “float” can occur, but this should illustrate the idea.

From all this emerges a very complicated system problem. A large number of individual pieces of paper travel through a very complex network. The present manual system demands handling them over and over again, each time incurring the possibility of human error, and a rigid time limit surrounds the entire operation. Out of this system, two distinct but closely related problems emerge. One is the transit operation. The other is the problem of keeping track of the “on us” items, i.e., the bookkeeping on the accounts held within each bank.

The five-year program which the Institute carried out for the Bank of America dealt with the bookkeeping and clearing for its branch banks. This was chosen because it is a large volume job, it is one of extreme importance, it needs speeding up to reduce float, and it primarily affects internal procedures. The transit problem immediately involves other banks, their procedures, and their standards. Out of this five-year program, techniques have evolved for the bookkeeping and check handling work and extensions in techniques are being developed which are applicable to the transit problem.

**Factors Affecting System**

Now, let's look at some of the main factors in this job and consider them from the standpoint of how they affect system design. A few of these factors seem unique to the banking business, but counterparts can be found in most applications which involve dollar accounting. Among those which are most important are the following: the need for economy, the volume and nature of the source documents, the high degree of accuracy required, the fact that system changes must be evolutionary, not revolutionary, and the nature of the filing problem required to keep track of the information.

Net economy is essential, of course, and this must include all factors—operating cost, equipment amortization, and the effect of the national tax structure. As of this time the computer industry must face fairly short equipment write-off periods, since the average user cannot help looking upon the venture as experimental, and because he has a fear of obsolescence. Hence equipment write-off is, today, a big factor.
The need for economy has one important influence on the handling of commercial checks. It dictates centralizing a large number of accounts within a given machine and, hence, implies central bookkeeping. This is largely because control circuits required to handle all operations represent an investment so great that it is necessary to spread this investment by handling a maximum number of accounts, thus decreasing the cost per account.

The time schedule is very rigid. Even though the volume of work may vary a great deal from day to day, it is difficult in bank accounting to carry over part of one day's work into the next in order to reduce the peak load and hence reduce the maximum rate at which the system must assimilate and process data. As mentioned previously, this rigid time schedule arises because of the clearing arrangements and the treatment of "go-backs." However, another important point affecting the time schedule arises from the fact that it is necessary to "prove" the day's work to find errors just as soon as possible after the receipt of the last item for the day. Furthermore, it is not practical to hold an entire day's work, then to process it at high speed after the last item has been received, since this would greatly increase system cost and complexity. Hence, it is necessary during the day to do all the work possible so that when the last item is received, most of the actual posting to individual accounts and altering of current balances is finished so that the system can proceed directly with a recapitulation and balancing.

This combination of time schedule and large volume of information forces one to consider simultaneous operation of the input, sorting, posting, and printing functions.

It is also necessary to have means for a rapid diagnosis and correction of errors so that the entire system can be balanced quickly at the end of the day. The tight time schedule obviously calls for minimization of down-time. Therefore, careful attention must be given to maintenance procedures.

The third principal factor affecting system design, i.e., the volume and nature of the documents, raises some very difficult problems.

The large number of checks and deposit slips which must be handled demand high speed processing and transcription. While it is possible to read the information from these documents when they are returned to the bank so that this information can be processed, it is still necessary to sort, examine, and file the checks and return them to the customer. Therefore, any system designed to deal with the commercial checking account business cannot ignore the paper-handling and transcription problems. Furthermore, during the multiple handling of each of the items, they become mangled, torn, folded, punched full of holes, stamped with endorsements, and scribbled upon with pen and pencil. These bedraggled documents are the ones which must be handled at high speed and from which information must be obtained through automatic means.

Consider the next factor—the need for accuracy. The banking business in particular demands very careful accounting procedures. Errors will be made in an accounting system whether this system is composed entirely of human beings or is entirely mechanized. However, it is essential that these errors be found and corrected before they have a chance to affect the customer.

Therefore, any machine designed for this purpose must place a very strong accent on detection and correction methods.

The fifth factor which was mentioned—system changes must be evolutionary—may come in for a lot of argument from those who can clearly see easier ways of doing things and are impatient when faced with procedures which seem redundant or unnecessary. However, the banking business is in very close contact with its customers. Furthermore, commercial check accounting is so standardized that competitive banks really haven't much to offer other than service. Slight differences in service to a customer can often determine where he does his business. Under these circumstances, no bank will change the customer's habit without careful thought and any change is usually brought about in a very gradual fashion.

It is difficult to generalize on the effect which close dealing with the public has on system design. In the specific system in this paper—that is, a system to handle the accounting in the commercial checking business—a number of things are traceable to the influence of the public's habits. For example, it was not possible, at the outset, at least, to spread the job of statement printing over all the working days during the month, since customers were already used to receiving statements at a given time. It was also considered inadvisable to abbreviate the statements—that is, to give to the customer only the net results of his month's transactions. Instead, it was considered essential to continue the present practice of providing a detailed record of all activity in each account. Also, customers have for years been able to obtain a special statement upon request, and this condition was carried over into the automatic system.

It was not possible to standardize on the width, length, or thickness of the check and deposit slips used by the customers. Furthermore, when it was desirable to preprint certain information on checks and deposit slips (such as the account number) it was impossible to restrict the printing of checks to a few suppliers, since many customers have their own printing arrangements and refuse to change them. This has an important bearing on the tolerances which can be expected in such printing operations and on the complexity of printing equipment which can be allowed.

Further effects were felt in the inability to standardize on service charge schedules. The system had to cope with several schedules on regular commercial accounts and also had to recognize the 10-plan (pay as you go) accounts, as well as the student 10-plan accounts re-
machine is used to obtaining information on his current balance whenever he so desires and this was carried over. Stop payments and holds had to be handled on short notice.

A last but important aspect of dealing with the public is the impossibility of controlling the volume of activity in a given customer's account. The number of checks the customer cashes can vary widely during different times of the year. This is obviously a point which can hardly be changed by any evolutionary process; therefore, the automatic system must be designed to cope with such fluctuations.

The nature of the filing problem is also worthy of note since it does affect the system. A large per cent of the file is affected during each working day in commercial check accounting. In the Bank of America system, for example, approximately one-quarter of the accounts have entries made to them every day, and, on an overall average, each entry involves about four items. Not only is it essential to have a complete record of this activity for use in service charge calculations, error detection, and printing of statements, but the data must be kept collated or at least must be kept so that the data on one account can be rapidly pulled together, to provide a complete record of that account. This requires a high-volume storage system organized in a manner that gives reasonable access time.

The same conditions apply to the filing of actual checks and deposits; i.e., the physical pieces of paper, with the further requirement that it is necessary to "pay the signatures" on the checks, and this is easiest to do when all the checks of the given account are grouped together.

The ERMA Program

Let us now turn to a brief description of the equipment which was developed by Stanford Research Institute for the Bank of America to handle its commercial check accounting problem. The general area of work handled is shown in Fig. 3. The bookkeeping for several branches is handled by the automatic equipment, and communication with this central location depends largely on messenger service. The first system handles the data for 32,000 active accounts, plus 8,000 clearing items, giving the equivalent of about 12 average-sized branches. At least 36 more units are needed and subsequent models will be made to handle 50,000 accounts.

Out of this program came techniques for high-speed handling of checks of assorted weights, sizes, and conditions; a means of automatically reading information from these checks while moving at high speed; and an automatic data-handling system. It is not the purpose of this paper to describe any of these in detail. However, these techniques are of interest here because they do represent the output of a program faced with the restrictions and demands which were discussed above.

The techniques used in the first engineering model of the equipment for this commercial check processing system employed binary coded numbers printed in magnetic ink for automatic reading of data from the documents. Further development work produced a system capable of reading Arabic numerals printed in magnetic ink without recourse to binary coding schemes. The first equipment produced using this character-recognition approach was employed in the traveler's check accounting operations. However, the development relates very closely to the commercial check bookkeeping being discussed, since the character recognition approach will be used in future models of that equipment. More will be said of this later.

Let us first consider the ERMA computer. A brief summary of the job being done by this electronic data-processing system is as follows: For each of the 32,000 active checking accounts which it is handling, it records the checks and deposits and keeps the current balance altered accordingly. It scans all incoming items to see if they correspond to "stop payments" or "holds" and to see if they result in overdraft or withdrawal below the hold level. It sorts the incoming items, which are entered in an entirely random order, and collates successive day's work so that all the activity for one account is kept together. It calculates service charges for each account, posts these charges automatically, and prints statements for all accounts. In addition to those operations, which represent the backbone of the work, the system provides lists necessary for analysis and control of the accounts. This includes such things as lists of current balances, lists of overdrafts, stop payments, holds, lists of credits and debits entered during any day, and summaries of the work handled, grouped in order to provide quick diagnosis and correction of errors.

It is a special purpose machine, with a wired program, rather than a stored program. It uses magnetic drum and tape storage and is based on standard vacuum tube circuits and relay switching networks. The system is large, containing approximately 8,000 tubes, 34,000 germanium diodes, and 2,400 relays. Two magnetic drums provide a storage of 3,000,000 bits, and 12 magnetic tapes provide 400,000,000 bits used in a manner which allows storage of 37,000,000 alphanumeric char-
acters. Input is through a combination of keyboards for manual entry of dollar amount and magnetic scanners for automatic entry of account numbers. Auxiliary input for such items as customer name and address is through punched paper tape. The bulk of the output is through a line-at-a-time printer. However, printed outputs for special interrogations can be obtained through the printing mechanism associated with each input keyboard. These keyboards are essentially mechanical adding machines with electrical “read in” and “read out.” The system uses excess-3, binary-coded-decimal notation on the magnetic drums and a similar but expanded code on the tapes to handle alphanumeric data.

Fig. 4 gives a view of the main body of the computer but does not show the tapes, inputs, high speed printer, power supplies, or maintenance console. Fig. 5 shows one of the tape units mounted in the tape racks and also shows the front of one of the circuit package racks. Fig. 6 shows several circuit packages. Twenty-four different types of packages are used to cover all logical functions, input/output functions, and communication with memories. Relays are also housed in plug-in packages. Fig. 7 shows the magnetic drums, and Fig. 8 gives a view of one of the manual input stations.

The machine shown in these figures is an engineering model designed with an eye toward production and maintenance. It will go into actual operation and will handle the work of a number of branches. This will allow a thorough shakedown of the operational features of the machine, as well as the engineering aspects, before further models are produced by a manufacturer. The point of view which was adopted in the design of the machine was fairly extreme. It was made to perform nearly all of the functions which could be desired in a system for this purpose. Operational experience will help determine areas where compromises should be made.

The diagram of the work flow through this centralized system (see Fig. 3) indicates that the checks and deposit slips are sorted into account number order after information has been transcribed from them for processing in the computer. Fig. 9 shows the engineering model of the sorter developed for this job. This particular model is a ten-pocket sorter, plus reject pockets, and is used to sort on a decimal basis on one digit at a time. The checks are automatically picked up from a stack at the far end of this picture by a controlled vacuum system. They are then transported between belts at a speed of 150 inches per second. After the checks are picked up and automatically registered against one edge, the binary coded account number printed on each check in magnetic ink is read and interpreted and a memory system is set so that the appropriate pocket gates will be opened when the check arrives. The gating on each pocket is accomplished by controlled vacuum ports in the drums shown above each pocket. The system operates at a speed of ten checks per second. (The techniques have
recently been extended to handle forty checks per second.) This system works with checks of various sizes and thicknesses; width may vary between 2½ inches and 4 inches, length between 5½ inches and 9½ inches, and a thickness variation between 12 pound paper and punch card stock. Typical checks which are processed by this sorter bear all the earmarks of the public's tender care. They are bent, torn, limp, and disfigured in every conceivable way.

While the work on reading of binary coded numerals was being carried out, plans also progressed for a more difficult but more desirable method, namely, reading numeric characters without the use of binary codes. This is more desirable because it avoids some of the printing problems connected with binary coding, it facilitates visual checking by operating personnel, and it requires less room on the document. Again, magnetic ink was used because it is not affected by over-stamping and other visual mars. Reading is accomplished in the first developmental system with a single magnetic head. Head width is considerably greater than the height of the characters being read, thus easing the registration problems during printing and automatic handling of the paper. The system also tolerates a relatively larger skew angle which may be developed either during the printing or reading operation.

An ideal way of obtaining field tests on this method was found in the travelers check operation, in which a punched card must be produced for every travelers check after it is returned to the bank. This card is used in the present travelers check accounting system. This application was ideal for a test of character reading in the sense that the printing could be carefully controlled through one or two commercial printers, and the characters normally used on these travelers checks are relatively large—about 6 characters per inch.

Fig. 10 shows a view of the travelers check scanning equipment which automatically transports travelers checks past the magnetic reading head, picks off wave-shapes characteristic of the numerals being scanned, decodes these numerals by sampling the wave form and converts these samples into binary code. In one scan of the check, the serial number of the check is read, as well as a digit denoting the dollar amount and a digit used for a “nines check,” and a punched card is produced. Checks which are not satisfactorily read for any one of a number of reasons are automatically fed into a reject pocket and a reject card is punched and off-set in the stack for easy identification. The electronic portion of this scanner consists of about 170 tubes. Approximately 50 of these tubes are used for the actual decoding operation. The others are used for control, arithmetic checking, and buffer storage for the punch. The small cabinet with a large number of control knobs in Fig. 10 is a special test device used to detect errors during a trial run in the laboratory. The error rate was so small that it could not be detected adequately without special gear.
This unit is finished and will be put into operation as soon as checks bearing the magnetic numerals are in use in sufficient numbers. Preliminary tests using a specially printed run of 100,000 travelers checks gave the following results: Out of the first 10,000 check passes, two errors were found; i.e., cases in which the scanner thought it produced correct results but which were proven incorrect by the external detection equipment. Additional error detection circuits were added to the decoder and no further errors occurred during the next 90,000 check passes. Rejected items, i.e., cases in which the scanner said that it could not read properly, ran as follows: Two per cent rejects occurred during the first 38,000 checks. (Analysis showed that 1.4 per cent were rejected because of malformed experimental printing type.) During the remaining check passes, 0.76 per cent rejects occurred, excluding the cases in which bad type caused reject. Currently, in the daily operation of the scanner, the machine generally rejects about 0.1 per cent of the checks and seldom rejects as much as 0.2 per cent.

One further area of development should be mentioned. Automatic paper handling systems of much wider application can be built if the dollar amount can be printed on the check in a manner which can be transcribed automatically. These dollar amounts might be written on the check by check-writing machines in large corporations, or they might be post printed by the banks during the first manual processing after the items return to the banking system. In any case, this poses the requirement of making the printing mechanism relatively inexpensive, hence printing tolerances cannot be held very closely and the character recognition system must be able to cope with these wider tolerances.

This post printing and reading, which has great potential in such areas as the department store and oil company credit business as well as in check handling, is now in the development stage.

**Conclusion**

This paper has attempted to show the magnitude of the check handling problem in national banking and the factors which influence the design of a system for automatically handling this problem. It has implied but not attempted to prove that bank check handling problems are fairly representative of financial accounting in general, particularly credit handling and centralized money management. It has implied, and it should again be emphasized here, that means for automatic handling and transcription of basic documents are an essential part of any system designed for this kind of operation. The paper has described an experimental program which resulted in equipment for actual use. This equipment by no means represents the ultimate, but it does represent progress and a good starting point for future development in the area defined by the general principles of financial accounting.

**Acknowledgment**

The authors wish to emphasize that the program discussed in this paper represents the work of many other people. This paper is intended to be introductory in nature and will be followed by more detailed papers written by members of the staff, covering the technical aspects of the program.

**Discussion**

**J. D. Mountain** (Mountain Systems, Inc.): What kind of numbers were printed on the checks in magnetic ink, the account numbers or dollar amounts?

**Mr. Noe:** The first system has just the account numbers printed and these are in a coded form. Subsequent systems will also include dollar amounts and hence replace most of the manual input operations. On travelers checks the job is simplified, there being only four dollar amounts to deal with; number one for ten, two for twenty, three for fifty, and four for a hundred.

**J. Svigals** (IBM): Does ERMA satisfy the need for economy? What is its cost and how much will it save?

**Mr. Noe:** The Bank of America people have not released actual figures on costs and savings. However, they would not have gone through with the program had they not foreseen adequate returns on the investment.

**T. C. Morrill** (Liberty Mutual Insurance Co.): Can ERMA be applied to other types of work than commercial banking and, if so, is it available for sale?

**Mr. Noe:** The equipment is not now available for sale. The question of future sales will be handled jointly by the bank and the manufacturer who produces it. The system, as it stands today, is very special purpose in that it handles only this particular dollar accounting job; but we who have been working with it feel it can be extended without too much difficulty to handle other jobs in the dollar accounting area.

**N. J. Dean** (Laboratory for Electronics): Are all checks posted as individual entries or are they posted as a single list total when there is a large enough number on one account?

**Mr. Noe:** They are posted as individual entries. For one thing, most of the items come in unsorted; in other words, in entirely random order. Also they do need posting individually at this stage because it is necessary at the input of the machine to protect it against human errors. For this reason the operator lists each item and accumulates the dollar amount, comparing the total with the total on the list which came with the batch. This insures that she didn’t punch the wrong key or that an item didn’t fall down the elevator shaft while being carried to the central ERMA office.
The Manual Use of Automatic Records

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Summary—Records that are to be processed automatically necessarily must be stored in media accessible to a machine and in codes suitable for machine interpretation. Consequently, such records may be not readily accessible to the unaided human clerk. Steps that may be taken to provide adequate facilities for the occasional manual interrogation and processing of automatic records are suggested and examined.

In the broadest sense, access to any automatic system is manual, human intervention being required in the operation of every system, if only to push a button to start it the first time. The problem of concern here thus arises from questions of degree. An automatic system operating unattended has its own tempo, a tempo often several orders of magnitude greater than the fastest human tempo. Information can be said to be processed automatically, if processed at the system's own tempo, and manually, if at a clerk's tempo. In general, the performance of any fully specified process can be controlled by circuit elements or by program steps, and hence may be regarded as automatic. It is chiefly the unforeseen, the rare, or the random which necessitate some form of manual intervention in the automatic process. A given system might thus be operated automatically at one time, manually at another. For example, the printing of all the information in the storage unit of a system by a printer operating at the system's own tempo, is an "automatic" process. The same information, displayed item-by-item on a monitor typewriter or some other display device, at the tempo of a button-pushing operator can be said to have been obtained manually. Between these two extreme cases, there is a whole spectrum of information processing rates and of system efficiency.

The automatic tempo of a system and the influence of manual intervention on the operation of the system depend on several factors; those of greatest importance here are the rates at which information can be introduced into the system, processed, and extracted, and the size of the information files. The files will be assumed to be large and the rates to be determined chiefly by the characteristics of the input, output, and storage facilities of the system. The problem of manual access to automatic records is therefore but one facet of the broader problem of designing data processing systems with optimal input, output, and storage facilities. It will be useful to analyze some of the characteristics of this broader problem in order to appreciate the particular effects of manual intervention on the efficiency of a system.

Storage devices are commonly classified as "random-access" or "serial-access." This classification unfortunately is confusing, for it is not precise, and it masks some important and useful distinctions. Storage devices now lumped as "random-access devices" may meet any one or more of the following essentially distinct and independent criteria:†

1) Information can be extracted from the device at random as rapidly on the average as if extracted in the order natural to the device.
2) The average access rate to information in the device is negligible with respect to the rate at which the information is required for use by associated equipment.
3) The basic unit of data (character, word, or block) is located by specifying suitable coordinates rather than by search.

The first criterion is based on a characteristic pertaining exclusively to the storage device. For any storage device, the access time to an item depends on the location of the item itself and often also on the location of the previously selected item. There exists, consequently, a preferred or "serial" order of selecting items, for which the average access time per item is a minimum. A device whose average random access time is comparable to its serial access time, is now characterized as "random-access."

As for the second criterion, if any arbitrary item of information can be supplied from storage as needed by the system with a negligible delay, the storage device again is termed "random-access" regardless of its specific physical nature. The third and last criterion is independent of time and often of the physical nature of the storage device as well. Again, however, it is common to designate any storage device addressed by coordinates as a "random-access" device.

Iverson has proposed to clarify the terminology by restricting the designation "random-access" to devices satisfying the first criterion. He adopts the following more precise terminology to characterize storage devices:

- **random-access or serial-access,** according to whether or not a storage device satisfies the first criterion;
- **immediate-access or delayed-access,** with respect to the second criterion;
- **coordinate-access or search-access,** with respect to the third criterion.

The distinction between immediate access and delayed access can be applied not only to the storage elements of a data processing system, but to the whole system as well. In this case, the characteristics of the

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† The author is indebted to Professor K. E. Iverson for suggesting these distinctions.