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A study of perpetual inventory systems

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A Study of Perpetual Inventory Systems

by

Charles Harry Schreiber, Jr.

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A STUDY OF PERPETUAL INVENTORY SYSTEMS

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I. INTRODUCTION

A. Management Information - The General Situation

Modern businesses are becoming more and more complex. As they grow in complexity, the professional manager requires more information in order to intelligently operate his business. As business grows and becomes itself complex, so do the rules and regulations governing its operation; ownership and control become separate functions, and detailed reports are required to evaluate management's stewardship of the resources available to it.

Detailed reports are therefore required on many aspects of the business, both to assist management to make intelligent decisions, and to inform the owners of the quality of management's work. The maintenance of the records necessary for these reports, and the actual production of them have become a major concern of managements. As the number of reports and records required by a firm increases, the amount of actual data processed in the office usually increases more than proportionally. With more data and more extensive records, the access time for any given piece of data will probably increase, as will the report preparation time. In the modern business world such "time" costs money, whether it is in terms of salary or machine expense, or in terms of lost business opportunities due to late or incomplete information.

The small concern turns to simple hand information systems, while the large company turns to more complicated systems, probably to machines which mechanically or electronically process data.

The growing concern with reports and information reflects an enlightened and scientific management; but the methods of attacking the situation do not. Managements have often "bought" the first semi-reasonable solution that was offered them. The first salesman to appear sold his wares. Managements began to buy the electronic computer; what has been called, "Top management's bright new toy, full of the wonders promised by automation.*" These immediate and ill planned acquisitions of systems have been underscored by one observer who noted that such orders had often been justified by such homely thinking as is reflected in the first line of a famous early English recipe for rabbit stew, "First get yourself a rabbit.**"

The acquisition of any system must be carefully planned, and must take into account the data to be processed, the requirements of the company, and the resources available to the company. Anyone with much experience in large organizations can point to the punched card system that "does not do the job as well as the accounting machines used to," or the computer that actually costs more per

* 23, p. 284.
** 29, p. 84.

item of processed data than did the former punched card installation. Often there is much in these claims, as many times the system has not been designed to fit the real needs of a specific management.

A reasonable point of departure in planning any information system would seem to be a logical determination of just exactly what information is required. Only then can one expect to be able to decide upon a coherent system by which to obtain this information. After this has been done, the objective should be to design the best possible information and communications system for meeting these requirements, whether it relies upon a computer, a simple manual or machine system, or entirely upon humans.

There appear to be two approaches to deciding just exactly what information is required:

1. Look at present reports and ask executives what other information they might desire.

2. Make a survey to determine what information should be of use to management, and attach varying degrees of usefulness to each type of information, to be weighed when considering the costs of producing such information.

As most managers are prone to ask for things which they never use, the second approach is probably the most reasonable. An experiment was made by a division of a major manufacturing company with respect to such unused, but produced, information. A committee decided that a number of costly reports were actually of no use to anyone in relation to their cost. For

several months, they directed that these reports be prepared, but they deliberately withheld them from their normal recipient. In ninety per cent of the cases they had no immediate comment. They had a number of executives who were slightly embarrassed four or five months later when they made some comment about not getting the report that month, only to be told that they had not received it for several months previous, and had not missed it. Most of the executives involved decided that they did not really require the reports.

Once one has determined what information is required, he must then design a system to produce this information. To do this, requires some consideration of just exactly what is involved in "data-processing." The actual processing of data appears to be made up of some combination of the following three functions:

1. Transcribing: Reproducing information in the same or different form to facilitate further processing, or as an end use (e.g. duplication, card punching, report writing, etc.).

2. Calculating: Performing arithmetical operations and quantitative decision making.

3. Filing: Storing information in some orderly sequence and refering to such stored information.

All data-processing can be construed to be some configuration of these three basic operations. "Data-processing systems" are schemes which simplify or mechanize one or more of these operations. "Integrated data-processing systems" are those

which smooth the transition from one function to another, usually through the use of some sort of common language device.

When one determines that he will automate or simplify his data-processing system, he must select his method, taking careful consideration of the amount and type of data to be processed. He must then use the system to its best advantage. An excellent analogy about what can occur if a system is improperly used is a story told by Lord Halsbury*.

> I have been concerned with a new development in plastics which makes it possible to mold, let us say, wings of aircraft or boat hulls on a scale much larger than would at one time have been thought possible. One builder of boat hulls, wishing to experiment with this new material, was so wedded to tradition that he proceeded as follows. He first took the plastic raw material and moulded it into large sheets. He then sawed these sheets up into planks, then he nailed the planks together to form the hull of a boat. It was more expensive and less satisfactory than a wooden hull and he dropped his experiment. He could not, you see, visualize a boat that was not built of planks, but was moulded in one piece.

For maximum savings and speed, the system used need not necessarily follow the traditional steps in order. As long as output and results are satisfactory, any accurate path through the required functions is acceptable; therefore, the

* 17 p. 3.

most economical method which is compatible with other requirements is probably the best way to acheive a given result.

Reports and information are the nemisis of modern managements. It may be possible to acheive better and more economical information through the use of some sort of system. From what has been said, the criteria for the construction of a good system seem to be the following:

1. Determine what information is required.
2. Determine what functions are required to produce this information.
3. Investigate systems which might be able to produce this information.
4. Determine objectively which system best fits the needs of the organization.
5. Utilize the system so selected in the optimum manner.

B. Perpetual Inventories - The Specific Problem

Having made a number of generalizations about data-processing, a specific data-processing operation will be examined, that of maintaining a perpetual inventory.

In many companies, both the accounting department and the production planning group keep their own perpetual inventory records, as they both consider them necessary for the fulfillment of their functions. There may be an almost complete duplication of effort, merely because the records are kept for different uses. In any given company, there is a good chance that neither method is up to date, and the expense for maintaining either is high.

The phrase "accounting type" perpetual inventory will be used to refer to one which contains both quantity and cost information, in contrast to what might be called the "inventory control" perpetual inventory, which is kept only in quantity. The accounting type of perpetual inventory requires more input and more processing, but it yeilds more and varied output reports.

More than one "systems" salesman has stated that satisfactory maintenance of perpetual inventory records and reports is the great unsolved problem in data-processing. This is the problem to be examined in detail in this thesis.

C. Scope of This Study

The general problem of data-processing has been discussed, and the specific problem to be considered has been selected. It remains to outline an orderly and systematic approach to the problem as posed.

According to the previously discussed criteria for data-processing, the first decision is whether and under what circumstances a perpetual inventory is actually required. If it is determined that it is necessary or sufficiently useful, one may then proceed to study the workings of a perpetual inventory, and possible systems.

In the case of the accounting type perpetual inventory, the specific inventory pricing method may put limitations upon the systems or configurations of equipment which may be chosen. To understand these limitations the the mechanics of several of the more popular methods of inventory pricing must be explored.

Before one can systematize, mechanize, or improve a procedure, he must understand clearly what is involved. This will lead to discussions of the required data; the necessary functions of filing, transcribing, and calculating; and the required output information.

After the decision as to what data is necessary, and what results are desired, one may then proceed to discuss various means of acheiving this end. This will occupy the major portion of this thesis. A number of manual, mechanical, and electronic systems will be studied. Each system will have specific applications; the accounting board is not good for all, neither is the computer. Some situations may call for complete systems set up merely for perpetual inventory; while in most, the perpetual inventory must be integrated into a larger, more complete, data-processing program.

The ultimate objective of this thesis will be to discuss various operational and proposed perpetual inventory systems, with special reference to the situations where they are applicable and practical. No effort will be made

in the body of the thesis to compare the absolute cost of specific systems; since requirements vary from company to company, and, in many cases, the final judgment on equipment will require consideration of the other uses of the same equipment or data. It should be possible, however, to set up some sort of objective criteria for measuring the cost and desirability of such systems.

II. THE NECESSITY FOR A PERPETUAL INVENTORY

A. Functions of a Perpetual Inventory

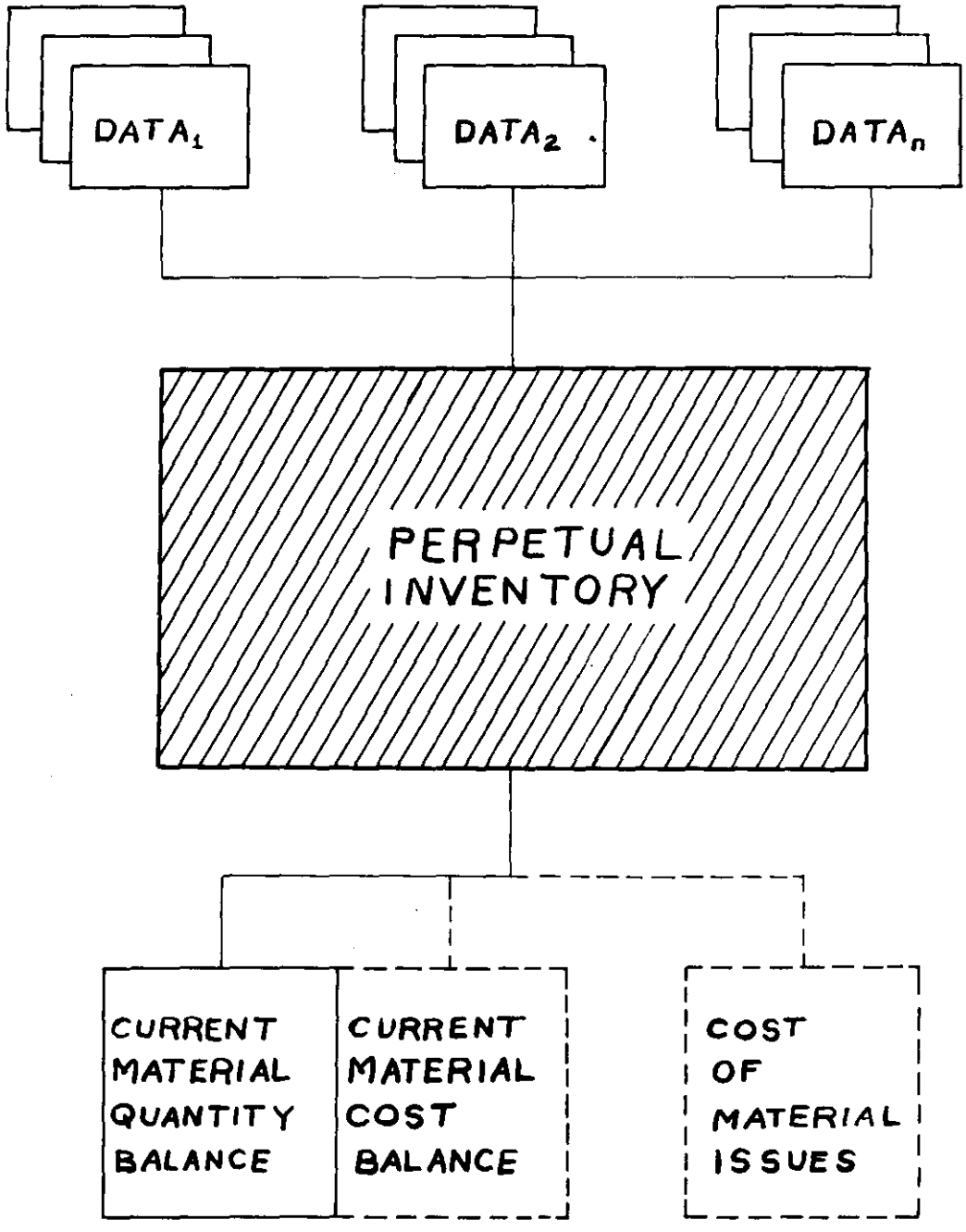
It has been emphasized that before one attempts to select or design a system to perform a given function, he must first determine that the function is, indeed, necessary and required. There is no logic in spending money on an efficient system that will perform a function which is not essential. It will be the purpose of this chapter to discuss the need for a perpetual inventory.

Before deciding whether a function is necessary, it is first necessary to define the limits of the function in question. The major function of the perpetual inventory can be summed up quite succinctly; a perpetual inventory tells how much an organization has of its physical stock in trade, and may tell the cost of this stock in trade. The objective is control; control of items in inventory, and control of the organization's investment in inventory.

The perpetual inventory itself may be considered as an unknown system. Certain data is fed into the system, and the system produces, as an output, a current material quantity balance, and, if this is the accounting type of perpetual inventory, current material cost balances and and the cost of material issues (see Figure I). The objective in the design of the perpetual inventory system is to minimize the total cost of producing the input data and of operating the system.

FIGURE I

THE PERPETUAL INVENTORY FUNCTION



TOTAL COST =

$DATA_1 + DATA_2 + \cdots + DATA_n + PERPETUAL\ INVENTORY$

The function of the perpetual inventory is to produce a current material quantity balance for each item of material, and possibly a corresponding cost balance and a cost of material issued amount. The problem now is to determine that this information is required. Indeed, some authorities* suggest that, for small firms of certain types, no perpetual inventory be kept. It is their contention that, in many cases, the information produced is not worth the cost involved. It will first be necessary to show the uses of the information produced by the perpetual inventory. It will then be up to the individual reader to determine whether the information derived would be worth the expense which would be incurred in his specific case.

B. The Inventory Control Type of Perpetual Inventory

What has been called the inventory control type perpetual inventory has uses both for "inventory control," and for more broad "accounting control." It might better be called the "physical control" perpetual inventory, for that is precisely what it does; it keeps track of those goods which are supposed to be in the possession of the firm. If it is a useful thing for a firm to know how much of each type of good it possesses or is supposed to possess, then this type of perpetual inventory is a useful thing.

* 34, p. 19-21.

Such an inventory gives a detailed, reliable, and current check on the inventory available in stock. This is a very important item for many manufacturing firms, particularly those with assembly lines. If all parts of an item are not available at the time set for assembly of the item, considerable time and effort may be wasted. To avoid this problem, many manufacturing firms install elaborate systems requiring automatic reorder of a part if the amount in inventory and on order drops below a certain point. Implicit in all such control plans is some sort of inventory control perpetual inventory system which tells the quantity of an item currently in stock.

The same problem is faced by some merchandisers who are selling the service of immediate delivery. They must have fast moving stock in sufficient quantity so that they will not alienate customers by not having their particular required item in stock. In many businesses, if a customer cannot obtain an item from one dealer, he can merely go elsewhere and have his requirements satisfied. Such problems again give rise to inventory control systems, embodying as a basic requirement a perpetual inventory.

From the standpoint of the accountant, a perpetual inventory kept only in terms of physical quantities will be of considerable assistance in controlling the assets of the firm. An efficient perpetual inventory system, with the

checks afforded by good internal control and a periodic inventory, can assure that the assets classified as inventory are used and accounted for properly. Such a system allows discrepancies to be localized and thereby aids in tracking down shortages and overages. A working perpetual inventory serves as a deterrent to pilferage or other dishonesty involving inventories, as the perpetual inventory gives a complete accounting of the supposed acquisitions and dispositions of inventory. A good, properly functioning perpetual inventory may allow the physical counting of the inventory to be carried on over a space of time, rather than all at once, with all activities of the firm suspended for the period of counting.

The inventory control type perpetual inventory, then, can be useful as the basis for an inventory control scheme, and can be doubly useful as a check on those assets of the organization classified as "inventories."

C. The Accounting Type Perpetual Inventory

The accounting type perpetual inventory provides all the information that the inventory control perpetual inventory provides, therefore, it can be useful in the same ways. It contains further information relative to costs and prices, and can be extremely useful in several additional areas.

One of the most important uses of this type of perpetual inventory is well summed up by the following statement, "For control purposes, we must know how much we have of each item, and how much it costs to hold on to it.*" This type of system includes the cost facet of the important problem of inventory control. It has been noted that many times there is a loss when needed items are not in stock; there are also losses due to shrinkage, obsolesence, and pilferage, and that loss caused by tying up the capital of the firm, when excessive stocks are maintained needlessly. There are various schemes which attempt mathematically or subjectively to balance these factors, but they all require the information that can come only from this type of perpetual inventory system.

Such a perpetual inventory is basic to any cost accounting systems in a firm dealing with inventories. If all costs of manufacturing an item are to be accounted for, it is necessary to attach some cost to the materials from which the items were made. It is impossible to truly compute the cost of an item, without knowing the cost of the material contained in that item. If cost figures are going to be used in the inventory accounts, this type of perpetual inventory is almost mandatory, as there would be no rational way to charge materials to a job, or the finished product into stock, without the information produced by such a system. It permits a constant measure of efficiency of material utilization of operating departments or cost centers.

* 30, p. 345.

With the accounting type perpetual inventory, it is possible to draw off interim reports regarding the state of inventories without the expense of conducting a physical inventory. It gives management even better control, as the availability of accounts which are reasonably up-to-date allows for frequent and specialized reports, and allows management access to information about inventories at the time when they need it.

It can be seen that the perpetual inventory is a useful tool of management. The inventory control type is useful for physical control of inventory; the accounting type is even more useful for control purposes; it is also more expensive. There is no doubt about it; as a general rule, more information costs more money. Management must weigh the usefulness of the perpetual inventory against the added costs of maintaining it. This paper will consider the expenses involved in many perpetual inventory systems, it is then up to the individual reader to decide whether the information outlined here is worth the cost to him. No overall statement can be made, but most firms presently operating perpetual inventory systems consider the information well worth its cost; this paper will discuss better and cheaper methods of obtaining this information.

Since the accounting type of perpetual inventory includes, as an integral part, the inventory control type perpetual inventory, and the accounting type is of most use in the control function, only the accounting type perpetual inventory will be considered when discussing systems. Any of the systems to be discussed would function satisfactorily as an inventory control perpetual inventory, merely by deleting the cost data and computations from the system.

III. THE PERPETUAL INVENTORY PROCESS

A. The General Picture

If it is established that a perpetual inventory performs a useful function and one wishes to determine the cost of such a perpetual inventory, he must first understand clearly just what is involved in the perpetual inventory process. It was previously noted that the perpetual inventory process encompassed three major elements: the input, the actual inventory computations and records, and the output reports. This was shown graphically in Figure 1. The purpose of this chapter will be to take this same figure and fill it in with more detailed information.

The data will be discussed in terms of the items that are actually required to perform the inventory calculations. Very little attention will be paid to the form of the data, as the system may dictate this form. The same holds true for the output; the contents of the output will be described, but the system and company usage will probably dictate its final form.

The item which will be discussed last in this chapter is actually the second step-the perpetual inventory system-the transition step from data to reports. The ultimate purpose of this report is to describe a number of systems which might serve as the perpetual inventory system. For this reason it will satisfy the needs of this

chapter merely to describe in a bit more detail what must, of necessity, go on within the system.

B. The Input Data

The input data for a perpetual inventory must include information relative to all transactions involving inventory. Every time that something significant happens to the inventory, it must be reported to the perpetual inventory mechanism, if the perpetual inventory purports to maintain a current record of the actual state of inventory. This input data may be paper forms, punched cards, punched tape, or magnetic tape; this will depend upon the system used and the configuration of equipment available. Although this report to the perpetual inventory may take many forms, there are only a small number of possible occurances,i.e., additions to inventory, issues from inventory, and losses from inventory. The individual firm may use many categories to describe these occurances, but these, basically, are the three main end effects.

In the case of an addition to inventory, there are three basic pieces of information which must be supplied: identification, quantity, and cost. The inventory has no record of any of these for the specific goods involved, and these are the pieces of information required in the inventory records.

There must be some sort of input data to report acquisitions from outside the firm. This information probably comes, in some manner, from the firm's purchase orders, after they have been correlated with receiving information. Such data is also available on the seller's invoice, if it is correlated with the necessary receiving information. There must be a reference to receiving information in all cases to determine that the firm actually received the goods; a receiving report, in quantities only, would have to be correlated with cost data. It will suffice to say that the cost comes from the purchase order or the invoice, while the identification and quantity are determined or supported by actual physical check of the quantity received. Often, copies of the purchase order are sent to the receiving personnel. If the quantities received are entered on a copy of the proper purchase order, one document is created containing both pieces of data.

When a manufacturing firm is involved, there are transfers from in-process inventory to finished-goods inventory or stock. This constitutes an addition to finished-goods and requires a credit to in-process inventory. There are several possible documents which might indicate such a transfer to the perpetual inventory. In many cases, the completed job cost sheet is the document which gives quantities and costs for manufactures. In standard cost situations an inspection report, passing

the goods into inventory, or even a tally sheet as they go past a certain point will suffice to give the quantity; the cost is standard cost, already listed in the perpetual inventory records.

Sales returns are another source of additions to inventory. The receiving on such returns provides the necessary data to debit inventory for quantity; the costs should be elsewhere in the company records.

Issues from inventory require less input information. There is no need for cost or price data, as the system already contains this information; a part of its job will be to supply this information. The input data must supply the identification and the quantity.

The sale of items is generally reported to the perpetual inventory by the documents arising from the sale. This is generally the sales invoice or the shipping material.

In almost any business situation dealing with goods, there is some type of scrap, rejects, or spoilage. These give rise to two possible inventory transactions. The first is obviously a credit to inventory and a debit to a loss account to record the loss from scrap and to eliminate the spoiled stock from inventory. The second transaction is a possible return to inventory of any recoverable and usable material. The first requires only a report of the loss quantity; the inventory records

contain the required pricing information. The second takes slightly more information. If this is a relatively infrequent occurance, such returns may be priced individually before being entered into the system. If such returns are normal occurances, the system may have a provision to price standard materials.

These have been examples of the input data and cover the general picture. To have a successful perpetual inventory system, any transaction effecting inventory must produce a document containing the required information for the perpetual inventory records.

C. The Results Required

In the true "systems" approach, the first step in the analysis is to determine what the required output is to be.. Since the limitations of the input information are known from experience, it is possible to discuss this first. It must be kept in mind, however, that it may be possible to alter the form of the input to suit the chosen system. Now the most pressing question is, "What must the system produce as an output?". The system is only as good as the information it produces is useful.

It has previously been stated that one of the primary reasons for a perpetual inventory is to tell how much a firm has in inventory, and how much, in terms of capital, it is costing to keep it. The reports to fill this requirement will be called inventory status reports.

These inventory status reports may be divided into two major categories, i.e. demand and periodic.

For order, production, or planning purposes, it is often necessary to know the status of individual items or groups of items; the perpetual inventory systems must have an immediated reference capability by which one may query the system on the status of a limited number of items. The actual operation may be a look-up in a file or a print-out from a computer, never-the-less, this capability must be present. This capability will fulfill the requirements for specific data for statistical work, for managerial calculations, and for accounting checks.

Another possible major requirement that this "immediate status report" capability will fulfill is that of pricing issues from inventory. When there is an issue from inventory, the balances of the account of the goods issued must be reduced by the price of the issue and the quantity issued. The perpetual inventory contains the price, the input contains the quantity. A combination of this information may be used as an output to make a report of cost of issues or cost of goods sold.

In addition to requiring immediate information, complete periodic reports on the status of inventories may be required. A monthly or quarterly lising of inventory might be useful, but under some of the simplest systems this may be impossible due to the sheer volume of data

to be processed by hand. If a system could produce quantities and costs of specific categories of stock, this might be of considerable use in analyzing the state of inventories. There might be other desired periodic reports, but their contents would be this same information, rearranged to suit the specific purpose.

If the firm has an inventory control plan as an adjunct to the perpetual inventory, there will be some sort of output to convey "buy" instructions as defined by the inventory control plan. Most plans state that the inventory quantity of an item drops below a specified number of units, a "buy" or make instruction emanates from the perpetual inventory system.

The output requirements can be summarized very simply. The requirements are the quantity and the cost of those items currently in stock. Such information may be desired for individual immediate reports, listings, or summaries by some particular characteristic of the items involved. In conjunction with an inventory control plan, there may be, as an output, an order of some sort to acquire certain items which according to the plans calculations are in short supply.

D. The Transition from Data to Results

The last general topic to be covered in this chapter, the transition from the input data to the output reports, is much less definite. In essence, this

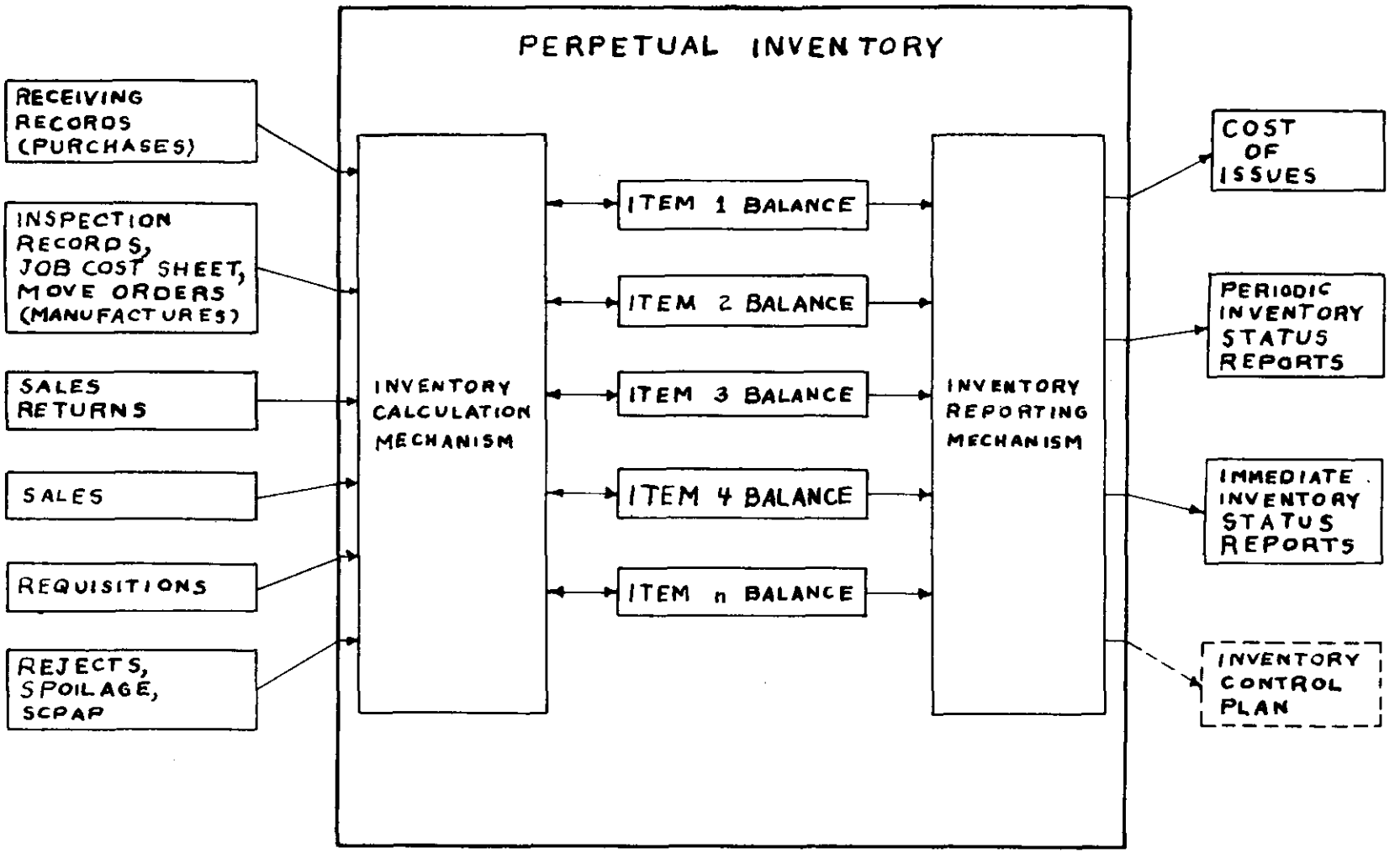
is the topic of this entire paper, so the discussion in this chapter will be limited to broad generalizations about the characteristics which the system must, of necessity, possess. In later chapters this field will be more fully explored in the discussions of specific systems.

Given the input and the output of a system, it should be possible to detail the major operations which must take place somewhere within the system. The system must possess a calculating mechanism, inventory records for all items in inventory, and an inventory reporting mechanism. A graphic illustration of this process is given in Figure 11, which expands the system picture given in Chapter 2. This figure details the flow of the actual data through the perpetual inventory mechanism into the final reports.

The capabilities required of the calculating mechanism will vary with the inventory pricing method involved, and with the volume of transactions. The calculations involved in updating a balance may be done by hand or on a large scale digital computer; but such calculations remain a requisite of any perpetual inventory system. The various systems to be discussed cannot eliminate or substantially change these computations and deliver the results in a reasonagle time.

The perpetual inventory system must, almost by definition, contain quantity and cost data. These will be called item balances for the purposes of this paper.

THE PERPETUAL INVENTORY PROCESS
FIGURE II



These item balances may be on "perpetual inventory cards," maintained for the purpose; on punched cards; on magnetic tape; in an electronic storage device; or in any other reasonable storage media. These will all be of concern later. The method of access to the balances will be important. Access may be either serial or random. Serial access means that, every time the file is to be consulted, it is necessary to start at the first item and go through all items in order until the proper item is reached. Random access means that the desired balance may be consulted directly, adding considerably to the speed of reference. In general, random access is by far the most expensive in terms of the cost of the records-keeping installation. This storage of "item balances" and access to them can be simplified or improved by various systems, but it cannot be eliminated.

The perpetual inventory must possess a reporting mechanism - some way to communicate its information to the people requiring the information. This reporting mechanism may be simple, as manually pulling a card and noting the balances written thereon, or it may involve printing out information from the memory of an electronic storage device.

The major steps have been covered; the data has entered the system, the necessary calculations have been made, the balance has been updated, and the report has been written. All of these steps, individually, could

be simplified and systematized, but some of the largest savings can be effected by simplifying and systematizing the transitions from step to step.

In the manufacturing industries it has been found that the real benefits from automation are derived from simplifying operations and the "transfer" operations (operations which move or position the item, rather than act upon it); this is also true of paper work operations. In the final analysis, after all extraneous operations have been eliminated, there remain certain basic operations which must be done to perform the required task; they cannot be eliminated. For the case of the perpetual inventory, these operations have been described. What remains is to find the most efficient way to perform the required operations, and to simplify the transition from operation to operation. It may well be possible to eliminate or combine transition steps without effecting actual operations. Judicious use of various types of data and information carrying media is the usual way to eliminate transition steps.

The major requirements for a working perpetual inventory system have been discussed. It will now be possible to proceed with discussions of various operational and proposed perpetual inventory system.

IV. INVENTORY PRICING METHODS

A. Significance of Pricing Methods to Perpetual Inventory

The "accounting type" perpetual inventory was defined, for the purpose of this paper, as a perpetual inventory which is kept in terms of both quantities and the associated costs. This definition implies some sort of cost calculation and account entry for each change in inventory quantity.

There are numerous acceptable methods for the "pricing" or "costing" of the transactions involved in maintaining a perpetual inventory, each involves slightly different input and requires somewhat different calculations.

The records necessary for inventory computations will have an important bearing on the perpetual inventory system. For the operation of one method, it is necessary to maintain and constantly reference elaborate and detailed original cost records; for another pricing method these records might not be used at all. There is a considerable distinction between records which may be filed back in some vault, and records which must be referenced for every inventory computation. The amount of material which must be at hand for immediate access for certain pricing methods may well limit the systems which can be

used, for the system must possess sufficient "memory" or reference capacity for the required information.

Each of the major acceptable inventory pricing methods has its own peculiarities in the area of computation. Some of the systems to be discussed may function quite well when one particular pricing procedure is used, but may be so involved as to be impractical or so inadequate as to be unacceptable when another pricing procedure is being utilized.

Since some of these pricing methods are particularly suited to certain industries, and since many companies are almost irrevocably commited to a specific system, it will be necessary to keep in mind the vagaries of specific pricing methods when discussing perpetual inventory systems. To do this satisfactorily it will first be necessary to define the characteristic features of the more commonly used methods for pricing perpetual inventories. These will be discussed in the following section, and summarized on Chart I which shows typical computations under each system, and Chart II which lists the mathematical functions and records required for each method.

B. Descriptions of Specific Pricing Methods

Identifiable Cost, Job Cost, Production Cost

It would seem reasonable to construe as the cost of a particular object, the total of all those costs readily identifiable with that specific object. This is probably the most expensive inventory pricing method; it requires a firm to keep separate records for each individual object held in inventory. The computations involved are not difficult, but the firm dealing with thousands of varied items would face a record maintenance job that would be e enormous. This method contrasts with other pricing methods which group all identical objects under a single item account, rather than account for each object as a separate entity.

This type of costing is generally applicable in situations like that found in the jewelry manufacturing industry where each precious gem over the minimum size is unique and has its own specific price.

It is quite common to find this type of pricing used in conjunction with other pricing methods in determining the cost of "custom" or other customer's specification job.

Average Cost

Issuing materials by some sort of average cost method assumes that each issue from stock is made up of uniform quantities taken from each shipment in stock at the date of issue.

What is generally referred to as the average cost method is also sometimes called the "running average", the "moving average", or the "weighted average". In the general method, issues are priced at an average price, calculated by adding the cost of any additions to the account balance for the item concerned, and then dividing this balance amount by the number of units presently in inventory.

Month End Average

A variation of the average cost method is the "month end average". This average price is derived by dividing the sum of the cost of the beginning inventory and the cost of the purchases during the month by the sum of the quantity of the beginning inventory plus the quantity of purchases during the month.

In pricing procedures, the average cost is either used to price issues for the month just ending (this requires issue records for the month to be maintained, and is not a true perpetual inventory), or this average cost is used to price issues for the next month.

First-In, First-Out

The first-in, first-out method of pricing accepts the supposition that the items issued are the oldest items in stock. To get the cost of the issue, it is necessary only to determine the cost of the oldest supply in stock. The actual cost of this stock is the price by the first-in,

first-out method.

If the supposition were, in fact, true, the system would be identical to the identified cost method. This method, however, requires less immediately accessible records as the records need only be kept in terms of quantities purchased at specific prices. If there are frequent purchases at varying prices, this method may require considerable record keeping, as records must be available for the total amount in stock at the time of issue.

Last-In, First-Out

In the last-in, first-out method of inventory pricing, the material issued takes the price of the last units received. This leaves the cost of the oldest items in the account balance, and charges out the most recent costs available.

If this pricing method is used in a perpetual inventory, the balance that results may be a mixture of objects with different costs, all left in the accounts to be referenced before issues can be priced. This could conceivably require considerable record maintenance and duplication of old records.

Highest Cost First

The highest cost first method prices issues as the highest cost items in the particular stores' account at the time of issue. This method requires the same records as do the first-in, first-out and last-in, first-out methods, but

it necessitates a greater selectivity when making calculations. It is necessary to select from the highest cost purchases in inventory, rather than from the oldest of the most recent, which would be the easiest points of attack for a listing.

Replacement Cost at Time of Sale - Market Price at Time of Sale

In the replacement cost type method of inventory pricing, the material account is charged with issues at replacement cost or present market price. This method implies some readily ascertainable replacement or market cost.

The mechanics of this method require only beginning balances in both quantity and amount, a market price, and the issue quantity.

Base Stock

The base stock method is more a system of inventory valuation than a method of pricing a perpetual inventory, however, there are certain considerations which will affect the perpetual inventory.

In the general method, a "base stock" is determined and is considered as a permanent investment. The base stock is usually valued at a low price which is not changed over time. Current purchases are charged into the accounts at current costs, and issues are usually priced by one of the pricing methods previously discussed. It is only when issues exceed purchases in stock that the base stock affects trans-

action pricing. At such times issues would be priced at base stock prices and receipts would be written down to base until the base stock quantity had been received. The operation of this method requires all of the criteria necessary for the "general" pricing method used, and in addition, some indication or test to determine when the base stock level is reached.

Standard Cost - Per Cent of Selling Price

The standard cost method carries material in the accounts at a predetermined cost. Any amount over or under the "standard cost" for a given purchase is charged into a "variance" account; all issues are priced at the standard.

This method does not required the maintenance of detailed purchase or manufacturing cost records in order to perform the inventory pricing function. The computations require only the standard cost, the quantity balances, and a material variance account into which variances from standard are charged.

The per cent of selling price method follows essentially the same procedure. In this method, items in inventory are carried at a fixed per cent of proposed selling price. This fixed percentage of the selling price then operates as a standard. All additions are entered at this price and any variance is placed in a variance account; all issues bear this same price.

C. General Comments on Pricing Methods

It is not unusual to find combinations of the methods which have been discussed. The two most frequent variations are to keep the perpetual inventory by one method while making up statements by another method, and using different methods for different classes of products.

The most usual circumstance is to find a method used in the perpetual inventory accounts, different from the method used for end of year balance sheet, income statements, and income tax purposes. It is not unusual to find standard costs in the accounts, while "last-in, first-out", "first-in, first-out", or "lower of cost or market" is used to compute the inventory value for statement purposes. This paper will not concern itself with the year end statements and the method of valuation used for them, if this does not effect the perpetual inventory. The statement method will concern this thesis only to the extent that certain of the equipment to be discussed can be used to facilitate taking and costing the annual inventory. If this aspect is important in the picture of a company, it should be bourne in mind that certain records, other than those necessary for the perpetual inventory, may be required to compute the year end inventory.

The situation is sometimes encountered, where different methods are used to price the perpetual inventory of different classes of stock. The overall perpetual in-

ventory of different classes of stock. The overall perpetual inventory system must be capable of differentiating between these classes, and must be capable of handling the calculations required for both methods (if one is less frequent and can be done on a "special" basis, this is still a consideration in the overall perpetual inventory problem).

A grasp of some of the peculiarities of these inventory pricing methods just mentioned will prove valuable when evaluating, for a specific situation, the systems to be mentioned in the chapters to follow. The charts accompanying this chapter should serve to highlight the properties required of a system by various of the popular pricing methods.

CHART I

TYPICAL INVENTORY CALCULATIONS FOR SELECTED INVENTORY VALUATION METHODS

PRICING METHOD	NECESSARY RECORDS	CALCULATIONS	
		ADDITIONS TO INVENTORY	ISSUES FROM INVENTORY
	units | unit cost | acc't. bal.	units | unit cost | acc't. bal.	units | unit cost | acc't. bal.
Identifiable Cost	item # 912 $ 1,000 item # 915 2,000 item # 917 2,500 Balance $ 5,500	Add item # 918 value $1,000 item # 912 $ 1,000 item # 915 2,000 item # 917 2,500 item # 918 1,000 $ 6,500	Issue item # 917 value $2,500 new balance: item # 912 $1,000 item # 915 2,000 item # 918 1,000 Balance $ 4,000
Average Cost	30 @ $ 0.30 $9.00	Add 10 @ 26¢ Bal. 30 $0.30 $9.00 Add 10 0.26 2.60 Bal. 40 ----- $11.60 $11.60 ÷ 40 = .29 Bal. 40 $0.29 $11.60	Issue 12 BAl. 40 $ 0.29 $11.60 Issue 12 0.29 3.48 Bal. 28 $ 0.29 $ 8.12
Month End Average	Balance at beginning of Mo. 30 $0.30 $ 9.00 Mo.Add 10 0.26 2.60 Mo.End 40 -----$11.60 Balance $11.60 ÷ 40 = .29 unit cost	(normal additions merely listed on records for month)	Next Month Issue 12 Bal. 40 $ 0.29 $11.60 Iss. 12 $ 0.29 3.48 Bal. 28 $ 0.29 $ 8.12

CHART I

TYPICAL INVENTORY CALCULATIONS FOR SELECTED INVENTORY VALUATION METHODS (Continued)

PRICING METHOD	NECESSARY RECORDS			CALCULATIONS					
				ADDITIONS TO INVENTORY			ISSUES FROM INVENTORY		
	units	unit cost	acc't. bal.	units	unit cost	acc't. bal.	units	unit cost	acc't. bal.
First-in, first-out	current FIFO records *			Add 10 @ $ 0.25			Issue 12		
	10	$ 0.25	$ 2.50						
	10	0.27	2.70	Bal. 30		$7.80	Bal* 40		$10.30
	10	0.26	2.60	Add 10	$0.25	2.50	Issue*(10)	$0.25	2.50
Bal 30			$ 7.80	Bal. 40		$10.30	(2)	0.27	(0.54)
							Bal. 28		$ 7.26
	*must retain units receipt records equal to total of units in inventory.						*receipt records may be deleted on these 12		
Last-in, first-out	current LIFO records			Add 10 @ $ 0.25			Issue 12		
	10	$ 0.25	$ 2.50						
	10	0.27	2.70	Bal. 30		$7.80	Bal. 40		$10.30
	10	0.26	2.60	Add 10	$ 0.25	2.50	Issue (10)	$0.25	(2.50)
Bal. 30			$ 7.80	Bal. 40		$10.30	(2)	0.26	(0.52)
	Updated LIFO records						Bal, 28		$ 7.28
	10	$ 0.25	$ 2.50						
	10	0.27	2.70						
	8	0.26	2.08						
Bal. 28			$ 7.28						

CHART I

TYPICAL INVENTORY CALCULATIONS FOR SELECTED INVENTORY VALUATION METHODS (Continued)

PRICING METHOD	NECESSARY RECORDS			CALCULATIONS					
				ADDITIONS TO INVENTORY			ISSUES FROM INVENTORY		
	Units	unit cost	Acc't. Bal.	units	unit cost	acc't. bal.	units	unit cost	acc't bal.
Highest cost first	10	$0.25	$2.50	Add 10 @ $ 0.25			Issue 12		
	10	0.27	2.70						
	10	0.26	2.60	Bal. 30		$7.80	Bal. 40		$10.30
	Bal. 30		$7.80	Add 10	$0.25	2.50	Issue (10)	$0.27	(2.70)
	Updated balance			Bal. 40		$.0.30	(2)	0.26	(0.52)
							Bal. 28		$ 7.08
	10	$0.25	$2.50						
	8	0.26	2.08						
	10	0.25	2.50						
	28		$7.08						
Replacement Cost	Balance 30		$7.80	Add 10 @ $ 0.25			Issue 12, market price 25¢		
				Bal. 30		$7.80	Bal. 40		$10.30
				Add 10	$0.25	2.50	Issue 12	$0.25	3.00
				Bal. 40		$10.00	Bal. 28		$ 7.30

CHART I

TYPICAL INVENTORY CALCULATIONS FOR SELECTED INVENTORY VALUATION METHODS (Continued)

PRICING METHOD	NECESSARY RECORDS			CALCULATIONS					
				ADDITIONS TO INVENTORY			ISSUES FROM INVENTORY		
	units	unit cost	acc't. bal.	units	unit cost	acc't. bal.	units	unit cost	acc't. bal.
Standard cost	Std. Cost $ 0.25 ea.			add 10 @ $0.26 or $ 2.60			issue 12		
	Bal. 30	$ 0.25	$7.50	Bal. 30	$ 0.25	$ 7.50	Bal. 40	$ 0.25	$10.00
				Add* 10	0.25	2.50	issue 12	0.25	3.00
				Bal. 40	$ 0.25	$10.00	Bal. 28	$ 0.25	$ 7.00
				*Material variance acc't.					
				Add 10	$ 0.01	$ 0.10			

CHART II

CALCULATIONS AND ASSOCIATED REQUIRED RECORDS FOR SELECTED INVENTORY VALUATION METHODS

VALUATION METHOD	CALCULATIONS REQUIRED	RECORDS REQUIRED
identifiable cost	addition (possibly multiplication)	individual records for each object in inventory
average cost	addition, subtraction, multiplication division	balances of material and cost
month end average	addition, subtraction, multiplication division	month's beginning balances, all purchases during month (issue record for month)
first-in, first-out	addition, subtraction, multiplication	records of all purchases of material currently in stock (by FIFO)
last-in, first-out	addition, subtraction, multiplication	records of all purchases of material currently in stock (by LIFO)
highest cost	addition, subtraction, multiplication	records of all purchases of material currently in stock
replacement cost	addition, subtraction, multiplication	balances of material and cost, current market prices
base stock	function necessary for general valuation method, plus check to determine whether base stock is involved	records for general method used, records for base stock
standard cost	addition, subtraction, multiplication	quantity balances, standard costs, access to variance accounts

V. MANUAL SYSTEMS

A. Systems Involving Visible File Records

What will be discussed under the heading of "manual systems" might better be characterized as "manual procedures." The so-called "systems" which fall in the manual category are, in general, ones which entail simplification or improvement of segments of what is a basic overall system. It would be possible to combine several of the manual procedures to be discussed into one overall system, or individual procedures could be utilized separately.

Some sort of record must be at the heart of every perpetual inventory system. It must contain both quantity and cost data, and whatever additional data is necessary to fulfill the requirements of the firm and of the inventory pricing method involved. In discussing manual systems, it would seem reasonable to begin with a description of a form of this central record, then to proceed with various procedures for improving the peripheral operations whose function it is to alter or draw information from this central record.

The visible file type of record is merely a sophistication of the simplest type of file which could be kept, i.e. a card in a file drawer or a notebook page devoted to a history of each item carried in stock. A short discussion of this type system will also supply a

general description of the other simpler hand records. The information conveyed by the perpetual inventory card would be the same, the only differences would be in ease of access and the advantages of "visible" inventory control procedures.

A typical sequence out of a visible file is illustrated in Figure III. The central record in this type of procedure is the information on the card or cards occupying the pocket labelled for the proper part or part number. A number of sequences like the one illustrated can be built into a rack or other device for convenient filing and access.

The chief advantage of the visible file over the normal file, with regard to the maintenance of the perpetual inventory, is that of easier, more rapid filing; the part name or number is immediately visible, rather than being buried in an alphabetized, but visibly homogeneous, mass. A popular advantage is its use as a part of an inventory control plan. A colored indicator may be used in the visible part of the pocket to indicate stock status. Reports and orders can then be drawn off selected items by inventory status, without the necessity of examining every card in the file.

Figure IV shows one possible set of cards which might be found in the pocket of a visible file. There are many configurations of data which might be

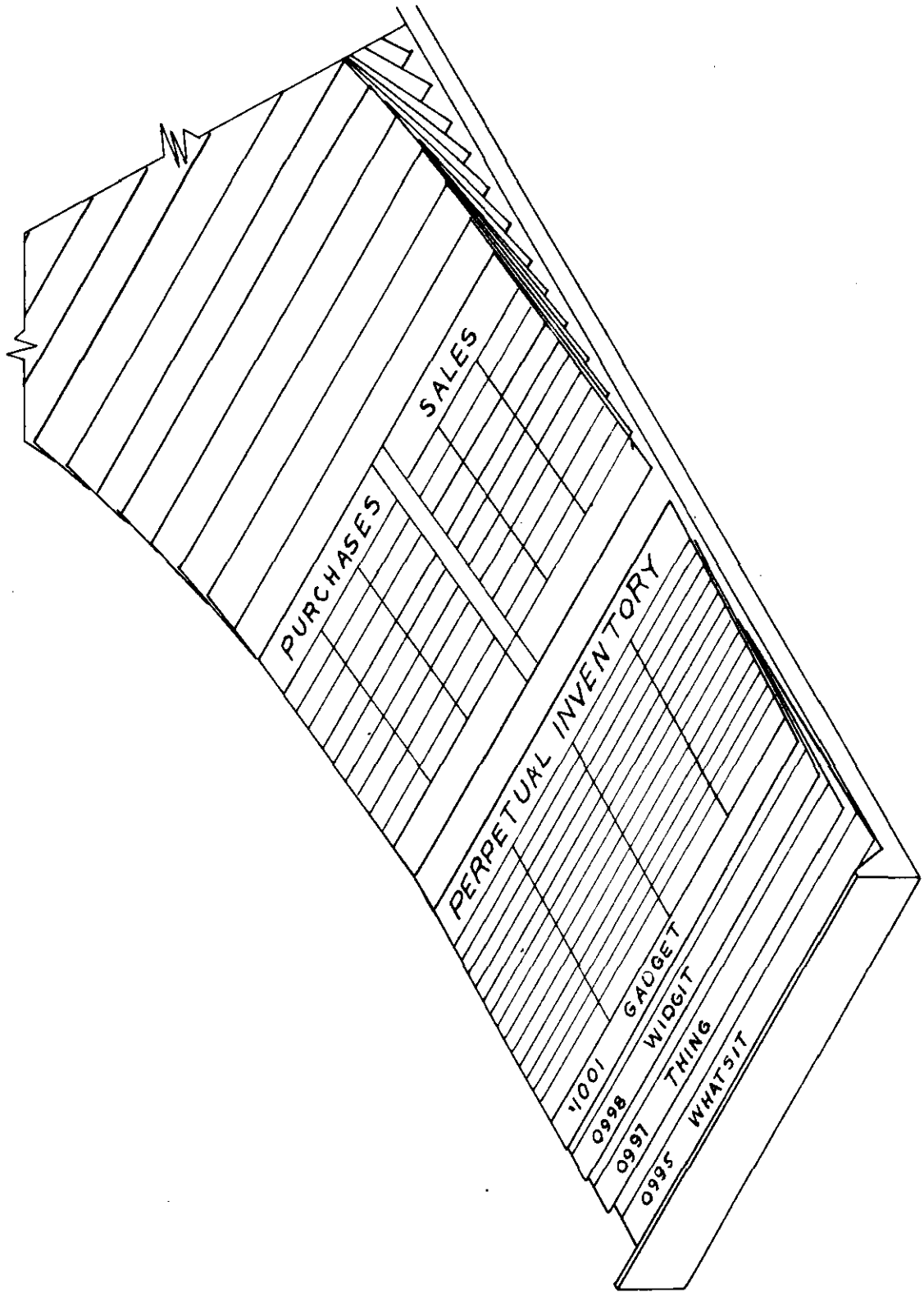
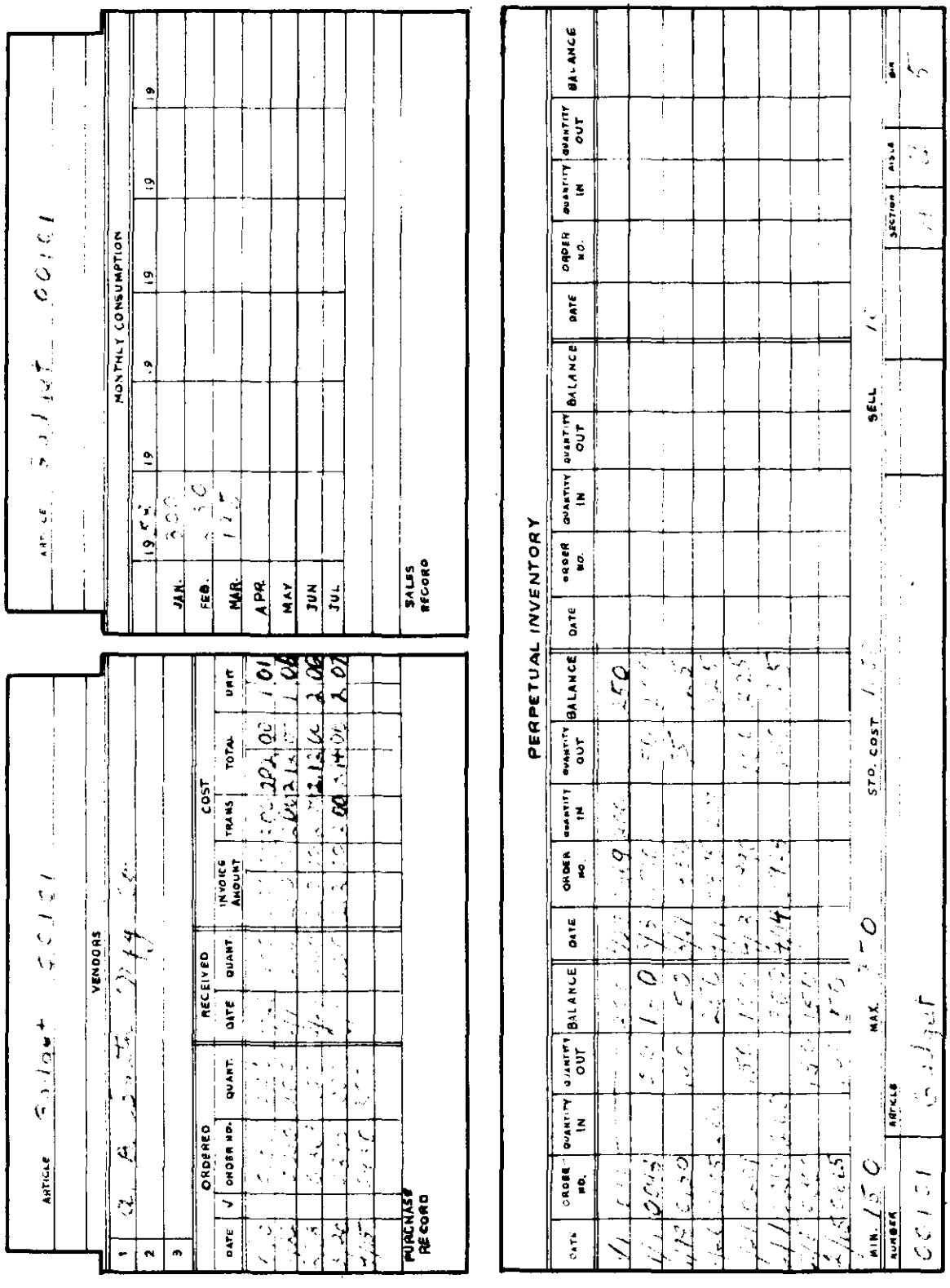


FIGURE III
TYPICAL VISIBLE FILE

TYPICAL VISIBLE FILE CARD CONTENTS
FIGURE IV



found in such a file; this is only one possibility. The data required in the pocket (or on the card) will be determined by the pricing system involved (if this is an accounting type perpetual inventory), and various company requirements. Although cost balances are not maintained, this particular set of forms would suffice for the use of the first-in, first-out or the standard cost pricing methods.

When a purchase is made, the quantity, purchase price, and unit cost are entered on the purchase record. If standard cost is used, an entry must be made to place the amount more or less then standard cost in the appropiate variance account. (The item for standard cost on the form is in parentheses due to the fact that it would be on the form only when the standard cost method of inventory pricing was the method in use.) There might well be another column on the purchase card to note the cost variance in the perpetual inventory records.

In this particular set of records, only the quantity of the purchase is recorded on the table called "Perpetual Inventory." Issues are also noted on this record with respect to quantity only. If issues are to be priced at standard cost, there is merely a multiplication to be made to arrive at the cost of issues to be posted on the requisition or sales order. A first-in, first-out method of pricing would require one to

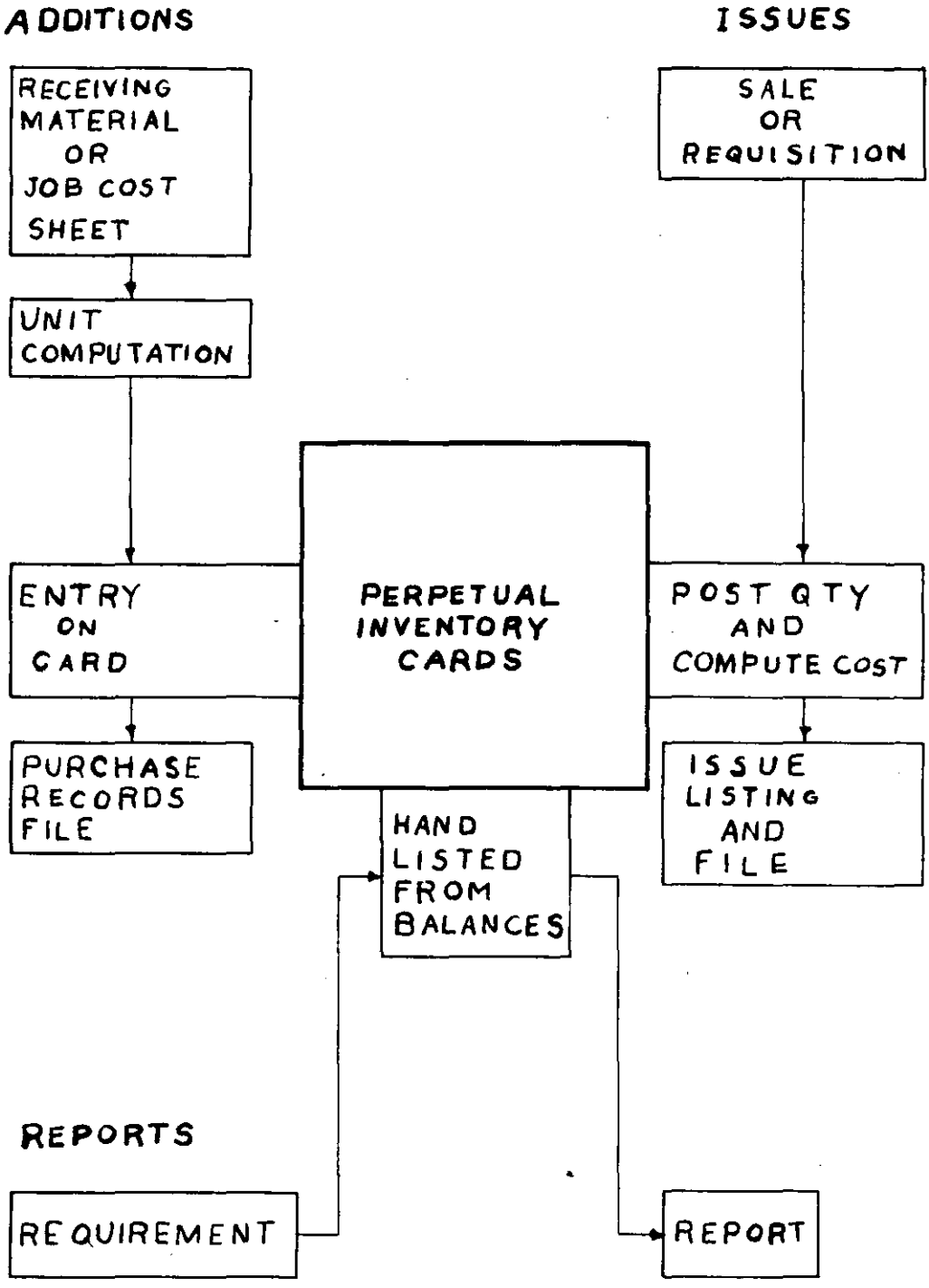
determine the inventory quantity, and then to ascertain from the Purchase Record what the appropriate cost would be. In either case, the entry to relieve the control account for inventories would be made from a summary of completed issue or sales requisitions. A better perpetual inventory card would require another column for cost balances, but this in turn requires more work for proper file maintenance.

The card for monthly consumption is merely a summary by months of the issues recorded on the perpetual inventory card. Its purpose is to aid in controlling inventories by showing the variations in monthly consumption of the item involved.

The information shown on the cards in the pocket described would b e typical of that to be found on any manual inventory records. The general operation of a system using a perpetual inventory card is shown in Figure V which reflects most of the operations that have discussed for the particular card which was illustrated.

Additions are hand posted to the perpetual inventory card from originating documents, usually receiving material. These originating documents may then go to a purchase listing or be used as the source document to debit the control account for inventories. In the case of standard cost, this listing may be modified to include the information required to adjust the variance account. This document is then filed.

FIGURE V
SYSTEM USING PERPETUAL INVENTORY CARD



Issues are posted to the perpetual inventory from the sales memorandum or requisition, the cost of the issue is computed on the card, this cost is posted to the issue document, and the quantity and cost of the issue are subtracted from the old balances to achieve the new balances. The completed issue document may be the source document for an issue listing or for a credit to the control account for inventory. If a minimum quantity was noted on the perpetual inventory card, and the quantity of the issue reduced the inventory below this specified quantity, the issue document may receive special notation or handling which will cause an order to be placed for the required goods. This issue document must then be filed. (It will be discovered that, in every system to be studied, the originating documents for each transaction must be filed; this operation will not necessarily receive mention in all subsequent cases. These documents must be maintained to conform with legal requirements and for references in case of suit, not generally as a necessary adjunct to a perpetual inventory system. Long-time record maintenance is a major problem in itself, and will not be discussed in this paper.)

Reports must be hand-listed from the records. A report requirement, either periodic or specific, is made; it is then necessary to refer to the individual cards for the desired data. The visible file equipment previously described allows visible coding of the pockets

which contain information for specific reports. This permits more rapid preparation of routine reports.

It can be seen that is relatively easy, by the visible file method or other such manually posted card methods, to keep the balances required for the inventory control type of perpetual inventory. All that would be involved would be addition and subtraction. This type or system is widely used for the inventory control type of perpetual inventory; there is more difficulty in using this type of central record for the accounting type perpetual inventory. The major difficulties are caused by the computations involved.

As shown in the description of the illustration this type of system is feasible for the first-in, first-out or standard cost methods of inventory pricing. These pricing methods seldom require involved computations and are therefore feasible for simple hand systems.

Slight modifications in the forms will allow satisfactory use of the identifiable cost and replacement cost methods of pricing. The identifiable cost method merely requires that the perpetual inventory card contain columns which identify the individual item in inventory and give its actual cost. The replacement cost method requires current entries on the card for "replacement cost," or easy access to replacement cost figures. (These would probably be noted, from some file, on the issue document previous to its arrival at the perpetual inventory files.)

The averaging, highest cost first, or last-in, first-out methods of pricing issues would be feasible using such a system, but the cost and the inherent difficulty of the computations and records keeping involved make this type of system impractical in many situations. In the case of the averaging methods, there is a division required after every acquisition. While this is not difficult in a manual system, it is time consuming and is quite conducive to possible error or guess work on the part of employees. All of the records are available for the last-in, first-out or highest cost first methods, but each issue could require a re-listing after every issue of all stock of an item currently in inventory, along with the related costs. This would be necessitated by partial issues from stock purchased at one cost and the need to reflect the remaining stock for that cost and purchase date.

The perpetual inventory card in one of its many forms is probably the most widely used item in current perpetual inventory systems. Manual systems involving such hand posted central inventory records are generally inventory control systems, but such a manually posted central record may be adapted to fit almost any purposes. Such a manual card system works best with standard cost or first-in, first-out methods of inventory pricing, but may be altered to fit others.

The chief advantage of the visible-file card over other card perpetual inventory records is the ease of access afforded by the visible name plate. It would be advantageous in situations where cards are often posted and consulted, i.e. in those situations where the time saved by better random access would pay the added equipment cost.

B. Manually Sorted Punched Card Procedures

The Manual Sorting Operation

The card was the necessary center of the manual perpetual inventory system. Maintenance of this card is the necessary central function. Since the card itself has been discussed, it is now possible to discuss the peripheral functions relating to the maintenance of this card. There are certain entries which must be made; they cannot be avoided on even the most efficient card. There may be considerable savings available in the operations which prepare the data for processing, enter it on the perpetual inventory card, and produce the reports.

One of the most inefficient and time consuming of the peripheral operations is manual sorting. For this reason, it is one of the operations that is often attacked from the point of view of improvement. One of the more efficient manual methods of sorting is the manually sorted punched card, called the Keysort or E-Z Sort Card by various manufacturers.

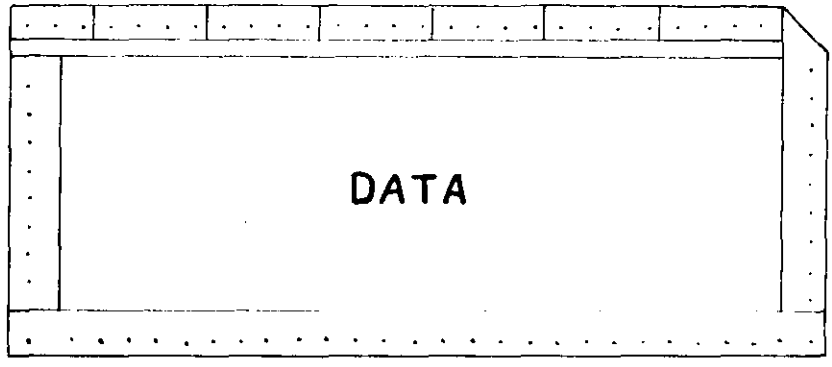
The manual sorting operation is illustrated in FigureVI. The basic data carrying medium is the card with holes around the edges. On this card the desired data is entered. Around the card, at specified locations, holes are cut out into slots; the locations are slotted in such a manner as to code certain information relative to the data on the cards.

If a number of cards are batched into a deck, a pick-like instrument can be placed into the whole deck through the small hole denoting a certain coding; the cards carrying this coding, being unsupported, will fall out. This is illustrated in Figure VI. Through the use of various simple procedures, it is possible to sort the cards into a sequence or to isolate specific cards by use of this coding.

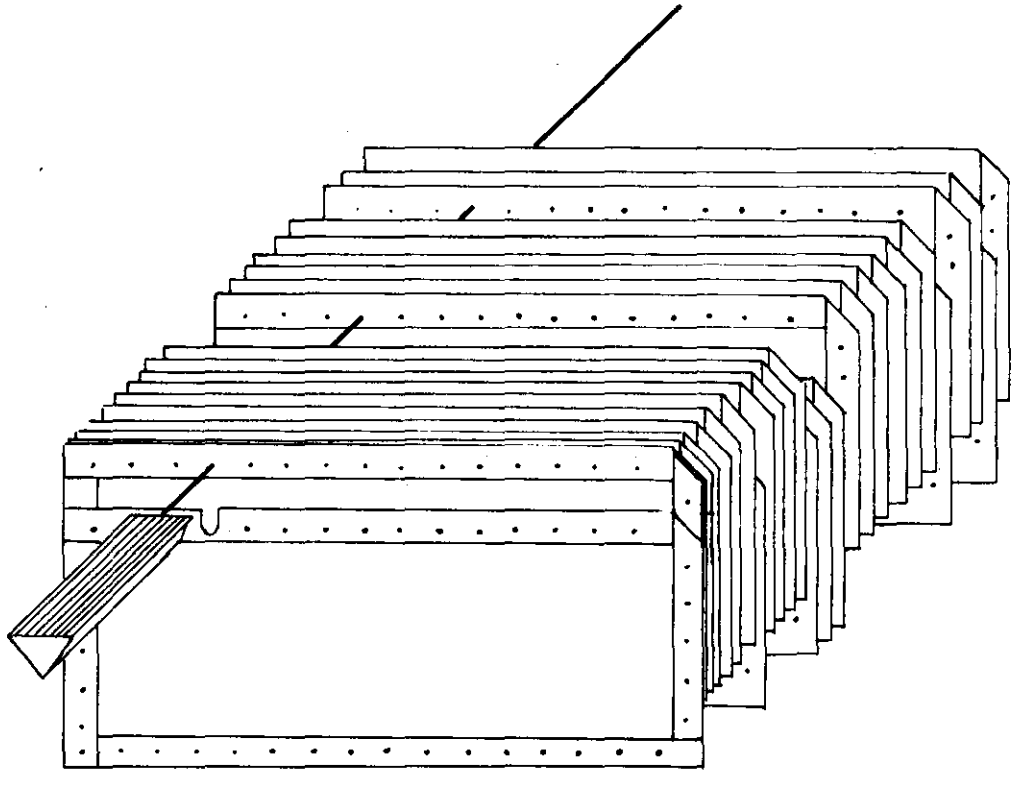
There are four broad general plans for incorporating this type of sorting into a perpetual inventory system. Three of these, which roughly parallel each other in most operations and utilize the card to perform peripheral operations, are illustrated in Figure VIII. The fourth method, which utilizes the punched card as the perpetual inventory card, is illustrated in Figure IX. Typical cards for this operation are shown in Figure VII.

THE MANUAL SORTING OPERATION
FIGURE VI

THE PUNCHED CARD



SORTING THE CARD



Inventory Card Method

The first method is most generally applicable to high cost inventories. In this method, a pre-punched card, containing much the same information as the illustrated Manual Inventory Card, is placed with every item in inventory. When the item is issued or sold, this card is forwarded to the perpetual inventory. If this is an issue to another class of inventory, a new card might be required to go with the item and could complicate the system. When the item is issued, it will be necessary to punch the account number or order number into the card.

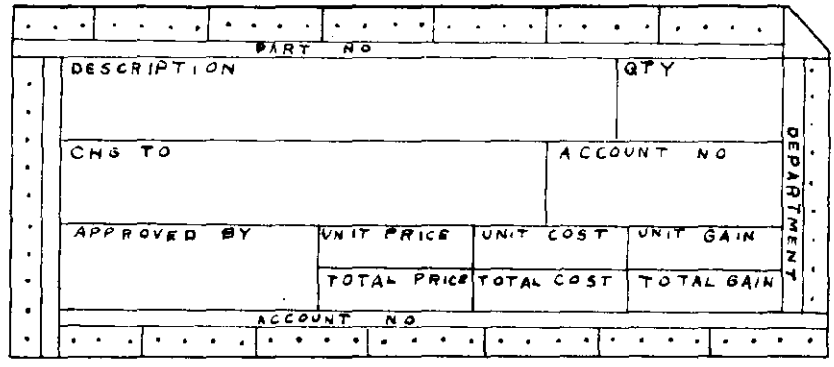
A periodic accumulation of these cards is then sorted, by sorting procedures, into part number sequence. It is then possible to approach the perpetual inventory files in a sequential order.

When the data has been posted to the perpetual inventory, the calculations made, and any required data posted back to the cards, the cards can be resorted into batches by account numbers or order number to facilitate accounting entries and to allow for more meaningful reports.

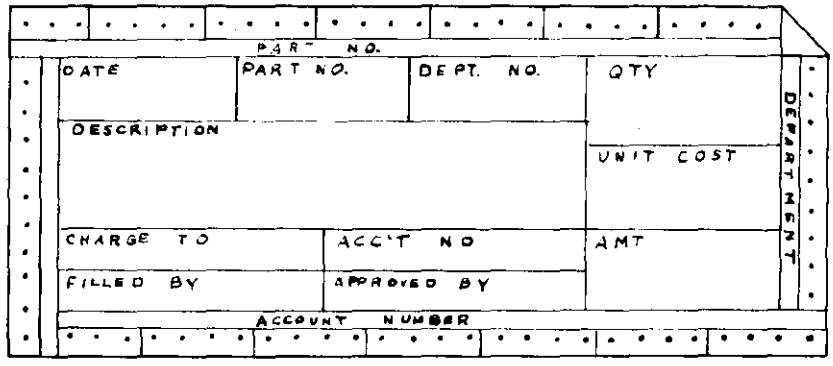
Diagrams and explanations for the handling of receipts in the first and third methods could be drawn, but they would roughly resemble the procedures for disbursements. For this reason, detailed explanations have been omitted.

MANUALSORT INVENTORY CARDS
FIGURE VII

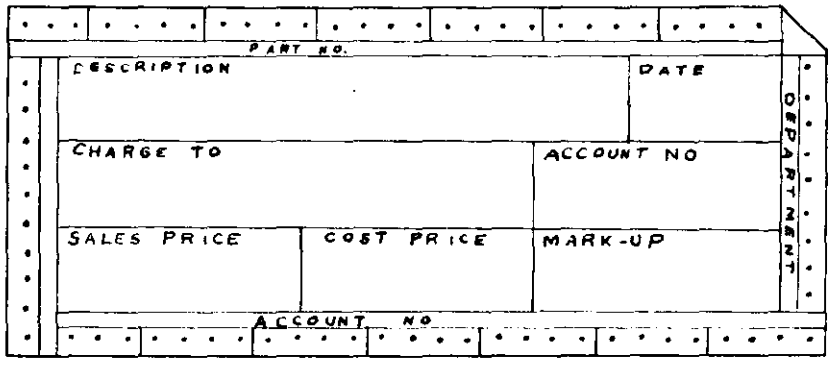
MANUALSORT INVENTORY CARD



MANUALSORT REQUISITION CARD

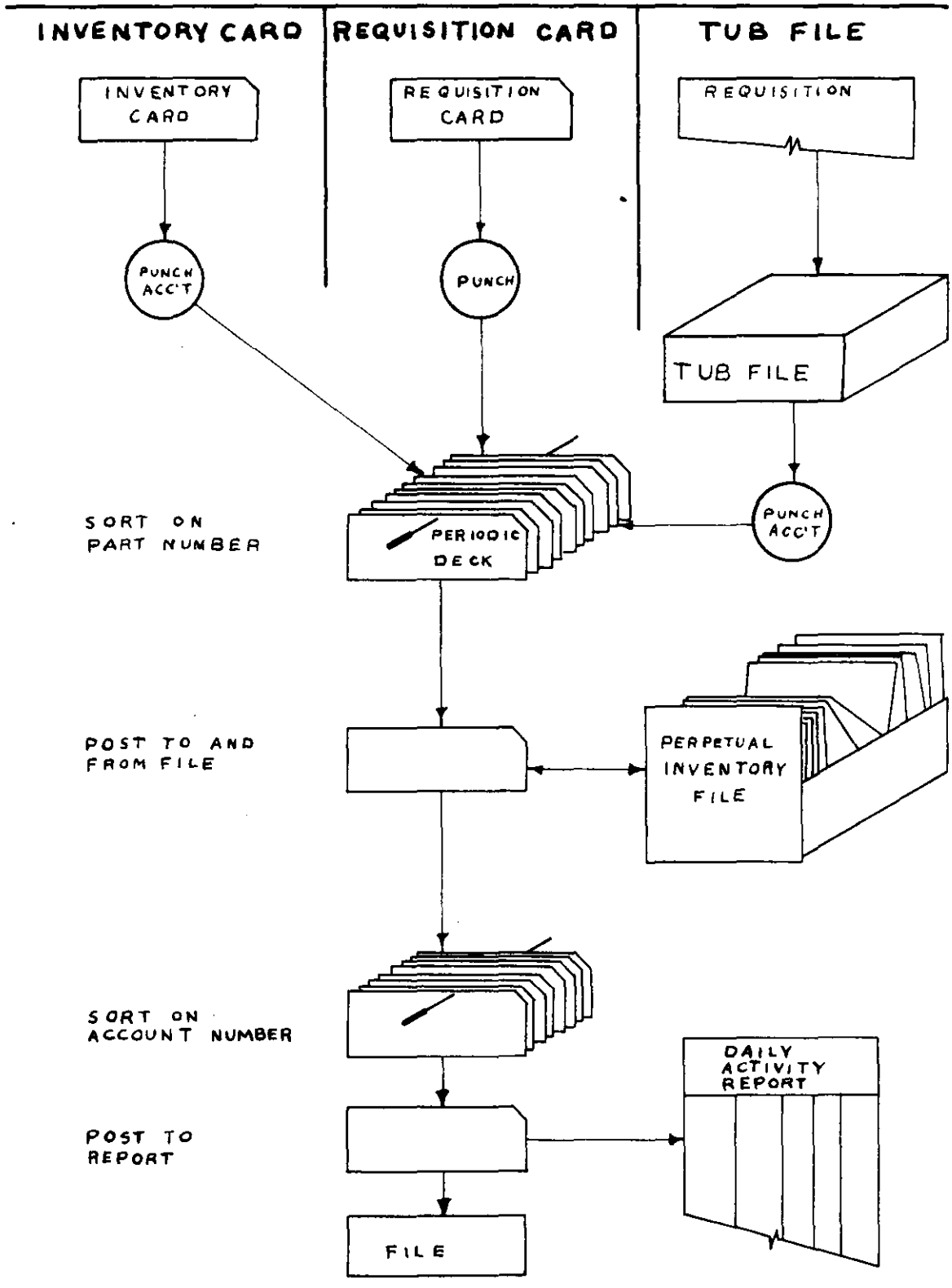


MANUALSORT TUB FILE CARD



MANUAL SORTING PROCEDURES

FIGURE VIII



Since this method implies nothing about the operations on the perpetual inventory records, it is applicable to any pricing method. Since there is a card identified with each item in inventory, it is an excellent method for the identifiable cost method of inventory pricing.

The Manual Sort Card Requisition

The major difference between the second method and the first is that the requisition itself is written on a number of cards much like the one illustrated; all of the information is written on the card. There may be a light paper and a carbon above the card, thus yeilding both an original for the issuer and the carbon to go forward. In the accounting department any necessary coding is punched into the card. This may consist of the part number, the account or order number, and such other coded information as the firm may desire.

After the card is punched, it enters into the periodic deck and follows the same course as described for the inventory card.

This method also implies nothing about the pricing method; it does not have the advantage of inherently being associated with a specific item in inventory, but an entry indicating such an association could adequately satisfy this requirement.

The Tub File Method

The basic tub file involves substantially the same operations as do the other Inventory Card method and the Manual Sort Card Requisition. Once again, the major difference is in the method of origination of the card. In this case, the requisition comes into the clerk who maintains a tub file of inventory cards. These cards maintain the basic data shown in Figure VII, and possibly more information. The file consists of a number of cards, pre-punched as to part number and other constant data, for each part carried in stock. These cards are filed in part number order.

When the clerk who maintains this file receives a completed requisition, he pulls one card of every part number on the requisition. He then posts the quantity and account number or order number to the card. The card is then punched to code any desired data such as account number, and it then passes through the same type of procedures that were outlined in the previous methods.

This method, as described, also implies no particular inventory pricing method. Its major advantages are the simplification in sorting for accounting distribution and elimination of the necessity of punching the part number in the card at the time of requisition.

If the standard cost method of pricing is involved, it would be possible to pre-print the cost and selling prices on the card before placing it in the tub file; thus eliminating some of the posting from the perpetual inventory records.

The Tub File Perpetual Inventory

The Tub File Perpetual Inventory is a rather different method from those previously illustrated, and is shown in Figure IX. In this method, the actual perpetual inventory record is a pre-punched card, one card for each individual item in inventory.

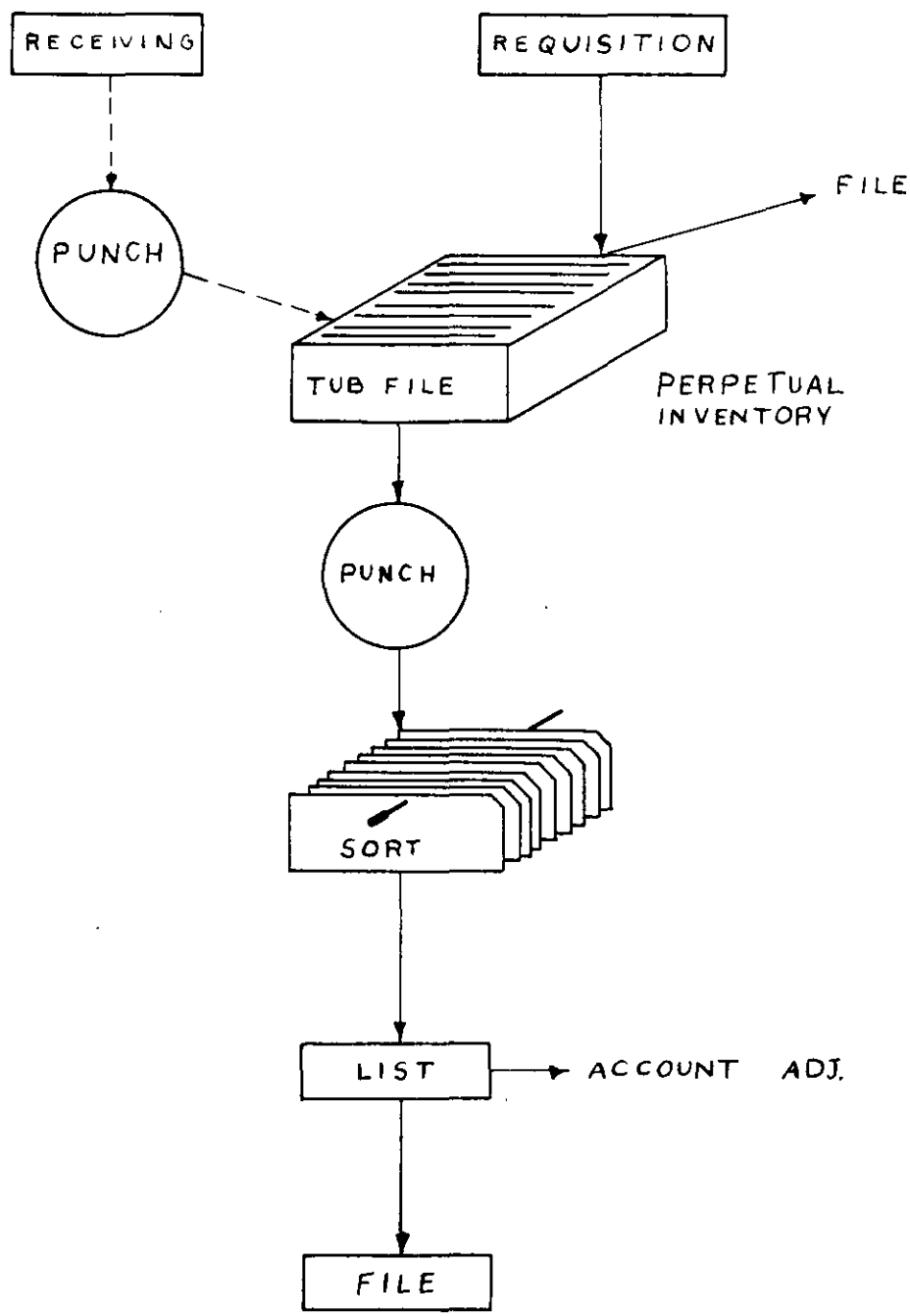
When an item is received, a punched card is prepared showing much the same data as the manual sort tub file card in Figure VII. This card is pre-punched as the part number, and any other desired constant information such as stock classification and possibly cost; it is then filed in part number order in the perpetual inventory tub file.

When a requisition is received, the cards are pulled for each item on the requisition, and any additional information such as order number is punched into the cards. (In this case, a large number of cards from the same order could be punched in a group by what is known as a "gang punch.")

The completed cards are then sorted into appropiate order to simplify listing for account adjustments, ect.

This method is particularly applicable in the case of the identifiable cost method of inventory pricing, as there is a card for each individual item; there is therefore an allowance for different costs on different items of the same part number. Major difficulties would

A MANUALSORT TUB FILE PERPETUAL INVENTORY
FIGURE IX



be encountered in applying this method to any other inventory pricing method except standard cost, due to the problems encountered in changing the prices on several cards to reflect a new average, or sorting through a number of cards to determine the oldest or the most expensive.

This is the only punched card method which tampers with the central record. The other three general methods are concerned with simplifying the surrounding operations. Economically, the method becomes more useful when the operation which it simplifies becomes more costly. Each fits best in the situation where the operation it simplifies is correspondingly more of a problem.

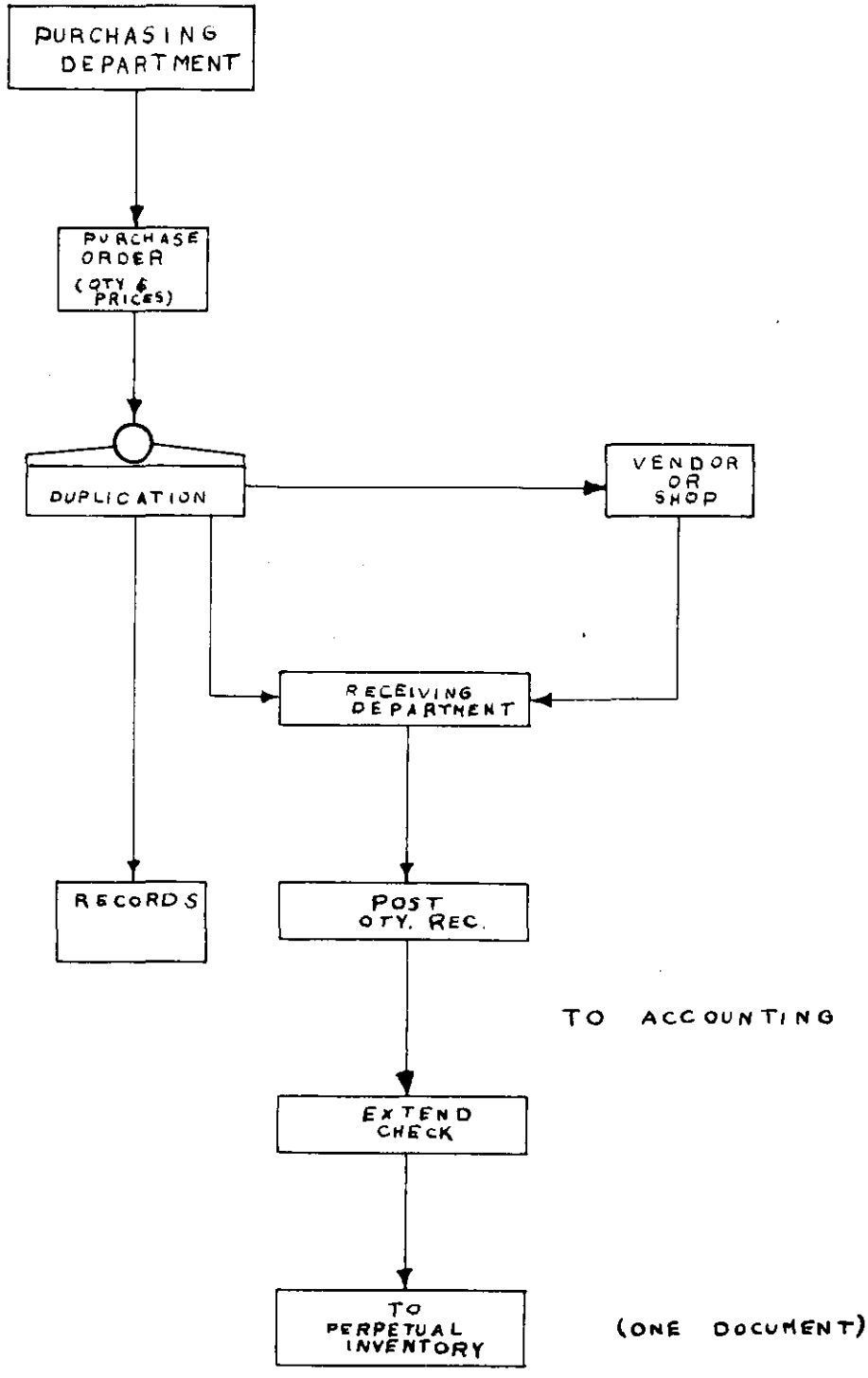
C. Applications of Duplicating Machinery

In any discussion of manual methods for maintaining a perpetual inventory, mention should be made of the economies which can be effected by the judicious use of duplicating machinery and methods. Every time an item must be copied from one form to another, there is both a waste of time and a possible chance for error. This section will discuss duplication in general, and the next section will discuss a particular configuration of equipment which allows several operations to be performed at the same time.

In designing a system, every time that one comes to a situation where a document must be produced, it is well to consider whether additional documents or portions of additional document can be created in the course of creating this document; these additional documents to be required at some later date. There is no sense in recording more than once, the same part number, description, and price; when the first entry could have been duplicated to produce the required documents, eliminating considerable work and a large chance for error.

A typical application of duplicating procedures to the perpetual inventory operation is illustrated in Figure X. The purchasing agent or the conrtol department originates a purchase order for certain items, but this order is originated in such a manner as to create several copies (carbons, dittos, mimeographs, ect.). At least two copies go forward to the vendor, if this is a purchase; or to the shop, if this is a manufacture; at least two copies go to the receiving or inspection department; and other copies are filed for the originators records. If this is a purchase, when the goods are received, the receiving department notes the quantities received on both of their copies and they forward one to the perpetual inventory with the required cost and quantity information added to it. By this method, it is necessary to refer only one document to the perpetual inventory, and this one document can be in the form most suitable for posting.

A DUPLICATING MACHINE PROCEDURE
FIGURE X



There is also much less chance for error on the document, as it is an exact duplicate of the original, with additional information appended to it.

When a number of cards are being made for the same part number, as in some of the punched card procedures, there is no reason to make several cards; it is possible to make one master, and to duplicate it the required number of times.

Even in the more complicated systems to be discussed later, one must be alert for situations where work could be simplified merely by duplicating procedures.

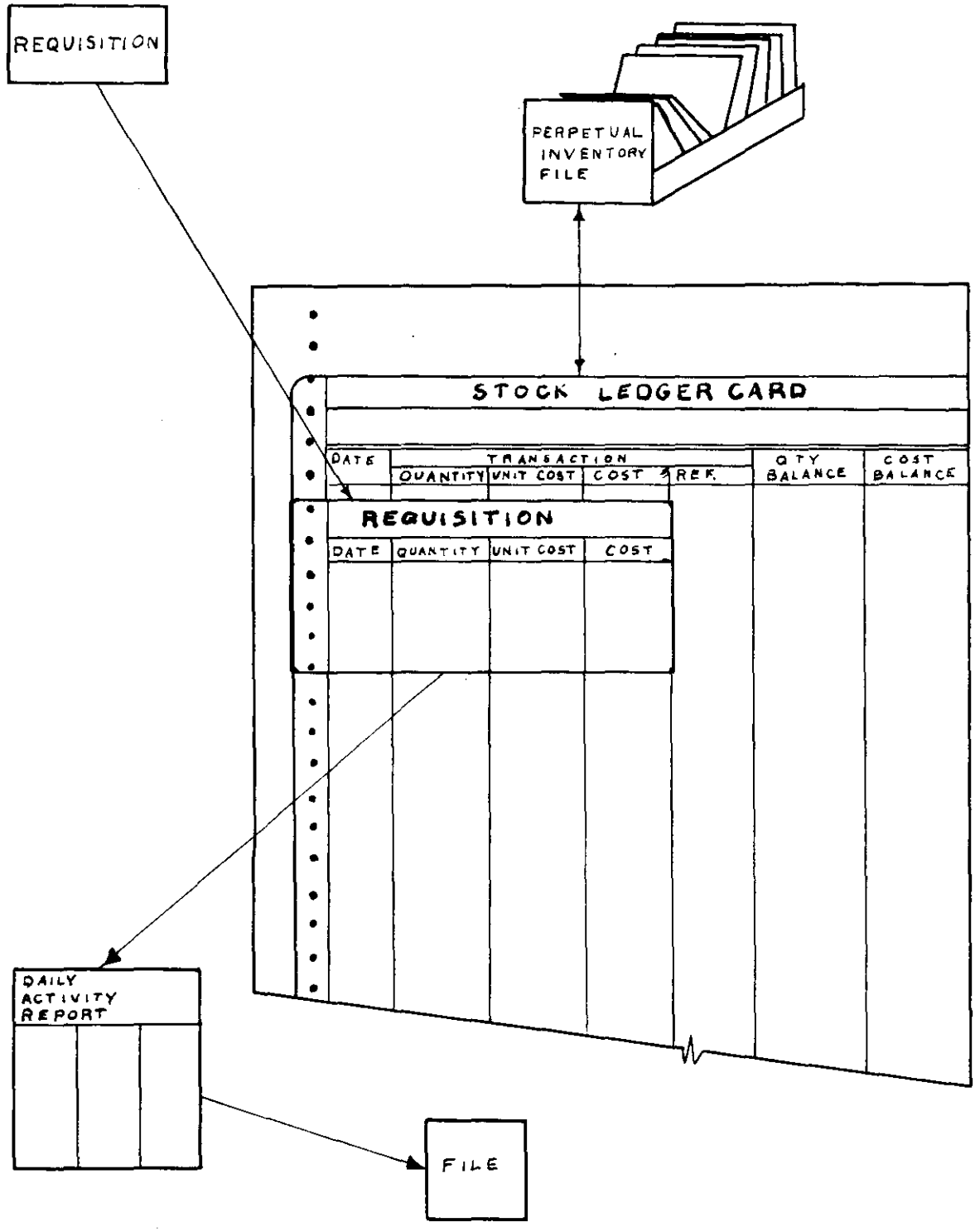
Peg Board Procedures

The peg board or "Collating Board" is a device to facilitate the posting of the same information simultaneously on several different documents.

The peg board, in most of its various forms, consists of a board, much like a drawing board, with a set of pegs sticking up on one or more sides. Special forms are designed in such a manner that, when different perforated forms which receive the same information are placed on the pegs in a specified way, they are prepositioned so that entering the data on the top form, enters it in the proper position on all forms.

This is a very general accounting method, but a specific application to perpetual inventory maintenance is illustrated in Figure XI. This particular case is that

A PEGBOARD PROCEDURE
FIGURE XI



of an issue from inventory, either a sale or an issue to manufacturing. Both the requisition form and the perpetual inventory card have perforations to fit the pegs of the peg board. When the requisition arrives at the perpetual inventory, the appropriate perpetual inventory card is pulled from the file and placed in a specified position on the peg board. The requisition is positioned on the pegs, on top of the perpetual inventory card, in such a position that the date, quantity, unit cost, and total cost columns fall directly above those of the perpetual inventory card, and in the next row to be posted. A carbon is inserted under the requisition, and the information is recorded on both forms simultaneously. This eliminates one major posting operation. This is not much, but, if the operation is done many times a day, it may be worth while.

Combinations of Manual Methods

Each of the methods discussed was useful in simplifying one aspect of the perpetual inventory problem. None of them is a system in itself. It is even possible that applications of all of these methods could be combined in one comprehensive perpetual inventory system.

In working with manual systems and simplification procedures, it is important to note that the procedure being simplified is the procedure that is significant in

the operation involved. Individual cards are useful when the identifiable cost of each item must be maintained, but in other situations they may be much too costly and involved for their worth. A sorting system is only useful when there is a significant amount of material to be sorted. Each manual system will differ greatly for these reasons, they must each be tailor made for the specific situation. There are no complete general manual systems.

Care must be taken, in evaluating a manual system for a specific application, to consider the pricing method involved. Some of the more complicated pricing methods are extremely involved and costly when certain of the manual procedures are used.

Many manual systems do simplify, and can save money. They are certainly worth investigation, before a company which is presently maintaining a simple manual system goes overboard on a more complicated and costly system.

VI. ACCOUNTING MACHINE METHODS

The accounting machine approach to the perpetual inventory problem generally retains the same type of central perpetual inventory that has previously been discussed. The conventional accounting machine, as produced by most manufacturers, is capable of the pre-positioning functions noted for the peg board, plus various changeable automatic calculations. It generally possesses a typewriter keyboard, and the capability of accumulating total "tapes" in various columns.

The calculation capabilities of the accounting machine make feasible its use with a number of the inventory pricing methods generally regarded as too complicated for the simple hand systems.

The accounting machine, in its general form, consists of a typewriter type device and a calculating mechanism. A common variation on the typewriter keyboard is to have the numerical portion in the form of the conventional "ten key" adding machine.

As in the typewriter, the document to be operated upon is placed on a carriage, as in Figure XII. The typewriter action provides the capability of making several carbons on various types of forms. It is possible to mount guides, supplied with the machine, to pre-position the forms to be operated upon. The combination of all these

capabilities permits the accounting machine to be used to achieve precisely the same results as does the peg board.

In the usual accounting machine perpetual inventory system, a single stock ledger card (or perpetual inventory card) is maintained for each item in inventory. Each posting to a specific card (record and computations of the change of status) takes up one line, filling in the appropriate columns on that line.

The calculation capability is the one that makes the accounting machine important for the perpetual inventory. The normal machine possesses two general calculation possibilities: accumulation of the total of the entries posted in a column over a period, and operation by one column on another.

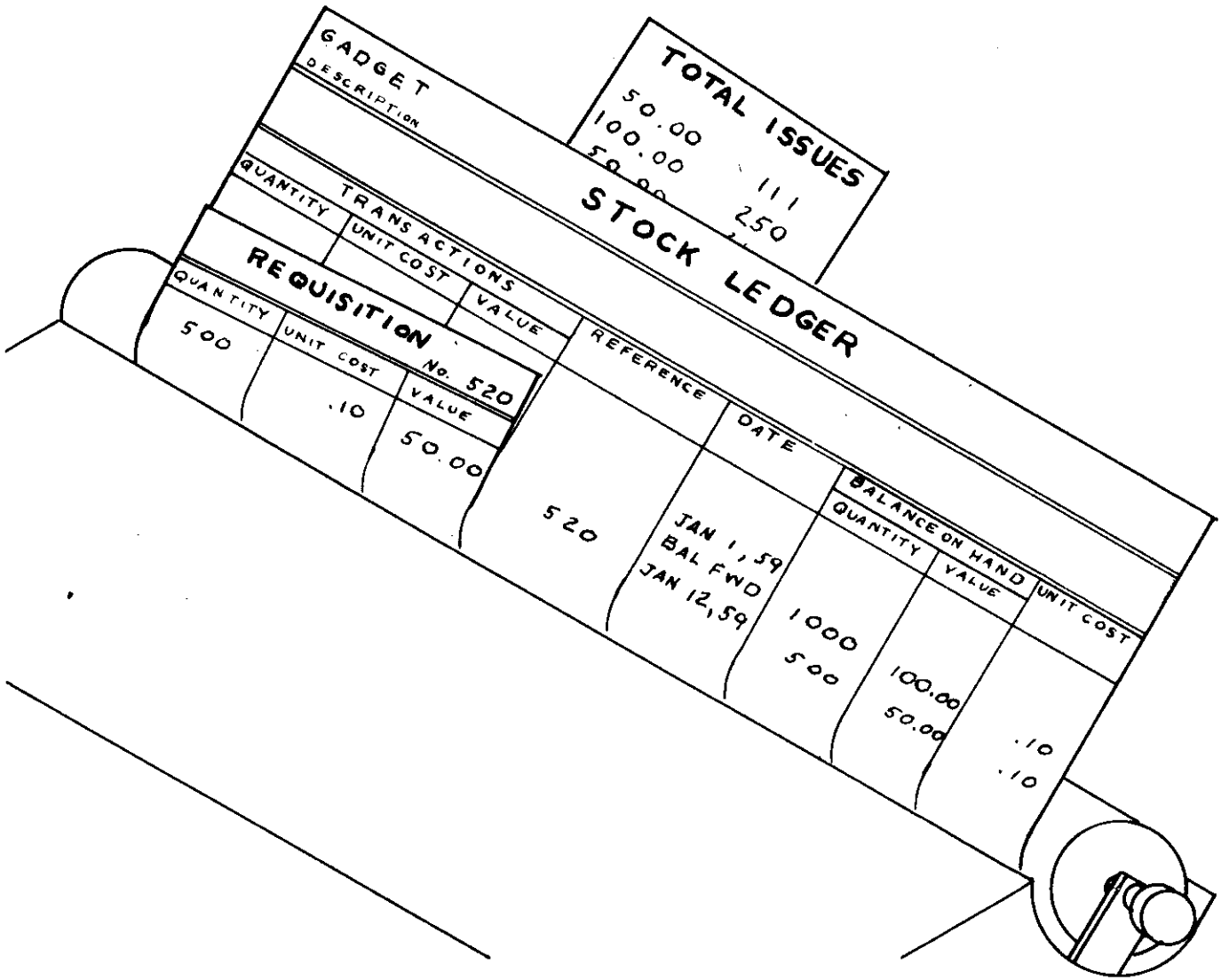
It is possible to achieve the total value of issues for a period by accumulating the total of all entries in the value column for issues for a number of perpetual inventory cards. It is also possible to run a "tape" carbon copy behind this column as a proof of this total. This can eliminate the accumulation of issue values and receipt values necessary for accounting entries and usually accomplished by comptometer or adding machine addition of the values on each document. As an alternative, such a tape can operate as a proof of this accumulation. The tape, if it includes a reference to a purchase order or requisition, provides an easy reference if questions arise at a later date.

Automatic operation by one column on another column allows, automatically, for averaging procedures, computation of variance, or computations for inventory adjustments. It is usually possible to add to, subtract from, multiply by, or divide by a figure punched into the machine, another figure punched into the machine. Any of the figures, or just the result may be printed in pre-determined positions on the cards. Directions for all these operations are set into the machine either by manipulating a control panel or by inserting plugs into some sort of a plug board arrangement. In general, these directions must be reset for each type of posting.

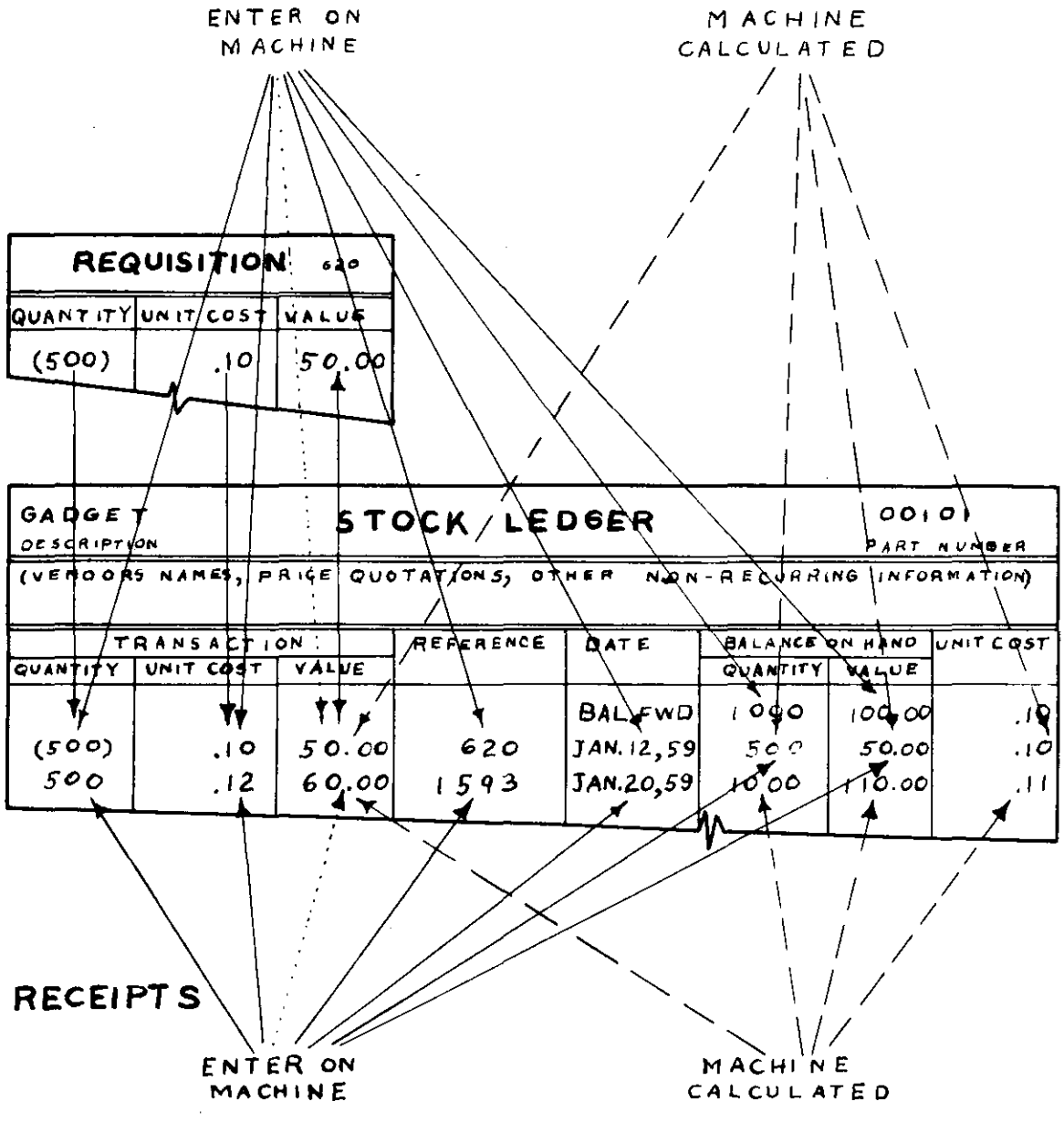
A combination of thses operations into a posting method for an average cost perpetual inventory is shown on Figures XII and XIII. Figure XIII shows the perpetual inventory card, and the entries and calculations to be made; Figure XII illustrates this particular configuration of forms, positioned in the accounting machine carriage. Usually the date may be set into the machine daily in such a way that it will print the date when a "date" key is punched.

In the case of an issue, the requisition would be inserted in front of the stock record, with a carbon in between; there would be a tape behind the stock record to record the accumulation of the total issues for a number of

THE ACCOUNTING MACHINE AS A POSITIONING DEVICE
FIGURE XII



ACCOUNTING MACHINE TRANSACTIONS
FIGURE XIII



such transactions. It would probably record both the issue value and the reference. The operator must enter the issue quantity (from the requisition) and the unit cost (from the perpetual inventory card), which are printed; the machine will then compute and print the issue value. The operator then enters the reference (from the requisition, probably the requisition number) which also prints. The operator then enters the previous quantity and value balances; the machine automatically subtracts the issue quantity and value, and prints the new balances. The unit cost may also be computed and printed as a proof - the average unit cost must be the same as the previous average, since there has been no addition to inventory. The posting is then complete, the requisition may be filed, and the perpetual inventory card returned to its file; the machine has accumulated one more account for the entry to the controlling account for inventory.

The receipt entries constitute an entirely differnet run. In this case, the receiving document is placed in front of the perpetual inventory card, with a tape under the card in the same position as that used for the issue case. The operator then enters the quantity, unit cost, and possibly the total cost of the receipts. If the total cost is not entered manually, it may be computed and printed automatically. The operator then enters the reference and the old balances; the machine

automatically computes the new balances and the new average unit cost. The posting is then complete, and the receipts can be filed. Once again, the tape has accumulated the amount for the controlling account adjustment.

This is only one example of a procedure for the use of an accounting machine for the maintenance of a perpetual inventory card. There are numerous other possibilities, but this should serve to illustrate a typical use for this type of equipment. The automatic addition-subtraction capability makes it useful in computing variances for standard cost, or for computing inventory adjustments when the inventory is carried at market or some such changeable price. The pricing methods which require keeping track of the actual items involved, or a series of specific costs, would pose a more complicated problem, but it is possible to design such simple procedures for these methods. There would be a good possibility that either a manual system or a more complex system would better suit these methods, as the accounting machine has such a limited memory and requires manual punching of all of the data for each entry.

Of the relatively simple methods, the accounting machine is probably the most versatile. It does away with the difficulties and error possibilities inherent in most of the more complicated inventory pricing methods, yet it contains features which are of use with even the simplest pricing method.

Various machines have slightly different capabilities. Machines are available with almost any number of total columns and various automatic features. Different machines have differing degrees of flexibility and complexity in the control panel. The more that is automatic about a machine, the higher, in general, the cost; and cost is an important consideration. The added cost of the features must be weighed against their additional value to the firm, but this will be discussed in greater detail in a later chapter.

An accounting machine, unlike the manual equipment previously mentioned, is a major investment for many small organizations. In many firms, the cost of an accounting machine cannot be justified wholly on the basis of its application to the perpetual inventory; it is necessary to consider other applications for the equipment. In many cases, the particular configuration of equipment required by the company will depend upon more than the requirements of the perpetual inventory. In contrast, there are many large firms which use at least some of their machines exclusively for inventory problems; here, considerably less flexibility might be required of the machine.

For many accounting machines, certain peripheral equipment is available which will adapt the accounting machines for so-called "Integrated Data Processing." This aspect will be discussed in a separate chapter on compatible equipment.

The accounting machine is a very general and adaptable piece of equipment and is, in many cases, an excellent vehicle on which to maintain a perpetual inventory. It can eliminate several posting operations, and it allows automatic computation of repetitive functions. Many large firms have found it difficult, indeed, to justify any other type of systems as being more economical or simpler. Systems designed around accounting machines have been successful, in a large part, because of the inherent simplicity of operation, and the easy access, through large, intelligible file cards, to all the information in the system.

VII. PUNCHED CARD SYSTEMS

A. Punched Card Equipment

Before discussing systems which utilize punched cards and punched card equipment, it will be necessary to sketch , very briefly, the card and the equipment to be subjected to such applications. In discussing punched card equipment, it would be well to remember that such equipment is relatively fast and costly. Several applications may be required to make the acquisition of such equipment feasible, and the requirements of these other applications may tend to limit or specify the equipment available to perform the perpetual inventory function.

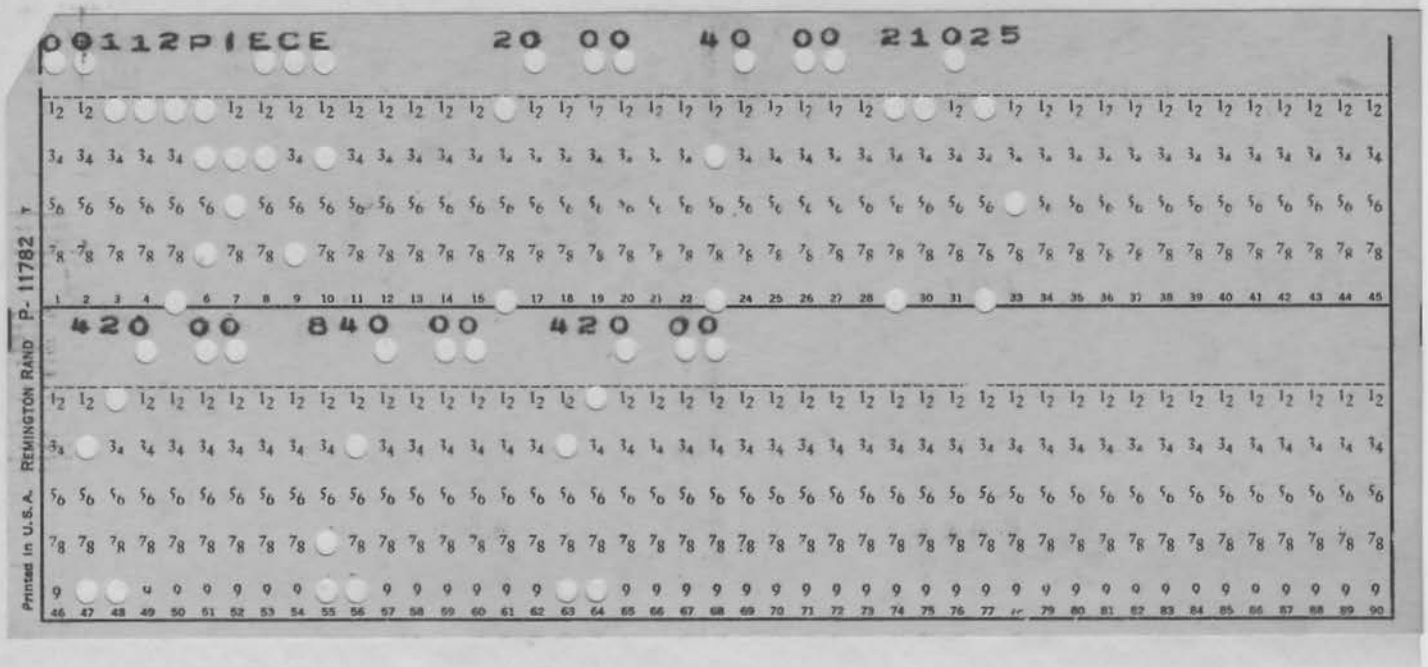
There are only a limited number of manufacturers of punched card equipment, so it will be possible to contrast slightly the products of the various manufacturers. The punched card, itself, is a card which is made of heavy stock, into which holes may be punched to code certain information. The major difference between this type of punched card and the manually sorted card is that the coding is read and operated upon by electrical or mechanical equipment. The card, as in the Keysort systems, is the basic data carrying medium.

There are three organizations which manufacture general punched card equipment; the products of each firm are slightly different, but in all cases, the cards can be

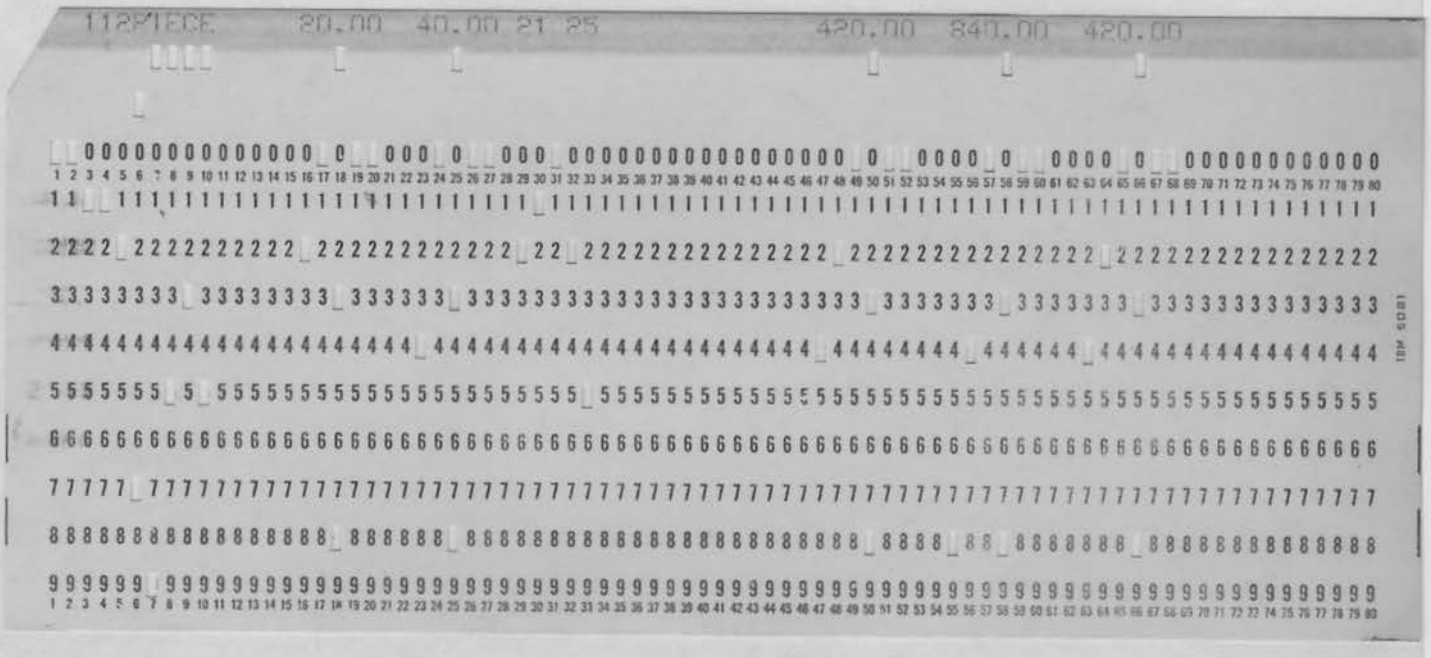
sorted and operated upon automatically. The cards utilized by these manufacturers are illustrated in Figure XIV. The most popular and widely used is the eighty column International Business Machine (IBM) card, which has rectangular punched holes as in the illustration. The Remington Rand card has circular holes and contains ninety columns of data. The Underwood-Samas punched card is much smaller than the other two, and contains either twenty-one or forty columns of data, punched into the card utilizing round holes. Since all data, as it is punched into the cards, is in coded form, it is possible to construct a machine to translate from one card to another; such machines are readily available.

A punched card installation may be rather expensive, and the choice of manufacturer may be a critical decision. Some mention will be made of advantages of one or the other type of equipment in specific applications, but a relative cost and value computation for the available equipment is always the best method of determining the equipment which is best for the job. The equipment produced by all three manufacturers is very much alike in function; to determine which system is best in a specific situation will require an examination of the functions critical to the operation and a comparison of the ability and the cost of each configuration which will perform this operation.

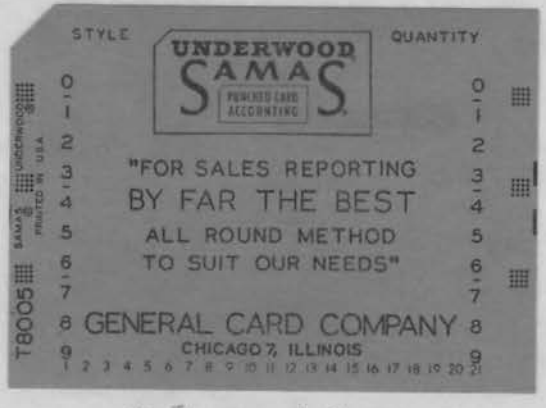
TYPICAL PUNCHED CARDS
FIGURE XIV



Remington Rand



International Business Machines (IBM)



Underwood Samas

In the general category of punched cards, there is a subdivision known generally as the "garment tag". This is a much smaller, multi-part tag which is often incorporated into retail perpetual inventories. The tag contains coded information, the same information in each part. There is a machine which will read this information and punch a larger card containing this information. There can be no operations on the card; it is possible only to punch information into the card, and to read information from the card. This garment tag type of punched card is generally used for the "inventory card" type of operation. Identifying data and possibly cost data are punched into the tag(usually in duplicate-two identical tags, divided by perforations). A set of cards is attached to each item in inventory. When an issue is made, one copy is pulled, and this is the originating document which enters the perpetual inventory system. The data is converted to whatever code is used in perpetual inventory system, and follows one of the general procedures.

There is a large body of punched card equipment which is produced by the various manufacturers. Each piece of equipment is designed to perform one or more basic functions. Before an attempt is made to combine these functions into a workable system, it will be helpful to understand each function. Each of the major manufacturers produces machines which are designed to perform the functions to be

discussed, or a combination of these functions.

The first function is a basic one, that of getting the data into the card in the first place. This is the general card punching operation. This may be accomplished by the manual keypunch or by the reproducing punch. The manual keypunch is probably the most general method. The operator has a device, somewhat like a typewriter; when he presses the keys, the machine punches the indicated holes. These keypunches come as purely manual or almost automatic, but the net result of operation is the same. The reproducing punch takes information from one card and reproduces all or part of it in another card. This machine may also have the capability to read specially coded pencil marks (mark-sensing) and reproducing the data contained in them as punched holes. The interpreter is a device which takes the punched coded information and prints it on the card in Arabic numerals and English characters, thus enabling the reader to determine the data content of the card without decoding the holes for himself. This interpretation function may or may not be an automatic part of the keypunch operation, and specific machines are available to perform this function. The verifier is merely a device to determine that the information punched is that which is desired. For the case of manual punching, it may be another device, similar to the keypunch into which the punched card is inserted. The desired data is depressed on the keyboard, and

if there is an error, the machine indicates it. For the reproducing punch, verification probably takes the form of checking circuits which are built into it.

The next function, and by far one of the most important, is that of sorting. One of the major advantages of the punched card is that it can be rapidly sorted by simple automatic machinery. The card can be sorted on any character or combination of characters punched into the card. The sorting operation is basic to almost any procedure.

The collator is a device which will interleave one set of cards into another according to some predetermined and preset criteria.

The tabulator or accounting machine is a device which will print the data which is punched in the cards in listing form, and which will accumulate and print certain totals as it lists. A summary punch is a device which will accumulate sums from a number of cards up to a predetermined point, and which will then punch a card which summarizes the data in the cards which have preceded it.

The calculator may vary from a simple calculating punch which makes one predetermined calculation over and over, to a small digital computer. The net result, as far as this chapter is concerned, is a multiplication or a division.

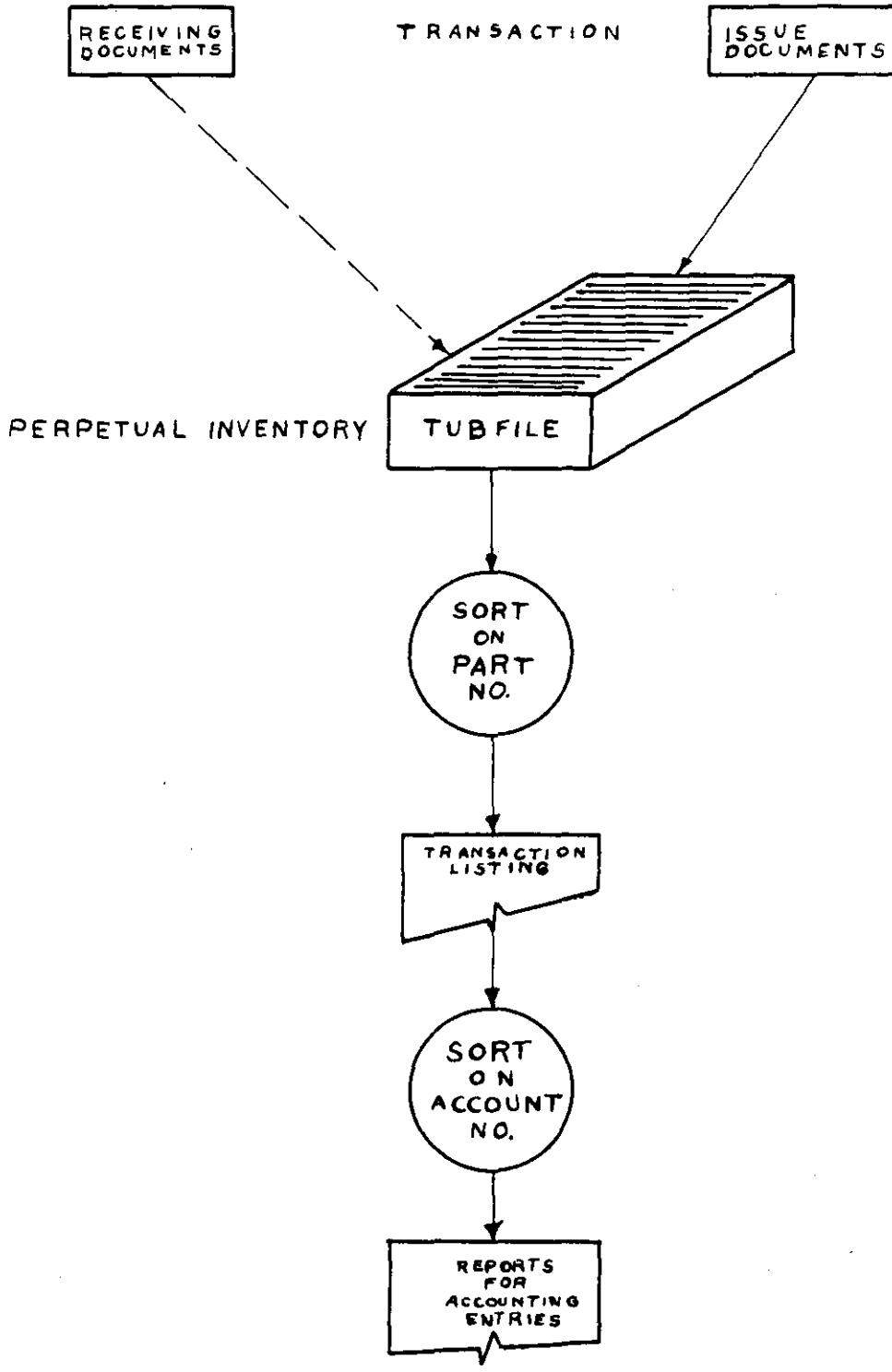
The above functions may be combined into many types of perpetual inventory systems. In the next two sections, the two general types of systems will be discussed. They constitute two entirely different approaches to the problem. Considerable modification of the procedures is common, both because of basic differences in perpetual inventory requirements, and due to the necessity of correlating perpetual inventory procedures with other punched card procedures and requirements of the firm.

B. The Tub File Method

Probably the simplest punched card method is the tub file method. It is not necessarily the best.

At the center of this method is a perpetual inventory tub file, similar to that found in the manual tub file method. This tub file contains one card for each item or economic quantity (i.e. dozen, if the item is sold only by the dozen, ect.). The description, part number, cost, possibly established price, and any other constant information are punched on the card, and interpreted across the top. The part number may be interpreted across the end of the card so that the cards may be stacked on end to conserve space. This tub file is the perpetual inventory. The operation of the perpetual inventory system is concerned with keeping this file current. A current inventory status report could be obtained merely by listing and summarizing the cards contained in this file.

TUB FILE PROCEDURES
FIGURE XV



The posting of receipts to such an inventory is a very simple operation. When an item is received, a card in the form of the perpetual inventory card is punched and interpreted for each item received. When this card is filed in the proper place in part number sequence, the posting is complete.

The posting of issues to this perpetual inventory consists of removing the appropiate cards from the tub file. When a requisition is received by the personnel charged with the maintenance of the file, they pull the proper number of cards for the indicated items, and the actual perpetual inventory posting is completed. At this time further information such as account number, order number, date, ect., may be keypunched or gang-punched into the cards.

Since cards have been pulled for each requisition, not in part number order, the cards must be sorted into part number order for a transaction listing. This is particularly important if this part number conveys some information with regard to stock classification or category. The transaction listing itself is a simple tabulating machine operation.

Another sort of the cards, this time by account number or order number allows another listing by accounts, to summarize the proper accounting entries.

This is a very simple "system", but in many cases it is an excessively costly one, and,for some pricing methods, the filing procedures would be rather more involved. The system eliminates hand sorting and hand listing, but it retains the necessity for visual access to the file to "pull" the inventory card. A large and varied inventory could make such card pulling a time consuming and costly job.

There is a card for each item in inventory, which is extremely useful if the inventory is composed of high cost items for which individual control must be maintained. For large quantity, inexpensive items, such a file would be extremely costly, and probably unnecessary.

This system will operate nicely for standard cost or identifiable cost procedures, but an averaging procedure would require a change of all cards for an item with each purchase of that item. Last-in, first-out; first-in, first-out; or highest cost first would require constant reference to dates on the cards, or filing the cards in an exact specified sequence, either of which,when done by hand, is time consuming and highly conductive to error.

The small Samas cards are particularly adaptable to this type of operation, since they are small, cheap, and take up little room.

This type of system might adapt quite to meet the needs of a jewelry wholesaler or a shoe manufacturer, but it

might prove impractical for a retailer of nuts and bolts. It is a simple, smooth functioning, system, but it possesses the limitations noted above.

C. Automatic Systems

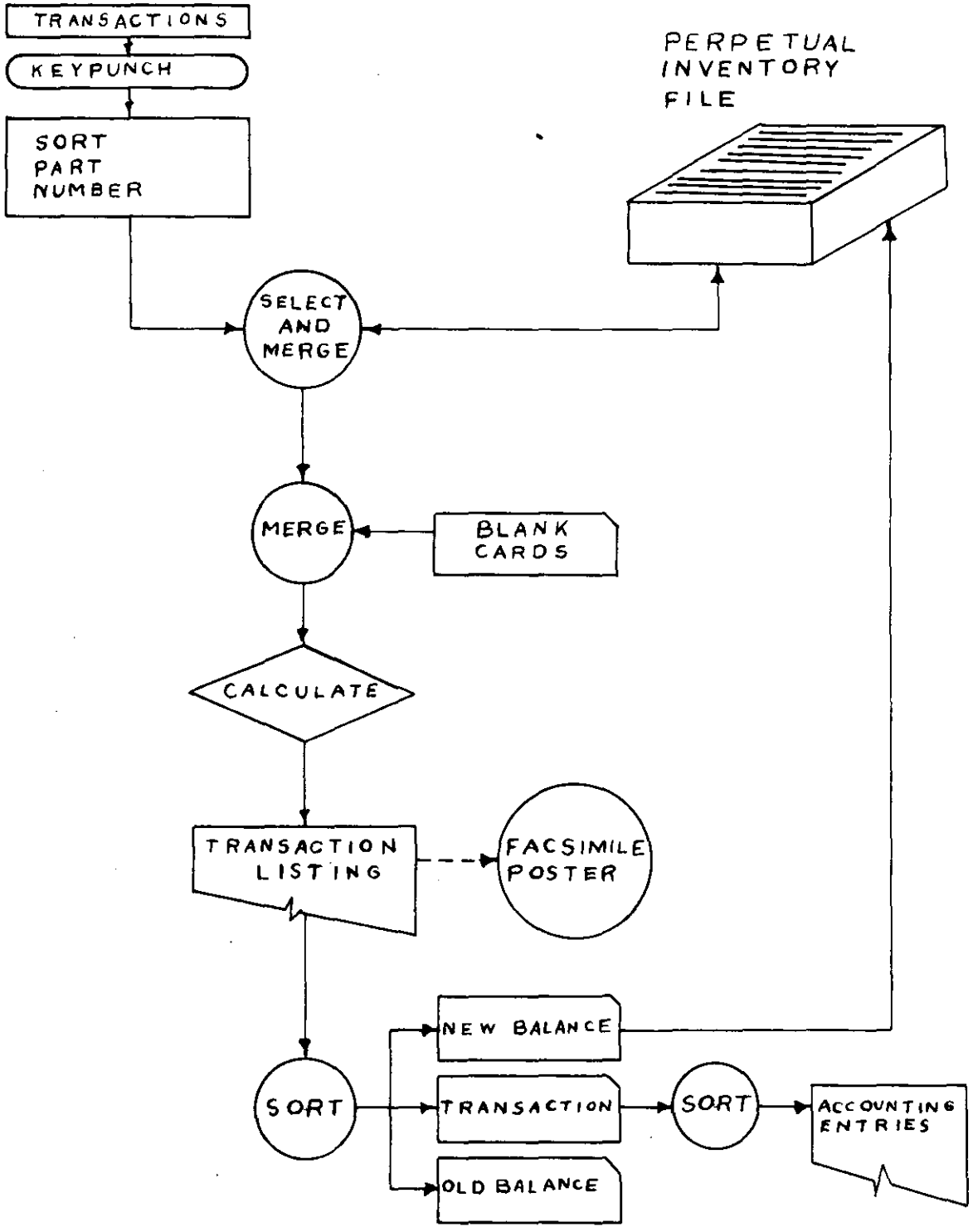
The term "automatic" in the title of this section infers that all operations on the card are automatic. All of the transportation between machines, and all machine operation is done manually, however, no visual or manual work or identification is done on the data once it has entered the system on a punched card. This type of system is often referred to as the "balance forward" approach, since one card is maintained which contains all current balances; a transaction entry substitutes, by automatic procedures, a new balance card for the old balance card.

In this case, the perpetual inventory itself is a file of punched cards. There is one or more cards for each part number; these cards contain the current quantity and cost balances, along with the constant data such as a description and a stock classification. A typical example of this method is illustrated in Figure XVI. The documents detailing the transaction enter the system either as punched cards, or as documents to be keypunched. Once the document is in punched card form, there is no more manual operation upon the data. The transaction cards are sorted by stock

number, and merged or "collated" with the corresponding part number cards in the current perpetual inventory files. A blank card (to become the new balance card) is then merged with each perpetual inventory card. The cards then proceed to the calculator, where the new balances are computed; and along with the constant data, the new balances are punched into the blank card to form the new balance card. At the same time, the unit cost, total cost, and other transaction information are punched into the transaction card. A tabulating machine listing may be made here, to show the completed transactions. The cards may then be sorted to eliminate the old balance cards (which may be destroyed), and to separate the new balance cards from the transaction cards. The transaction cards are then sorted by account number or other classification, and are listed and summarized to produce information for accounting entries. The new balance card must be merged into the perpetual inventory file to complete the cycle.

There is another possible procedure that will produce an additional visible perpetual inventory card in the form of those generally used for manual systems, and sometimes referred to as a "cost history" card. This type of card, which contains a history of all transactions with regard to the specific item, may be very useful for visual checking,and an interpretation and record of stock activity.

AN AUTOMATIC PUNCHED CARD SYSTEM
FIGURE XVI



For this case, the complete transaction listing (i.e. with old and new balances, etc.) is printed on special paper. This special paper is then run through a machine called a facsimile poster, which, by a spirit duplicating process, will print the transaction on a perpetual inventory card which is properly positioned in the machine. This is an expensive departure from automatic procedures in terms of filing cost, but the added information is often quite valuable to the firm that requires knowledge of past inventory activity.

This procedure is a very general one, and will work satisfactorily for all pricing methods except the identifiable cost method. It would, however, be possible to keep a card for each item in inventory, and match for it with every stack of individual transaction cards. If the volume of cards were high, this procedure would be extremely time consuming, and the slower tub file method would probably produce a better, more economical result.

Any other of the major pricing methods seem to be readily adaptable to use in this type of procedure, the more complicated pricing systems requiring more calculating equipment or procedures. Standard cost merely requires a simple multiplication for each transaction. The average cost method requires addition to achieve new balances, and then division to produce the new average cost.

The first-in, first-out, or last-in, first-out calculating procedures are slightly more complicated, but may still be performed on relatively simple equipment. A description of the first-in, first-out calculations will serve to illustrate this general type of procedure. An inventory card is required for each purchase lot; these cards are filed, automatically, in first-in, first-out order. Additions to inventory require only the addition of a new card to the perpetual inventory file. Issues follow the same general procedure as described, up to the point of calculation, with the exception that all balance cards for an item are merged with the transaction cards effecting that item. In the calculation operation, the calculator accumulates the issue quantity from the issue cards. The quantity of the first inventory card is tested against the issue amount. If this card contains enough units, the new balance and cost are punched into the card. If the card contains an insufficient quantity, it receives a special punch to indicate that this amount is exhausted, and the calculator continues through the perpetual inventory cards until it has satisfied the issue amount. Any further cards for this item are ignored, and the calculator goes on to another item. On a second run through the calculator, the value of issues is accumulated, issue prices are accumulated, and this information is punched into the transaction card. If, as is normally the case, one of the perpetual

inventory cards requires an altered amount, a new perpetual inventory card is punched automatically by the calculator for this particular amount at the stated price. There has been a special code punched in those cards to be eliminated, these may be sorted out by controlling on this special code.

Similar procedures are feasible for last-in, first-out and highest cost first. A procedure such as the first could easily be modified to produce the adjusting data for a replacement cost type of pricing method.

The "automatic" punched card systems provide a very general approach to the problem of maintenance of a perpetual inventory, but a high volume of transactions must be maintained to justify the cost of such an installation.

VIII. ELECTRONIC DIGITAL COMPUTER SYSTEMS

A. The Computer Mechanism

The most recently developed inventory maintenance device is the digital computer. Before outlining the two basic approaches to the perpetual inventory problem which utilize this equipment, it might be well to describe the device commonly refered to as a "digital computer." The term itself is a generic term, describing a whole family of similar devices. For the purposes of this paper, it will suffice to discuss their general family characteristics, and to mention certain special feature available on some specialized or more complex computers.

The digital computer consists of three major parts: the memory, which contains both the instructions to be followed for the operation involved, and the data to be operated upon; an accumulator or arithmetic unit, in which all computational operations take place; and an instruction reading and performing device, which reads the instructions from the memory and performs the operation in the accumulator. An apt analogy to a digital computer is that of a person, possessing no power of choice, given a set of instructions and data, and given a desk calculator. The person reads the instruction; he then performs the operation called for by the instruction, reads the next

instruction, performs that operation, etc. Since he has no power of choice, he can do only the instructions given him, and he can operate only upon the data supplied him.

The speed of operation, the size of the memory, and the number of possible instructions all vary between computers. The requirements for these items also vary from operation to operation.

The input for most computers is on magnetic tape, but some use punched paper tape, punched cards, or manual keyboard input. If magnetic tape is used, the data must be translated into this medium; if punched cards are used, the input-output operation is considerably slower. The requirements of the particular job, and the general requirements of other company operations will determine which type of input is best.

The operations inside the computer include all of the normal arithmetical computations, plus a number of comparison operations. The number and extent of these operations again varies with the computer.

It would be extremely difficult to discuss the detailed characteristics of any but the simplest digital computer, as most computers are customized to meet the specific requirements of the purchaser or renter. If a computer is to be considered, it would seem wise to determine the requirements of the firm, ascertain which

computers might satisfactorily fulfill these requirements or be modified to fulfill them, determine the cost of these configurations of equipment, and make the necessary cost computations.

The computer itself consists of a memory, an arithmatic unit, and a control unit. Its chief advantage is tremendous speed and flexibility in making calculations. The firm may or may not be able to economically utilize these capabilities.

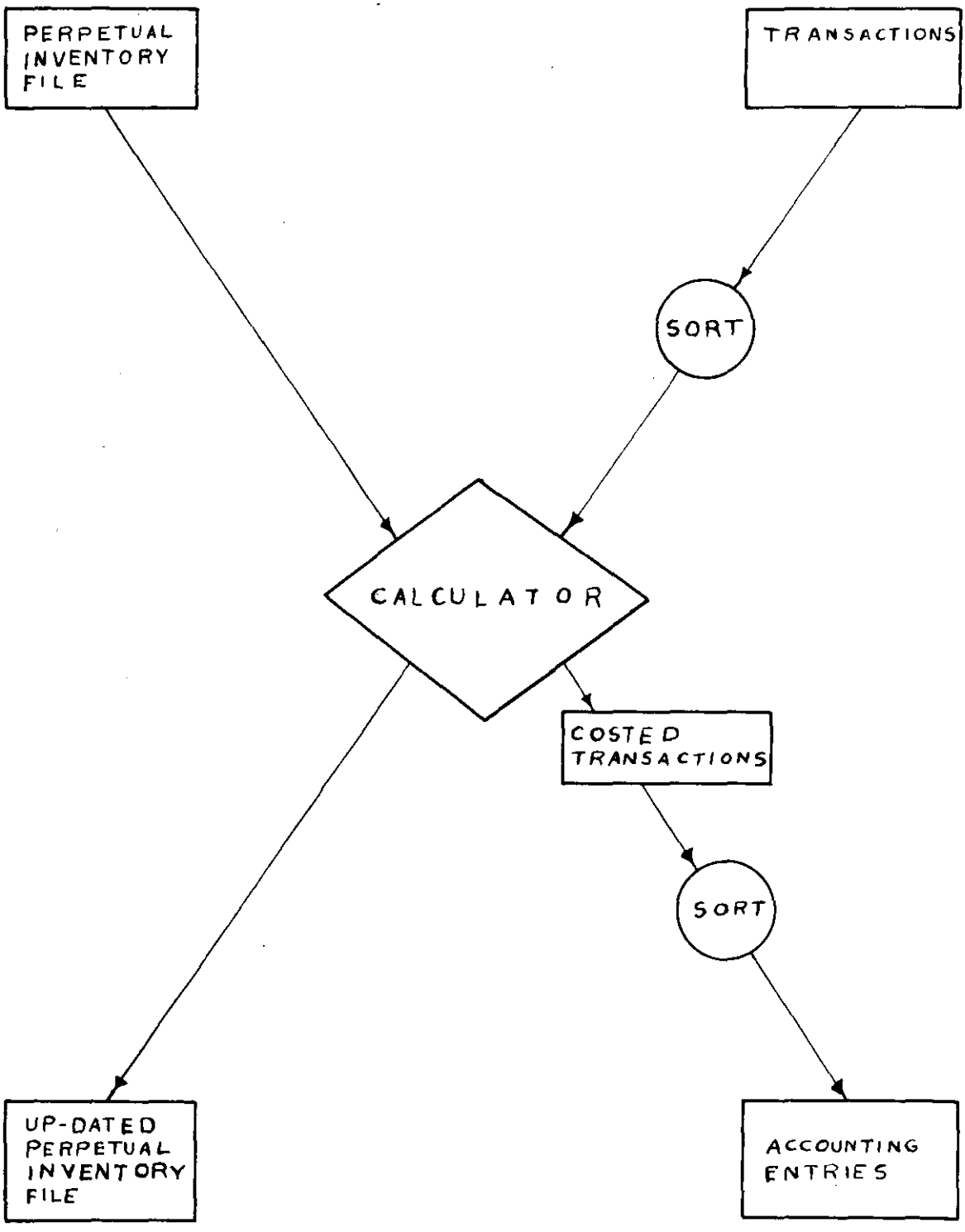
B. Periodic Processing

The discussion of computers, as applied to perpetual inventory maintenance, can be divided into two general areas: the periodic processing of perpetual inventory data on a general purpose machine, and the operation involved in constant, on-line perpetual inventory maintenance. The first involves a machine which must be used to perform several operations for the firm; the second involves a special purpose device which is concerned with nothing other than maintenance of the perpetual inventory.

The usual procedures for the maintenance of a perpetual inventory on a general purpose machine are not unlike those for the systems previously discussed, as can be noted in Figure XVII. The perpetual inventory file is

PERPETUAL INVENTORY ON A GENERAL PURPOSE DIGITAL COMPUTER

FIGURE XVII



in part number sequence, probably on magnetic tape. The first major operation is to sort the transactions into part number sequence (which is normally done with punched cards, as large scale sorting operations tend to be clumsy on a general purpose computer), and to record them on a medium suitable for computer operation , in this case magnetic tape. The machine is given certain instructions with regard to how the tapes shall be processed; once the operation has started, it proceeds automatically. In this case, the computer reads the first transaction part number, and sorts through the perpetual inventory file tape until it arrives at the proper part number. The computations are then performed; the type of computation performed being almost wholly analagous to those performed in the automatic punched card method. A new, updated balance is placed on the perpetual inventory tape, and any information desired for reports is recorded on still another tape. This procedure then repeats itself until all of the transactions have been posted. The report tape can then be sorted, or printed as is, to yield any data required for accounting entries.

Once the sorting for account entries has been accomplished (and this may make use of equipment other than the computer), the operation is completed. This constitutes a very simple computer operation; the only justification for utilizing a computer lies in the speed

of computations and the savings thereby available when there is a large mass of transactions to be posted. It is an operation which can usually readily be programmed on a general purpose computer, but which is seldom important enough to justify , in itself, the expense involved in the acquisition of a digital computer.

C. Constant Inventory Maintenance

The other general type of system utilizing a computer for perpetual inventory maintenance involves the use of a special purpose computer which is used for constant, instantaneous perpetual inventory maintenance. (The term "special purpose computer" means either one which is indeed built for this special purpose, or a conventional general purpose machine which has been modified for this purpose.) This is an entirely different type of operation from that first mentioned, nad is practical only in those cases where perpetual inventory maintenance is such a problem as to warrent this expenditure on inventory alone.

The operation of a typical special purpose inventory computer might best be illustrated by reference back to Figure II, which shows the perpetual inventory process in detail. The special purpose machine constantly performs the whole illustrated procedure. Units to perform all of the illustrated functions are built into the machine. The most important single point about such a system is that all

quantity and cost balances are maintained in the memory of the computer. This yields what is known as "immediate random access". If the machine is queried about any balance, this balance is immediately available without the necessity of proceeding sequentially through the data, which operation would be the case if the information were contained somewhere on a roll of magnetic tape. When a part number is specified, immediate contact with the balance is available.

The machine records any transaction almost instantaneously, and probably produces a transaction tape for the record. Because of the amount of data and the speed of processing, this type of operation does not lend itself to detailed account distributions. If only a few accounts are involved, such distributions are possible utilizing tapes for each account which would be posted along with each transaction. If a number of accounts are involved, memory locations may be designed for each account, and the balance only for the account is maintained in this location. The drawback to the memory location approach is that no readily accessible document is available to show the detail of the account distributions.

The actual input to such a machine may be from either one or several sources. If the input is from one single device, there is, of course, some limitation on the amount of data which can be entered in a given period of time. The use of such a system will, however, yield the speed of calculation and the convenience of immediate access. If immediate posting is required after every transaction, then more than one input would, indeed, be useful.

If such a special purpose machine has multiple input and referencing capabilities, there would probably be a number of entry machines or devices, all having access to the memory, with a device to keep their signals from conflicting. These read-in, read-out facilities could be spaced in many ways; they could all be in the same area, or they could be widely spaced and connected by wire.

The output reports from this type of system may be in almost any form, and consist of a printing out of the contents of the memory, or of a translation of account tapes.

These are special purpose machines but many -particularly parts suppliers, and others, with large and varied inventories-companies have a perpetual inventory problem so acute as to suggest such a system. The knowledge that such equipment is available may be helpful in considering difficult perpetual inventory problems.

The digital computer is an extremely expensive item; a perpetual inventory is an operation that can be easily programmed on almost any general purpose computer, and for which special equipment is readily available. The major problem is to determine whether the value received exceeds the expense required.

IX. COMPATIBLE SYSTEMS

A. Multiple Use of the Same Information

In the general operation of the firm, all divisions have, necessarily, to deal with essentially the same basic data. Each division uses it or processes it in a slightly different manner. When a purchase is made, at least a portion of the data regarding the purchase is required by the purchasing department, the receiving department, the accounting department, and probably the "planning" or "production" department. A sale affects the sales department, the shipping department, the accounting department, and the purchasing or planning department. The same situation holds true for most transactions or actions of the firm; every action, almost invariably, involves data which must be processed into information for more that one consumer, each consumer having his own specific requirements.

In the introduction, the all too common dual perpetual inventory situation was noted; both the accounting department and the production department maintaining their own perpetual inventory. The production department has certain requirements which its perpetual inventory supply; the accounting department has certain other requirements which its perpetual inventory must satisfy. The production perpetual inventory is concerned,

in the main, with inventory control problems and contains special information concerning such items as reorder points and economic lot quantities; the accounting perpetual inventory contains the relevant cost data; they both contain the quantity data. A considerable duplication of effort is inherent in any such dual operation.

The concept of so-called "integrated data processing" is concerned with combining all these separate requirements into one unified system. It is aimed at the elimination of duplication of effort, and thereby the reduction of costs. If a certain computation is necessary for several different purposes, this is no justification for making the computation several different times. It might be possible to so arrange the system, that this computation is made once, before the data is passed on for the more specific operations.

As was emphasized when duplicating equipment was being discussed, there is no reward for performing the same operation twice when one operation might have satisfied both requirements.

B. The Concept of a Common Language Medium

The development of modern electronic and mechanical equipment required the use of symbolic, coded input and output. Holes in a card, holes in paper tape, or magnetized spots on a tape carry the data; this is the only type of data that the machine can read.

The symbols are coded groups of marks and spaces, or charges and no charges. It is relatively easy, by use of some sort of translation device, to transfer the information in one symbolic code to another symbolic code. This is the major point in most modern integrated data processing schemes; once the original data is recorded in coded form, in a so-called "common language" or machine language, there need be no further manual transcription of the data. The information can be read many times, by many machines, for many separate operations.

The normal common language media are punched cards, punched tape and magnetic tape. The coded data may be created by a punch or code operation, or it may be created as a byproduct of an accounting machine operation. Since the accounting machine operates on the data within its mechanism, it must contain the data in coded form. This coded form can be reproduced in a punched tape or card simultaneously with the normal machine calculations and entries. It is merely a machine wiring problem to select for reproduction only certain data to be recorded on the common language medium. There are numerous devices available to translate information from one particular coded language into another.

The rush to integrated data processing began in the late 1940's when some enterprising person noted this obvious translation capability of the symbolically coded machinery.. The key to such a system was the five-channel punched teletype tape, which could readily be transmitted over existing teletype facilities. This meant that the system could be extended to, or close to, the transaction point. The processing at the point of origination of the data could be done on equipment which created common language data, and this data could be relayed by teletype or by mailing a roll of tape to any consumer of the information. Along with the transmission capability there is an automatic reproduction capability inherent in the entire operation. Punched cards could be reproduced easily, but their bulk and weight made long distance transmission expensive. Tape could be transported easily, or transmitted, and, at the destination, it could be translated into punched cards.

Given common language devices, it is necessary to develop an overall system, encompassing not just the perpetual inventory, but all functions which related to it or to the data required by it or produced by it. This is no longer an accounting or a control problem , it is now a unified problem. The data and the information resulting from processing must be produced in such a form as to satisfy the needs of all.

This would seem to be the overall aim of the systems designer, to design a system which encompasses all requirements with no duplication of effort and producing no extraneous material. The perpetual inventory is just one segment of the overall problem. This segment, however, probably takes the form of one of the punched card or computer systems mentioned previously; its input is already in usable form when received, otherwise, there would be few differences.

C. Illustration of Integrated Data Processing

It should be obvious that each integrated data processing installation is a "custom" installation. There is no basic integrated data processing system. The very justification for such a system is the fact that there is a tremendous volume of data to be processed; the data and requirement will vary between firms, therefore the system must be unique for each firm.

A typical integrated data processing sequence is illustrated in the following description of a sales transaction and the processing of the data produced by the sale. This is only one of the transactions that affect the perpetual inventory, and the perpetual inventory is only a small part of the operation.

When a sale is made, the sales slip is typed on a machine which also produces a punched tape, recording all of the information typed on the sales slip in the preselected tape format. This information goes by teletype to the warehouse, where an identical tape is produced. The items of the sale are readied for shipment, and any corrections to the tape due to shortages, backorders, ect. are made; the tape is then run through a preset accounting machine to print the information contained on the tape in the form for the bill of lading and the packing slip. The information is then transmitted to the home office, where the punched tape is placed in an accounting machine, and the machine produces an invoice by reproducing the information on the tape, and extending the unit cost times quantity on both the invoice and on the tape.

The tape is then available as input for the perpetual inventory system, for a sales report, and for any other purpose. The importance of such a system to the perpetual inventory is in its capability to get the required information to the perpetual inventory system rapidly and in a form that can be readily processed. If the perpetual inventory system is prepared to accept and process data in the form available from the integrated data processing system, there is no real modification to the perpetual inventory system for such operations.

The advantages of such a system are both the savings realized by eliminating the costs of unnecessary duplication and processing, and the competetive advantage of such a system both in speed and in service to the customer. If information on a failing is immediately available, immediate action can be taken to correct it.

X. COST CALCULATIONS

A. General Cost Considerations

After it has been decided that a perpetual inventory is a useful thing, and after the various systems have been examined, the question arises, "Which one, if any to select?" The answer to the question, "Which one?" lies in relative cost calculations; the answer with regard to whether to maintain a perpetual inventory in the first place, is rather more subjective.

The details of the reasons for maintaining a perpetual inventory have been summarized in Chapter II. The objectives of this chapter will be to investigate the factors which must be considered in determining the relative costs of various perpetual inventory systems.

The usual stated reason for any improvement is to lower cost and raise profits. An objective manner of getting at the costs and virtues of increasingly complicated systems would be by examining the various stated advantages of system improvements. A survey by Robert F. McLaren gives the following specific reasons for changing management information producing systems*:

> "1. To produce savings in the method of handling work.
>
> 2. To simplify handling and processing of voluminous and complex jobs.

*16 p. 8.

3. To provide a system that would permit basic data to be used in many ways for better overall information.

4. To insure that the work was done by the most accurate method possible.

5. To obtain faster results of operations to meet deadlines and to provide information when it is timely enough to be significant."

The first two items lend themselves to objective measurement, and will be discussed in detail in the next section. The third item brings in the subject of integrated data processing. The study for the installation of such a system must be extensive, and cannot be discussed here; it should suffice to recognize that if, after a detailed study, it is determined that such a system is to be installed, it will effect the perpetual inventory system. The data generally a part of such a system includes the basic data necessary for the maintenance of the perpetual inventory, therefore, the perpetual inventory system in any specific case must be adaptable to the specific integrated data processing scheme in use.

The other two items involve, in a large part, subjective judgements. Their value is not subject to exact analytical examination. These items may place an added value on a more expensive perpetual inventory system and make it more acceptable. The cost of inaccurate work is difficult to measure, but there is no doubt that such a cost exists. If the perpetual inventory lists a zero balance for an item, when actually there is

an overage, and more is ordered on this basis, there is a cost, a cost that is wasteful in terms of firm assets. No general rules can be made for measuring the losses due to error, but this is an item which must be taken into consideration in evaluating a manual system against a more error proof automatic system.

The importance of timely information can only be estimated by the man who receives the report. The loss incurred by lack of knowledge is in many cases a supposition or an outright guess. That there is often a loss due to lack of information is undoubted, however there is always some question as to the usefulness of all the reports produced for management.

These two factors, accuracy and timeliness, are difficult to judge, but they are most certainly relevent to any cost determination. These terms will be lumped, together with the value of any other special features, in a category to be refered to as "added value" The value of flexibility in the system, the negative quality of possible obsolescence, and the growth possibilities of the system will also enter into this term.

Relative cost computations have been mentioned throughout this paper, it is now necessary to specify just exactly what is meant by this terminology. This may be summarized in the following equation:

$$\text{relative cost} = \frac{\text{computable cost/yr} - \text{added value/ yr}}{\text{base cost/yr}}$$

In examining this equation, it must first be recognised that a "relative" figure must be tied to some "base" figure to which it is relative. In this case, the base for any given set of computations must be constant, but it can be the cost of any simple system. The added value term is the sum of the values of all of the less objectively measureable aspects of the plan. The computable cost is the measureable cost of the system. The added value of each system is subtracted from this cost to give the cost figure relative to the cost of other systems under examination. The actual cost of two systems might be the same, but if one produces correct, timely information, while the other does not produce the information until it is useless, there is definitely an added cost to the second system; that of not having the information on time.

B. The Measureable Costs

The items which have not yet been discussed are the tangible cost and expenses of operating a perpetual inventory system. These are readily calculated, and are necessary for almost any rational appraisal of competetive systems. The computable cost term is the sum of all these costs.

The two terms which immediately come to mind in any such determination are "labor" and "materials." Labor may or may not be a major factor, and the actual productive labor time to be utilized on any system is

reasonably easy to estimate. In a manual operation, it takes a clerk a certain amount of time to perform an operation; there are a certain number of operations to be performed; multiplication will yeild an answer. Other factors, such as efficiency of use of labor,,are important, but this type of overhead computation is not an unusual one. Another labor item to consider is the cost of training. It is relatively low for a visual card file system, but high for a computer installation. This cost must be written off over the expected tenure of the employee. There are also the normal overhead costs for labor; all of these entering the labor cost picture.

The cost of buying or renting the equipment must enter the calculations. In the more expensive installations, the interest that could have been earned by the productive investment of the equipment expenditure must be considered. Any modifications to the building such as strengthening foundations or airconditioning must be included in the calculations.

It must be understood that the computations being made are yearly computations, and that any long-term investments in the system must be amortized over the estimated life of the system. There is also another relevant computation, and that is an out of pocket cost computation. This is exactly what it means, the cash necessary to acquire the system in working condition

XI. SUMMARY

The production of management information was introduced as a major business problem, and this paper has discussed the perpetual inventory problem as one aspect of this major overall problem.

It was established that, in many cases a perpetual inventory was valuable, and certain specific reasons were given for the necessity of maintaining a perpetual inventory in terms of both quantities and costs. The decision as to whether a perpetual inventory is necessary must be made by comparing the usefulness of the perpetual inventory with its probable cost. Some firms may not require the extravagance of a perpetual inventory, but most firms of any size have a mass of material to control that is so large as to require the maintenance of a perpetual inventory.

If the decision was made to have a perpetual inventory, it was then necessary to set up the functional criteria to which the system must conform. The study of these criteria consisted of a discussion of the inventory pricing methods with which the system might have to deal, and with a detailed examination of the steps in the perpetual inventory process.

A cross section of the major perpetual inventory systems was then discussed to illustrate how each system

goes about fulfilling the requirements previously specified. Each system has its own specific virtues and weak points. In particular, some of the simpler hand systems become extremely awkward to use in connection with the more complicated pricing systems. The volume and type of inventory transactions will also do much to specify the type of system.

The overall systems situation and systems plans of the firm were other important factors. The presence of equipment which could be utilized for perpetual inventory maintenance, with no additional outlay, may well dictate the general form of the perpetual inventory system. The integration of the perpetual inventory information and other information from the same sources into a comprehensive integrated data processing system is also another possible consideration.

The all important items of cost and value were covered were mentioned last. Because of the wide variety of operations, the diverse types of equipment available, and the common necessity of adapting the system in some manner to the equipment existing to fulfill other requirements, no attempt was made to specify costs for specific systems. The usual costs run roughly in the order in which the systems were presented, but many factors can effect these costs.

Rather than attempt to detail the costs, a procedure for judging such costs was set down. The optimum system in a given set of circumstances was the system that gave the relative cost in the following equation (the answer would be one or less).

$$\text{relative cost} = \frac{\text{computable cost/yr-added value/yr}}{\text{base cost/yr}}$$

This met the end objective of this paper: a program which would lead to a more intelligent selection of perpetual inventory systems. This program consists of:

1. An examination of the information actually required.
2. A study of those systems which could economically satisfy those requirements.
3. Relative cost computations to determine the optimum systems.
4. A decision as to system, based on the relative cost calculations, the overall systems plans of the firm, and the relative importance of the perpetual inventory to the information problems of the firm.

APPENDIX

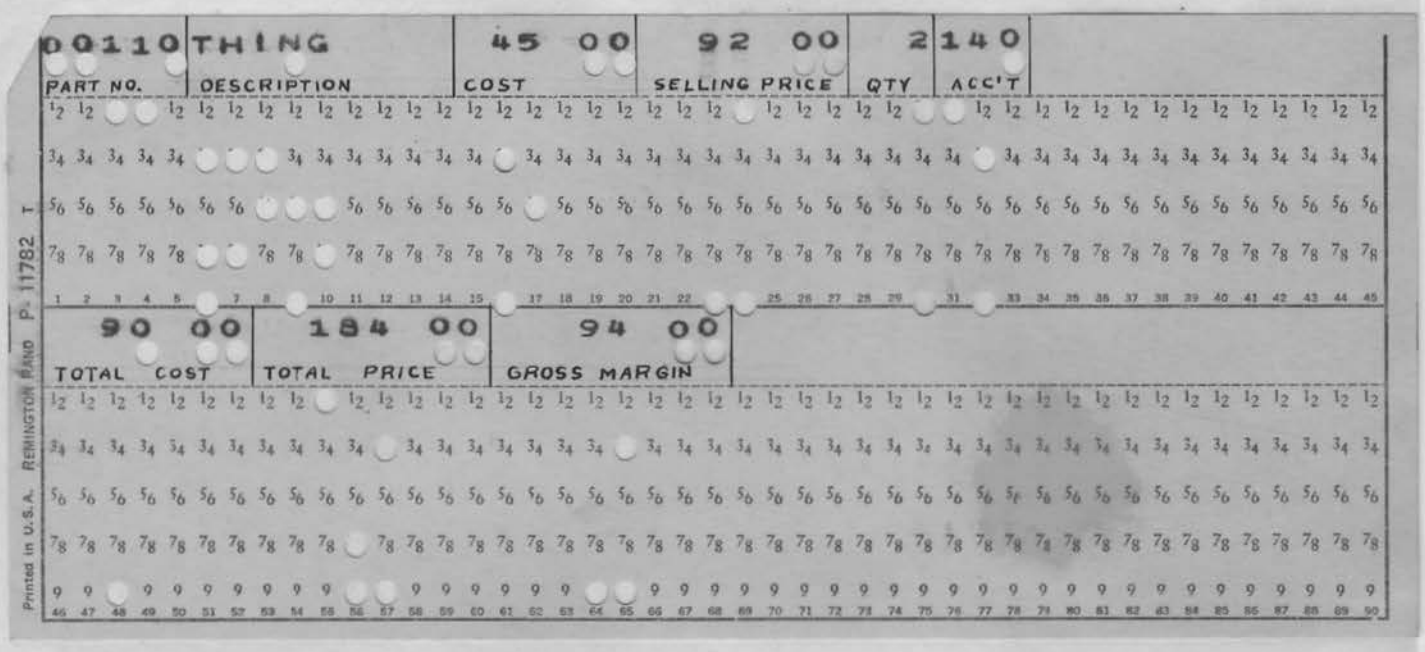
A Typical Punched Card System

The punched card illustrated below is a typical card which might be found in an inventory card punched card system. More data might be included on the card in an actual situation, but the illustration contains the data necessary for the perpetual inventory.

The listings on the following pages are typical of the output of such a system. The output of any of the systems described would contain reports very similar to these.

prepunched in card

punched in card at issue



machine calculated

ISSUE LISTING

PART NO.	DESCRIPTION	COST	SELLING PRICE	QTY.	ACC'T NO.	COMMENTS	TOTAL COST	TOTAL SELLING PRICE	GROSS MARGIN
101	GADGET	500.00	1000.00	10	101		5000.00	10000.00	5000.00
103	WIRGET	500.00	1000.00	12	120		6000.00	12000.00	6000.00
104	WHATSIT	320.00	650.00	4	101		1280.00	2600.00	1320.00
110	THING	450.00	920.00	2	140		900.00	1840.00	940.00
112	PIECE	200.00	400.00	21	25		4200.00	8400.00	4200.00
113	PART 7	150.00	300.00	2	101		300.00	600.00	300.00
115	PART 7	150.00	300.00	15	25		2250.00	4500.00	2250.00
227	COMPONENT	480.00	900.00	2	140		960.00	1800.00	840.00
234	PORTION	70.00	150.00	5	120		350.00	750.00	400.00
234	PORTION	70.00	150.00	8	101		560.00	1200.00	640.00

ACCOUNT LISTING

PART NO.	DESCRIPTION	COST		SELLING PRICE		QTY	ACC'T NO.	COMMENTS	TOTAL COST		TOTAL SELLING PRICE		GROSS MARGIN	
112	PIECE	200	00	400	00	21	25		4200	00	8400	00	4200	00
115	PART 7	150	00	300	00	15	25		2250	00	4500	00	2250	00
101	GADGET	500	00	1000	00	10	101		5000	00	10000	00	5000	00
104	WHATSIT	320	00	650	00	4	101		1280	00	2600	00	1320	00
113	PART 7	150	00	300	00	2	101		300	00	600	00	300	00
234	PORTION	70	00	150	00	8	101		560	00	1200	00	640	00
103	WIRGET	500	00	1000	00	12	120		6000	00	12000	00	6000	00
234	PORTION	70	00	150	00	5	120		350	00	750	00	400	00
110	THING	450	00	920	00	2	140		900	00	1840	00	940	00
227	COMPONENT	480	00	900	00	2	140		960	00	1800	00	840	00

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