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Title: COMPUTER-ASSISTED INVENTORY CONTROL MODEL FOR AUTOMOBILE SPARE PARTS DISTRIBUTION

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A model was developed for the inventory control of the Volkswagen spare parts distribution in Greece. The model utilizes the capabilities of a digital computer, and features four systems, the necessary system files and various routines.

Flexible statistical forecasting techniques are included for forecasting the distributor parts demand. Computerized procedures are illustrated with flowcharts and each procedure is identified as a system. The factory order system prepares the factory order; the additions system updates the parts master file with the parts arrivals from the factory; the transactions system handles the transactions with the dealers; and the dealers centralized inventory control system provides dealer sales forecasting, dealer inventory reports, and an evaluation of the dealers performance. The model furnishes the distributor with important inventory management

reports, whose contents are described.

This model, to be implemented in Greece to replace the present manual Kardex system, entails the minimum of computer installation and operations costs, it is not restrained to a particular computer and is tailored to meet the current Volkswagen factory regulations.

Computer-Assisted Inventory Control Model for Automobile Spare Parts Distribution

by

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This thesis is dedicated to my parents.

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I. INTRODUCTION

Inventories are of primary importance to the business organizations because of the needs they serve, the large investment they represent and require, and because of the costs which are associated with their care. Inventories are idle resources possessing economic value and, if not controlled effectively, many consequences such as excessive or insufficient stocks, lost sales, lost goodwill, etc. will result.

The need for effective inventory control has already been recognized and is now receiving a great deal of attention. Scientific inventory control is becoming imperative due to pressures, such as trends in costs, product line policy and the competitive sales market. The advent of computer systems has made possible a rapid and radical change in the field of inventory control.

The reasons for inventory control are almost the same in all countries but their degree of importance is dependent upon the standard of living, the government regulations, the wages and so on. The author is personally involved in the distribution of Volkswagen cars and spare parts in Greece and is particularly interested in the control of the spare parts imported from West Germany and distributed in Greece.

In order of importance the following reasons make the computer-assisted inventory control of the Volkswagen spare parts in Greece highly desirable. First, the capital investment costs, part of the inventory carrying costs, are extremely high in Greece due to the import regulations being in effect for the relief of the balance of payments problem. Second, the product line is proliferating and as a result more items must be imported, stocked and handled; the obsolescence is faster and the unit sales and inventory turnover are lower. Third, the ineffectiveness (mainly in terms of speed and subjection to error) of the manual order processing, transactions billing and master file updating is serious. All the inventory records are now maintained in a Kardex file and the forecasting of demand is, in general, judgmental and thus many sacrifices are necessary in terms of both the kinds of data to be collected and the degree of inventory management sophistication. Finally, the rising labor costs offer another incentive for a computer-aided inventory control system.

The purpose of this thesis is to design a model, mainly a schematic or iconic one, of controlling the Volkswagen spare parts inventory in Greece by utilizing the capabilities of a digital computer.

It is specifically desired that the following objectives be fulfilled. First, the model should include statistical forecasting techniques appropriate for forecasting spare parts demand in Greece.

Second, computerized procedures are to be designed for preparing factory orders. Third, it is desired to assist the dealers by providing uniform control of their inventories, by making the sales forecasts for them, and by providing various reports essential for their inventory control. Fourth, various reports to be used by the distributor management are also desired to evaluate the effectiveness of dealers' inventory control, to study the distributor parts status, parts ordering and so on. Fifth, the model should entail the minimum of computer systems installation and operational costs. It should be flexible and should not be committed to the constraints and particularities--in terms of hardware and software--of any computer company. Finally, it definitely should be built to meet the Volkswagen factory constraints.

II. PRINCIPLES OF INVENTORY CONTROL

Introductory Concepts

The inventory problem involves two basic factors: quantity and time or how much to order and when to order. The decision on how much to order directly influences when or how often to order. The larger the quantity ordered, the less often an order has to be placed.

Maintaining large inventories involves costs, placing orders also involves costs. It is through a comparison of these opposing costs that the decision on the order quantity can be made. Before answering the question of how much to order, it is advantageous to discuss the costs involved in inventory decisions.

The following two classes of inventory costs are distinguished: Inventory carrying costs and ordering costs. The inventory carrying costs include all the expenses incurred by the company because of the volume of the inventory carried and include the following elements: First, the capital costs associated with the capital investment required for the inventory. Funds allocated to inventories are not available for other uses; the opportunity cost therefore is determined by the alternative uses for the capital that would return, for example, eight percent. On account of the Greek import regulations these are the highest of all costs. Second, costs associated with storage, handling, depreciation, insurance, and taxes contribute to the

carrying costs. Ordering costs form the second class of inventory costs and are involved in the procurement of inventory and include the expenses of clerical operations such as order filing, reviewing, processing and so on. In addition to the two basic classes of inventory costs, there is the out of stock cost (sales are lost because the parts are not on hand), very hard to estimate because other than incurring higher ordering cost for special ordering, people are involved and the customer is left unsatisfied.

Returning to the question now of how much to order, its answer hinges on balancing the two basic costs just described. It is the relationship of these two costs that forms the basis for the economic order quantity model. The economic order quantity (E.O.Q.), refers to the amount of an item that should be ordered at one time in order to minimize the inventory costs. The economic order quantity model is based on premises that greatly simplify its structure but diminish its reality. The assumptions underlying it are:

1. Demand is known and constant.
2. The lead time is known and constant, or the replenishment is instantaneous. This assumption erases the possibility of out of stock cost being incurred.
3. Inventory costs are assumed constant without regard to size or value of order (the discount prices are ignored).

Figure 1 shows the assumed structure of inventory level in

relation to time (1). Q units are ordered when the inventory has declined to zero at constant demand rate, just as a new order, for an amount Q, is received. The average inventory under such a behavior is Q/2.

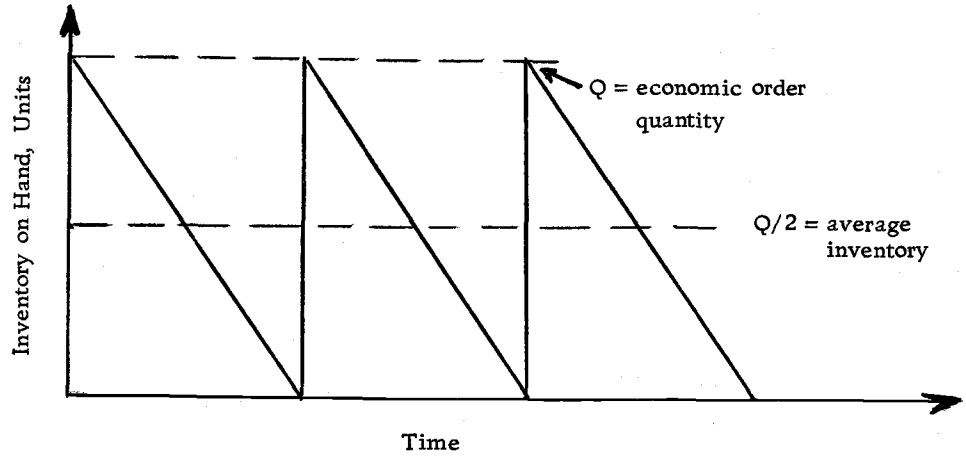

Figure 1. Structure of Economic Order Quantity Model.

If C_o is the cost of placing an order--this cost is considered to be independent of the size of order--the unit cost of placing an order is C_o/Q, and if S is the annual demand in units, C_oS/Q is the annual ordering cost. As shown on Figure 2 this ordering cost decreases with an increasing order quantity.

If C_u is the unit purchase cost of an item, and i is the percentage of annual carrying cost to unit cost, C_ui is the annual carrying cost per unit. The average inventory is Q/2 and the annual carrying cost is then $C_uiQ/2$ and as shown in Figure 2 it increases

linearly with increasing order quantity.

The total inventory costs, T, are then the annual ordering costs plus the annual carrying costs shown on Figure 2 graphically and mathematically below,

$$T = \frac{C_o S}{Q} + \frac{C_u i Q}{2}$$

In order to find the value of Q that minimizes the total costs T is differentiated with respect to Q and the first derivative is set to zero, thus:

$$\frac{dT}{dQ} = -\frac{C_o S}{Q^2} + \frac{C_u i}{2} = 0$$

and solving for Q, $Q = (2C_o S/C_u i)^{1/2} = \text{E.O.Q.}$

In practice, inventory situations that meet such rigorous assumptions are rare indeed. There are, however, enough situations that are sufficiently close to warrant some limited application of the economic order quantity formula, as, for example, inventories of relatively small dollar value used in large quantities. The usefulness of the E.O.Q. formula can be increased by introducing various modifications of its underlying assumptions as some relaxing of those assumptions will make its use more realistic. The idealization contributes to quick calculations and serves as a convenient reference condition. It provides an excellent background against which to demonstrate the interactions between various inventory factors. It

clarifies some basic principles that apply to all inventory situations, the most important of which is that order quantities are directly related not to demand but rather to the square root of demand. Thus, assuming constant ordering and carrying costs, a doubling of demand will not require a doubling of inventory; rather as demand becomes larger, less inventory will be required per unit of demand. Another principle is that the costs are relatively insensitive to changes in order quantities, in the region of the E.O.Q.

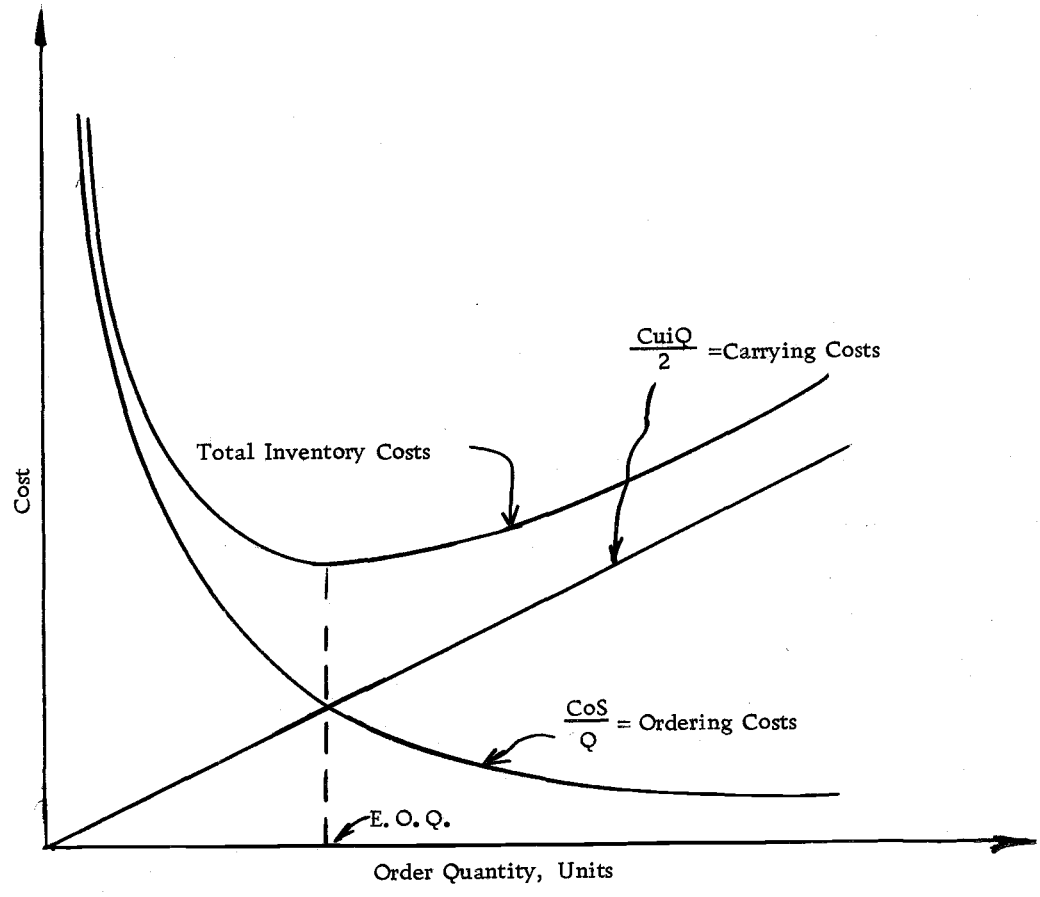

Figure 2. Cost Order Quantity Relationship.

Basic Inventory Systems

Because of the unrealistic nature of the economic order quantity model, two basic systems have been designed to put the economic order quantity formula into actual practice (2). Those two systems may be thought as procedures and also answer the other important question of when to order. Both systems are realistic as they operate under uncertainty with respect to demand and lead time variations and they consequently have buffer stocks to absorb those variations. They are the fixed order quantity system and the fixed reorder cycle system.

In the fixed order quantity system, frequently referred to as the Wilson formulation, the reorder quantity is fixed and a reorder is placed whenever the inventory on hand drops to a particular level, referred to as the reorder point. The typical operation of this system is illustrated in Figure 3 (1).

The fixed order quantity system lends itself to the application of the economic order quantity formula as the fixed order quantity may be based on the economic order quantity or it can be based on practice. It is to be noted here that both demand and lead time may vary. This system is also known as the perpetual system for it requires accurate perpetual inventory records so that it is possible to determine when the order point has been reached without

significant delay.

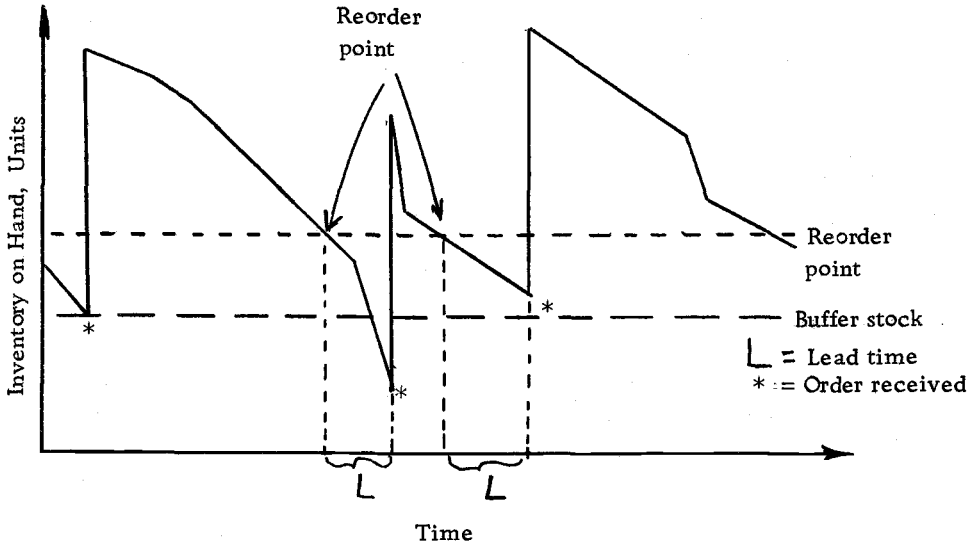

Figure 3. Fixed Order Quantity System.

In the fixed reorder cycle system, known also as the replenishment system, orders of varying size are placed on a fixed periodic cycle and its operation is illustrated in Figure 4. There is no fixed order quantity with this system. Instead the inventory is reviewed at periodic intervals, R, and if there has been a demand since the last review, an order is placed equal to the amount by which a fixed replenishment level exceeds the actual inventory level at the time of review. The buffer stocks needed here are larger than those required for the fixed order quantity system in order to provide for the possibility of running out of stock not only during the lead time, but also during the review time, R. This system is also known as the periodic system.

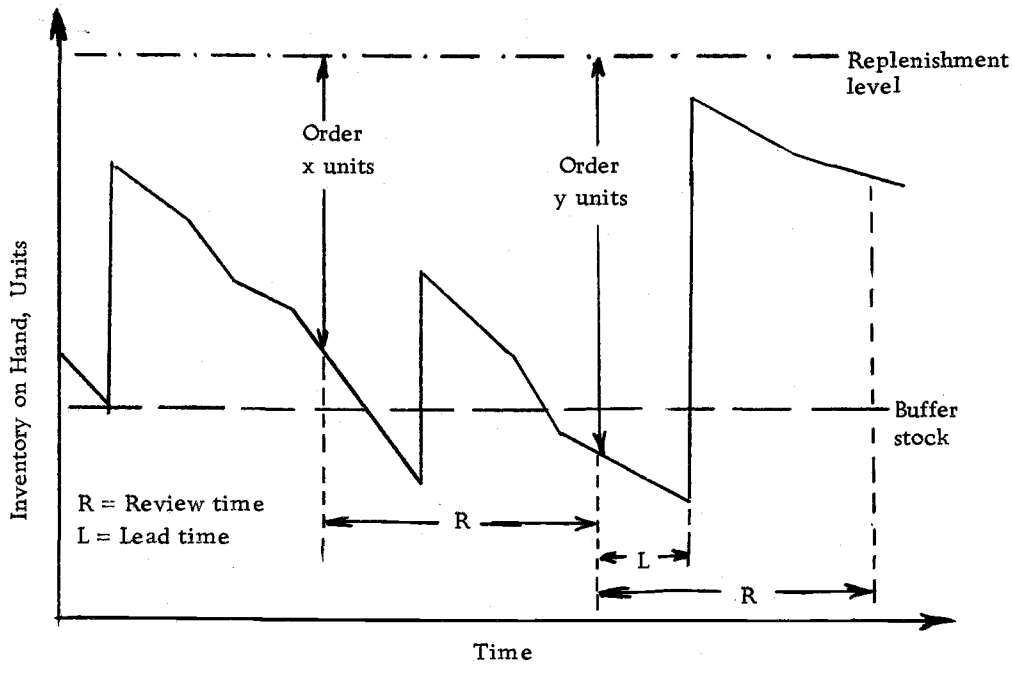

Figure 4. Fixed Reorder Cycle System.

ABC Inventory Classification

The ABC inventory classification, known also as the ABC analysis and as "Pareto's Principle," is a very powerful concept in inventory control (9, 11). Most inventory management problems are created when the truth and the pragmatic value of this classification is ignored. In any inventory to be controlled, a selected small fraction of the items in the inventory accounts for a larger fraction of the value of the inventory. This principle states clearly that all the items in an inventory are not of equal importance. It implies that effort, time, and money and other assets to be spent or used in

the control of inventories should be allocated among its items in proportion to their relative importance. It suggests the practical necessity to subdivide an inventory for the purpose of controlling it effectively. The key to this concept is management by exception. Any inventory can be separated into three distinct parts as shown on Figure 5 (7).

1. "A" items: High value--those relatively few items whose value accounts for 75-80% of the total value of the inventory. These will usually be from 15-20% of the items.
2. "B" items: Medium value--a larger number in the middle of the list, usually about 30-40% of the items, whose total value accounts for about 15% of the total.
3. "C" items: Low value--the bulk of the items, usually about 40-50%, whose total value is almost negligible, accounting for only 5-10% of the total.

The breakdown into A, B, and C items is, of course, an arbitrary one; further subdivisions can be made. With the electronic computer now at the disposal of the inventory management, it is possible to obtain listings of all the items in the inventory according to their relative importance if one year's past sales are available.

The high value "A" items need the tightest possible control and the highest priorities to reduce lead time. The order quantities should be carefully determined and the items should be frequently

reviewed. Those items justify the most careful control method and they thus lend themselves to the fixed reorder cycle system. At the other extreme, the low value "C" items need the simplest possible control; one year's supply can be ordered once and the economic order quantity formula applies here as well as the fixed order quantity system. Class "B" items would have an intermediate level of control.

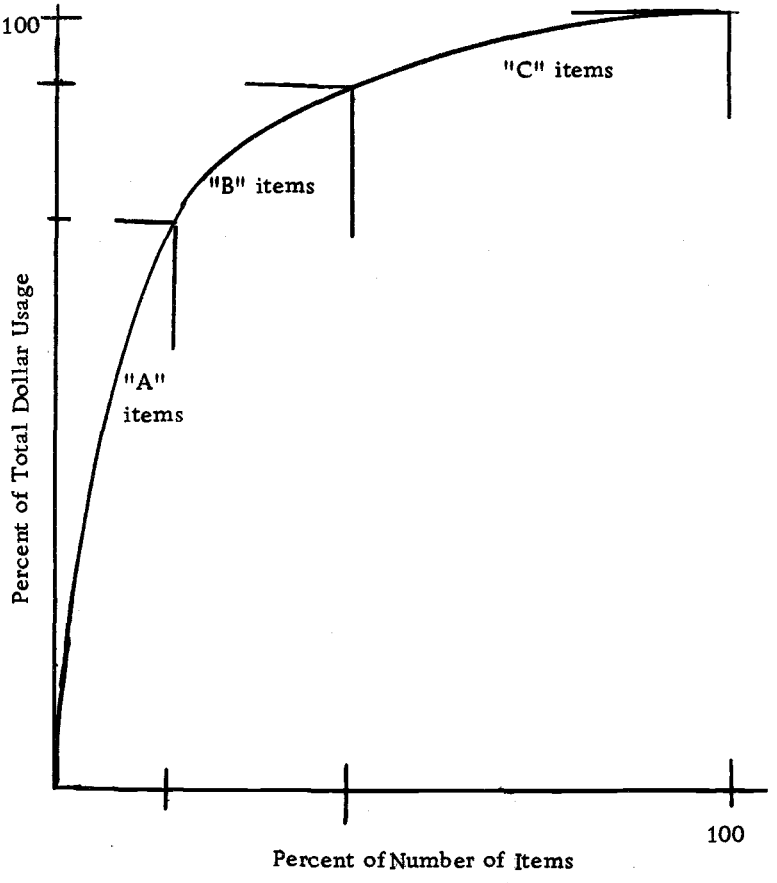

Figure 5. Distribution of Inventory Dollars.

Uncertainties in Inventory Control

In any inventory the two major uncertainties are demand and lead time (or supply) variations. These two uncertainties give rise to the buffer or safety stocks. The buffer stocks are a function of the following elements:

1. The ability to forecast demand accurately
2. The length of the lead time
3. The ability to forecast or control the lead time
4. The size of the order quantity
5. The service level desired

For the purposes of this thesis the lead time for spare parts delivery is fairly constant, and the discussion hereafter will be restricted to the demand variation only. If the demand and lead time vary the best way to determine the buffer stocks is by Monte Carlo simulation (1, 9).

The recommended stock level, including the buffer stock, is given by the following:

$$\text{Stock Level} = (\text{Average Monthly Demand}) \times (\text{Lead Time in Months}) + (\text{Safety Factor}) \times \text{M. A. D.}$$

M. A. D. is the mean absolute deviation used for estimating the forecast error and is equal to the sum of the absolute deviations over the number of deviations. The absolute deviation is taken as the

difference of the forecasted demand from the actual demand. Thus, with past demand and past forecasted demand available, the M. A. D. can be easily obtained, especially with the use of the computer. Safety factor is a factor depending upon the service level desired. The service level is here taken to mean (sales/demand) × 100 and is expressed in percentage. For every service level there is a corresponding safety factor as shown on Table 1 (7).

Table 1. Safety Factors for Desired Service Levels.

Level of Service	Safety Factor
50.00%	0.00
78.81	1.00
84.13	1.25
94.52	2.00
97.72	2.50
99.18	3.00
99.87	3.75

Thus the buffer stock required for demand variation can be determined by specifying the service level, and obtaining the M. A. D. from past data. This technique is for a normal distribution, which is a sufficiently good approximation.

Forecasting

The importance of reliable demand forecasting in deciding on the inventory size is conspicuous. Forecasting is taken to mean the projection of the past data into the future.

Forecasts can be classified in various ways, but the distinction can be made between judgmental forecasting and statistical forecasting. Forecasts based on judgment, sometimes called predictions, are based on the expert opinion of individuals. Statistical forecasts ranging from extremely simple techniques of simple averages to highly complex techniques of statistical analysis are used widely and have the advantage of reducing the number of factors to which the forecaster must apply his judgment. Various forecasting methods will be now described.

The simplest method of using past demand data to forecast future demand is the straight moving average method. Here the quantities demanded for a given base period are summed up and the sum is divided by the number of time intervals to obtain the average in the time interval. In the straight moving average method, each month, the base period is updated by dropping the earliest month's demand and adding the latest month's demand, hence the term moving average. If the long term item sales is fairly stable, this is an adequate method. Certain items are particularly affected by the

overall growth in sales and the straight moving average method is not always useful as it lags behind the trend and the lag is aggravated by the length of the prediction period.

Improvement in demand forecasting can be made by the use of the weighted moving average method which always weighs the individual month's history in such a fashion that the recent months are more significant in determining the average than the earlier months. This method is more sensitive to change than the straight moving average and it does not lag in trend as much.

The single exponential smoothing is another form of the weighted moving average and it accomplishes the same results with fewer calculations and less data. It is more effective as it permits the rate of response to be easily adjusted (3). The operation of the single exponential smoothing is based on a period by period adjustment of the latest forecasted average, F_{t-1}, by adding (or subtracting) a fraction, α, of the difference between the actual demand in the current period, D_t, and the last forecasted average, F_{t-1}. The result yields the new forecasted average in the current period, F_t:

$$F_t = F_{t-1} + \alpha (D_t - F_{t-1})$$

The fraction of the difference between the actual current demand and the previous period forecast, α, is the exponential smoothing constant which is selected and must be between 0 and 1. By

rearranging the above equation the one shown below results,

$$F_t = \alpha D_t + (1-\alpha)F_{t-1}$$

This equation is simple and it must be remembered that the term F_{t-1} has been generated by a sequential process which in fact represents all of the past actual demands. The selection of the exponential smoothing constant can be made in such a way that recent data is emphasized as heavily as desired. A relatively large value of the exponential smoothing constant, say 0.5, will cause the forecasted average F_t to respond quickly to changes in actual demand; a small fraction, say 0.01, will respond more slowly. Brown (3) recommends beginning with a smoothing constant of 0.3 and reducing it to 0.1 after six months. A value of 0.1 for the exponential smoothing constant is a satisfactory compromise between a very stable system that fails to track real changes and a nervous system that fluctuates with demand.

These three methods will never predict a demand higher than the highest recorded in the past, and consequently lag in demand and may thus be classified as non-trend methods of forecasting. The future is always kept within the limits of the past. In order to escape from this restriction other forecasting methods have been developed and they do account for trend by adjusting for it.

Double exponential smoothing is a method that corrects the

single exponential smoothing for trend. The apparent trend from period to period is simply the difference in the average forecasts from period to period, $F_t - F_{t-1}$. The new average trend adjustment, T_t, is:

$$T_t = \alpha \text{ (current apparent trend)} + (1-\alpha) \text{ (last average trend adjustment)}$$

$$= \alpha(F_t - F_{t-1}) + (1-\alpha)T_{t-1}$$

The expected demand including an adjustment for trend is, then, the new average forecast, F_t, as computed from the single exponential method, plus a fraction of the new average trend adjustment, for the current period. The expected demand is then:

$$\text{Expected demand} = E(D_t) = F_t + \frac{(1-\alpha)}{\alpha} T_t$$

Other forecasting techniques, which adjust for trend are regression (the method of the least squares being a specific regression technique) and correlation (if corrected for trend). Correlation is a statistical method of determining and measuring the relationship of a company's sales to other activities many of which are external to the firm.

All the trend adjusted forecasting methods are applicable for forecasting items if there is indeed a trend, but great caution should be used in applying trending methods. If there is not truly a trend, the inventory operation will be more costly since the system may

regard random fluctuations as trend and overrespond. Trend methods have the deficiency that they assume that any change will continue at the same rate. Thus, seasonal variations with little past demand, will bias the computation in a negative way and the results will be misleading. Trend methods should not be used with items lacking sufficient past data (new items), but it can be used for forecasting seasonal items if the seasonality has already been established.

The demand for some items exhibits a seasonal characteristic. Tests should be applied before classifying an item as seasonal (3). First, the peak demand must occur during the same period each year. Second, the peak demand should be substantially greater than in normal variations in the average demand. Past demand data for at least two years is a prerequisite to seasonal forecasting. One of the seasonal forecasting methods developed is the base series method (2).

The basis of the methodology is to develop a base series for a particular month. This base series is calculated from last year's data. The average of last year's quarter centered on the particular month may be used as the base series, although the best way of choosing between alternatives for the base series is to try one and evaluate the accuracy of the resulted forecast. Thus, if the forecast of November 1970 is desired, the base series is computed from the October, November and December 1968 moving average demand.

Then a demand ratio, DR_t, is calculated by dividing the base series into the actual demand of November, 1969, which is one year less than the desired forecasted month. This demand ratio is then smoothed and corrected for trend, before the expected demand ratio, EDR_t, is finally obtained as follows: First, the forecast average ratio, FAR_t, is computed from:

$$FAR_t = \alpha DR_t + (1-\alpha)FAR_{t-1}$$

where α is taken as 0.1 and FAR_{t-1} is the forecast average ratio of the month preceding the current centered month, that is of October, 1969 to follow the same example. If there is no FAR_{t-1} available, it is taken as unity. Second, the apparent trend, FAR, is calculated from:

$$FAR = FAR_t - FAR_{t-1}$$

This would be the apparent trend of 1969 to follow again the same example. Third, the average trend adjustment, T_t, is then calculated from:

$$T_t = \alpha(FAR_t - FAR_{t-1}) + (1-\alpha)T_{t-1}$$

where T_{t-1} would be the average trend adjustment of the month preceding the current centered month. According to the example, T_{t-1} would be the October, 1969 average trend adjustment, and if it is not available, it is taken as zero. Finally, the expected demand

ratio, EDR_t, is calculated from:

$$EDR_t = FAR_t + \frac{(1-\alpha)}{\alpha} T_t$$

The expected demand, $E(D_t)$, is then computed from:

$$E(D_t) = (EDR_t) \times (\text{Base series})$$

All the terms shown on the right hand side of this last equation refer to November, 1969, to follow the example, and the expected demand, $E(D_t)$, is that of November, 1970.

Before leaving the discussion of forecasting it is fitting to discuss the E.O.Q. determination when the costs are not known precisely, or when they are unobtainable (12). This method requires that data of the previous year's orders be available. For simplicity the example will include only eight items, but the method can be extended to as many items as desired, especially with the use of the computer.

The E.O.Q. in units was given earlier as:

$$E.O.Q. = \sqrt{\frac{2C_o S}{C_u i}}$$

this equation can also be written as:

$$E.O.Q. = K\sqrt{\frac{S}{C_u}}$$

where $$K = \sqrt{\frac{2C_o}{i}}$$

The E.O.Q. can also be expressed in terms of annual dollar usage as (7):

$$E.O.Q. = K\sqrt{SC_u}$$

It is shown in the literature (7, 12) that the constant K can be found for all items if the number of orders and the annual demand are known from:

$$K = \frac{\text{Summation of } (SC_u)^{1/2} \text{ for all items}}{\text{Summation of all the numbers of orders for all items}}$$

The E.O.Q. number of orders is given as:

$$E.O.Q. = SC_u/(E.O.Q. \text{ in dollars})$$

Table 2 shows the typical application of this method of determining the E.O.Q. for eight items. The annual orders of 9.7 or 0.8 for items 4 and 8 respectively may be somewhat disturbing, but the purpose of this example is to illustrate the E.O.Q. determination method and the numbers of E.O.Q. orders may very well be rounded to the nearest whole number, if decimal points are involved.

Table 2. E.O.Q. Determination.

Annual dollars usage SC_u	$(SC_u)^{1/2}$	Orders placed	E.O.Q. in dollars	Number of E.O.Q. orders	Item number
90,000	300	12	1,860	48.4	1
10,00	100	12	621	16.1	2
6,400	80	12	495	13.0	3
3,600	60	12	372	9.7	4
900	30	12	186	4.9	5
144	12	12	75	2.0	6
81	9	12	56	1.5	7
25	5	12	31	0.8	8
	596	96			

K = 596/96 = 6.2

III. INVENTORY CONTROL MODEL

Of the two basic inventory systems, the fixed reorder cycle system makes it possible to group orders for many individual items from one supplier. In this case, the supplier--the Volkswagen factory in West Germany--will ship only once a month at fixed dates. Those items, however, that belong to the "C" classification and qualify for the E.O.Q., will be ordered only once a year. Furthermore, the items of high dollar value usage--the "A" classification--will be reviewed once a month very carefully and individually as it will be explained later in detail.

With regard to the buffer stocks determination, the Volkswagen factory insists that a stock level equal to eight months demand be maintained. The lead time is three months including the review time, if the orders are mailed at the factory prescribed dates. Thus, a three months' demand stock is necessary to absorb the demand variation on account of the lead time and the other five months demand stock is imposed to absorb the demand variation. At present this eight months' demand stock will be used, with modifications as explained later, and occasional checks will be made against the demand variation buffer stock utilizing the safety factor and M.A.D. procedure.

In reference to the forecasting methods, the single exponential

smoothing method will be used for forecasting the monthly demand of the nonseasonal parts. No correction for trend will be made because of the possible bias associated with the trending methods. For the seasonal items, however, the base series method will be used and correction for both seasonality and trend will be made. The seasonality of the parts will be established after each part has had a demand history of two years and tests will be made to determine such a possible seasonality. Finally, all parts will be tested for the E.O.Q. formula usage during each forecasting. More details of forecasting will be discussed in the factory order system.

For the efficient implementation of the above models and techniques a digital computer will be utilized. Computerized procedures for preparing factory orders and for controlling the dealers' inventory are desired. In order to fulfill these goals, various memory capabilities are necessary. Information pertaining to the parts status and to the parts activities must be retained with recall of the information to be of random or sequential access depending upon the specific application.

In order to prepare factory orders, data of past demand and data of present status (quantity on hand, quantity on order etc.) are essential. All the data must be stored in random access storage devices so that it can be read off at high speed; consequently magnetic disc files appear to be the most feasible storage unit (4, 5, 6, 10).

In order to control the inventory of the dealers, more data are necessary. These data will include information about the dealers' status inventory and their transactions with the distributor. The dealers will replenish their inventories periodically, like the distributor. Their inventory replenishments will occur at prescribed time intervals during each month. Individual sequential memory devices, namely magnetic tapes, will be used for recording their inventories as well as for recording the distributor's transactions with the dealers, so that the distributor can process all the dealers' orders effectively. With regard to the latter transactions of the distributor with the dealers, those transactions will be recorded daily on a magnetic tape which will be merged with another tape having the transactions of the previous days. There is no need to use fast access memory units for those transactions, as their contents will be used for various reports or other processes periodically and the high cost of the disc files would not be justified, although magnetic discs will be employed to utilize the data being read off from the tapes. The tapes can also be put aside for future reference or back up information.

All these procedures--factory order preparation, dealers' transactions--are closely related with each other as will soon become more clear. It is important that a program or a series of programs exists and be written in such a fashion, so that it can receive data regarding factory order preparation, factory arrivals, dealer orders,

dealer returns, and so on. After examining the data and after giving them preferences in a preestablished order, the programs will distribute the data to their appropriate corresponding function (which might be a transaction or a factory order). This program is now designated as "daily data distribution," and a detailed discussion of it is given later.

Before continuing further, it would be appropriate to decide on the type of data input to be fed into the whole system operation, in addition to the input data stored in the devices mentioned previously. In accordance with the goals regarding the minimum computer installation and operation costs as well as flexibility of hardware and software, cards will be used for data input. Table 3 shows the card codes to be used for the data input cards. This list is not meant to be exhaustive as additions and modifications can be made if necessary.

From the above remarks a general inventory control model can now be diagrammed as shown on Figure 6. This model features four main systems and the inventory system files. The major data storage is the parts master file shown. It is a magnetic disc file and includes parts status, various codes, each corresponding to a specific activity of the parts, costs, current data for forecasting, in fact all relevant data about each part except its past demand of the last three years, which is put on the magnetic disk demand file. The transaction tape records the distributor transactions with all

Table 3. Input Card Codes.

	MASTER FILE CHANGES
2	Part additions
4	Part removals
6	Part number change
8	Part price change
9	Part location change
	DEALER SALES AND ADJUSTMENTS
10	Dealer sales
12	Dealer quantity adjustments
14	Dealer location changes
18	Dealer revisions to suggested order quantity
	DISTRIBUTOR ADDITIONS
20	Pending receipt of an ordered item
24	Pending receipt of a non-ordered item
28	Received item
	DISTRIBUTOR TRANSACTIONS
30	Back order credit to dealer
32	Dealer back order cancellation
34	Dealer returns
37	Dealer back orders
38	Dealer emergency orders
39	Dealer monthly orders
	DISTRIBUTOR ORDERS
40	Suggested order quantity revisions
42	Cancellation
44	Placed on order
46	Back order from factory

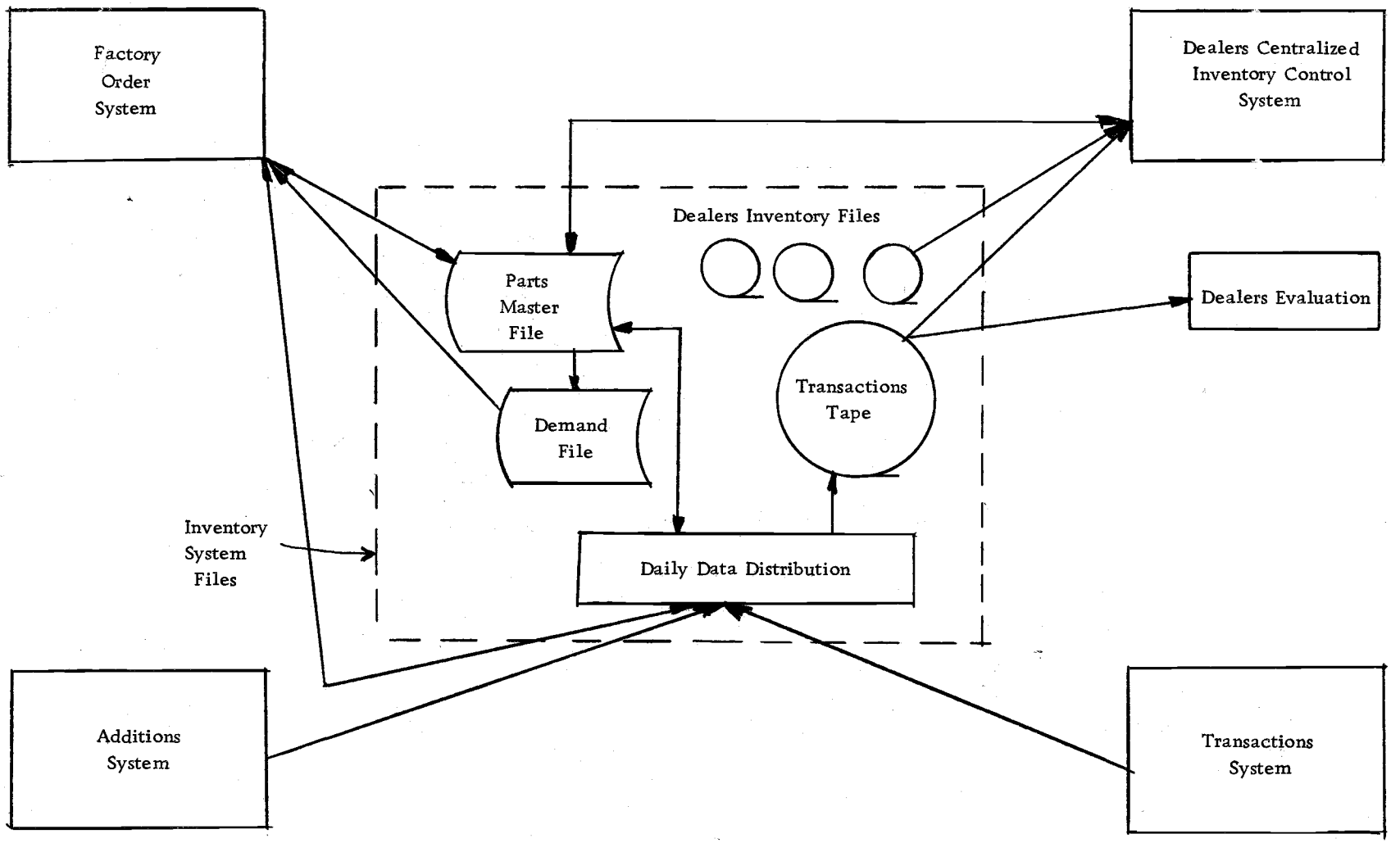

Figure 6. Inventory Control Model.

the dealers by dealer and by transaction type having a code shown on Table 3. There are as many dealer inventory files as there are dealers and each file contains the dealers parts status and the past sales history.

The function of the factory order system will be to forecast the distributor's demand, to prepare a suggested order quantity listing, to provide for revisions and finally to prepare the factory order. The function of the additions system will be to process data on the parts arriving from the factory and to update the parts master file. The function of the transactions system is to process all the transactions data and to produce the invoices and the appropriate documentation. The function of the dealers centralized inventory control system will be to provide a uniform inventory control system for all dealers. It will forecast the sales for them, it will provide them with necessary management reports and will replace the present Kardex system. Finally, the dealers evaluation sub-system purges the transactions tape of past data and at the same time produces various reports useful in evaluating the performance of the dealers.

IV. INVENTORY SYSTEM FILES

The major component of the inventory system files is the parts master file. A detailed discussion of the parts master file contents follows along with the discussion of the routines associated with the manipulation of the parts master file.

Parts Master File Contents

The parts master file will contain the following information in parts number sequence for each part:

Part number: Generally, the part number consists of nine digits and is given by the factory. The first three digits refer to the automobile model, the fourth digit refers to the group (engine or chassis), and the fifth and sixth digit refer to the subgroup (piston or cylinder or door) and the last three digits are the part number per se. The parts master file contains all the parts in part number sequence with respect to the group and not to the model. The part number is to remain in the file until it is deleted and exhausted from all inventories from all dealers, unless a number change has been made.

Description: The description is in English and is supplied by the factory.

Location of part on distributor warehouse: Each location is identified by various digits corresponding to sections, bins and

shelves.

Date part was placed on parts master file: This date is inserted when a part arrives at the distributor for the first time.

Current quantity on hand: This quantity may be changed with every daily data distribution run and depends on sales, or additions from the factory or returns from the dealers.

Current on order quantity: This quantity may be changed at every daily data distribution, if an order to the factory has been made, emergency or regular monthly. It includes all the quantities ordered and being ordered if an order(s) has been cancelled.

Order history: Four spaces are provided. The first space shows the on order quantity due in, and that quantity is the one ordered three order cycles ago and it has been adjusted according to the information received from the factory in the meantime. The second space is reserved for the on order quantity, which had accumulated until the factory order cycle, two cycles ago. The third space shows the on order quantity of the last cycle, orders which should arrive within three months. These quantities move over one space at each factory order cycle. Finally, the fourth space shows the on order quantity since the last factory order cycle and it will be accumulating until the new factory order cycle, when it will move.

Current back order quantity to dealers: This quantity is being updated with every daily data distribution run if the part requested is

not available.

Current back order quantity to dealers frequency: This quantity shows how many times this part has been back ordered to the dealers since the last cycle and is updated with every daily data distribution run.

Current demand: This number refers to the quantity demanded (sold as well as back ordered) since the last cycle, and it is updated with every daily data distribution run, if demanded of course, and it is D_t, as designated in the forecasting section.

Current demand frequency: Shows the frequency this part has been demanded since the last cycle, it is updated with every daily data distribution run. This quantity is useful in relocating a part in the warehouse according to its frequency, and it is also useful in knowing which parts have a frequent movement so that they can be included in the initial parts stocked by a new dealer.

Date of last demand: self-explanatory.

Distributor package quantity: This quantity is imposed by the factory and must be considered when forecasting a suggested order quantity or when the latter is revised.

Dealer package quantity: This quantity is established by the distributor.

Back order quantity from the factory: This quantity is updated with the daily data distribution run after information was received

from the factory that this part will be back ordered by a particular amount.

Distributor unit cost: This cost includes the import duties.

Dealer unit cost: This cost is established by the distributor.

Retail unit cost: This cost is established by the distributor and is uniform regardless of the dealer's location.

Overstock or discount quantity: Overstock will occur every time the on hand quantity is larger by a preestablished percentage than the recommended stock level. In such a case discount quantities may be established to encourage the dealers to purchase in large quantities. Discount quantities will also exist for most of the fast moving parts, and the invoicing program (part of the daily data distribution) will consider price reductions if the quantities requested are in excess of the discount quantity.

Suggested order quantity: This quantity shows how many parts have been suggested to be ordered during the current factory order run, it will be updated with every factory order run as explained later.

Current forecasted quantity: This quantity designated as F_t in the forecasting section is generated from the forecasted quantity of the previous cycle, F_{t-1}, and the current demand, D_t.

Forecasted quantity of last cycle: It is F_{t-1} referred to above.

FAR_{t-1}: Last cycle's forecast average ratio (for seasonal items).

T_{t-1}: Last cycle's trend adjustment (for seasonal items).

Dealer with stock: Three of the dealers will be shown here by the dealer number to identify the dealer who has stock of this part.

At this point it would be advantageous to devise codes and subcodes, by which the parts can be characterized in terms of activity, behavior and type. The use of codes and subcodes will save considerable space in the expensive disc file. Various reports then may be obtained by selecting data on parts with their appropriate codes and subcodes.

CODE 1: An "S" under this code will designate a part superseded by another part; a "Z" will designate a superseding part and a "D" will designate a deleted part. Anywhere the "S" part prints, the "Z" part will print under and vice versa for quick reference.

CODE 2: This code will be reserved for a transfer superseded part to signify that this particular part has been superseded by another part, but it can still be placed in the same bin with the superseding part and used identically. This information is supplied by the factory.

CODE 3: This code refers to the interchangeable parts and under this code six numbers (actually subcodes) will be used out, only one of which will be printed and it will refer to the type or types of cars that may use this particular part (for VW, Porsche or Audi). This information is given by the factory.

CODE 4: This code refers to the factory order type. Ten

numbers are used here, but only one will be printed to refer to the type of order designated by the factory (part, accessory, or paint, etc.). Those numbers will be used when the factory order cards are printed with their order number.

CODE 5: All the seasonal items will be identified under this code with an "A." A "1" or "2" or "3" or "4" might be added to refer to the quarter during which a peak demand occurs.

CODE 6: Overstocked parts will be identified with an "O" and parts chosen for discount quantities with an "R."

CODE 7: An "X" under this code will refer to "stop on sales." This code will be temporary and will be generated by a disagreement of the parts master file data and the bin quantity which has just been checked by a clerk. When a part is coded as such no sales are accepted, despite the fact that the parts master file still shows an on hand quantity, and back orders will be made until the trouble has been corrected and an adjustment has been made to the on hand quantity.

CODE 8: Under this code various subcodes will be used to refer to the activity of the part and these subcodes are changed automatically according to a routine which is part of the daily data distribution program. Subcode "1" will refer to a new part that has just been introduced in the parts master file, but has not yet had a sale. Subcode "2" will be given to that part with the first sale and will refer to slow moving parts. Subcode "3" may supersede subcode

"2" and refers to fast moving parts; this switch will be based on a frequency of movement to be established by the parts department. Subcodes "4" and "5" will refer to the superseded and deleted parts respectively and will be given automatically with the designation of CODE 1. From subcode "5" and on various subcodes may prove useful in writing down the distributor's unit cost of this particular item for depreciation, tax and insurance reasons. These subcodes will be added as necessary.

CODE 9: This code is for the use of the distributor, when requesting various management reports. The subcodes under this code refer to the part classification. Table 4 shows the part classification. This is a sufficient discussion of the parts master file contents.

Table 4. Part Classification.

10	VW Parts
11	Industrial Engines
12	Parts other than VW
30	Accessories
50	Radios
60	Batteries
70	Heaters
75	Air Conditioners
80	Miscellaneous (literature)
90	Signs

The contents of the demand file need only a brief mention. Demand will mean sales as well as back orders. Demand will be recorded in part number sequence and will cover the last three years and will be used for seasonal items forecasting. The frequency of demand by month will also be recorded.

Daily Data Distribution

As indicated earlier a series of programs is desired in order to update the parts master file, draw data from it and other inputs (cards and other files), make the necessary calculations and comparisons, transmit the appropriate data to the various systems associated with the whole inventory model and, finally, produce the appropriate documentation.

This series of programs, designated already as "daily data distribution," will link and control three systems. First, it will be associated with the factory order system to increase the on order quantity in the parts master file; second, with the arrival of parts from the factory it will link the additions system with the parts master file to increase the on hand quantity or to decrease it, if cancellations are made; and third, with the transactions system in order to decrease the on hand quantity if a sale is made to update the demand quantity and produce the necessary invoices.

All the functions described above should not be executed

independently if an effective inventory system is desired. There would be little gain in having a system that would not process dealer orders if the parts master file shows an out of stock condition of various parts because it has not been updated with the quantities already on the distributor's premises, but not yet recorded in the parts master file. Similarly, the factory order would be very misleading if it is based on false demand because dealer orders have not been run to record the demand, or based on false on hand quantity because the parts that have been put in the bins have not been recorded in the parts master file.

In view of the above remarks, priorities must be established as to which functions will and must override other functions. First of all, new parts must be added or removed and the various adjustments must be recorded with regard to changes in price or location or part status (superseded or deleted). Then, the distributor receipts must be recorded followed by the dealer returns to the distributor and the back order cancellations. At this point the inventory is at the highest quantity (maximum) for all parts and the dealer orders may now be executed. The dealer back orders would take precedence over the emergency dealer orders and the monthly dealer orders would come last. Finally the distributor factory orders will be processed.

Since there are coded cards for all the adjustments, changes,

receipts, orders and so forth, all the cards may be fed into the daily data distribution program and then the computer will read and execute those cards according to the precedence specified. It appears that the execution of the daily data distribution should be done by the computer operators after the distributor closes for the day and all the cards have been prepared during the day according to the information received. The daily data distribution will produce various listings, which will be discussed as they appear in the systems discussion. In terms of the card codes given in Table 3, the daily data distribution program will read and execute the cards in the sequence shown in Table 5.

Table 5. Daily Data Distribution Program Execution Sequence.

Additions of new masters
Removal of old masters
Various adjustments:
Location
Deleted/Superseded
Price change
On hand quantity
Distributor additions
Dealer returns
Dealer back order cancellations
Dealer back orders
Dealer emergency orders
Dealer monthly orders
Distributor factory orders

Distributor Inventory Status Report

It is imperative to have a report, which will show for every part in the parts master file its location, availability, costs, along with the codes already mentioned. This report will serve mainly as a location book, so that clerks will know where each part is located; as a price and availability catalogue, so that various inquiries from the dealers may be answered with one glance; and finally, as a total inventory worth accounting report. This report will be printed in part number sequence every day (or every other day) and its contents to be printed from left to right on special sheets with printed columns are shown in Table 6.

Table 6. Contents of Distributor Inventory Status Report.

Part number
Description
Location in warehouse
Quantity on hand
Quantity on order (total)
Quantity on order due in
Back order quantity to dealers
Three dealers with stock
Unit cost
Dealer cost
Retail cost
Overstock or discount quantity
Last sale
Suggested order quantity
CODES 1 through 9

The very last page of this report should show all the parts summed up according to the part classification, Table 4, with the extended value (unit cost times quantity on hand) for each classification with the total extended value of all the parts in the inventory as of the date the report was run.

V. FACTORY ORDER SYSTEM

The operation of the factory order system will now be explained in detail. The function of the factory order system will be to forecast the distributor's demand, to prepare a suggested order quantity listing for any parts desired, to provide for revisions of this suggested order quantity listing, and finally to prepare the factory order cards.

Flowchart Explanation

It is convenient to start the description of the factory order system with a general and a brief look at the system operation as shown in Figure 7. It is essential for the factory order that a suggested order quantity be generated for every part. This suggested order quantity (S.O.Q.) is produced by a special program that takes the on hand and on order quantities from the parts master file and calculates the forecasted current monthly demand on the basis of more forecasting details, to be explained shortly. The suggested order quantity is revised by the parts manager, if necessary, and suggested order quantity revision cards (code 40) are punched for the revisions. These cards are fed into the daily data distribution and the suggested order quantity in the parts master file is revised. The placed on order cards (code 44) are now produced on the basis of the suggested

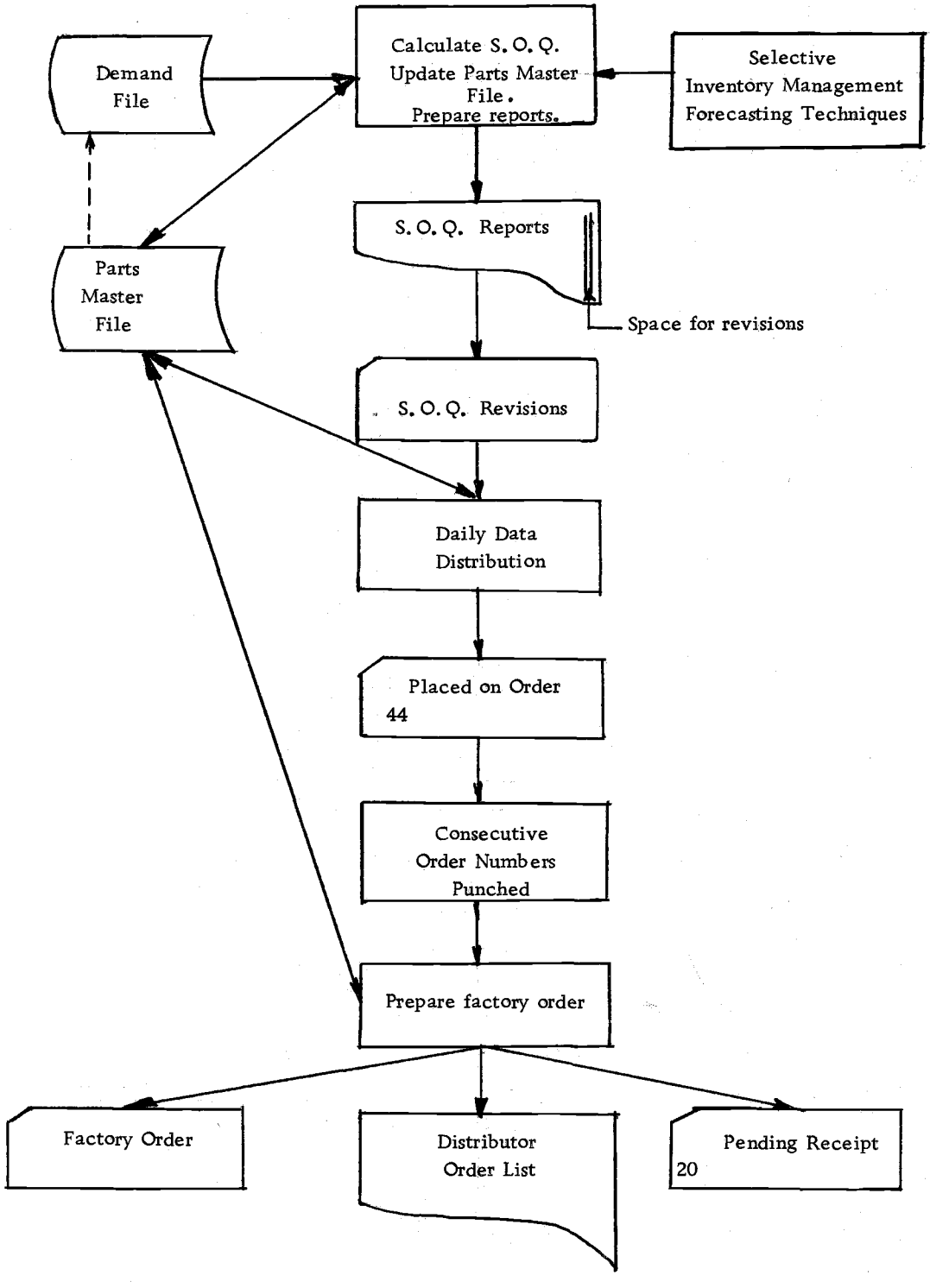

Figure 7. Factory Order System Flowchart.

order quantity stored in the parts master file. The placed on order cards are produced after the orders are sorted according to the factory order types. They are now given their corresponding consecutive order numbers before they are processed by a program that will punch the factory order cards to be air freighted to the factory. The same program will also produce the pending receipt cards (code 20), which are put in a drawer to become data input cards when the parts arrive; and the distributor order list, which is a continuous sheet showing all the orders placed. The list will show the extended costs in part number sequence for each factory order type.

Suggested Order Quantity Generation

The suggested order quantity will be equal to the recommended stock level minus the on hand and on order quantities. The on hand and on order quantities will be read from the parts master file. The recommended stock level will be equal to the forecasted current monthly demand times a factor, called K, which will generally be equal to eight to account for the three months lead time and the five months demand variation buffer stock.

Checks will be made of the suggested order quantity to reduce the inventory costs. Before applying the procedures for calculating the suggested order quantity the part will be checked to determine if it qualifies for the economic order quantity formula. The prerequisite

for consideration for E.O.Q. qualification would be data for one year in the parts master file. Also, parts that have an annual demand less than an established monetary value will have a suggested order quantity equal to the last 12 months demand and the suggested order quantity calculation based on the forecasting methods will be disregarded. The computer will be reviewing each part that qualifies for E.O.Q. at every factory order cycle and it will print a suggested order quantity (E.O.Q.) only if the on order and on hand quantities are less than the eight months recommended stock level.

To avoid small orders another check to be applied to the suggested order quantity would be that of the ten percent limit. If the suggested order quantity is less than ten percent of the on hand quantity, the suggested order quantity becomes zero, and it will be ordered during a later cycle. The last check will be that of the package quantity. The factory will ship only in unit packages and does not break up packages. If the package quantity of a particular part happens to be 50 and the suggested order quantity is 152, the factory will ship 200 parts. The package quantity is in the parts master file and before the suggested order quantity is printed it will be compared to the package quantity to order whole numbers of packages.

Selective Inventory Management

At present a typical Volkswagen distributor's inventory consists of approximately 20,000 different items. These items run from complete bodies at a cost of well over $1,000 to small hardware items worth only a fraction of a cent. Some distributors report that about 5% of the items account for more than 85% of the sales, or that 88% of the items account for less than 5% of the total annual sales.

The parts manager should not, and cannot, give equal attention to all the items. Neither he nor his key personnel can afford to devote as much time to the management of a small washer as to the management of an engine. It is imperative therefore that the parts manager manage the inventory selectively or that he applies Pareto's principle (ABC Classification) discussed earlier.

Items may be placed in special groupings such as new parts, high value parts, seasonal, and so forth and the computer can be instructed to print the suggested order quantity in various reports, each one corresponding to a special grouping and these reports can be reviewed by the manager in more or less detail or not even at all depending upon their importance. It is convenient to segment the parts into the following seven categories, with their coding designation underlined:

1. Superseded, S: All those parts that have been

superseded by another part are already shown in the parts master file with an "S." It is important to review these parts very carefully, as they will eventually become deleted and they must not be reordered. The superseding part "Z" will be printed below the "S" part and the suggested order quantity of the "S" part must definitely be revised. The suggested order quantity of the "Z" part must be increased by an amount equal to the suggested order quantity of the "S" part. Parts that have already been deleted and are coded as "D" in the parts master file will never have a suggested order quantity, the computer will be bypassing all those "D" parts.

2. New, N: These parts are the parts that have been recorded in the parts master file for less than six months and they can be selected on the basis of the date of introduction into the parts master file. When forecasting these parts with the single exponential method, the exponential smoothing constant will be 0.3 and after six months it will be reduced to 0.1 as explained already.

3. Seasonal, A: All the parts to be considered for seasonality must have been recorded in the parts master file for a minimum of 24 months and the seasonal forecasting method will be used.

4. High Value, V: High value items are those parts recorded in the parts master file for more than six months and whose semi-annual demand in dollars is greater than a monetary value established by the parts manager.

5. High Fluctuation, F: This classification is designed to catch those parts that are not seasonal, either because they have not been in the parts master file more than 24 months, or because they did not qualify for seasonal items when tested. The prerequisite for those parts will be one year in the parts master file. They will qualify as high fluctuation items if the straight moving average of the last quarter's demand minus the straight moving average of the current year's demand divided by the straight moving average of the current year's demand equals a specified percentage of fluctuation.

6. Straight, T: Those parts that do not belong to any of the above categories, but for which a suggested order quantity has been generated are classified as straight. They move in a regular manner and they do not need any special reviewing, although they can be reviewed if wished.

7. Non-Suggested Parts, P: Those parts that belong to none of the above categories and for which no suggested order quantity is generated (because there is sufficient stock on hand or on order).

Before running the factory order program the parts manager prepares a "Distributor Inventory Report Control Sheet," whose contents are shown in Table 7.

If the parts manager does not fill the distributor inventory report control sheet, the program will make the forecasting for all parts according to the standard values of the exponential smoothing

(0.3 for new parts, 0.1 for others), of the K factor (eight), of the high value annual demand established (say $5,000.00), and of the fluctuation percentage decided (say 30%). The suggested order quantity will then be calculated, with the checks mentioned, and it will print a suggested order quantity report for all the parts in each of the seven report categories shown in Table 7.

Table 7. Contents of Distributor Inventory Report Control Sheet.

REPORTS	Value	K Factor	α	Priority
Superseded, S				
New, N				
Seasonal, A				
High Value, V	____$			
High Fluctuation, F	____%			
Straight, T				
Non suggested Parts, P				

If the parts manager indicates changes on the distributor inventory report control sheet, control cards will be fed into the computer to modify the values of K, α, and so on. The priority order can be changed as desired. The change of K will be imperative during the spring months to project for the July month, when no orders are processed by the factory because it is closed for summer vacations. Depending upon the economy, the high value annual demand in dollars might be decreased or increased. If the high value items are more

important than the superseded, the former will be given priority one and the latter will be given priority four. If no report of the straight or non suggested parts is desired a hyphen will be put under the priority column.

Thus summarizing, the program will exist in a standard form (with values chosen once a year or so to take care of the exponential smoothing constant, the K factor, etc.). This program will do the forecasting for all the items and it will print their suggested order quantity into seven suggested order quantity reports for revision in a prescribed priority order. Changes to the above values and order are possible with the distributor inventory report control sheet.

Table 8 shows the contents of the "Suggested Order Quantity Report." All those items will be printed in part number sequence of the corresponding category in appropriate columns printed with appropriate headings. The reports will have a column for possible revisions at the right hand side. There will be no danger of duplicating the suggested order quantity of the same part in two or more reports, because once a part is printed in a report, say superseded, it will not be printed in a report of lower priority, say high fluctuating. The very last page of each report will show the total worth of the suggested order quantities, the on hand quantities, the on order quantities and the back order to dealers quantities.

A report will be printed after the seven category reports giving

a summary of dollars worth of the quantities being suggested for order, of the on hand and on order quantities and of the back orders to dealers. This summary will be presented by report type.

Table 8. Contents of the Suggested Order Quantity Report.

Part number
Part description
Date introduced in the parts master file
Demand of last 12 months shown by month
Recommended stock level
Forecasted monthly demand
On hand quantity
On order quantity total
On order quantity of four past cycles
Quantity of back orders to dealers
Frequency of dealers back orders since last cycle
Unit cost
Extended unit cost
Months of supply based on on hand quantity and forecast
Package quantity
Suggested order quantity
Designations other than the one reported (F, V, etc.)
Revisions space

From Suggested Order Quantity Reports to Factory Order Cards

The suggested order quantities are reviewed by the parts manager and the revisions are marked on the space provided in the reports.

Cards are produced from those revisions designated as "S.O.Q. revision" cards (code 40) and are fed into the daily data distribution. The S.O.Q. is revised and the on order quantity is increased. For those parts whose suggested order quantity did not need a revision, the on order quantity is increased by the suggested order quantity already in the parts master file. At this instant the switch is made in the on order history spaces. What was the current month now becomes the last month and the demand and demand frequency data is transferred from the parts master file to the demand file. Cards designated as placed on order (code 44) will be punched as part of the daily data distribution outputs. If nonmonthly orders are to be made, such as emergency orders or airfreighted orders, those orders will be punched on cards coded as 40 and they will be fed into the daily data distribution to revise the on order quantity.

The factory requires that all orders, regardless of type--monthly or emergency--are made in the form of cards which are air mailed to the factory. Furthermore, all parts are categorized by the factory into ten factory order types, and it is on the basis of these factory order types that the order numbers are given by the distributor every time an order is made. Factory order numbers are assigned in a consecutive fashion and have been given since the initial establishment of the distributionship. These numbers have been increasing in a consecutive fashion, dependent of the factory

order type, ever since that time. Thus if an order is made, all the parts that belong to the same factory order type are given the same factory order number, which is one number higher than the last order number used regardless of the factory order type.

To provide a factory order number, the placed on order cards (code 44) are punched in groups according to the factory order type. A factory order number is manually punched on each different group of cards coded 44. Cards coded 40 show the part number and the quantity ordered, whereas cards coded 44 show the part number, the quantity ordered, the factory order type and the order number that has just been inserted.

The very last program of the factory order system will take the placed on order cards (code 44) and it will produce factory order cards, pending receipt cards (coded 20) and the distributor order list.

The factory order cards are identical to the placed on order cards except the distributor number is shown on every factory order card. This distributor number is assigned by the factory in the same way the distributor assigns numbers to his dealers.

The pending receipt cards (coded 20) are duplicates of the placed on order cards, but have a different code. The pending receipt cards are put into a drawer to become data inputs when the item arrives.

The distributor order list is a continuous listing of the ordered

parts in part number sequence. In includes in various columns, the part description, the quantity ordered, the unit cost, the extended cost, the location in the warehouse, and the order number. The order date is shown at the top of the first page. The very last column is reserved for indicating the deletion of a part. If a part has been deleted during the days that have elapsed since the preparation of the suggested order quantity, a "D" will be shown in that last column and the card for the deleted part will be manually removed from the factory order cards. To compensate for the order deletion, a cancellation card (coded 42) will be made, and put into the next daily data distribution run. The last page of the distributor order list gives the dollar worth of all the parts ordered by factory order type and the grand total worth of the order.

VI. ADDITIONS SYSTEM

The additions system, which updates the parts master file from the arrivals of the ordered quantities from the factory, will now be discussed and the reader will find it convenient to refer to Figure 8 showing the operation of the additions system.

The pending receipt cards (coded 20), produced from the factory order system, have been put in a file pending information from the factory regarding the status of the order, that is, whether the order will be received or cancelled or back ordered. This information arrives from the factory in various forms (via letters, cables, teletype, etc.), and it is then transferred to a "factory order adjustment sheet" which is simply a sheet with six columns, the first two of which are for the part number and order number, and the last four for the quantities received, back ordered, cancelled, and received of a non-ordered item respectively.

If the part quantity ordered agrees completely with that to be received, the pending receipt card is picked up from the file and is placed in another file pending the parts arrival as contrasted to the former file that was waiting information from the factory. If the quantity shown on the pending receipt card does not agree exactly with that shown on the adjustment sheet, the pending receipt card is removed, and several things may happen.

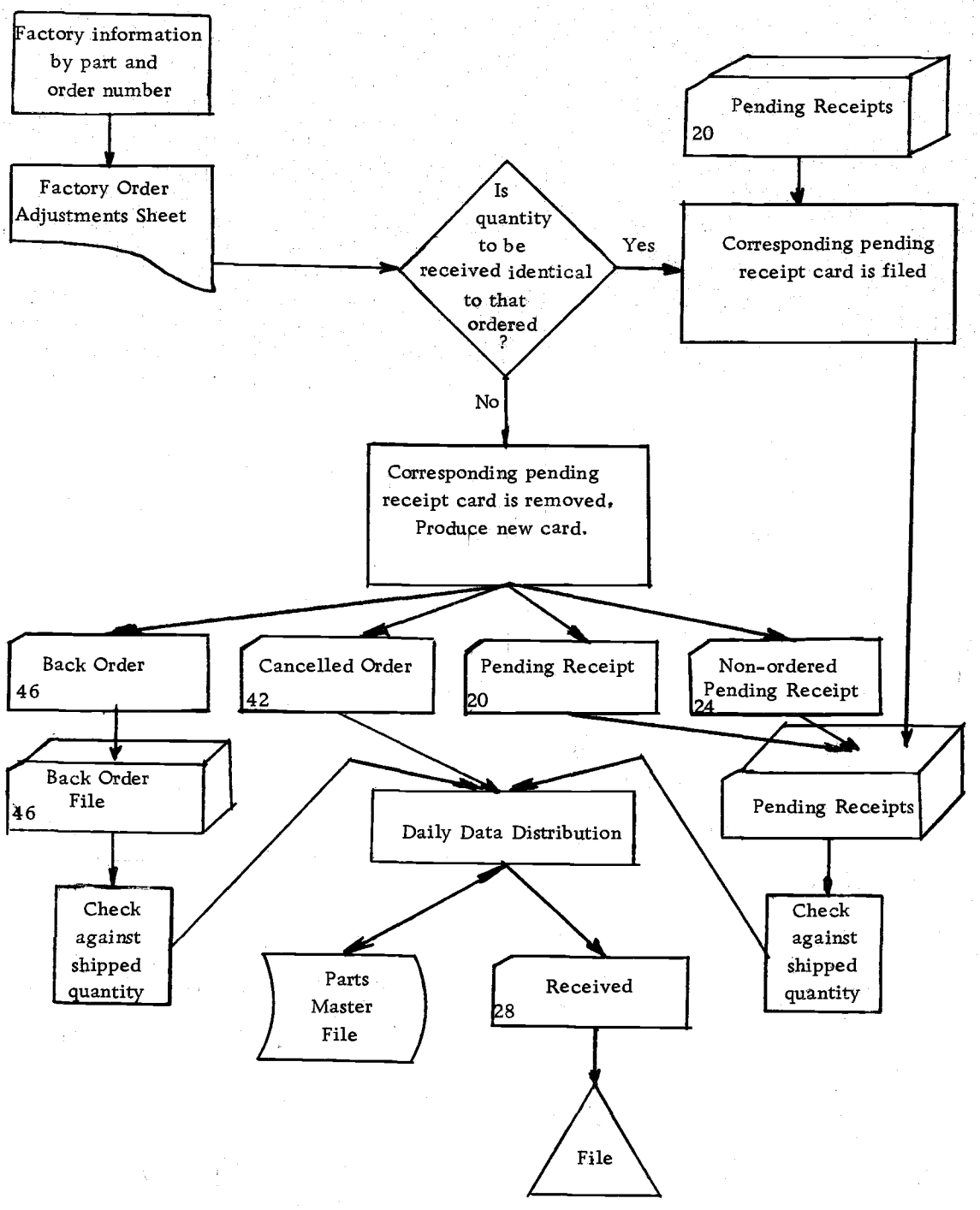

Figure 8. Additions System.

1. If the quantity of the part ordered is back ordered in full or partially, a factory back order card (coded 46) is made, showing the appropriate quantity, and is put in the back order file waiting the parts arrival. It is advantageous if these cards are of different color for distinction from the original pending receipt cards.

2. If the quantity of the ordered part is cancelled in full or partially, a cancellation card (coded 42) is made with the appropriate quantity shown as well as the part number. This card is immediately (the same day) fed into the daily data distribution, which, when reading this card, will reduce the on order quantity accordingly.

3. If the quantity to be received is less than the quantity ordered, a new pending receipt card (again coded 20) is made showing the quantity to be received and it is put in the pending receipt file waiting the parts arrival. For the balance of the quantity not to be received, a back order or a cancellation card is prepared according to the information received and it is processed as explained in 1 or 2 above.

4. If the quantity to be received is greater than the quantity ordered, the pending receipt card from the file is removed, a new one is prepared for the ordered quantity and processed, as if it were a pending receipt card. For the quantity to be received in excess of the ordered quantity, a non-ordered pending receipt card (coded 24) is made and put into the pending receipt file waiting the parts arrival.

When the daily data distribution reads this card coded 24, it will not reduce the on order quantity in the parts master file, but it will increase the on hand quantity.

When the parts arrive their corresponding cards are picked up from the back order or pending receipt files and, if the quantity that was just put in the bin is the same as that shown on the cards, these cards are put into the daily data distribution, which will increase the on hand quantity and decrease the on order quantity. In case the quantity put in the bin does not agree with that shown on the card the discrepancy is marked on the space provided on the card. On the basis of this discrepancy, a cancellation card is made, and another card (coded 20) for the quantity put in the bin is made. Both of these cards are fed into the daily data distribution.

The daily data distribution will produce cards (coded 28), called "received cards." These cards are put in a file and every week and every month a listing of factory parts receipts will be made. The daily data distribution will also print a daily factory orders cancellation list for the use of the parts department.

If the reader is amazed with the many cards involved in this system, it must be remembered that one of the goals established in the beginning was that of minimum installation and operation costs. The whole system could be put on a disc file but not only does the daily data distribution involve card inputs, but most of these cards

were already produced as duplicates of the factory order cards; furthermore, as the factory operates at the present, once an order becomes a back order, the factory drops its original order number and the distributor has no number reference when the part arrives. The computer would not know which back order was which, without an identifier number, and human judgment would probably do better.

VII. TRANSACTIONS SYSTEM

The parts, that had been ordered from the factory, have arrived at the distributor's warehouse and they have been recorded in the parts master file as additions by an increase of the on hand quantity of the pertaining parts. These parts will now be depleted from the parts master file as they are sold to the dealers via the dealers' monthly, emergency orders, or even back orders. All those orders will be processed by the transactions system, shown in Figure 6, which will also take care of any dealer back order cancellation or dealer returns.

Flowchart Explanation

The operation of the transactions system will now briefly be discussed with reference to Figure 9. The transaction cards, most of which will be orders and each one having a code (from 30 to 39), are fed into the daily data distribution and the parts master file is updated with an increased demand, and is checked to determine if the requested order can be filled. If the order cannot be filled, the dealer is invoiced, but not billed and a back order card (coded 37) is produced; this back order is put in a file. Each week various back order status reports are printed. Eventually this back order will return to the daily data distribution for reprocessing. If the

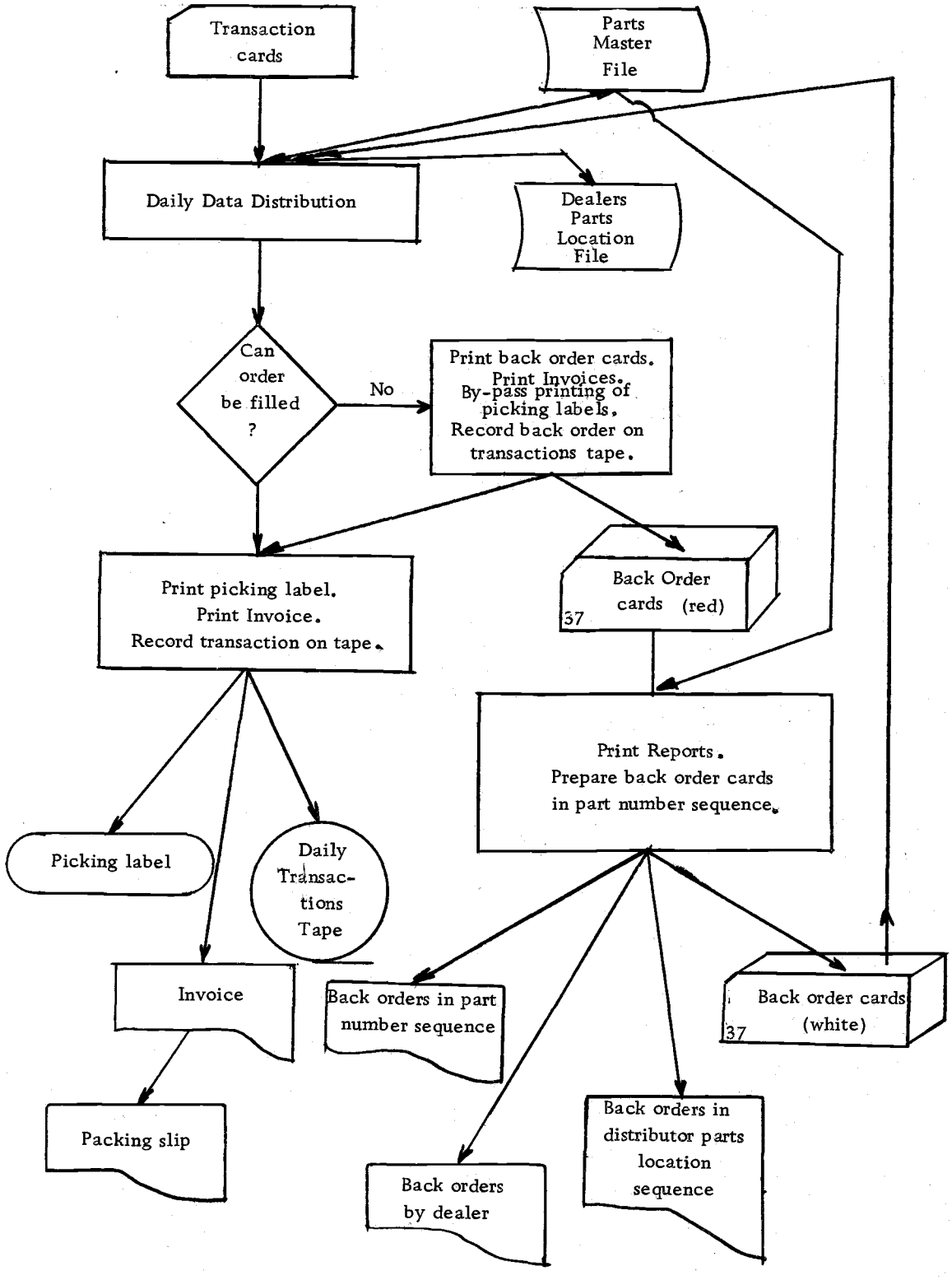

Figure 9. Transactions System.

order can be filled a picking label is produced, the dealer is invoiced and billed, a packing slip is printed, and the transaction is recorded on the daily transaction tape, which will later be merged with the transactions tape of the previous days. The order that could not be filled and became a back order is also recorded on this tape.

Thus, the daily data distribution links the dealers' transactions to the transactions tape. This transactions tape will later link all those transactions with the centralized dealer inventory control. Returning now to the transactions more details will be discussed below.

Unfilled Dealer Orders

In the event that a dealer's order cannot be filled, the daily data distribution will produce a back order card (coded 37) showing the type of the transaction (monthly order or emergency order), the dealer's number, the date, the part number and the quantity requested. It is convenient, if these back order cards are red as contrasted to the other cards that will be white. Every week these back order cards will be fed into a program which will read all the data from these cards, for all the dealers involved, and will produce, in part number sequence, white back order cards coded again 37. These white back order cards are put in a drawer for future use. It is from this file that they will return to the daily data distribution. Three reports are produced showing the back order status.

The first report is the back orders report in part number sequence showing the quantity back ordered, the dealer's number, the dealer's order type, and the date of the transaction. Since there might be many dealers that have requested this part and each dealer might have requested this part with a monthly or an emergency order, the quantity shown right after the part number will be that of the total quantity requested. In another column the individual quantities requested will be shown for the corresponding dealer's number and date. Thus, it is conceivable that the same part number repeats itself down the report. This report will be useful for the parts manager, who might wish to special order this particular part depending on the quantity back ordered and on the on order quantity due to arrive within the present cycle (this can be checked from the distributor inventory status report).

The second report will show the back orders by dealer number in parts number sequence. It will be identical in appearance to the above listing with the only difference being that only one dealer will be shown per report. A copy of which will be mailed to the dealer.

The third report, which will be produced only if requested, will show all the back orders by distributor warehouse location to check whether there is indeed an out of stock condition as shown by the parts master file.

Returning to the point in Figure 9 just before the red back order

cards are produced, it is shown that the dealer will be invoiced for this part. The reason for recording this back order transaction on the invoice copy, which shows the same dealer's filled orders in part number sequence, is that the dealer can be informed of this back order before he gets the copy showing all his back orders of one week. The printing of the picking label is bypassed in the meantime and no billing has taken place. Billing will take place, when the back order is filed. In the event that a back order card (coded 37) cannot be filled again, after it has been fed into the daily data distribution, another red back order card will be produced but the invoicing will be bypassed this time as it occurred once earlier.

Filled Dealer Orders

If a dealer's order card is fed into the daily data distribution and can be filled, the parts master file is updated (by reducing the on hand quantity and by increasing the current demand) and a picking label is first produced. These picking labels are produced in distributor part location sequence (for the same dealer ordering), to save steps for the clerk picking up the items to be sent to the dealer. The picking label also shows the part number, the part description, the quantity, the page number and line of the invoice which records this transaction and the dealer's part location. This last information will help the dealer's clerk store the item in the dealer warehouse

as the picking label is attached to the part. The dealer's part location is taken from a disc file that shows the dealer's parts location; it is understood that all the dealers do not need to be in such a file, but the major ones will be.

The same program that has produced the picking labels continues to print four identical documents, one of which will be the packing slip (to be sent to the dealer with the items shipped) and the other three will be the invoices (one for the dealer, one for the distributor accounting department, and one for the distributor parts department for future reference). Each one of these copies will be distinguished from the other by the headings and color, but their contents will be identical.

Table 9 shows the contents of the invoices. At the top of every invoice (or packing slip) will be the dealer number, the date of the invoice, the invoice number (to be a consecutive number given automatically for each invoice), and the transaction type (monthly order or emergency order, or back order or even a dealer return). The part number, the part description, the quantity shipped, the quantity back ordered, the dealer unit cost and the extended dealer cost (unless it is a back order) will be shown in that order in columns. On the last page of the invoice the total extended cost of the order will be shown. Each invoice might contain many pages, each of which will have a certain number of lines, but it is conceivable that there might

be one invoice with only one line.

Table 9. Contents of Invoices.

At the top of each page:
Dealer number
Transaction type
Invoice number
Invoice date
At columns from left to right:
Part number
Part description
Quantity shipped
Quantity back ordered
Dealer unit cost
Dealer extended cost

No order number is shown in the invoice, as the invoice number coupled with the date will serve as an order number for the dealer. If the dealer, however, insists that an order number supplied by him be put on the invoices, this can easily be done by putting it in the place of the part description, which, in such a case, will be deleted. The invoice number will still be shown at the top as this is very important because it is the invoice number and the date that will be recorded in the transactions tape for further use.

If a back order can be filled, in the place of the part description

in the invoice the date of the original order date is shown. The original invoicing date is enough for tracing the back order and this original date is carried on all back order cards.

The reader might be wondering why an invoice is made out before the order is shipped or even before that particular part is picked up from the warehouse. The advantage of invoicing, and billing for the filled orders before shipping lies in the fact that no parts will be shipped without a billing for the parts. Money has been lost and is now being lost with the improper billing by the manual system in Greece. Furthermore, the invoicing is made at the time the picking labels are printed while the whole system is in operation and thus no extra time and money is used for separate invoicing.

It might happen, although rarely, that the dealer has been billed for a part that he will not receive immediately, because the on hand quantity reflected in the parts master file does not agree with the warehouse on hand quantity, which is less. Discrepancies, which are detected while the parts are being picked from the bins, are referred to as back order credits and to compensate for these discrepancies the back order credits cards (code 30) have been devised. A back order credit card is punched showing the part number, the dealer number and the quantity of the part to be given credit. This card is fed into the daily data distribution and the part is placed on back order

to the dealer, the on hand quantity in the parts master file is increased by the amount back ordered so that the master file will only account for the parts actually shipped, the stop on sales check is created in the parts master file (so that only back orders will be accepted), and the dealer is given credit with a new invoice. This invoice is identical to other invoices except that a minus (-) sign is printed in front of the quantity shipped and the extended cost, and a plus (+) sign is printed in back order quantity column. In the meantime a clerk checks the bin, from which the part was missing, and the bin's vicinity for possible misplacing of the part.

If parts are returned from the dealer and are brought back by the distributor, the dealer return cards are punched and fed into the daily data distribution. Then the on hand quantity of the parts master file is increased by the quantity shown on the card and the dealer return invoices are produced, for the dealer shown on the card, with corresponding minus signs in front of the extended cost. Return charges might be incurred by the dealer for returning the parts but the details will be decided in the future.

Thus, various transactions cards will be fed into the daily data distribution and depending upon the card codes the parts master file will be updated accordingly and invoices will be printed.

VIII. DEALERS CENTRALIZED INVENTORY CONTROL SYSTEM

Thus far it has been shown how parts were ordered by the distributor, how those parts were added to the distributor file and how those parts along with other parts on the distributor's files were transacted with the dealers. All those transactions are now on the transactions tape and they can be referred to by the date of the invoicing, the invoice number, and the dealer number; each transaction is classified by its code corresponding to the card codes of Table 3. The other information recorded on the transaction tape at the invoicing time include the quantities shipped and back ordered, the extended dealer and distributor costs; and the part classification. The transactions are of course in distributor parts location sequence.

Referring to the goals established at the beginning of this work and to the model shown in Figure 6, it is desired that all dealers be put on a centralized inventory control system. Such a system would add a great deal to the effectiveness of the dealers; since it would do all the forecasting for the dealers; it would supply the dealers with valuable reports on the basis of which they could record their sales and refer to the status of all their parts. In short, this system aims at putting the computer's usefulness at the disposal of the dealers through the distributor and ridding the dealers of the necessity of the

Kardex system, which needs careful manual and often tedius updating. Finally a report will be printed for the distributor showing the transactions of all the dealers within the prescribed time interval in such a fashion as to evaluate the performance of the dealers.

Flowchart Explanation

Figure 10 shows the operation of the dealers centralized inventory control system. The daily transactions tape is merged with the transactions tape showing the transactions accumulated within the last couple of months. The accumulated transactions tape has a special designation--such as an "X" placed on a particular space--for those dealers, whose forecasting for the current cycle has been made, and those dealers will be referred to as "tagged" dealers. As the new daily transactions tape is merged with the accumulated transactions tape, certain dealers--to be specified by the distributor parts department--are selected for their forecasting run, they are tagged and then they are placed on a "selected dealers transactions" disc file for further processing.

Fom the "selected dealers transactions" disc file a special program will do the forecasting for the dealers and will also print out various reports. Inputs to that program for the current cycle, other than the disc file itself, are the dealers' sales cards, and cards showing any adjustments with regard to the quantities or parts

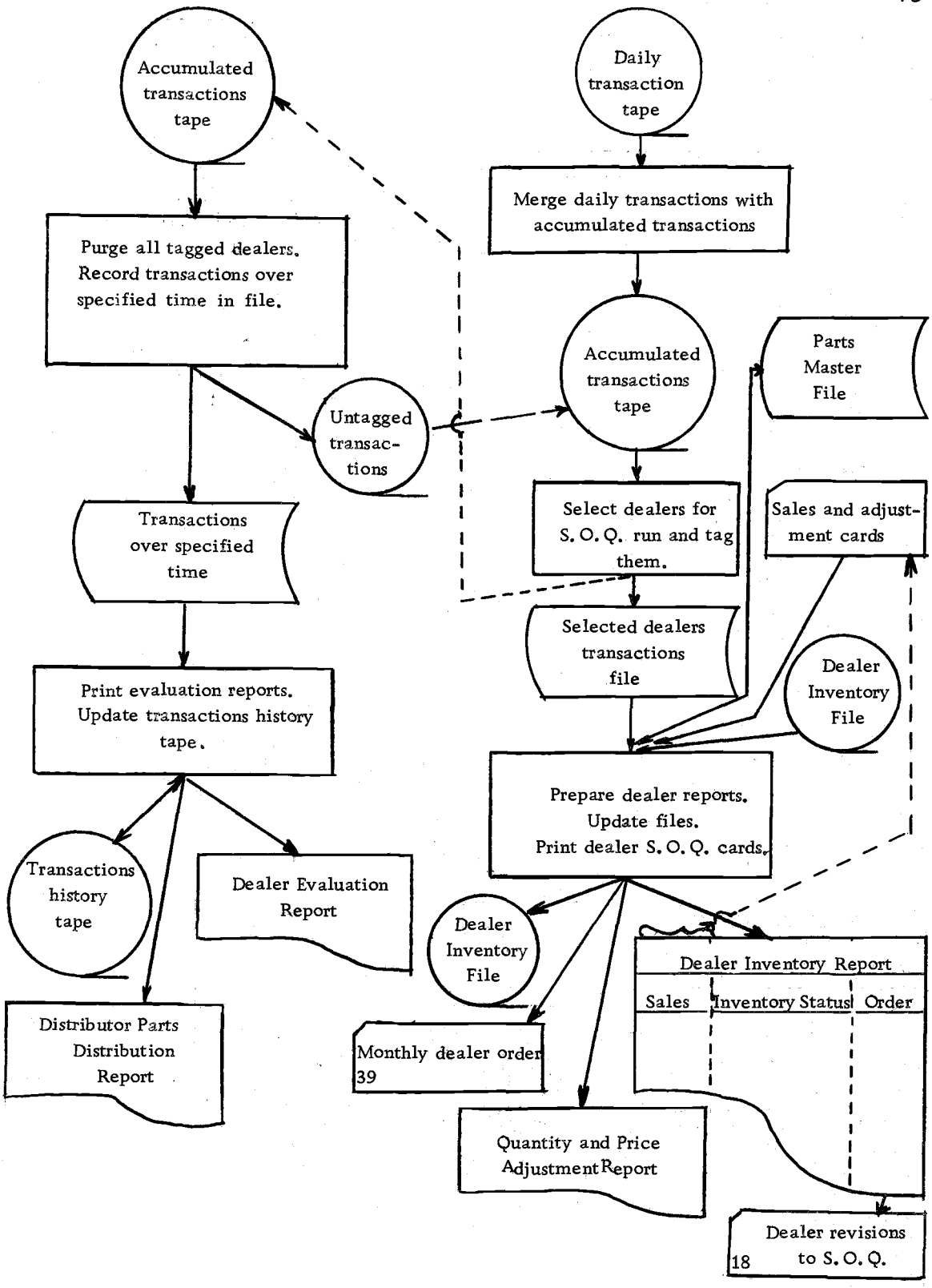

Figure 10. Dealers Centralized Inventory Control System.

location at the dealership. The other input will be the dealers inventory tape for the last cycle showing the sales of the past 12 months. The parts master file is also used as input as it is from here that the prices will be obtained. After the execution of this program the updated dealer inventory tape is produced and it will be used during the next cycle for the dealer. Outputs of this program also include the dealer monthly order cards (coded 39), the quantity and price adjustments report to be mailed to the dealer, and the very important dealer inventory report, which will be explained shortly in detail. The dealer monthly order cards (coded 39) will stay at the distributor and, unless revisions are made by the dealer (cards coded 18), those cards will be fed into the daily data distribution when the dealer's monthly order is processed. Finally, the parts master file is updated with regard to those three dealers that have stock of the part; this updating is based on the on hand quantity shown on the dealer inventory report.

Returning to the accumulated transaction tape shown in Figure 10, this tape is purged of all the tagged dealers and the transactions of the current month are put on a disc file for preparation of the dealers evaluation, it will be explained soon.

Dealers Sales Forecasting

The forecasting of the dealer sales will not be as sophisticated

as the distributor demand forecasting (in terms of reports for superseded and seasonal parts and so on). The distributor by having a more sophisticated forecasting serves the dealers needs and the lead time is only a matter of several days. If parts are needed immediately they can be airfreighted to various parts of Greece within a few hours after a telephone call from the dealer. The single exponential smoothing method will be used for all items to obtain the monthly average forecast, F_t, which will be multiplied by a K factor of four to give the recommended stock level. The package quantity check as well as the 10% limit check are still considered here. The economic order quantity will also be used for the dealers and its monetary value in terms of annual usage in dollare will be established by the distributor either after various analyses, similar to that for the distributor, or by establishing it as 1/5 of that of the distributor.

Essential for the dealer suggested order quantity generation are the dealer's current sales (to be used as D_t), the on hand quantity, and the on order quantity. The dealer's current sales will be submitted, on dates fixed by the distributor for each dealer, by the dealer on the dealer sales report (part of the dealer inventory report). The sales from this report are transferred into cards (coded 10) by the distributor data processing department. Any quantity or location adjustments are also submitted on the dealer sales report and they are transferred into cards (coded 12 and 14). The on hand and on

order quantities are quantities are taken from the dealer inventory tape and they are also adjusted by the transactions stored temporarily on the "selected dealers transactions file." Those transactions shown by the dealer inventory tape are for one cycle, which might be more than one month if this particular dealer did not order last time. The suggested order quantity for each part for the particular dealer, whose cycle is being run, is printed on the monthly order cards (coded 39), to be filed in the distributor's parts department.

Other outputs of this forecasting program will be the updated inventory tape, the dealer inventory report which includes everything the updated inventory tape includes, and the quantity and price adjustments reports. These two reports will be discussed very soon. Finally, the parts master file is updated, if appropriate, to indicate the dealer having stock of the part.

Dealer Inventory Report

The dealer inventory report is a continuous document recording all the parts the dealer has and is made of three parts; the dealer sales report, the dealer inventory status report, and the dealer order report. The contents of each report are shown on Table 10 and each report may be torn apart from the other report at perforation lines.

The dealer inventory status report, the middle portion of the whole printed report, reflects the dealer's inventory at a particular

Table 10. Contents of Dealer Inventory Report.

Dealer Sales Report:

- Space for recording daily sales
- Part Number
- Dealer unit cost
- Quantity adjustment + (plus)
- Quantity adjustment - (minus)
- Location change, old
- Location change, new
- On hand quantity

Dealer Inventory Status Report:

- Part number
- Part description
- Dealer unit cost
- Retail unit cost
- On hand value
- Location
- Quantity received during last cycle
- Quantity adjusted during last cycle
- Sales history of last 12 months per month
- On hand quantity
- Months on record
- Months of supply left
- Back ordered quantity
- Suggested order quantity (S.O.Q.)
- Package quantity

Dealer Order Report:

- Order quantity (same as S.O.Q.)
- Part number
- Revised quantity (space provided for)

date (the date the computer ran the report) and it will serve in connection with the other two adjacent reports--the dealer sales report and the dealer order report--as a replacement of the Kardex system. The Kardex system is now used by some of the dealers in a very unorganized fashion. This whole report will require much less updating (just sales and adjustment recording and order revisions), since everything else will be done by the distributor's computer for the dealer at a nominal cost.

On the description column of the dealer inventory status report, space will be provided under the description of each part to furnish the dealer's parts manager with additional information regarding the parts activity. Thus, if a part is seasonal an "A" will be printed, if the part is superseded and "S" will be printed, if it qualifies for the economic order quantity, and "E.O.Q" will be shown and so on. Caution will be exercised when taking these designations from the parts master file to transfer them to the dealer's inventory report as to never print a "D" for the deleted part, unless the distributor is out of stock.

The very last page of the dealer inventory status report will print (1) the dealer's total inventory parts in count and in dollars value, (2) the suggested order parts in count and in dollars, (3) the current receipts in count and dollars and (4) the current sales in count and dollars. Current means the current month or as of the

date the sales report was filled out. This date will be established for each dealer by the distributor. The inventory report will be run a few days later but the program that will take the transactions from the tape will include the transactions only until the above date.

At the top of the dealer's inventory status report and on each page the following items will be printed; the dealer's title, the dealer's number, the report number, the cut-off date and the reports date.

The dealer order report, which will occupy the right hand side of the whole inventory report, will be used by the dealer's parts manager to place his order. The only thing he will have to do is to revise the suggested order quantity if he does not wish to receive the quantity suggested. He will have all the necessary information on the middle portion of the report to study the part's activity. After he has made the revisions, he will tear the order report from the other part of the whole report and will mail it to the distributor on a prescribed date. The distributor's data processing department will punch cards for the revisions. Those cards (coded 18) will be fed into the daily data distribution, when that particular dealer's order is processed, along with the other order cards (coded 39) which were prepared a few days earlier and have been at the distributor's part department. Cards coded 18 will supersede cards coded 39 for the same dealer.

The dealer sales report, the left hand side portion of the dealer inventory report, will be used by the dealer's parts department to

record the daily sales. The sales will be recorded from left to right by adding each sale to the previous total and recording the accumulated sales. On the cut off date the dealer will send the sales report to the distributor, whose data processing department will punch into cards (coded 10) the accumulated sales. If the dealer had made any changes in his location of the parts, he will record the changes in the spaces provided and the distributor's data processing department will punch cards (coded 14) for these changes. Furthermore, if the dealer sells parts to another dealer or if parts are lost or stolen, the quantity will be recorded in the minus space provided for quantity adjustments. If the dealer buys parts from another dealer, the appropriate quantity will be recorded in the plus quantity adjustment space provided. These quantity adjustments will be punched into cards by the distributor (coded 12). Cards coded 10, 14 and 12 for that particular part for the dealer, will be fed into the program that will produce the dealer inventory report and will serve as inputs along with the dealer inventory tape, the transactions stored on the disc, and the parts master file.

The dealer's title, the dealer's number, the cut off date, and the reports number and date will be shown on the dealer sales and dealer order reports on every page. Both those reports will be signed and mailed to the distributor on prescribed dates. If these dates are adhered to and the little updating required is done

carefully, the dealer will be happy that he got rid of the Kardex system. With this new report, which will be given to the dealer in two copies (to be used as sales recording, as price catalogue, as location directory and as general reference) the dealer will in a sense have his own parts master file. The on hand quantity shown on the sales report minus the sales accumulated should equal the on hand stock in the bin, unless a new shipment has arrived after the report was pritned.

Inventories adjustments are vital as they directly influence the inventory's value. Consequently, a quantity and price adjustment report will be printed in two copies for the dealer's accounting department and the dealer's parts department at the same time the dealer's inventory report is printed. Inventory adjustments will consist of quantity and price adjustments, the former being initiated by the dealer--as already explained--and the latter being initiated by the distributor due to cost increases.

The quantity and price adjustments report will contain the items shown in Table 11 and it will be printed in part number sequence for the parts that had an adjustment. With this report the dealer will not have to go through the entire dealer inventory report to determine what adjustments have been made in the prices. He is aware of the quantity adjustments since he made them. The last page of the report gives the total dollars adjustment for the worth of the dealers

inventory. Most of the adjustments will be quantity adjustments (because of the dealers interpurchases) unless major price changes have been made.

Table 11. Contents of Quantity and Price Adjustments Report.

Part Number
Part description
Type of adjustment (quantity or price or both)
Old price
New price
On hand quantity
Quantity adjusted
Dollars adjusted

It is highly recommended that the dealer submits both his sales and order reports every month at the dates prescribed. If the dealer skips one cycle and does not order parts, he will probably order some other emergency, but he must not skip a cycle in sales submission as he will not get a report for that month. It is advisable that the submission of the sales report be compulsory.

Dealers Evaluation

As mentioned earlier, it is desirable for the distributor to evaluate all the dealers in terms of their transactions on a monthly

basis. The accumulated transactions tape (shown in Figure 10) will eventually be infinitely long--a situation detrimental to the computer time--unless it is purged at various intervals of past transactions. The purged data can be printed in reports or placed on other tapes for reference. Furthermore, there is no need of having in the tape the transactions of those dealers whose forecasting has already been done. Thus, every month--preferably on the first of each month--the accumulated transactions tape will be purged of data for all the tagged dealers. After this purging the tape will include only those dealers that are untagged with their transactions that go back to the last time they were tagged. This interval can be more than one month if the dealer(s) did not submit the sales report(s).

During the purging of the tagged dealers the transactions of all the dealers within the last month will be recorded on a magnetic disc file from which they will be further processed. Once the dealers' transactions of the last month are on the disc file they can be processed by appropriate programs to produce various reports reflecting the transactions of each dealer. The monthly reports are also recorded on the transactions history tape covering 12 months and being updated every month by dropping the twelfth month and adding the latest one.

The dealer evaluation report contents are shown in Table 12. Each report will show the date at the top along with the dealer's title.

Table 12. Contents of Dealer Evaluation Report.

I. Part Classification in Extended Dealer and Distributor Costs with the Grandtotals at the Bottom of Report for:

1. Current month
2. Same month last year
3. All last 12 months

II. Distribution of Transactions in Item Counts:

	Orders	%	Back Orders
Monthly Orders			
Emergency Orders			
Back Orders			
Miscellaneous			
		100%	

III. Sales by Certain Products in Item Counts:

	Current Month	Same Month Last Year	Last 12 Months
Spark Plugs			
Blaupunkt radios			
Seat Covers			
etc.			

IV. Order Frequency During Current Month by Item Counts:

1 2 3 4 5-over.

The report will be segmented into four subreports printed on the same page for quick examination. The information pertaining to past transactions will be taken from the transactions history tape. All the information shown on the report will also be recorded in the tape for next month's use. The dealer can be evaluated by examining his order frequency. For example, the dealer who ordered many parts twice or three times or more during the current month will undoubtedly have many emergency orders and he is not operating efficiently. The dealers' loyalty to the distributor can be also checked by examining the sales by certain products, which will be traced in the disc file by the part number. The dealers that buy the radios and other accessories from other sources can be detected from the item counts sold during the current month.

All the dealers evaluation reports, as many as the number of dealers, will be recapped at the end to obtain on a single report, the distributor parts distribution report for the current month. The contents of this report will also be recorded in the transactions history tape.

IX. MODEL EVALUATION

Looking in retrospect at the development of the inventory control model for the Volkswagen spare parts distribution in Greece, an evaluation of this model would be in order.

The model features four systems, and the necessary system files, daily data distribution, and various routines. These four systems have vital and specific functions and provide effective overall inventory control. Several of the outputs of the systems, the pending receipt cards and the dealer monthly order cards, to name the most important, become inputs to other systems such as the additions and the transaction systems. Thus, full utilization of the systems outputs is made through card recirculation.

The tapes and many of the cards involved can certainly be replaced by disc files or even drum files, but the cost that would be incurred does not justify these expensive storage units. Furthermore, tapes are necessary for back-up information as well as for future reference. Discs will be employed for processing the taped data, but there is no reason to tie up expensive memory units continuously.

The daily data distribution is a very important asset to the whole model. It can be argued that it has the disadvantage of postponing the function of each system until the daily data distribution run once a

day, but the advantage of obtaining a balanced data distribution by considering all the functions of the system in terms of priorities seems to outweight this disadvantage.

When implementing this model certain portions of it may be modified to take advantage of new technological advances and other factors such as new factory policies or regulations. After this model is implemented and the business is increasing in terms of volume, complexity, and hopefully in terms of return of investment, it is conceivable that major modifications could be economically justified. One such major modification would be the addition of another system that would teleprocess the dealer orders via the telephone or the teletype without the need of dealer order cards, and with instantaneous updating of the parts master file as well as retrieval of data from it.

There is a question whether the operation of this inventory control model would be feasible in Greece in terms of the high costs involved. There are not sufficient data available at this time to determine when the inventory control system can be implemented. A continuing economic analysis will need to be made in Greece to determine the costs of such a system and the benefits derived. There is no doubt that such a system will eventually be economically worthwhile. There are many examples of companies in the United States employing computers in inventory control to support such a conclusion.

A last question would be the acceptance of the computerized inventory system by the Greek dealers. Since this model will not be implemented overnight, dealer orientation and training will precede the installation of the model to condition the dealer to this innovation. The dealer will certainly accept the system as it will increase his profits.

X. CONCLUDING REMARKS

A computerized inventory control model for Volkswagen spare parts distribution in Greece has been designed. Examination of this model leads to the following conclusions:

Statistical forecasting techniques were selected for forecasting the distributor parts demand. These techniques are flexible enough as they can be adjusted by changes in the exponential smoothing factor and the K factor to account for the buffer stocks. The utilization of the ABC analysis along with the printing of the seven reports offer an excellent inventory forecasting management.

Computerized procedures were designed to prepare the factory order through the chosen forecasting techniques and the appropriate computer hardware and software. A system was also designed to update the parts master file with the parts arrival from the factory.

A system was developed to control the inventory of all dealers in a uniform fashion. This system provides sales forecasting, dealer inventory reports (to rid the dealers of the manual Kardex system), and an evaluation of the performance of the dealers.

The whole model operation furnishes the distributor parts department with various management reports reflecting the parts status, the parts ordering, the parts back-ordering and all the transactions. Many decisions with regard to changes in the forecasting

techniques can be made after studying these reports.

The model entails the minimum installation and operation costs in view of the hardware and software involved. Furthermore, the model is not restrained in any way to any computer company and it meets the Volkswagen factory regulations.

Finally, the implementation of this model by the Greek Volkswagen distributor will be to his advantage, as it will improve his inventory control.

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