

4046 (2) Sept-671.

ICL

SCAN system 1 for inventory management

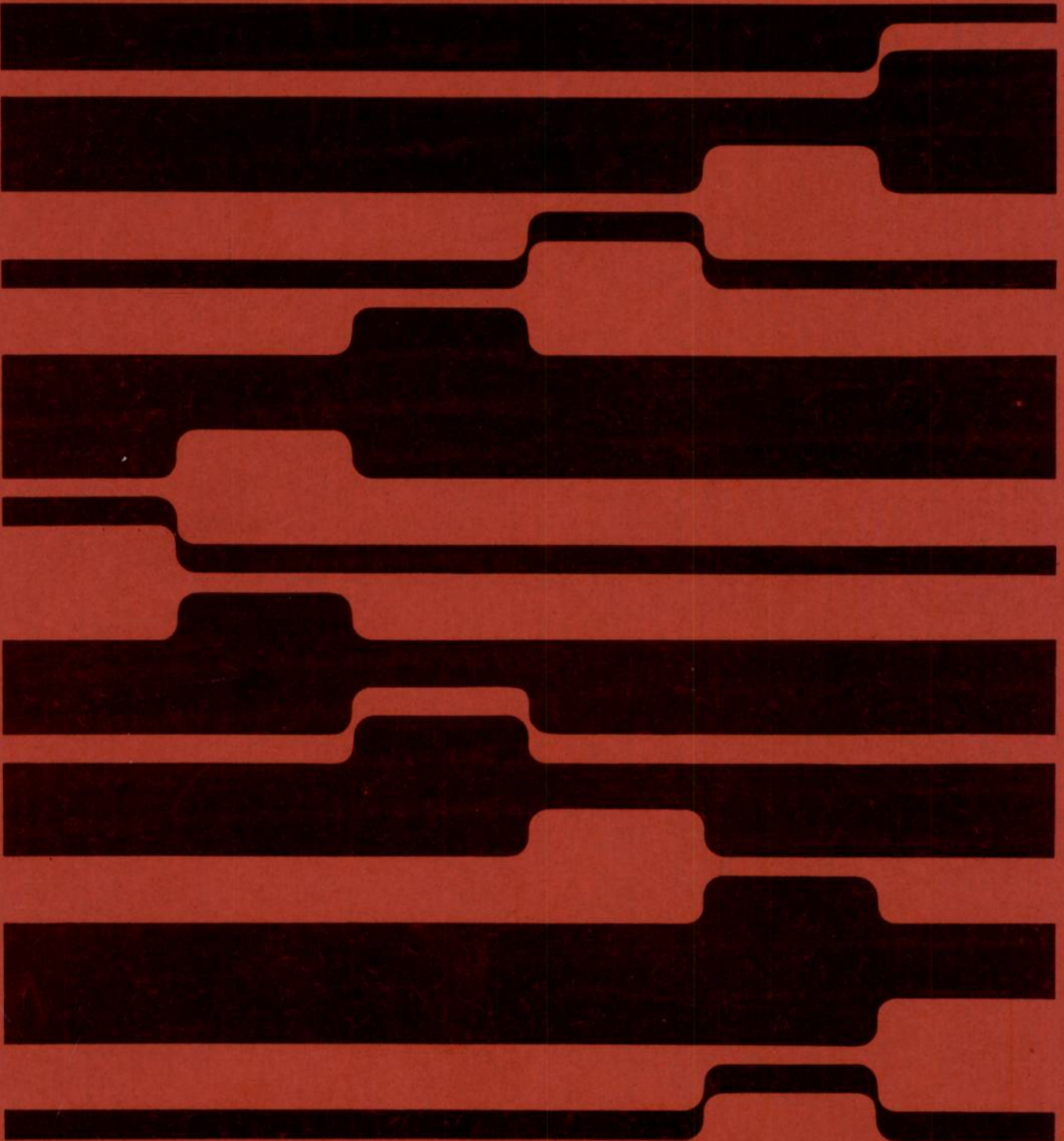
1900 Series

OXFORD UNIVERSITY COMPUTING LABORATORY

Copy 1

COMPUTING SERVICE

4046





ICL

**SCAN
system 1
for
inventory
management**

1900 Series

Original
Copy 1 4046

The policy of International Computers Limited is one of continuous development and improvement of its products and services, and the right is therefore reserved to alter the information contained in this document without notice. ICL makes every endeavour to ensure the accuracy of the contents of this document but does not accept liability for any error or omission. Any equipment or software performance figures and times stated herein are those which ICL expects to be achieved in normal circumstances. Wherever practicable, ICL is willing to verify upon request the accuracy of any specific matter contained in this document.

This document is offered solely on the relevant standard ICL terms of issue given below

The ICL documentation contained in this manual is issued on the terms that it may be used only by the person to whom it is issued ('the Inquirer') and solely for the purposes of deciding whether to request issue or use of the relevant program on ICL's standard terms and of using any program so issued; that it is confidential; that the Inquirer will so instruct all employees having access to it and will not disclose it or any part or element of it to any third party; that copyright and any patent or other rights are reserved to ICL, and that the Inquirer will promptly return the manual at ICL's request.

With effect from 9th July 1968 the name of International Computers and Tabulators Limited has been changed to International Computers Limited

Technical Publication 4046

© International Computers Limited 1967

First Edition June 1967

Second Edition September 1967

Reprinted May 1970
(incorporating Amendment 1)

Note: SCAN System 1 has been extensively modified and expanded to increase the facilities available in the operational routines and to provide compatibility of file formats with the magnetic tape version of SCAN System 2. This manual replaces the first edition and the SCAN System 1 Operating Manual for Inventory Management. The system, the associated programs and the file formats described herein similarly replace those described in these earlier two publications.

Issued by Technical Publications Service
International Computers Limited
Head Office: ICL House, Putney, London SW15
and printed in Great Britain by
ICL Printing Services, Letchworth, Hertfordshire

Contents

Copy 1

4046

Preface

Chapter 1 Inventory Control	1
1.1 Introduction	1
1.2 Inventory Management and the Computer	1
1.3 Re-order Point Control	3
1.3.1 Automatic Revision of Re-order Points	4
1.3.2 Safety Stock	4
1.3.3 Replenishment Order Quantity	5
1.3.4 Demand Forecasting	7
1.3.5 Forecasting Frequency	7
1.3.6 Control Optimality	7
1.3.7 Monitoring of System Performance	8
1.4 Inventory Analysis	8
Chapter 2 General Description	9
2.1 System Characteristics	9
2.2 Outline of System Routines	10
2.2.1 File Creation Routines	10
2.2.2 Analysis Routines	12
2.2.3 Operational Routines	15
2.3 Program Availability	18
2.3.1 File Formats	18
2.3.2 Program Structure	19
2.3.3 Machine Configuration	19
Chapter 3 System Description	21
3.1 General	21
3.2 Input/Output Records	22
3.3 Processing Functions	22
3.4 File Creation Routines	23
3.4.1 Master File Create/Maintenance Routine	25
3.4.2 Skeleton History File Generate Routine	37
3.4.3 Master File Record List Routine	39
3.5 Analytical Routines	41
3.5.1 Stock Profile Analysis Routine	41
3.5.2 ABC Analysis Routine	45
3.5.3 Control System Selection Routine	49
3.5.4 Demand Analysis Routine	51
3.5.5 Optimal Prediction Parameter Routine	55
3.5.6 System Performance Estimation Routine	59

3.6	Operational Routines	63
3.6.1	Magnetic Tape Creation Routine - Transaction File	63
3.6.2	Sort/Merge Routines	65
3.6.3	Stock Updating and Allocation Routine	67
3.6.4	Allocation Report Routine	73
3.6.5	Under Minimum/Over Maximum List Routine	75
3.6.6	Stock Forecasting and Monitoring Routine	77
Chapter 4 System Implementation and Integration		81
4.1	General	81
4.2	Data Collection	81
4.3	Basic Data	82
4.4	Internal System Relationship	83
4.4.1	Analysis Routines	83
4.4.2	Operational Routines	84
4.5	External System Relationship	92
4.6	Frequency of Processing	97
4.6.1	Analytical Routines	97
4.6.2	Operational Routines	98
4.7	Operational Control	98
4.7.1	Transaction List	98
4.7.2	Replenishment Orders List	98
4.7.3	Stock Activity Report	99
4.7.4	Allocation Report	99
4.7.5	Under Minimum Report	99
4.7.6	Over Maximum Report	99
4.7.7	Reported Items List	99
4.8	Parallel Run	99
4.8.1	Initializing the System	100
Chapter 5 File Formats		101
5.1	Demand History File	101
5.2	Stock Master File	105
5.3	Transaction File	107
5.4	Paper Tape Formats	111
5.5	Magnetic Tape File Formats	112
5.5.1	Demand History File	112
5.5.2	Stock Master File	114
5.5.3	Transaction File	116

5.5.4	Profile Results File	119
5.5.5	Composite File	
	Replenishment Order Requisition File	
	Allocated Demand File	
	Priced Receipts File	
	Over Maximum Stock Level File	120
5.6	Parameter Record Formats	121
5.6.1	Run Parameter Record	121
5.6.2	Field Type Table Records	121
5.6.3	Function Records	123
5.6.4	Item Selection Record	127
5.6.5	Stock Profile Analysis	127
5.6.6	SORT (Input to ABC Analysis)	128
5.6.7	ABC Analysis	129
5.6.8	SORT (Input to Control System Selection Routine)	130
5.6.9	Control System Selection	130
5.6.10	Demand Analysis	131
5.6.11	Performance Estimation	132
5.6.12	SORT (Transaction File)	134
5.6.13	MERGE (Transactions)	135
5.6.14	Stock Updating	136
5.6.15	Forecast	136
Chapter 6	Operating Procedures	139
6.1	Master File Creation/Maintenance Routine	139
6.1.1	Create Function	140
6.1.2	Merge Function	141
6.1.3	Insert Amend Delete Extract Functions	142
6.2	Skeleton History File Generate Routine	144
6.3	Master File Record List Routine	146
6.4	Stock Profile Analysis Routine	147
6.5	Sort Routine (Input to ABC Analysis)	149
6.6	ABC Analysis Routine	150
6.7	Sort Routine (Input to Control System Selection Routine)	152
6.8	Control System Selection Routine	153
6.9	Demand Analysis Routine	155
6.10	Optimal Prediction Parameter Routine	156
6.11	System Performance Estimation Routine	157
6.12	Magnetic Tape Creation Routine - Transaction File	158

6.13	Sort/Merge Routines (Operational)	159
6.13.1	Sort Routine (Input to Merge and/or Stock Updating and Allocation Routine)	159
6.13.2	Merge Routine (Input to Stock Updating and Allocation Routine)	160
6.14	Stock Updating and Allocation Routine	161
6.15	Allocation Report Routine	163
6.16	Under Minimum/Over Maximum List Routine	165
6.17	Stock Forecasting and Monitoring Routine	167
6.18	Exception Conditions	169
Chapter 7 SCAN System 1 Simulator		171
7.1	General	171
7.2	Input Section	171
7.3	Processing Section	171
7.3.1	Input Validation and Control	172
7.3.2	Simulation	172
7.3.3	Initial Conditions	172
7.3.4	Performance Analysis	173
7.4	Output Section	173
7.4.1	Parameter Check List	173
7.4.2	Simulation Report	173
7.4.3	Performance Analysis Report	173
Chapter 8 Simulator Input File Formats		177
8.1	The Simulator File	177
8.2	Header Card	177
8.3	Principal Parameter Card	177
8.4	Cyclical Factor Cards	179
8.5	Control Parameter Card	179
8.6	Demand Data Cards	181
8.7	Control Totals Card	182
8.8	Trailer Card	183
Chapter 9 Running the Simulator		185
9.1	Program Summary	185
9.2	Run Instructions	185
9.3	Exception Conditions	186

Appendix A Mathematical Description

A.1	General	187
A.2	Stock Updating Routine	188
A.2.1	Closing Stock	189
A.2.2	Available Stock	189
A.2.3	Re-order Quantity	189
A.2.4	Outstanding Order Balance	190
A.3	Demand Forecasting	190
A.3.1	Forecast Interval	190
A.3.2	Adaptive Prediction Techniques	191
A.3.3	Cyclical Variation in Demand	193
A.3.4	Significance Test for Cyclic Variations	195
A.4	Safety Stock	196
A.4.1	Variability of Replenishment Delivery Times	198
A.5	Re-order Point	199
A.6	Control of Prediction Optimality	199
A.7	Replenishment Order Quantity	200
A.7.1	Minimum Order Quantities	202
A.8	Performance Estimation	202
A.9	Supplementary Formulae	204
Appendix B Normal Probability Table		205
Appendix C Bibliography		207

Illustrations

Figure		Page
1	Variation of Stock with Constant Demand and Constant Replenishment Delivery Time	2
2	Variation of Stock with Variable Demand and Variable Replenishment Delivery Time.	2
3	Variation of Stock with Variable Re-order Point and Constant Replenishment Order Quantity	4
4	Effect of Order Quantity on Cost	5
5	Variation of Stock with Variable Re-order Point and Variable Replenishment Order Quantity	6
6	Master File Create - Record List	26
7	Master File Maintenance - Sample Listing	34
8	Master File Record List - Demand History File	38
9	Master File Record List - Stock Master File	38
10	Stock Profile Analysis - List and Frequency Table	42
11	ABC Analysis - List	44
12	ABC Analysis - Summary Table	46
13	ABC Analysis - Preliminary Analysis Table	46
14	Control System Selection Routine - Inventory Listing	48
15	Demand Analysis - Full Printer output	52
16	Demand Analysis - Abridged Printer output	52
17	Optimal Prediction Parameter Analysis - Printer output	56
18	System Performance Analysis - Item List	58
19	System Performance Analysis - Summary Table 1	60
20	System Performance Analysis - Summary Table 2	60
21	Transaction File Creation - Transaction List	62
22	Stock Updating and Allocation - Replenishment Order List	70
23	Stock Updating and Allocation - Stock Activity Summary	70
24	Allocation Report	72
25	Under Minimum Stock Level Report	74
26	Over Maximum Stock Level Report	74
27	Stock Forecasting and Monitoring Routine - Reported Items List	77
28	Interrelationship of Routines	87

Figure		Page
	(a) Analysis I	87
	(b) Analysis II	88
	(c) Stock Updating and Allocation I	89
	(d) Stock Updating and Allocation II	90
	(e) Stock Forecasting and Monitoring	91
29	External System Relationships	93
	(a) Invoicing and Related Procedures	
	Finished Goods Stocks	93
	(b) Purchase Order Routine	94
	(c) Audit Report and Composite File	
	Adjustment Routines	95
30	Data Sheet - Demand History File Record	102
31	Data Sheet - Stock Master File Records	104
32	Data Sheet - Transaction File Records	110
33	Simulator Parameter Check List - Print	
	Format	174
34	Simulator Simulation Report - Print Format	175
35	Simulator Performance Analysis - Print	
	Format	177

Preface

The size of a company's inventory has always been of importance to management. To-day, in the face of increasing competition and rapid technological change, the skill with which an inventory is managed can have a far-reaching influence on both financial management and trading success. Traditional methods of control of inventories are no longer adequate: they do not provide the information that progressive management needs; moreover, their response to changes in management policy in the face of changing conditions tends to be slow and uncertain. When managers themselves attempt to fill this deficiency by close personal attention to the detail of stock control, the cost in management man hours is high and, particularly in an environment of expansion, the strain on the organization may be considerable.

In recognizing this vital need, I.C.T. has developed its SCAN System 1 for Inventory Management using the 1900 series computers. The system provides an adaptive control technique which responds automatically to changing patterns and levels of demand as they change. With the aid of the computer, control of each item is reduced to routine.

SCAN is a re-order point control system which has its main application where demand cannot be known in advance with any precision and where stock is replenished at intervals. It is, therefore, particularly suited to the control of finished goods warehouse stocks, consumable stores and some classes of maintenance spares.

Supporting the control system itself, inventory analysis routines enable the profile and content of an inventory to be examined in detail if required. In addition, the analytical routines provide management with a means of testing alternative operating policies, and the effect of each on stock levels, before deciding between them. The routines then ensure the best possible performance from the control system, which will seek to reduce inventory investment to a minimum consistent with the desired level of customer service.

The I.C.T. SCAN System 1 is fully described in this manual which includes details of supporting computer programs and a discussion of the mathematical foundation of the techniques used.

This manual has been written with at least three classes of reader in mind. Busy managers and those requiring only a general appreciation of adaptive inventory control and the I.C.T. SCAN System need read only Chapters 1 and 2. Systems analysts, programmers, O & M practitioners and data processing managers require a much more detailed understanding of sophisticated systems of management control. This is provided by Chapters 3, 4 and 5, whilst operating instructions for running the programs are given in Chapter 6.

Detailed study of the action of the control system is sometimes necessary for special investigation. Moreover, such detailed study can be invaluable in obtaining an understanding of how the system will work in practice. The basic routines described in Chapters 2 and 3 have, therefore, been supplemented by a system simulation program which is described in Chapters 7, 8 and 9.

Appendix A, the mathematical foundation of the system, will obviously be of interest to operational research workers, but it has been written with a wider readership in mind and to this end considerable explanatory comment is included. A bibliography is included for those wishing to make a deeper study of the subject but, here again, a few titles of interest to the general reader are included.

Chapter I Inventory Control

INTRODUCTION

1.1

Unless supply can be matched exactly with demand at all times, stocks must be held. Such an exact match is seldom possible except, perhaps, in large scale line production plants, and even here external factors can, and do, destroy this equilibrium. The stock acts as a buffer which absorbs, or is intended to absorb, fluctuations in the rate and incidence of both supply and demand.

If these fluctuations are absorbed, the stock is there when it is wanted and continuity of service is maintained. If they are not absorbed, sales may be lost, production plans dislocated, or plant immobilized for lack of an essential spare part: customer goodwill suffers, progress costs rise and business opportunities may be lost. Inadequate stock always leads to reduced profits.

It is not enough to have adequate stocks of only some items. The need applies to every item in the inventory.

If stocks are increased to avoid this danger, the extra inventory must be housed, insured and accounted for, the extra financial investment must be serviced and extra provision must be made for wastage and obsolescence.

Balancing these two sets of opposing costs is difficult enough, since it requires careful examination of each and every item in the inventory. However, this is not the end of the problem because the solution, as stated, assumes unlimited availability of funds. This is never true and in the life of a business there are usually competing demands for the capital that is available. Moreover, once extra capital has been invested in inventory it may be a long time before it can be recovered and, where product development is rapid, the risk associated with this investment is likely to be high.

Too much stock and too little stock are both expensive luxuries that no business should afford. Too often, both extremes are present in the same inventory. Too much stock of the slower moving items (the items for which the demand is low and intermittent) gives rise to inflated inventory values, whilst too little stock of the fast moving items (the items for which the demand is high and, perhaps, growing) leads to frequent stock-outs (failures to meet demand). The situation is further aggravated when stocks of associated items (normally used or sold together) become unbalanced.

INVENTORY MANAGEMENT AND THE COMPUTER

1.2

The principal objectives of inventory management may be briefly stated. They are:

- 1 The setting and maintenance of the correct level of service for each item in the inventory, i.e. ensuring that the frequency of stock-out is kept within acceptable limits.
- 2 Efficient operation of the stores or warehouse.
- 3 Ensuring that the results achieved justify the amount of capital invested in stock and that this amount is within the limits dictated by overall company financial policy.

No attempt has been made to place these objectives in order of importance; this can be decided only in a specific set of circumstances, and even then the choice is likely to be difficult.

The computer is unrivalled in the assistance which it can give to the attainment of these objectives, because of the exceptional ease and speed with which it can examine and analyze data and report selectively on its findings.

However, setting up a computer-based stock control system involves many man-years of effort in systems analysis and programming. To save a substantial part of this work, I.C.T. has produced the 1900 SCAN System for Inventory Management. The system philosophy used has been developed and tested over a number of years and takes advantage of operational research techniques which have become available in the last decade or so. The system is fully supported by a series of interlocking

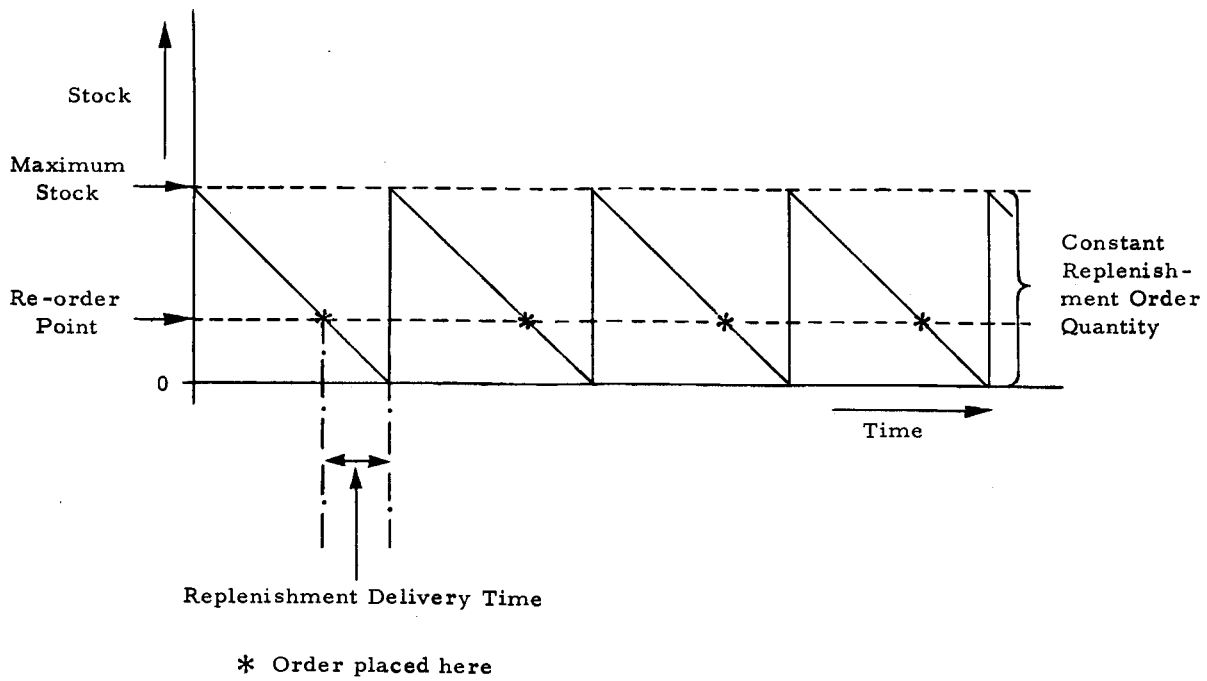


Figure 1 Variation of stock with constant demand and constant replenishment delivery time

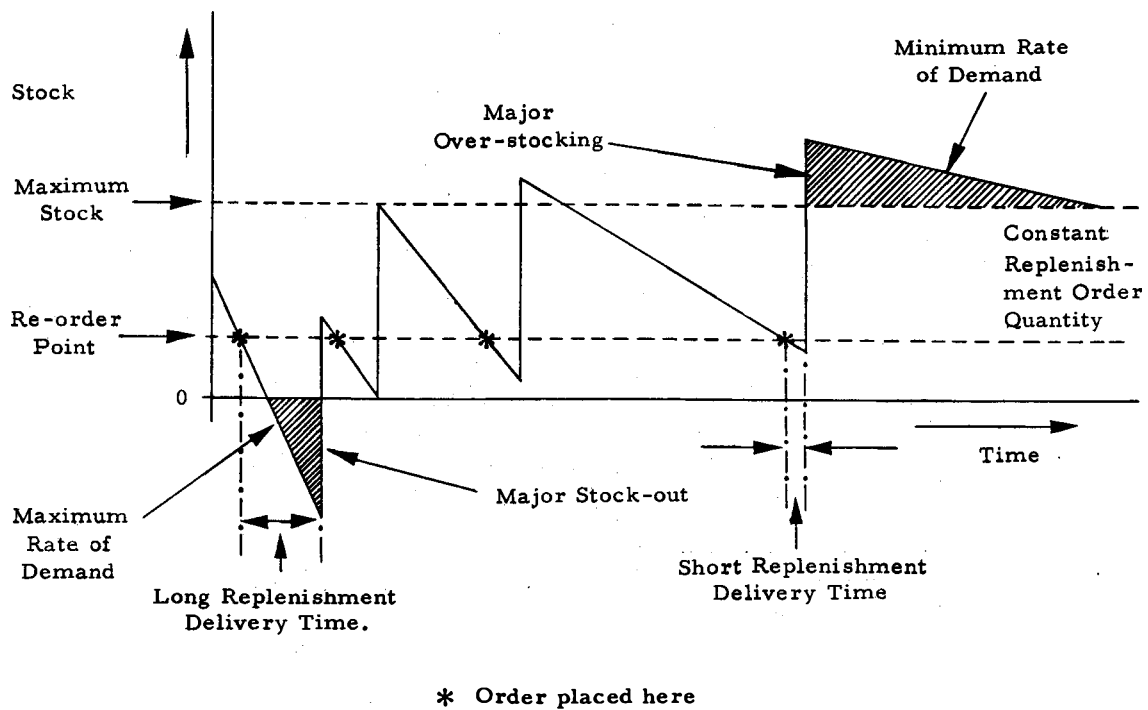


Figure 2 Variation of stock with variable demand and variable replenishment delivery time

programs: flexibility is assured by a number of choices which may be exercised by the user to control the way in which the programs operate and by the provision of links (via magnetic tape files produced by the system) to connect with user routines such as order control, invoicing and costing.

SCAN System 1 uses a re-order point system as the basic model and provides an automatic, adaptive control system which adjusts to changes in demand as they occur. Apart from the routines for day-to-day control of inventory, a number of routines provide for analysis of inventory and the testing of alternative management policies so that the best may be selected without resort to the slow and often expensive method of trial and error.

The system may be used for the control of finished goods and distribution warehouse stocks and, in general, for the control of stocks where future demand is unknown, e.g. maintenance spares, small tools and consumable materials.

Items the demand for which is linked to a production programme are excluded, since the needs of production control are fully covered by the I.C.T. 1900 PROMPT System (Production Reviewing, Organizing and Monitoring of Performance Technique). The techniques used in the SCAN System 1 are applicable to some items in this category and it is possible to use SCAN in association with PROMPT, which latter system then exercises the overall control.

RE-ORDER POINT CONTROL

1.3

Where future demand is unknown, inventory control reduces to continual and regular review of each item and a decision on either

- 1 when to re-order, and what quantity to order, or
- 2 what quantity to specify (or schedule) for each new time period.

The former is the essence of a re-order point control system, whilst the latter is a supply scheduling system. The two are closely related and the second may easily be derived from the first. The SCAN system offers both facilities which may be used together in the same system for different groups of items.

Re-order point control is a simple concept. Stock is allowed to be consumed without control action being taken until a pre-set stock level (the re-order point) is reached. This is the amount of stock which, it is estimated, will be consumed in the time required to obtain a further supply (the replenishment delivery, or lead time).

When the re-order point is reached, a further supply is ordered. If this order is placed at the correct time, further supplies will be received just as the existing stock is exhausted. If the order is placed too soon, there will still be stock on hand when the new supply is received and the stock of that item will have been higher than was necessary. If the new supply is ordered too late, stock will be exhausted before the new delivery arrives and, for a time, demand cannot be satisfied: stock-out occurs and some demand must be back-ordered, i.e. recorded for action when new supplies come to hand - assuming that customers are prepared to wait.

The ideal situation, when the rate of demand and the lead time are constant, is illustrated in Figure 1 which is a graph of stock variation for a particular item and shows the effect of re-order point control. Stock falls until the re-order point is reached (indicated by an asterisk) when a fresh supply is ordered. This is delivered one lead time later.

It will be noted that the same quantity is ordered each time.

Demand rates and replenishment times are seldom constant in practice. If both exceed maximum expectations during the same replenishment cycle, customer service is badly affected. If both fall below minimum expectations at the same time, over-stocking results. The effect of these extreme variations is illustrated by Figure 2.

Because the variability of the demand rate and the lead time must be taken into account, it is undesirable to operate on fixed re-order points. This is the principal failing of most simple inventory control systems. Apart from those items which receive special Management attention, revision of re-order points is too infrequent and is often based on highly subjective opinion. Inevitably, control suffers.

Using operational research techniques, digital computers reduce control of stocks to a largely automatic process which:

- 1 Revises re-order points on a routine basis in response to changes in demand.
- 2 Indicates when and what replenishment quantities are required.

Automatic inventory control maintains any level of customer service set by Management and depends on statistically minimized re-order points, which contain two elements:

- 1 Cycle stock to cover the average expected demand in the replenishment delivery time.
- 2 Safety stock to maintain the service level specified by Management.

Safety Stock

The level of the safety stock depends on the accuracy of the demand predictions and the customer service level required by Management. Customer service level is a measure of the degree to which demand is met immediately from stock: the higher the service level, the fewer the number of stock-outs, and the greater the safety stock and the stockholding costs. Perfect service is unattainable and a balance must be struck between cost and service.

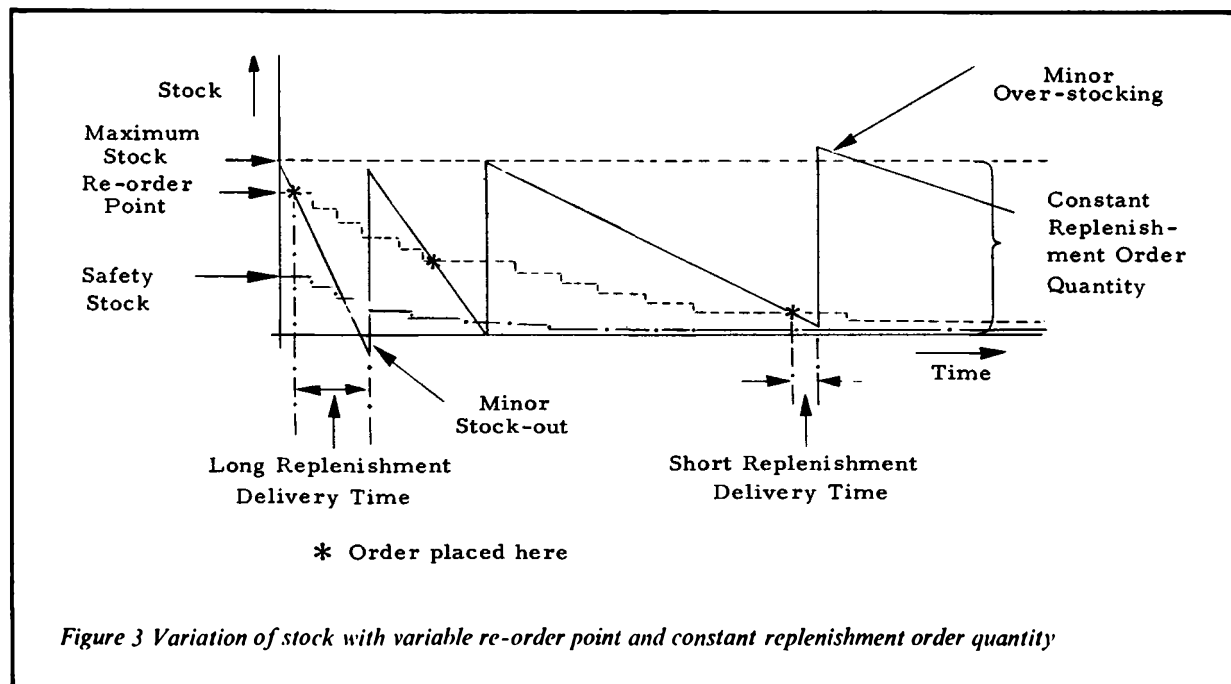
Safety stock is most important for those items with the highest usage rates and, for these at least, it is desirable to evaluate the cost of various service levels before a decision is made.

Items with low usage rates tend to be re-ordered infrequently and hence tend to require small safety stocks, unless the lead time is unreliable. The need here is to ensure that no excessive safety stocks are carried, since these items are in the majority in the average inventory.

In practice, the inventory is subdivided into a small number of groups and a customer service level specified for each.

Once the service level is fixed, the calculation of safety stock is automatic. It is recomputed whenever a new prediction of demand is made.

The effect of variations in safety stock in a variable re-order point system is illustrated in Figure 3. Simultaneously with the fall in the rate of demand (indicated by the graph of stock variation becoming less steep as one looks from left to right across the diagram), the demand has become more stable and the safety stock is progressively reduced in response to this change. A constant replenishment order quantity is used here. The effect of varying this is considered in the next section.



A fundamental objective of adaptive inventory control is to adjust stocks to respond as closely as possible to changing demand. If demand is expected to rise, stocks must be built up; if demand is expected to fall, stocks must be run down. If Management have advance warning of an impending change they must intervene to achieve the correct result. When the system detects the change in the demand it will respond automatically.

For stockholding to be minimal, replenishment orders must not be initiated until stock is within one replenishment delivery time of exhaustion. The final adjustment can be made only by varying the replenishment order quantity. This indicates one method of Management intervention, when necessary: an additional replenishment may be placed 'outside' the system, or the placing of an order requested by the system may be delayed. This type of intervention will be required only in exceptional circumstances.

The correct determination of replenishment order quantities is obviously essential, and must depend on the estimated future demand. Large, infrequent orders increase the range of variation of stock - see Figure 5 - and inflate both the average and the maximum stock levels. Small, frequent orders have the opposite effect.

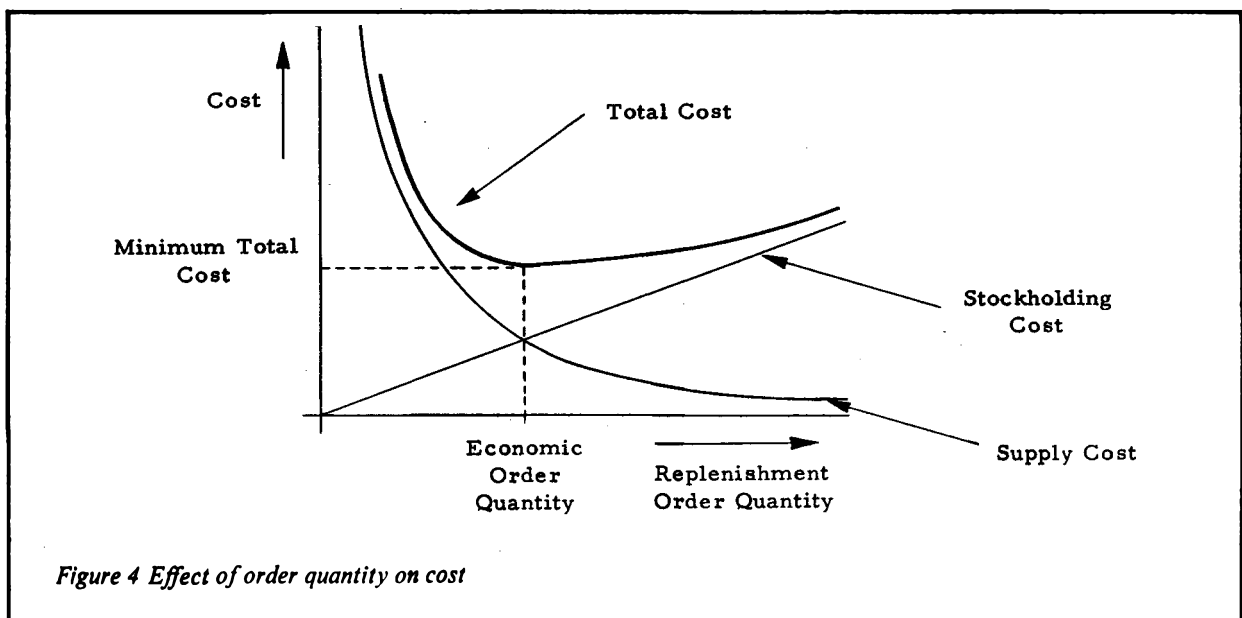
Deciding the order quantity also determines the ordering frequency and hence the order cycle time, which is the interval between successive orders. The system may be instructed to operate on a fixed order cycle time or to calculate order quantities by reference to the economics of the situation.

The major costs of operating a stores or warehouse are:

- 1 *Service cost*: the cost of satisfying demand, i.e. the cost of all operations which stem from the receipt of a customer order, or stores requisition, including the associated data processing costs.
- 2 *Maintenance cost*: the cost of providing, maintaining, heating, lighting and making secure the warehouse and its fittings and equipment, plus supervision and control system costs.
- 3 *Supply cost*: the cost of ordering, machine set-up (if appropriate), receiving, checking and supplier accounting.
- 4 *Stockholding cost*: the cost of stockholding, including the cost of capital invested and the cost of insurance, obsolescence and losses in storage.

Service and maintenance costs influence stockholding policy and can impose restraints on the control system. Such restraints will be constant over relatively long periods of time and are unlikely, therefore, to affect routine control.

Supply and stockholding costs, which directly influence control strategy, are in opposition. Orders for large quantities tend to make supply costs small and stockholding costs high, whilst small orders have the opposite effect. This is shown graphically in Figure 4. The total cost first falls as the replenish-



ment order quantity increases: it reaches a minimum value at the economic order quantity. Any further increase in the order quantity will increase the total cost.

In practice, it is difficult to determine the supply and stockholding costs accurately and this approach can give only an approximate answer - it will be noted that the total cost curve in Figure 4 is fairly flat in the region of the minimum value; the choice of order quantity is not, therefore, critical. The mathematical formula which is derived from the total cost curve and which is used to calculate the economic order quantity may, therefore, be used as a Management regulator to secure acceptable levels of total inventory investment and ordering activity. These levels may be selected as the result of computer analysis of the inventory (or a random sample). They may be adjusted subsequently in a similar way if trading conditions change. Management is thus able to tune the inventory control system to suit prevailing conditions.

A time-based ordering policy ignores the unit cost of the item; the economic order quantity approach takes unit cost into account as well as rate of demand. The latter will tend to order smaller quantities of items with high annual usage value and larger quantities of items with small annual usage value when compared with the former. Now that the problem of accurately determining supply and stockholding costs (so long a serious disadvantage with this approach) can be avoided, use of economic order quantities should always be carefully considered as the basis of the replenishment ordering policy, especially for the items with high annual usage value. However, this method is not suitable if demand is subject to seasonal variations or strong trend.

To cater for situations where economic order quantities are not appropriate, the following time-based ordering policies are available in the SCAN system:

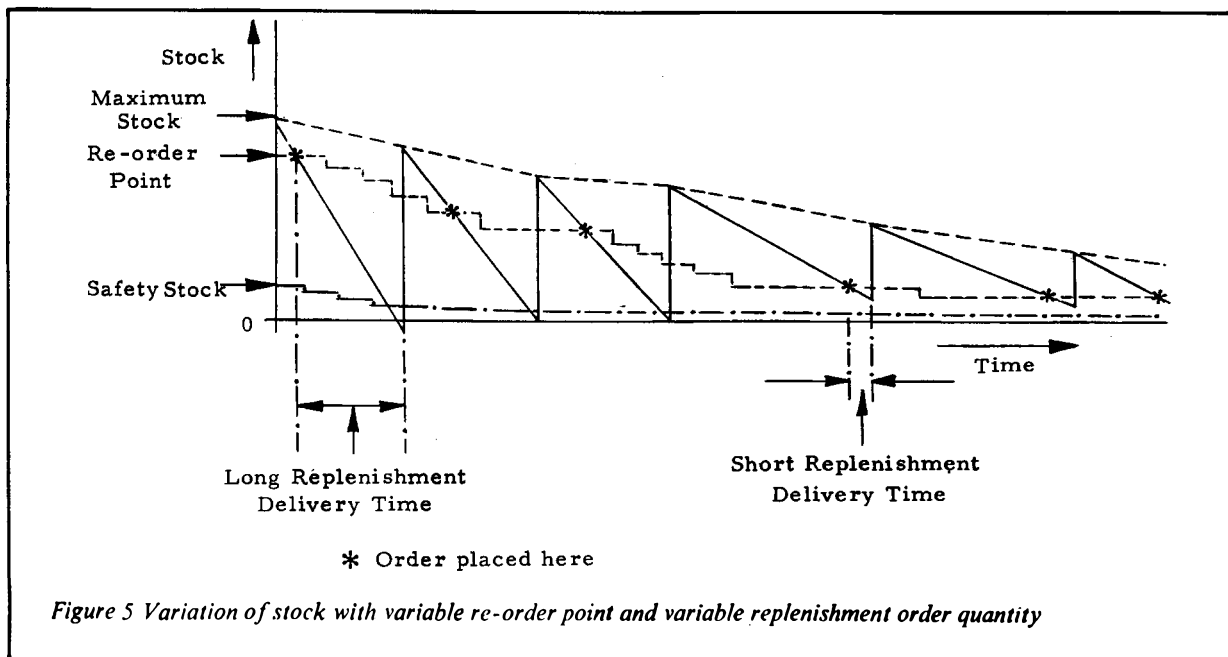
Statistical minimum order quantity: this is the minimum order quantity to ensure stable control. By its use stock investment will be reduced to the minimum possible at the expense of frequent ordering.

Preferred ordering interval: an ordering interval is specified for each item by the user and the system will base its order quantity calculations on that interval. There is an automatic check to ensure that the resulting order quantity is not less than the statistical minimum order quantity.

The preferred ordering interval may be used in two ways - with random re-ordering or with cyclical re-ordering.

Random re-ordering: this is the true re-order point control system - a new replenishment order is requested as soon as the stock reaches the re-order point. If the stock records are updated daily, new replenishment orders will be requested daily.

Cyclical re-ordering. it may be more convenient to have a single weekly or monthly list of replenishment orders. In these circumstances, cyclical ordering is used. The preferred ordering interval specified for each item controls the frequency with which that item's stock is replenished.



Cyclical re-ordering is also used in two special cases. Firstly, when the stock records are updated weekly or less frequently, and lead time or ordering intervals are short (say, one or two updating intervals), random re-ordering introduces disturbances into the control system. These are avoided by the use of cyclical re-ordering.

Secondly, when suppliers are issued with requirement schedules or bulk orders, cyclical re-ordering may be used to add a new period's requirements to the schedule each period and so continually update the schedule automatically, or it can be used to issue a weekly or monthly call-off each week or month.

Cyclical re-ordering may also be used to operate a policy of joint replenishment. By suitable setting of the preferred ordering intervals of a group of associated items, these items will always be ordered together; each time this occurs the stocks of those items will be brought into balance. It could, of course, be arranged for some items in the group to be ordered each month and the remaining items in the group to be added to the list, say, every third month.

Whatever the ordering policy chosen for each item (the choice is individual to the item) the SCAN system may be used to evaluate the likely level of stockholding and ordering activity which will result. In addition, it will show for each item the effect of economic order quantities compared with time-based ordering so that the user may choose, if he wishes, a time base for ordering that corresponds approximately to the economic order quantity.

The effect of variable re-order points *and* variable re-order quantities is illustrated by Figure 5. Maximum stock, and hence average stock, depends on demand variability and the specified customer service level (determining safety stock) and on order cycle time. The system is completely adaptive over time.

Demand Forecasting

1.3.4

Many mathematical techniques for short-term forecasting are available. At the end of each forecasting interval a new prediction of future demand is made, using the previous prediction and the actual demand which occurred during this interval.

The revision of demand estimates forms part of the automatic routine which updates the re-order point and replenishment order quantity for each item (in accordance with the specified lead time, customer service level and replenishment ordering policy). The constants used in the equations are chosen separately for each item by statistical analysis of historic demand data, and are selected to minimize the variability of the prediction errors, and hence safety stock, over time. Where no historic demand data are available for analysis, these constants must be established arbitrarily in the first instance. The system itself accumulates a record of past demand so that analysis may be undertaken in due time.

The system will follow trends and seasonal variations in demand, but will take time to adjust to sudden, large, permanent changes in demand. When such changes are expected, it is usually desirable to adjust stocks by Management intervention prior to detection of the change by the system itself.

Forecasting Frequency

1.3.5

The frequency of demand forecasting determines the minimum frequency of stock updating. The latter usually depends upon systems and data collection problems, but must be at least as frequent as demand forecasting and should always be as frequent as can be conveniently arranged. In many cases daily updating will be necessary and should always be sought unless the demand is geared to a longer time cycle, e.g. single weekly demands which are always received on Monday.

The forecasting frequency depends on the statistical structure of the demand: in practice, the minimum permissible time interval is chosen unless the demand is geared to a longer time interval or lead times are unduly long. The forecasting interval is seldom less than a week or greater than a month for the items in reasonably regular use.

Control Optimality

1.3.6

The optimality of control depends on the accuracy of demand prediction and it is essential that prediction errors are as small as possible over time. If they are not, safety stock will be unnecessarily large and costs will be inflated.

Monitoring of System Performance

1.3.7

The system keeps a check on its own performance and signals any danger of loss of control. At such times, which should be infrequent, the most recent demand data may be re-examined and any necessary adjustments made to the control factors. In the meantime the system automatically increases the sensitivity of the forecasting system to accelerate adjustment to any permanent change in demand which may have occurred.

If arbitrary forecasting constants have been adopted in the absence of demand history for analysis, the monitoring system will detect any bad choices and report on the items concerned.

INVENTORY ANALYSIS

1.4

It will be clear from this chapter that technical differences between the various items in an inventory matter to an advanced inventory control system such as that encompassed by SCAN System 1, whereas they were of no concern previously. The system includes a number of programs which take care of this detailed analysis. It is not essential prior to setting the control system to work and is not always possible - as has already been noted - but it is desirable.

Inventory analysis is also used to assist Management to determine operating policy on a quantitative basis not previously possible and the value of this will be obvious from what has already been said.

There is a third use of inventory analysis which has been exploited by inventory managers, systems analysts and management consultants for a number of years. This is the facility of ordering the items of an inventory on the basis of commercial criteria such as annual usage value, gross profit margin, or stock value. The first two of these criteria put at the head of the list the items that really matter to the business, and at the bottom of the list the items whose continued retention in the stock list should be reviewed. The items at the head of this list are also those items which are likely to respond most quickly to automatic control; the reverse is true for those items at the bottom of the list. Thus, the speed with which stocks will respond to automatic control may be estimated in round terms.

Such a list will also direct attention to the most fruitful items for investigation when it is wished to use the technique of Value Analysis.

A list in sequence of item stock value shows where the stockholding is concentrated.

Such lists are extremely valuable during initial investigation of an inventory and may also be used for periodic review (say, annual) of the performance of the control system.

It is common experience to find that some 10% to 20% of the items in an inventory account for more than three quarters of the total annual turnover of that inventory. To be able to isolate and list this important section of the inventory automatically is obviously of considerable value to Management.

Chapter 2 General Description

SYSTEM CHARACTERISTICS

2.1

The routines described in Chapter 3 form the basis of an integrated, adaptive system for:

- 1 Analyzing demand history in order to:
 - (a) classify items on the basis of both frequency of movement and commercial importance,
 - (b) establish control parameters and initial values for use by the operational system,
 - (c) assist Management in the selection of the most suitable operating policy in the light of prevailing conditions.
- 2 Processing stock transactions in order to maintain an up-to-date record of the stock situation.
- 3 Allocating physical stock to each demand in accordance with a predetermined system of priorities.
- 4 Reporting on current stock values, unsatisfied customer demand, new stock replenishment orders required, and items requiring progress action.
- 5 Control of stock levels by use of variable re-order points and variable re-order quantities which respond to changes in demand.
- 6 Monitoring of the system's own performance and reporting when there is risk of loss of control optimality.

The system includes links to facilitate integration with other important data processing routines such as:

Purchase and manufacturing order control

Sales invoicing procedures

Product sales analysis

Production scheduling

Cost accounting

Continuous inventory stock audit control

The system may also be used in association with the I.C.T. 1900 PROMPT System of production control.

The criterion by which the SCAN system operates is that a stock replenishment order is placed for an item whenever its available stock falls to, or below a re-order point. This may be on the day that the causal stock transaction is reported to the system (random re-ordering) or the user may choose to generate replenishment orders on a periodic basis, irrespective of the level of available stock at the end of each period (cyclical re-ordering).

The re-order point is the control trigger which determines when to order in the case of random re-ordering: in the case of cyclical re-ordering, a replenishment order is requested whenever the system detects that the end of the specified cyclic period has been reached.

The re-order quantity is computed to give Management the opportunity to:

minimize the sum of supply and stockholding costs, or

order the minimum necessary to maintain system stability, or

order at specified regular intervals.

It indicates 'how much to order' when the system calls for replenishment action.

The choice between these various techniques may be made individually for each item.

By monitoring the errors between actual demands and predicted demands (forecasts) within specified limits the system warns Management of any loss of forecasting efficiency.

The system is particularly suitable for the control of finished product warehouse stocks but the techniques employed may be used in many other areas of inventory management where the stock holding is not directly dictated by a production programme.

OUTLINE OF SYSTEM ROUTINES

2.2

The routines forming the basis of the systems fall into three classes:

File Creation/Maintenance

Analytical

Operational

The integrated control systems flowchart (see Figure 28) shows this natural division and how the routines are related one to another. Chapter 4 suggests methods of integrating this control system with other important user commercial routines.

Where applicable, all routines will accept punched card or paper tape input under operator control.

File Creation Routines

2.2.1

These routines are required:

- 1 Initially to create, and subsequently maintain the master files used in the system.
- 2 To provide a facility for examining, on demand, the contents of one, or more, item records in the master file.
- 3 Regularly to write all period stock transactions to a magnetic tape file.

Master File Create/Maintenance Routine

All business systems require Master files to be created initially before any attempt is made to operate the system regularly on the computer. Thereafter, in the normal course of events, changes to the item records held on the Master files occur periodically and provision must be made to allow these changes to be effected quickly and easily without hindrance to the system.

The system described within this manual uses two such Master files, namely *Stock Master* and *Demand History* files.

Stock Master File

This is the central file of the system. It must contain details of every item in the inventory. In addition to price and descriptive information, each item record contains all the balances required by the system, together with supplementary information designed to measure control efficiency. This file is regularly updated by the system to record the effect of stores transactions: it serves to initiate reports of unacceptable or dangerously low item stock levels, stock-out occurrences, replenishment order requisitions and unsatisfied customer demands. It also accumulates the data for the regular updating of the Demand History file - see below - and may be used by user routines to provide periodic stock lists, stock status reports and detailed stock evaluations.

Demand History File

Keeping a record of historical demands for each item in the inventory is desirable in any stock recording system. This permits the review of this demand history at any time when need arises.

So that access to this information may be obtained at reasonably short notice, the system provides for regular updating of a magnetic tape file containing this information. A demand history extending up to 104 time periods (weeks or months) is allowed for, the length of the time periods being decided by the user when the system is first set up.

This file may be used in several ways:

- 1 for the analysis of a sample of inventory items during preliminary study in order to establish the inventory profile, i.e. the way in which the stock holding is distributed across the items relative to their contribution to annual stock turnover value;

- 2 for the analysis and classification of the total inventory if this is desired prior to setting the system to work, and again when review of control performance is required - usually this review will be required annually;
- 3 for the review of special sections of the inventory, e.g. slow movers, when required;
- 4 for the examination of the demand history of specific items;
- 5 to compute optimum forecasting parameters (and seasonal factors, if required) initially, and to recompute them periodically as need arises;
- 6 to assist in the selection of operating policy initially, and when business conditions change.

The Demand History file is also used as a matter of routine by the SCAN System 1 for those items included in the adaptive control system.

For both files the following functions are available:

CREATE Master file on magnetic tape: This function is designed to create a master file containing the item records. A list is printed giving details of each item record and may be used as a master file reference.

MERGE files: Normally, file creation is a 'one off' task when preparing files prior to running a system but if it is desired to build up a master file gradually, the data forming each part of the file may be used to create a number of part files. The merge function will allow any two part files to be brought together at any one run and a single master file to be created in the desired sequence.

EXTRACT records: This function is to allow selected records from a master file to be extracted and written to an output magnetic tape file. These records are deleted from the master file. After performing some action on these records - depending upon the circumstances - the extracted records may be merged with the main file for operational control.

DELETE records. This function simply deletes any required item record from the master file and records the action on a listing.

INSERT records: This function is designed to place a new item record in its correct sequence in the master file.

AMEND records: Any field or number of fields within an item record for either master file may be updated or altered by using this function. A list is printed of such amendments together with the old (or previous) field values.

Note: With all the above functions, except MERGE, a list recording the action is printed.

Skeleton History File Generate Routine

This program is ancillary to the Master File Create routine.

Part of the information in the Demand History file is common to the Stock Master file. Therefore, to save the extra cost and increased risk of error if this information were punched twice, this program copies the common information from the Stock Master file to the Demand History file. If the latter file omits certain items, the information is copied only for those items present on the Demand History file.

Where there is no special information to be recorded on the Demand History file this program will create this latter file automatically from the Stock Master file, entering only the common information and leaving the rest of the item record blank.

Situations affecting the use of this program are as follows:

- 1 If it is desired neither to enter the analytical routines nor initially to forecast demand, but to use the Demand History file to accumulate data, a 'skeleton' Demand History file may be created directly from the Stock Master file.
- 2 If historical demand data is not available and inventory analysis cannot, therefore, be performed until sufficient demand history has been accumulated, a 'skeleton' Demand History file may be created directly from the Stock Master file, as explained above. However, in order to use adaptive control for certain items, it is necessary to add certain additional information to the appropriate item records. This may be effected by the use of the Master File Maintenance program. All other records in the Demand History file will be treated as fixed re-order point items, but the system will progressively accumulate the demand history for all items in the Demand History file.
- 3 If historical demand data is available and analysis is required, prior to setting up the system, it will be necessary first to create the Demand History file and then add the common data.

If only selected records, from the Stock Master file are required, a part file must be created first, containing the selected item records and then matched against the Stock Master file to transfer the common data.

Magnetic Tape File Record List Routine

This routine is designed to allow users to examine the contents of one or more selected item records held in either the Demand History or Stock Master files.

Any number of item records may be printed in one run and the listed record contains the names of the fields as well as their alphanumeric value. This program could also be used to provide a permanent Master file reference.

Analysis Routines

2.2.2

These routines are used to study the structure of the inventory and to set up the control system factors and parameters initially. They may also be used at any subsequent time when:

- (a) additional items are included
- (b) the system's performance is re-evaluated
- (c) re-setting of prediction parameters is required.

Stock Profile Analysis Routine

The function of this routine is to analyze demand history (item by item) and determine, by calculating the frequency of movement, the most suitable time interval for forecasting in terms of the basic time unit in which demand data have been collected. For example, if demand data were aggregated in weekly parcels, a minimum forecast interval of '1' in Figure 10, page 42, would mean that a new prediction of demand should not be made more frequently than once a week.

In some circumstances it may be necessary that the data be recorded or presented to this program in terms of the demand in each of a consecutive series of months: in this case a forecast interval of '1' means that forecasts of future demand should be made monthly.

This analysis will enable Management to select the fast moving items from their total inventory for possible inclusion in the adaptive control system. Any item with a recommended forecast interval of greater than four weeks (or one month) should not be an automatic choice for inclusion: these items are demanded less than six times a year and will normally be regarded as slow movers. If the unit cost of a slow mover is high it may be necessary to maintain a tight manual control or to operate on an imprest system whereby each unit of stock is replaced when it is used: if the unit cost is low a simple fixed re-order point control system may be quite adequate because the economics of replenishment order size become the overriding consideration. However, any item may be included in the adaptive control system subject to observance of the minimum forecast interval recommended by the Stock Profile Analysis.

It may well be that certain items fall into the 'fast moving' category, but that the cost of collecting data regularly and processing it does not justify their inclusion in the system. The next program to be described - ABC Analysis - assists in isolating items of this type but the final choice of items to be included rests with Management.

A special case is the 'static' item and this is indicated by a forecast interval of '0' which means that there is no recorded demand in the data examined. These items should be reviewed to see if their continued retention in the stock list is justified.

Each item processed in the Stock Profile Analysis routine is evaluated, over the demand history supplied, in terms of average annual sales (or usage), average annual gross margin (sales value minus cost value) and current stock value (at cost). The items included in the Stock Profile list (see Figure 10) may be selected on the basis of recommended forecast interval. In addition, a summary table may be printed if required, to show on a cumulative percentage basis for each forecast interval in turn the item count, annual sales, stock value and annual gross margin.

The list may be used for comparative study both before and after implementing the control system to review system performance and to evaluate the stockholding position. The ABC Analysis routine may be used in addition when a more detailed study of these aspects is required.

ABC Analysis Routine

This extension of the Stock Profile Analysis routine enables Management to study the commercial aspects of an inventory in greater depth. However, any such study cannot be divorced from consideration of the frequency of movement of the items since this determines the practical range of choice of control techniques. This routine recognizes this need.

It is universal experience that when the individual items in an inventory are judged on the basis of the contribution of each to the value of the annual turnover, overhead expenses or gross profit, the range of variation is very large. If the items are arranged in descending sequence of annual usage value, for example, and the contribution of each is summed progressively across the inventory, it may well be found that the first 10% or 20% of the items account for more than three-quarters of the total turnover: on the other hand, the last 20% of the items will probably be found to contribute only a few percent of the turnover.

This same pattern will be found again if the items are sequenced by gross margin or frequency of movement.

It is obviously important to know how the stock value is distributed across the inventory in relation to the criteria already discussed and one important purpose of inventory analysis is to highlight the manner of this distribution so that corrective action may be taken. Very often it will be found that inadequate stocks of the important items are carried - leading to high cost of the resultant poor customer service - whereas the stocks of the more numerous, slow moving items are excessive for the level of customer service required. Since the investment in the latter can be recovered only slowly, the capital available for investment in increased stocks of the more rewarding, high turnover items is unnecessarily restricted.

The Stock Profile Frequency Analysis table (see lower half of Figure 10) gives a first assessment of the stock profile, i.e. the distribution of stock value in relation to frequency of movement, annual usage value and gross margin. The ABC Analysis routine may be used to provide a series of reports to supplement this information.

As a possible first run, it may be used to print a summary table (see Figure 13, page 46) which shows for each progressive 5% (approximately) of the selected criterion (annual usage value, gross margin, or stock value) the progressive percentage values of the other two criteria and the item count.

It has been found useful in practice to classify each item according to its contribution to annual turnover and a simple ABC classification is commonly used. Because of the importance of the frequency of movement, this classification is supplemented in the SCAN system by a numeric suffix which may be 1, 2, or 3. Inclusion of this combined class code, e.g. A1; in various reports produced by the system gives a quick appreciation of the importance and nature of the item in question.

How the ABC classification divides the inventory is a matter for individual choice and must depend on local circumstances, but a typical subdivision would be given if the 'A' items represented the top 80% of the annual usage value, the 'B' items represented the next 15% and the 'C' items accounted for the remainder.

The user may similarly choose the manner in which the movement frequency suffix (1, 2, or 3) divides the range of recommended forecast intervals, which are derived directly from the calculation of the average frequency of movement for each item. '1' will always relate to a forecast interval of 1. '2' and '3' may be used to distinguish between the medium speed and slow movers, or between the slow movers and the moribund items, although the former will generally be preferred.

The ABC Analysis Summary and Stock Profile Frequency Analysis tables may be used to help define the various classes of the ABC classification. Whilst the ABC Analysis routine may be used to list the items in any of a number of sequences, the preferred sequence will be descending value of item turnover. When the data are presented to the program in this sequence, the ABC classification is carried out and the input file updated with this information. At the same time either a full or a restricted listing of the items may be printed. For example, a list of low usage value items, or slow movers, could be produced so that these items can be specially reviewed. A typical list is illustrated by Figure 11, page 44.

This program will also produce an analysis table showing the contribution of each of the nine classes (A1 to C3) to turnover, gross margin and stock value - see Figure 12, page 46.

Control System Selection Routine

To cater for the needs of the various classes of item to be found in a single inventory, 1900 SCAN System 1 provides a number of control techniques, one of which must be selected for each item. The preferred choice for the fast moving items is the automatic adaptive control system briefly described in Chapter 1. This may use a policy of either random or cyclical re-ordering.

Whilst this system may be used for every item (subject to observance of the recommended forecast interval, as already noted) it may be preferred to use fixed re-order points and quantities, or an imprest system for the slow moving, high cost items and the former for items of low usage value. Again, a choice may be made between random and cyclical re-ordering.

Thus, there is a choice to be made between four different methods of control. Later planned developments will increase this choice to six when a special method of dealing with slow moving items is added to the system.

The remaining three analytical routines are specific to the items to be included in the adaptive control system. If, therefore, a selection may be made at this stage, processing time will be saved since the subsequent analysis need deal with the selected items only.

The choice of control system is expressed by allocating a 'system marker' to each item. This may be done in this routine by allocating a system marker to each of the nine classifications generated by the previous routine. This is notified to the program at run time: each item is then given a system marker dependent on its ABC classification.

This routine records both the ABC classification and the system marker in the Stock Master file. The system marker may be transferred across to the Demand History file by use of the Skeleton History File Generate routine (already described) if this is required.

The second use of this routine is print a list of the stock items in sequence of stock code number and showing the annual turnover value, gross margin and stock value for each item as well as the ABC class code. This list provides a valuable record for subsequent reference; it is illustrated by Figure 14, page 48.

Demand analysis Routine

Items selected for analysis (i.e. either an initial selection from the Stock Profile and ABC Analyses, or a sample of a company's product lines) are processed in this routine and a statistical analysis is performed on the demand history available in order to compute mathematical characteristics necessary to proceed with further analysis.

There are several parameters available which allow for flexibility in performing this analysis.

One such parameter allows only those items to be processed which have a recommended forecast interval equal to or less than the value of the parameter selected; e.g. if demand data were collected weekly and the parameter were set to four, only items which had a forecast interval of four weeks or less would be processed. All other item records would be written directly to magnetic tape or other output media from input.

There is a choice of confidence limits to be used in a statistical significance test (see page 205).

Two types of print format are available and the user may have either a full format with all calculated results or an abbreviated format. This does not alter the basic function of the routine, but does allow the user the benefit of a more sophisticated printout if desired and statisticians and O.R. personnel will find this helpful. The two alternative forms of printout are illustrated by Figures 15 and 16 on page 52.

The user may also decide whether a further full search technique is applied for all selected items or only these items where seasonality and trend have been detected.

The main function of this routine is (a) to determine a near optimal proportional control prediction parameter using an analytical method that involves serial correlation coefficients, and (b) to test for either seasonality or trend in each item's demand history. If an item has a suspected seasonal pattern or trend it is further analyzed in the next routine (using a fast search technique), but it is possible to use the results from this routine without the necessity for further analysis, unless the presence of either seasonality or trend makes it desirable to process at least the items affected in the next routine.

Optimal Prediction Parameter Routine

The function of this routine is to search the original demand data and obtain the best pair of prediction parameters, for use in the Box-Jenkins prediction equation (see Section A.3.3, equation 17, of Appendix A).

However, if suspected seasonality has been indicated by the Demand Analysis routine, seasonal factors are computed and applied to the appropriate demands before the search is made. Depending upon the results of this analysis, the pair of prediction parameters giving the best results is written to magnetic tape together with seasonal factors, where appropriate, and various mathematical factors necessary to effect operational control.

System Performance Estimation Routine

This routine estimates, for each item included in the control system, the safety stock, average stock and total stock to be expected from the use of the control parameters determined from one or both of the two previous routines. It is intended to show the effect of various operating policies selected by Management.

The estimated stock level and order quantity are computed for each item for a selected average order interval and four other intervals grouped about it.

There are a number of choices available to enable Management to use this routine (on one or more occasions) to evaluate several policies and to determine an acceptable operating policy for the system.

Any currency unit may be used; no conversions are necessary as all values are expressed as decimals in terms of the same currency unit as the input data.

Two major summary tables are provided. The first table, for all items included in the analysis, provides annual turnover and current stockholding values, together with the estimated safety stock value based on the calculated control factors - for various groups of items and in total. Further summaries are provided of expected average stock value and the annual number of replenishment orders appropriate (a) to the minimum ordering interval (e.g. one week for weekly data), (b) for the preferred ordering interval (which may be different for each item, or selected for all items initially as a constant) and (c) for the economic re-order quantity using investment rates and ordering costs selected by Management. Stock turnover ratios are provided for each summary.

The first table may be provided alone if required, to enable Management to examine the effect of alternative ordering policies on all, or part, of their total stockholding before deciding on specific customer service levels and ordering intervals for each item.

The second summary table will provide current stockholding values using a range of investment rates and a selected ordering cost in the economic order formula (see Section A.7, equation 34, Appendix A). This second table may be suppressed if desired. A blanket ordering cost may be used or individual ordering costs may be specified when the Demand History file is first set up. The latter will usually be required for 'own manufacture' items to reflect variations in machine set-up costs.

Operational Routines

2.2.3

The operational routines provided in SCAN System 1 could form the basis of a user's data processing system. All stock transactions are 'captured' on magnetic tape and processed against the Stock Master file to provide updated stock balances. These, in turn, are used to provide exception reports for Management action and magnetic tape files for entry to computer routines in other business systems areas. In this way, the user may expand the system to include all desired areas of data processing.

It is not strictly necessary to enter the analytical routines: arbitrary classifications may be given on the basis of the Stock Controller's knowledge, and thereafter the operational routines would provide the desired control. However, it is a valuable experience for Stock Controllers to process their inventory records through the analytical routines described above. As described elsewhere, it is highly desirable to keep a check on the system performance by their use.

Magnetic Tape Creation Routine - Transaction File

This routine is described under the heading of operational routines because it is the point at which all stock transactions are 'captured'. This then provides the entry point to the operational routines.

A common input format is provided for each type of transaction and the transactions may be written to a magnetic tape file in any sequence.

The following types of transaction may be input to this program:

- (a) *Audit request*: this may contain details of the current physical stock position for the item to be matched against the Master file record.
- (b) *Stock adjustment*: any correction to the physical (or on-hand) stock balance.
- (c) *Stock receipt and scrap*: any goods or stock received from a supplier or factory. The facility for processing data on scrap is provided.
- (d) *Returns outward*: this caters for stock which has been returned to the supply source for replacement, after being debited to stock.
- (e) *Unscheduled issues*: if stores issues are made such that the normal system is by-passed the Stock Master file must be updated in arrears. However, the issue normally requires invoicing and a later program carries the relevant data forward.
- (f) *Returns inwards*: normally, this records the return of an unscheduled issue or a return of goods from a customer for credit.
- (g) *Replenishment order adjustment*: provided to amend the stock on order balance.
- (h) *Demands*: these are orders placed by customers (or factory on a store).

In addition to creating a magnetic tape file this routine lists each transaction on the printer for reference. A facility is provided for batch control totals if required.

Sort/Merge Routines

Standard sort/merge software may be used either to sort the transactions file into the required sequence for processing in the next routine or to merge a recirculating file (containing outstanding transactions) with the current transactions file and sort the combined records into one file in the required sequence - normally, priority code within due date within transaction code within item number.

Stock Updating and Allocation Routine

This routine constitutes the hub of the control system from which most 'exception' reports and data for use in other routines are generated.

Besides maintaining a record of stock availability and applying re-order point control to all stock items, it also feeds the Stock Forecasting and Monitoring routine with the necessary demand data to effect variable re-order point control on selected stock items and to build an historical demand array for all items for future analysis.

It is recognized that not all items in an inventory will require the same control techniques and, consequently, this routine updates all Stock Master file item records affected by current stock transactions and applies to each item the selected form of re-order point control as indicated by the numeric value of a system marker contained within the record.

Before updating the various balances for an item, an audit request, if present, is processed to give current stock-on-hand information.

After each record has been updated, stock allocation is effected by processing each customer demand separately against the stock-on-hand balance, in the sequence in which they are presented to this program.

Where each demand is fully satisfied a record is created for output. This record is eventually used, via user routine, for invoice/despatch note preparation and possibly for sales statistics, credit control and cost accounting routines.

If a demand cannot be satisfied, an unallocated demand (or back-order) record is created.

This record is recirculated back into the system, so that, upon entry to the Stock Updating and Allocation program next time, it may be given prior attention for allocation before the processing of new demands.

In addition, a priority code may be used for each, or selected demands to control priority of allocation for those customer demands.

A user option may be exercised, via operator control, to back-order each demand that cannot be fully satisfied, or, only that part of a demand which cannot be satisfied from physical stock.

Individual customer demands not requiring immediate allocation are written to an output magnetic tape file from this program and recirculated until such time as their due date falls within one lead time period from the current processing date. These demand records will then be classified as forward demands and added to the demand accumulators. A further option is provided to set a date such that when the due date of these forward demands comes within the range of this date option, allocation of these demands will then be attempted.

The user may decide to extract such demands not required for immediate allocation and exercise some other form of control or processing.

Upon completion of allocation the available (on hand minus back-orders plus on order) stock is compared with the re-order point and a replenishment order requested, if the re-order point is not less than the available stock. The order may be a minimum quantity set by Management, an economic order computed to conform to parameters pre-set by Management, or an order computed to last over a pre-selected ordering interval, based upon the usage rate. A maximum order size may also be specified.

A facility for cyclical ordering is provided, i.e. replenishment orders are requested at regular intervals - not necessarily each time the Stock Updating routine is processed. Cyclical ordering has a definite fixed time interval between successive replenishment order generations.

An exception report is printed giving details of these orders.

If the replenishment orders are adjusted before submission to a supplier, the amount of the adjustment must be notified to the system; otherwise the on-order balance will be incorrect.

All receipt and issue transactions will be output with cost data for use in costing routines developed by the user.

The physical stock balance is checked to see if it is outside the range of minimum and maximum stock limits set by Management. If it is outside this range a record is output to magnetic tape to enable a report to be printed by a subsequent program. Such reporting may be dispensed with at user option, but the system will always report any items on shortage and any items where the available stock does not cover the known forward demand.

A summary of stock activity and opening and closing balances is printed to enable controls to be balanced and to provide Management with a summarized report on stores activity since the previous Stock Updating run.

Allocation Report Routine

In addition to producing 'exception' reports for Management action, entry points to other business system areas are provided by magnetic tape files created by this routine. Primarily, the program is designed to print a report of all demand allocations and back-orders resulting from the Stock Updating and Allocation routine. Additionally the program will provide entry points to Purchase Order Control and Invoicing routines.

If automatic purchase order control is used, a file of outstanding or unplaced replenishment orders will likely be merged with current replenishment orders generated by the previous program.

This will depend upon the frequency of processing of the various routines adopted by the user. If, for example, the frequency of updating were daily, but purchase order control were weekly, then a Replenishment Order file would be merged each day with the file produced by this program in order to add new orders. At the end of the week (say), the user's purchase order control routines would be entered and the Replenishment Order file processed. Alternatively cyclical re-ordering would be used on a weekly basis to produce a single weekly list of orders required.

Note: The user is, of course, at liberty to amend the recommended order quantities; however, any such amendments must be fed back into the system in order to adjust the stock on order balance held on the Stock Master file - if this is not already catered for in the user routine.

Under Minimum/Over Maximum List Routine

This routine is designed to print two exception reports:

- 1 Under Minimum Stock level list
- 2 Over Maximum Stock level list

The user has the option of either including meaningful values for these stock limits in the Stock Master file or setting the maximum stock level to zero to prevent generation of the Over Maximum report. If an under minimum stock level report is printed, definite progress action on the listed items is required if stock-out is to be avoided.

Management may, or may not, take action to reduce the stock investment in the case of an over maximum stock level report, depending upon the reasons why the physical stock exceeds this Management limit.

Additional to the two reports, three magnetic tape files are produced, one of which extracts the over maximum records (if any) from the input file.

This file is then rewound to produce the second report. A second file is designed as an entry point to user cost accounting and invoice checking routines by extracting the priced receipt records. The third file is used to recirculate the remaining record types back into the system. If audit records are present, this circulating file becomes an entry point to an Audit Control routine as well.

Stock Forecasting and Monitoring Routine

This routine is the key to adaptive control if required; each item included in the adaptive control system is processed and a new predicted demand for the next time period is computed by an automatic forecasting technique.

Using the new predicted demand, the re-order point and a re-order quantity for the next period are computed.

If economic ordering is desired, the re-order quantity is determined from parameters selected by Management.

Only those items due for reforecasting at that point in time are processed. If an item has a seasonal demand pattern, seasonal factors specified by Management or calculated by the Optimal Prediction Parameter Routine are used in making the forecast of demand.

Demand history is updated during this routine so that a Demand History file is always available for re-analysis at any time.

Control over the continuing validity of the prediction parameters is effected by automatic monitoring of the forecasting performance.

All items held on the Demand History file are processed but a forecast is made *only* for those items having the appropriate system marker within the record.

Note: Recalculation of the re-order point for those items involved may raise the re-order point above the available stock level. If stock updating and allocation is performed frequently enough, new replenishment orders will be generated quickly. However, if there is a significant time lag between forecasting and normal updating, it will be necessary to re-enter the Stock Updating and Allocation routine immediately in order to generate any additional replenishment orders now required.

PROGRAM AVAILABILITY

2.3

Programs are available for each of the routines described in this manual as forming part of the 1900 SCAN System 1. This excludes the suggested user routines which are described by way of illustration how the SCAN system may be integrated with other important data processing routines. Which these are will be clear from the text.

File Formats

2.3.1

The suite of programs supporting 1900 SCAN System 1 includes file creation routines which may be used to create from punched cards or paper tape the major files used by the system. The user may, however, prefer to write his own programs to create the two Master files, if the required data is already recorded in other magnetic tape files which are used in his other data processing routines.

Similarly, it may be more convenient to some users to generate some of the stores transaction records in his other routines, e.g. Order Amendment Transactions from an automatic ordering routine. These should be in the format specified in this manual and the file should be merged with the file created by the SCAN Transaction File Create routine before entry to the Stock Updating routine.

Planning aids to assist preparation of punched card/paper tape input to the magnetic tape file creation routines are illustrated in this manual. Pads of these planning aids may be purchased from I.C.T. Printing and Stationery Department, Falk Factory, Works Road, Letchworth, Herts., England, under the reference numbers shown in the illustrations.

If the SCAN file creation routines are to be used, the specified punching formats must be adhered to. In any case the specified magnetic tape file formats must be adhered to unless the user modifies the SCAN programs. This should be avoided if possible since I.C.T. will not then be able to maintain any part of the modified programs and the user will not easily be able to take advantage of any developments as the result of I.C.T.'s continuing work in the field of inventory management systems. Modification of either of the Master files used by SCAN System 1 will render the SCAN file maintenance, file copying and print programs inappropriate to that file.

The Demand History file is unlikely to need amendment since it is internal to the system: spare words are provided in the Transactions file format, but I.C.T. should be consulted before any of these is allocated to special user requirements: the programs using the Stock Master file have been so arranged to allow the user to add an extra 64 words of data to each record (192 words in the 16K version) without affecting the operation of the SCAN programs. The latter will not have access to this extra data, however, and the user will need to make special arrangements for adding this extra data to the file at the time of file creation, or the insertion of new records, and for maintenance of the extended part of each record.

It is not possible to cater for all eventualities in a generalized system, but these arrangements should minimize the need for user amendments.

Program Structure

2.3.2

The programs are divided into input/output and processing sections to facilitate user amendment should this be unavoidable. The source languages used are PLAN 3, 1900 FORTRAN, 1900 Compact COBOL and 1900 Basic FORTRAN (FORTRAN II). The 1900 FORTRAN programs have PLAN input/output sections. Basic FORTRAN is used only for the two simulator programs which are written entirely in that language.

Machine Configuration

2.3.3

The programs (excepting the SCAN System Simulator) may be run on any 1900 series computer to the following minimum specification:

Central processor with 8K word core store, console typewriter and floating point facilities (hardware or extracode)

4 magnetic tape units (20 kch/s)

1 line printer (120 p.p.)

1 card/paper tape reader

Separate versions of some of the programs will also be available for a 16K central processor to give faster run times possible with a larger machine.

The SCAN System 1 Simulator programs require a machine to the following minimum specification:

central processor, as above but with 16K word core store

1 line printer (120 p.p.)

1 card/paper tape reader

A special system (1900 SCAN System 2) is available for the 1901 computer with 10 kch/s (cassette) tapes, but otherwise to the same minimum specification as above. For details of this, reference should be made to the appropriate manual.



Chapter 3 System Description

GENERAL

3.1

This chapter describes the basic specification of the I.C.T. SCAN System 1 comprising:

- 1 File Creation routines
- 2 Analytical routines
- 3 Operational routines

Each routine is described under the following headings:

- Objective
- System Flowchart
- Input
- Processing
- Output
- Peripherals

Note: See Section 2.3.3 for the minimum system configuration.

INPUT/OUTPUT RECORDS

3.2

The punched card/paper tape and magnetic tape file records described in Chapter 5 and referred to in this chapter contain, besides the necessary fields to produce the results indicated on the report formats shown, additional fields for data in common use for throughput to the entry points provided to other commercial Data Processing systems.

PROCESSING FUNCTIONS

3.3

The major processing functions of the I.C.T. 1900 SCAN System 1 are as follows:

- 1 From an analysis of demand history, the calculation of the minimum forecast interval, the classification of the items in the inventory according to frequency of movement and annual usage value, and the guidance of Management in selection of the control system to be used for each item.
- 2 By statistical analysis of demand history, the computation of:
 - mean demand
 - serial correlation coefficients
 - optimal Box-Jenkins prediction parameters
 - cyclical factors for seasonal items
 - standard deviation of errors and of demand
 - mean error
 - initial values to start the forecasting process
- 3 A statistical test on the serial correlation coefficients to detect significant trend and seasonal demand patterns.
- 4 Estimation of the likely effect of various customer service and replenishment ordering policies to assist Management to select the appropriate ones.

- 5 Application of a suitable replenishment order strategy.
- 6 Automatic allocation of available stock to demand.
- 7 Preparation of outputs indicating replenishment requirements, stock allocation and items requiring progress action.
- 8 Determination of re-order points and replenishment order quantities from predictions of future demand.
- 9 Monitoring of prediction errors.

The system issues the following control information for Management action on a routine basis:

- 1 Replenishment order quantities selected to:
either minimize the sum of supply and stockholding costs over time (economic re-order quantity), or
maintain system stability (minimum statistical re-order quantity) and
observe Management ordering policy (minimum or maximum re-order quantities)
or conform to a fixed size chosen by Management.
- 2 The replenishment order quantities may be requested on a random basis, i.e. as need is detected, or on a fixed cycle, e.g. once a month.
- 3 A report of all items whose forecast errors exceed stated limits.
- 4 A report of all stock items below a minimum stock level.
- 5 A report of all stock items above a maximum stock level.
- 6 A report of all allocated demands showing quantities allocated and unallocated (back-ordered).

FILE CREATION ROUTINES

3.4

Master File Create/Maintenance Routine

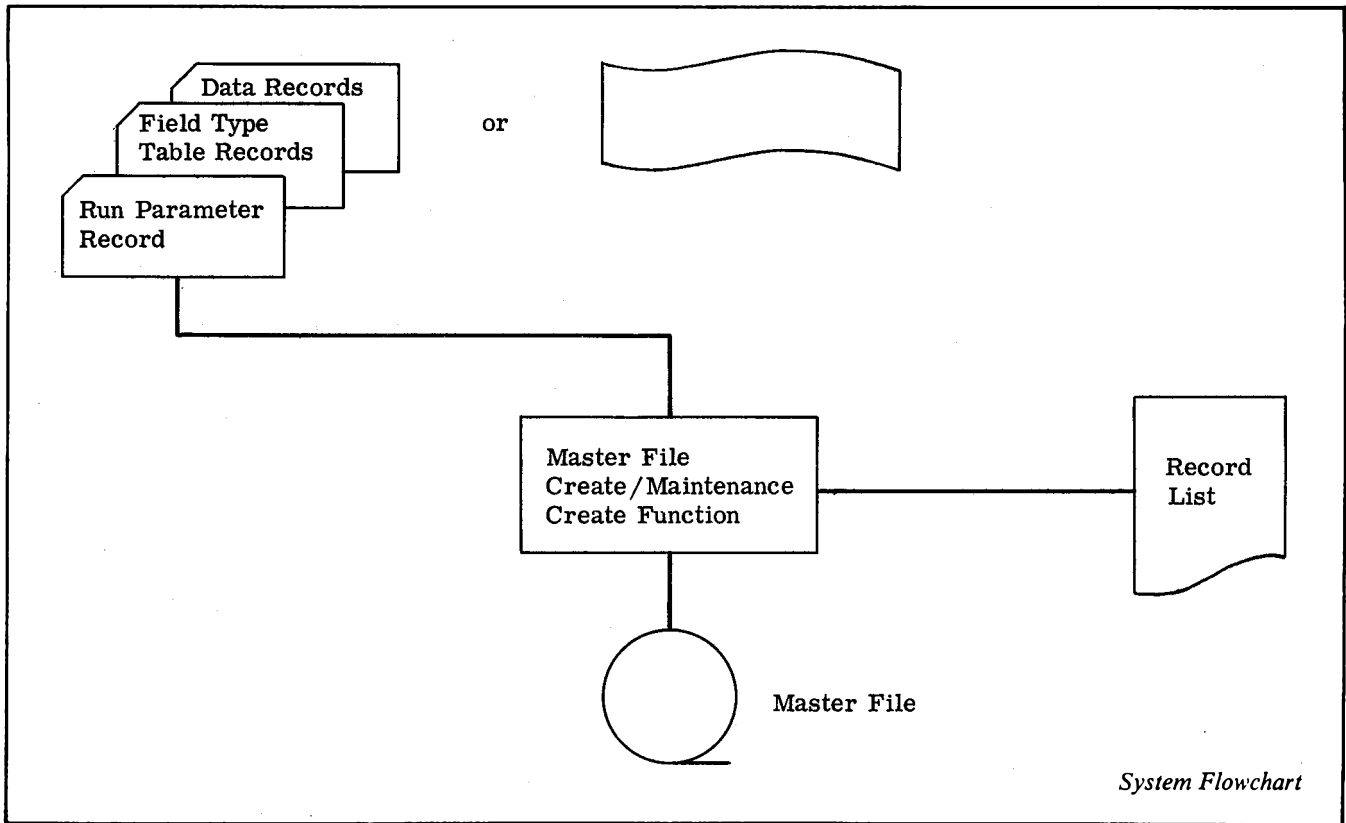
3.4.1

Objectives

- 1 To create a magnetic tape file from data input on punched cards or paper tape.
- 2 To merge two part files.
- 3 To insert a new record or records into a magnetic tape file.
- 4 To amend any field of any item on a magnetic tape file.
- 5 To delete any record from a magnetic tape file.
- 6 To extract a record or records from one magnetic tape file and produce two part files.

Note: This routine applies only to the two Master files used in I.C.T. SCAN System 1, see 'Demand History file' and 'Stock Master file'.

System flowchart, input, processing and output is as follows for each program function separately:



01	0111	1	1	0	0.000	1	1	0.10	0.00	EACH	267.171	01.992	02.142	2	963	104	52
02	0111	A1	15	QTBS	J HAIG												
03	0111	0	556	568	600	700	939	1100	1017	858	802	798	750	749	633	600	
03	0111	14	550	350	280	317	323	350	382	395	400	450	576	600	678	600	
03	0111	28	593	581	550	450	449	439	420	400	415	421	450	500	509	520	
03	0111	42	509	450	448	500	514	527	550	552	580	650	675	677	700	800	
03	0111	56	772	768	750	718	603	590	500	308	237	298	287	300	345	360	
03	0111	70	375	530	540	550	540	530	540	550	540	409	400	396	380	384	
03	0111	84	386	376	295	347	244	246	378	244	691	190	200	293	356	388	
03	0111	98	288	536	588	594	446	806	999999								
04	0111	0	1.97	1.99	2.08	2.40	2.74	2.99	2.83	2.52	2.25	2.22	2.00				
04	0111	11	1.69	1.39	1.44	1.34	1.04	1.00	1.08	1.12	1.41	1.47	1.51				
04	0111	22	1.50	1.57	1.78	1.84	1.95	1.62	1.59	1.57	1.49	1.34	1.34				
04	0111	33	1.30	1.15	1.20	1.06	1.07	1.33	1.19	1.92	1.14	1.14	1.19				
04	0111	44	1.35	1.42	1.29	1.71	1.82	1.83	1.64	2.33	999999						
01	0112	1	1	1	0.000	1	1	0.20	0.00	EACH	227.832	00.333	00.355	2	1212	104	1
02	0112	A1	15	4	OZ	FLASKS	J HAIG										
03	0113	0	221	239	371	295	287	189	221	238	271	311	252	247	271	297	
03	0112	15	273	208	215	263	292	199	273	247	239	281	285	271	261	283	
.
.
.

Figure 6 Master File Create Record List - Demand History File

MASTER FILE CREATE

Input

- 1 Run parameter record - defined in Section 5.6.1. This record names the output magnetic tape file.
- 2 Field type table records - defined in Section 5.6.2.
- 3 Data records - defined in Chapter 5:
 - Section 5.1 for the Demand History file
 - Section 5.2 for the Stock Master file

Processing

This function is designed to create a Master file containing item records in the standard MTH format with header label, qualifier block, data, trailer label.

File creation is achieved by specifying the name of the output file together with other parameters on the run parameter record followed by field type table records, followed by the appropriate data records containing item record details. A list is printed giving details of each item record and may be used as a Master file reference.

Various data type validity checks are performed during the creation stage.

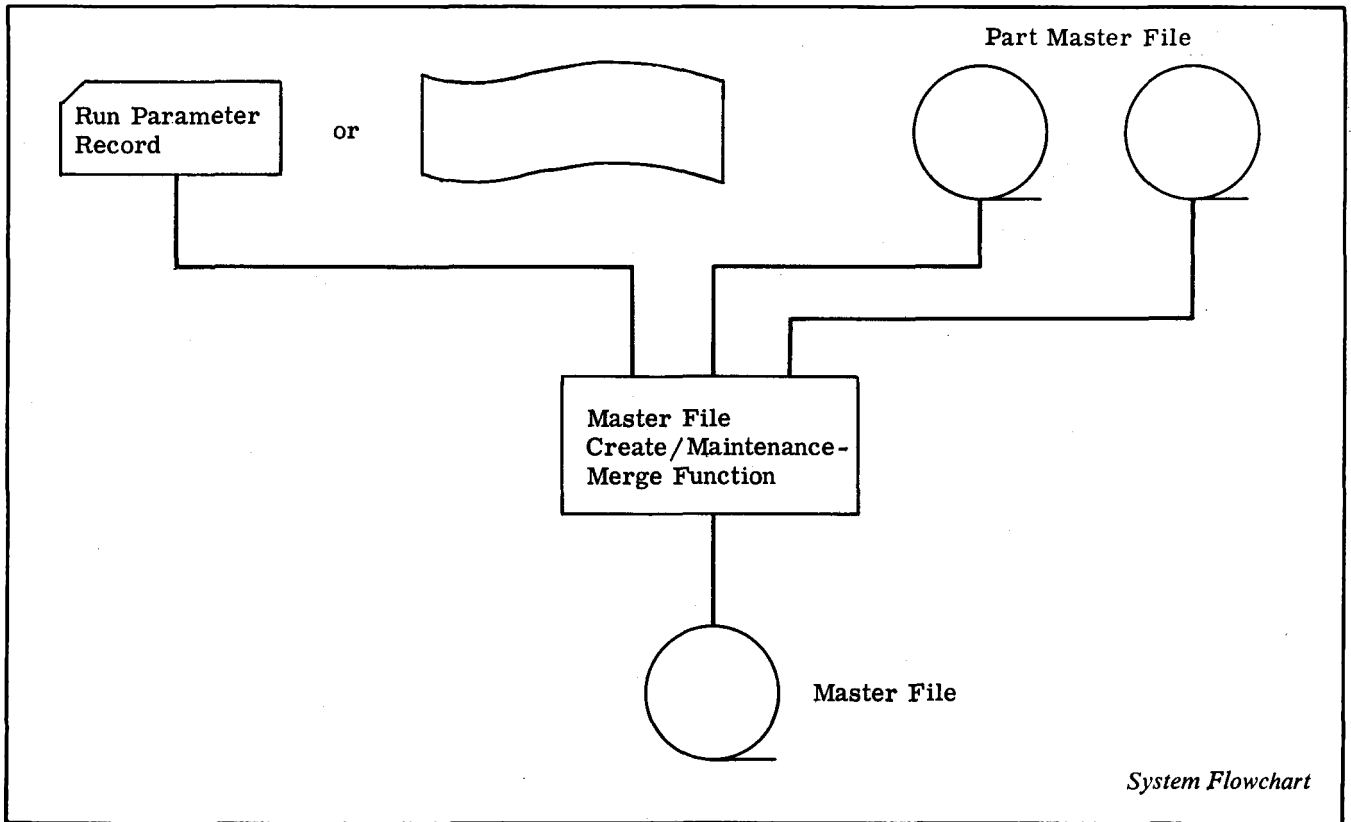
Note: The data records can be in any sequence within item number. Batches of item numbers need not be in sequence.

Output

- 1 One magnetic tape file as determined by input
 - Demand History file - defined in Section 5.5.1, or
 - Stock Master file - defined in Section 5.5.2.
- 2 Printed list of item record details.

Peripherals

- 1 card reader or paper tape reader
- 1 magnetic tape unit
- 1 line printer.



System Flowchart

MERGE Files

Input

- 1 Two magnetic tape files, both of which may be either:
 - Demand History - defined in Section 5.5.1 or
 - Stock Master - defined in Section 5.5.2
- 2 Run parameter record - defined in Section 5.6.1.

Processing

Normally, file creation is a 'one off' task when preparing files prior to running a system, but, if it is desired to build up a Master file gradually, the data forming each part of the file may be used to create a number of part-files.

The merge function will allow any two part-files to be brought together and a single Master file created in the correct sequence.

A 'merge' is signalled to the program by giving identical names to both input files and one output file on the Run parameter record.

Thereafter, each record is read off the input files (after verifying the file names) and written to an output file. This is given a file generation number one greater than the larger of the input file generation numbers.

Note: Each part-file must be in ascending item number sequence prior to using the merge function.

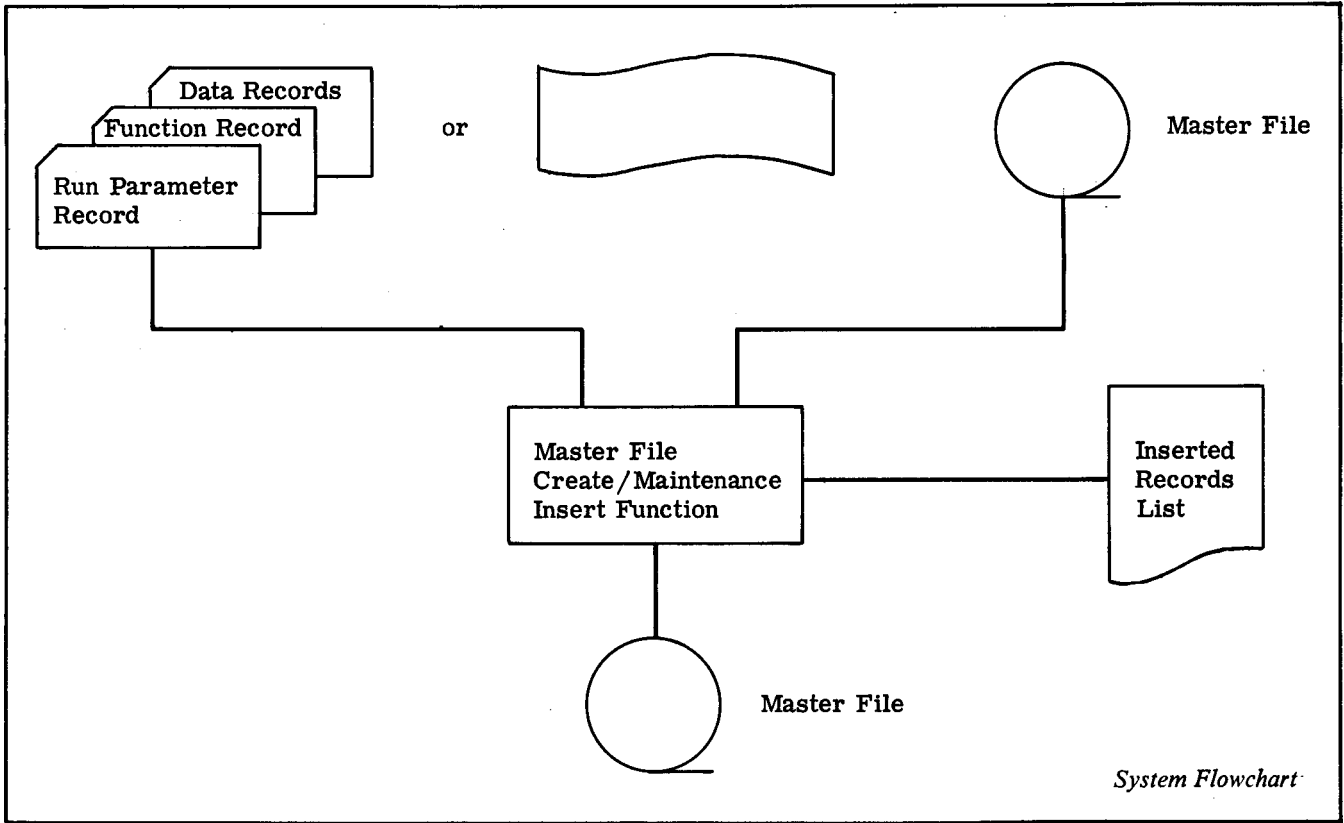
Output

One magnetic tape file (format as input files):

Demand History or
Stock Master.

Peripherals

- 1 card or paper tape reader
- 3 magnetic tape units



INSERT Records

Input

- 1 One magnetic tape file which may be either:
 - Demand History - see Section 5.5.1, or
 - Stock Master - see Section 5.5.2
- 2 Run Parameter Record - see Section 5.6.1.
- 3 Function Record, type '31' - see Section 5.6.3.
- 4 Data Records to correspond to input magnetic tape file (1):
 - Demand History - see Section 5.1, or
 - Stock Master - see Section 5.2

Processing

This function is designed to place a new item record in its correct sequence in a master file and is achieved by comparing item numbers on the input magnetic tape file and function records until the correct position is found. An updated master file is output together with a printed list of each inserted item record details.

The input file name is checked against that specified on the Run Parameter record; function record type '31' tells the program to perform the INSERT function as well as holding the item number of the record to be inserted.

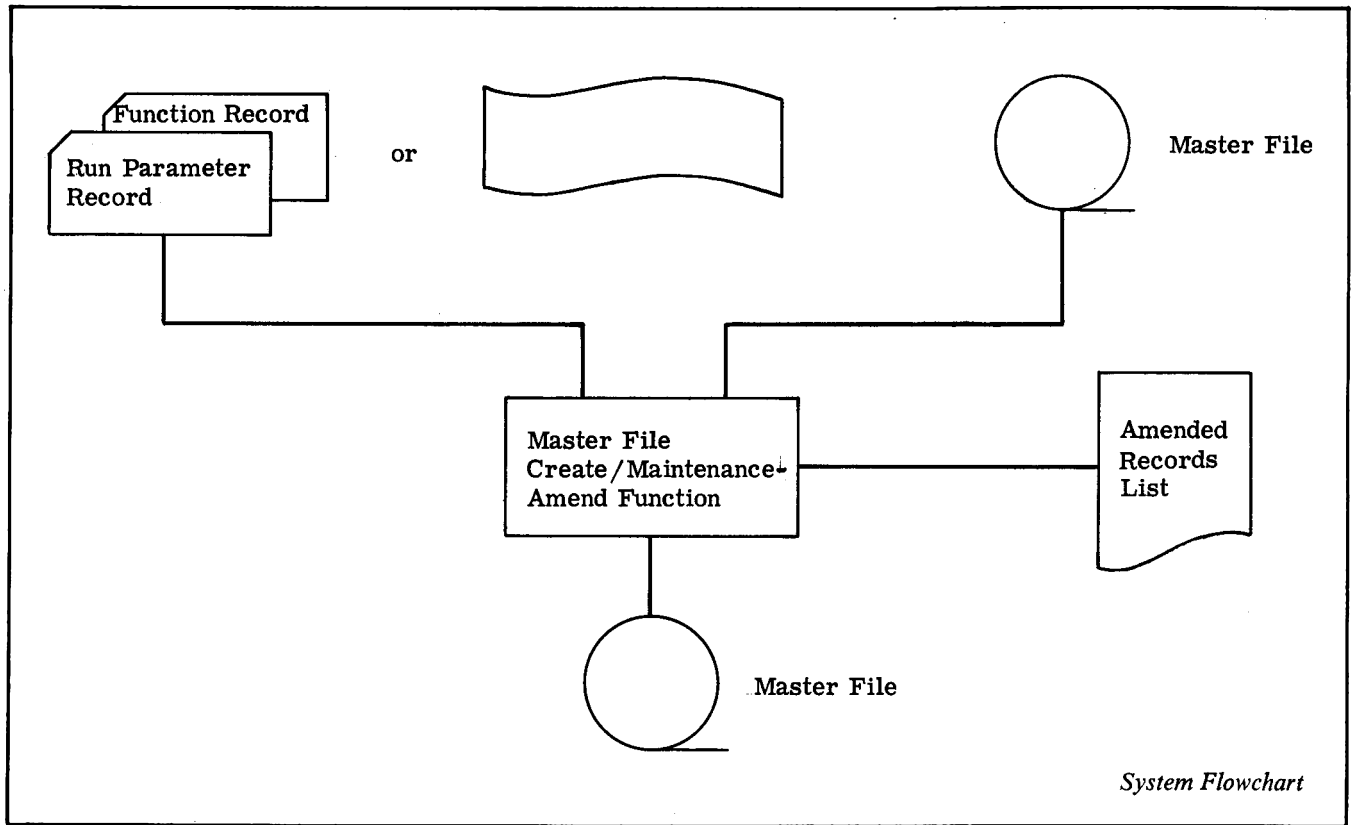
Each batch of data records pertaining to an item is preceded by a function record and followed by a '99' record - see Operating Procedures.

Output

- 1 One magnetic tape file in same format as Input (1):
 - Demand History or
 - Stock Master
- 2 Printed list of inserted item record details.

Peripherals

- 1 card or paper tape reader
- 2 magnetic tape units
- 1 line printer



System Flowchart

AMEND Fields

Input

- 1 One magnetic tape file, which may be either
 Demand History - see Section 5.5.1, or
 Stock Master - see Section 5.5.2
- 2 Run Parameter Record - see Section 5.6.1
- 3 Function Record, type '32' - see Section 5.6.3

Processing

Any word or number of words within an item record for either master file may be altered by using this function.

After verifying the correct input tape label with the run parameter record, each function record item number is matched against the master file records.

Immediately following the item number on the function record is the word number corresponding to the field within the item record which is to be amended. The function record may contain one or more pairs of words numbers and field values.

The word number is used by the program to amend the corresponding field.

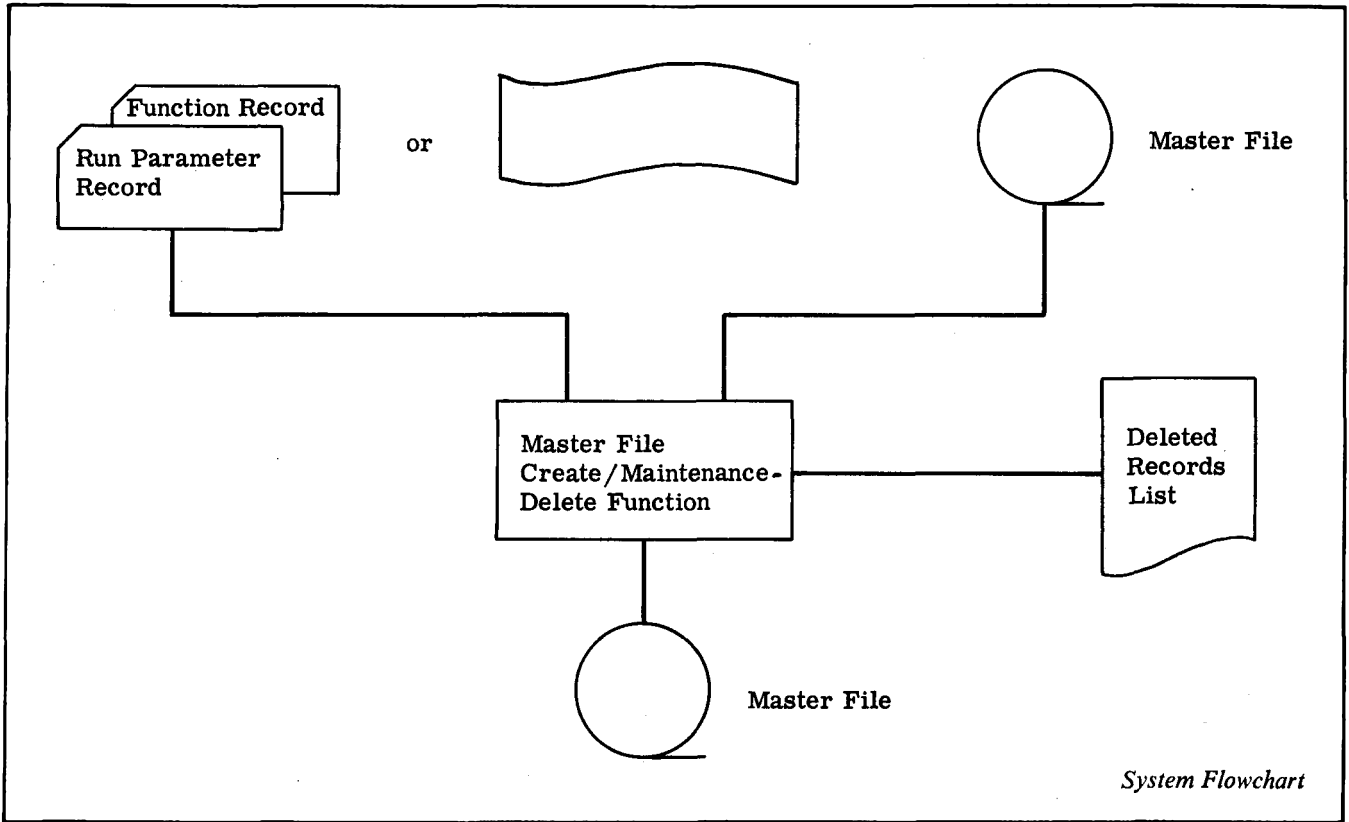
An amended master file magnetic tape is output together with a list of all such amendments including the previous field values.

Output

- 1 One magnetic tape file in same format as Input (1)
 Demand History or
 Stock Master,
- 2 Printed list of each amendment together with old field value.

Peripherals

- 1 card or paper tape reader
- 2 magnetic tape units
- 1 line printer



System Flowchart

DELETE Records

Input

- 1 One magnetic tape file which may be either
Demand History - see Section 5.5.1, or
Stock Master - see Section 5.5.2
- 2 Run Parameter Record - see Section 5.6.1
- 3 Function Records, type '33' - see Section 5.6.3.

Processing

This function simply deletes any required item record from the master file and records the action on a listing.

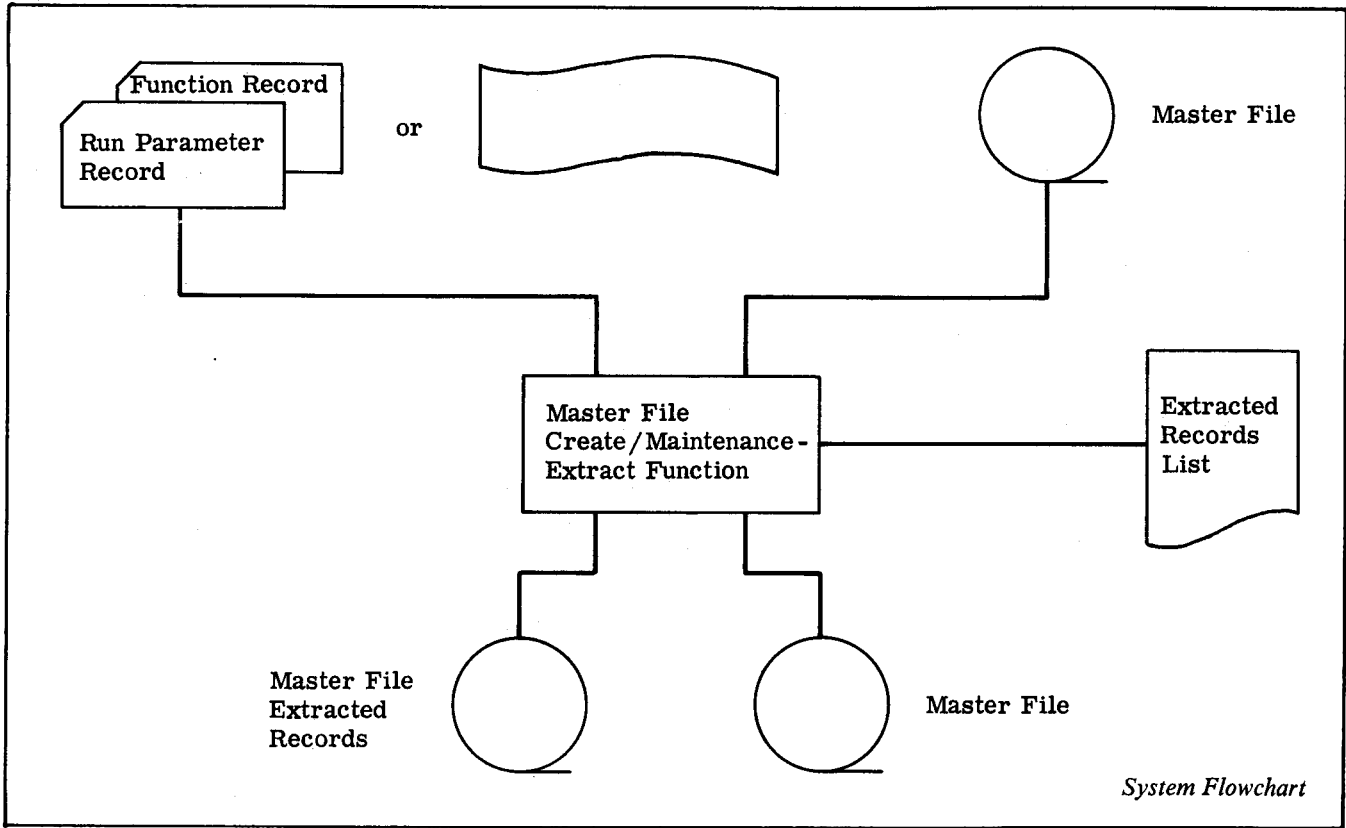
After verifying the correct input tape label with the Run parameter record, each function record (containing the item number of the record to be deleted) is matched against the input file. A magnetic tape file is output excluding the deleted records.

Output

- 1 One magnetic tape file in same format as Input (1):
Demand History, or
Stock Master
- 2 Printed list of deleted items.

Peripherals

- 1 card or paper tape reader
- 2 magnetic tapes
- 1 line printer



01	0113	1	1	1	0.000	1	1	0.10	0.00	EACH	01.87	2.142	2	748	28	1	
02	0113	A1	15							PINT BOTTLE BON CHARLIE							
03	0113	0	968	687	622	621	618	587	598	601	628	697	685	627	639	682	691
03	0113	15	600	600	632	600	580	575	510	564	521	610	616	620	635	999999	
ITEM NO	0113	INSERTED															
ITEM NO	0114	WORD NO 005 AMENDED FROM A1										TO A2					
ITEM NO	0129	DELETED															
ITEM NO	0137	DELETED															
ITEM NO	0145	EXTRACTED															
ITEM NO	0149	EXTRACTED															
ITEM NO	0158	DELETED															
ITEM NO	0187	DELETED															
ITEM NO	0190	WORD NO 022 AMENDED FROM 2										TO 3					
ITEM NO	0196	DELETED															
.	.	.															
.	.	.															
.	.	.															

Figure 7 Master File Maintenance List - Demand History File

EXTRACT Records

Input

- 1 One magnetic tape file which will usually be:
 - Demand History - see Section 5.5.1, but may be
 - Stock Master - see Section 5.5.2
- 2 Run Parameter Record - see Section 5.6.1
- 3 Function Record, type '34' - see Section 5.6.3

Processing

This function is designed to allow selected records from a master file to be extracted and written to a magnetic tape file. These records are then deleted from the master file. Its main purpose is to allow item records to be re-analyzed if circumstances warrant this action. After such analysis the extracted records may be merged with the main file for operational control.

After verifying the input tape label with that on the Run parameter record, the function records are matched with the input file. Where an item number is matched, the tape record is written to one output tape file. If there is no match, the input tape record is written to the other output master file.

A printed list of all such extracted items is also output.

Output

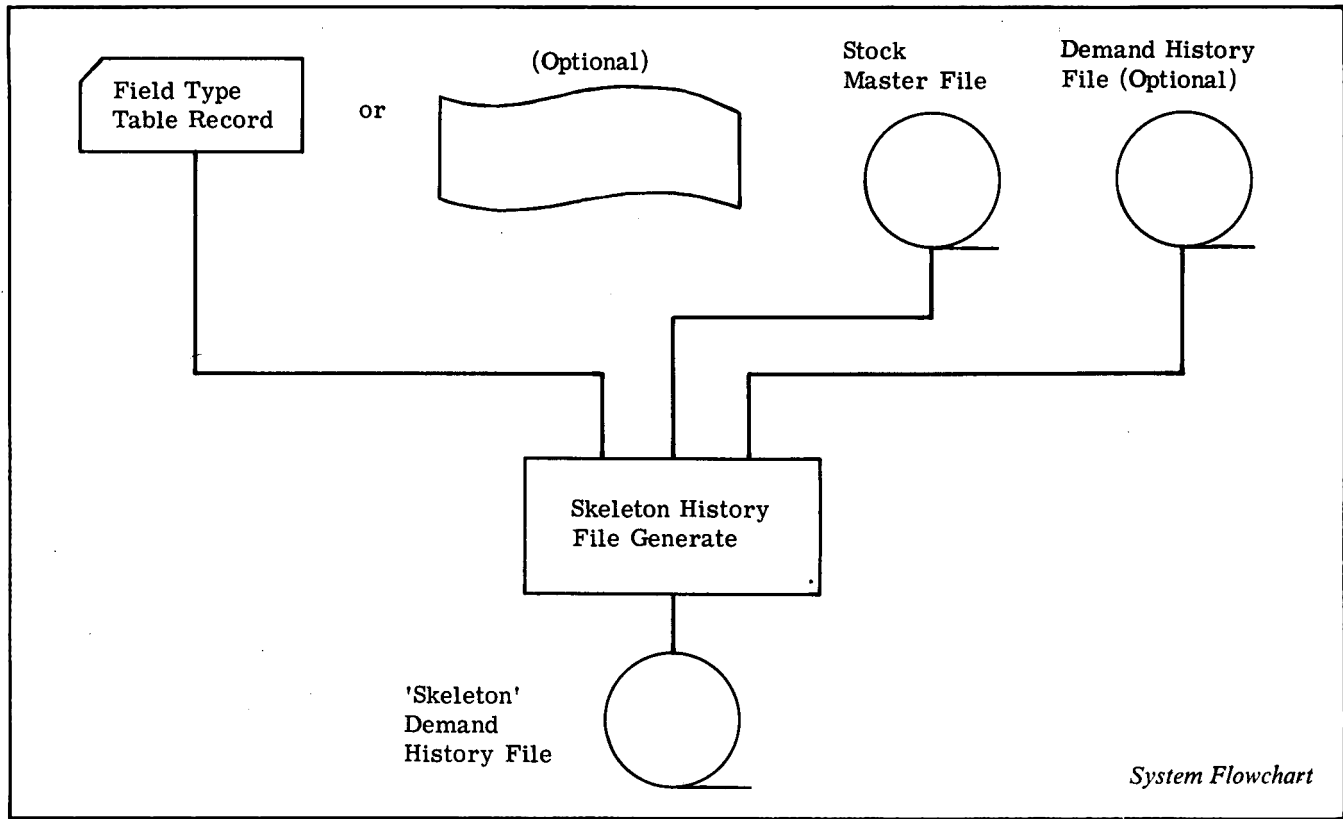
- 1 One magnetic tape file containing extracted item records in format as Input (1).
- 2 One magnetic tape file containing records not extracted from the input file (format as Input (1))
 - Demand History, or
 - Stock Master
- 3 Printed list of extracted item numbers.

Peripherals

- 1 card or paper tape reader
- 3 magnetic tape units
- 1 line printer

Source Language: (for all functions)

PLAN 3



Objective

To create, or add data to a Demand History magnetic tape file from a Stock Master magnetic tape file and thus reduce the amount of keypunching required to produce data common to both files, with a consequent reduction in transcription errors.

Input

- 1 Stock Master magnetic tape file - defined in Section 5.5.2
- 2 Demand History magnetic tape file if common data to be added to existing records in this file, or
- 3 Field type table records - see Section 5.6.2 - if no Demand History file is present and a 'skeleton' Demand History file is to be created.

Processing

- 1 If a complete skeleton Demand History file is required from the Stock Master, a switch is set via the console, and the program writes a Demand History magnetic tape file containing data common to both files, namely:

Item number

Class code

Description

Location code

Unit of measure

Cost price

Sales price

Lead time

Closing stock balance

System marker

Mean absolute deviation of errors (this is given a value = 1).

The field type table records contain data used for file maintenance and are present only if no input Demand History file is present.

- 2 If a Demand History file is present as input, together with a Stock Master file, no field type table records are required, as the necessary data would have been entered when the Demand History file was created.

No switch is set and each item on the Demand History file is matched against the Stock Master file.

Where a match is obtained, a record will be written to an output Demand History file, containing the original data present on the input Demand History file and the data common to both files (see above list). If some of this common data was already present in the input Demand History file, it is overwritten by the corresponding data from the Stock Master file.

Output

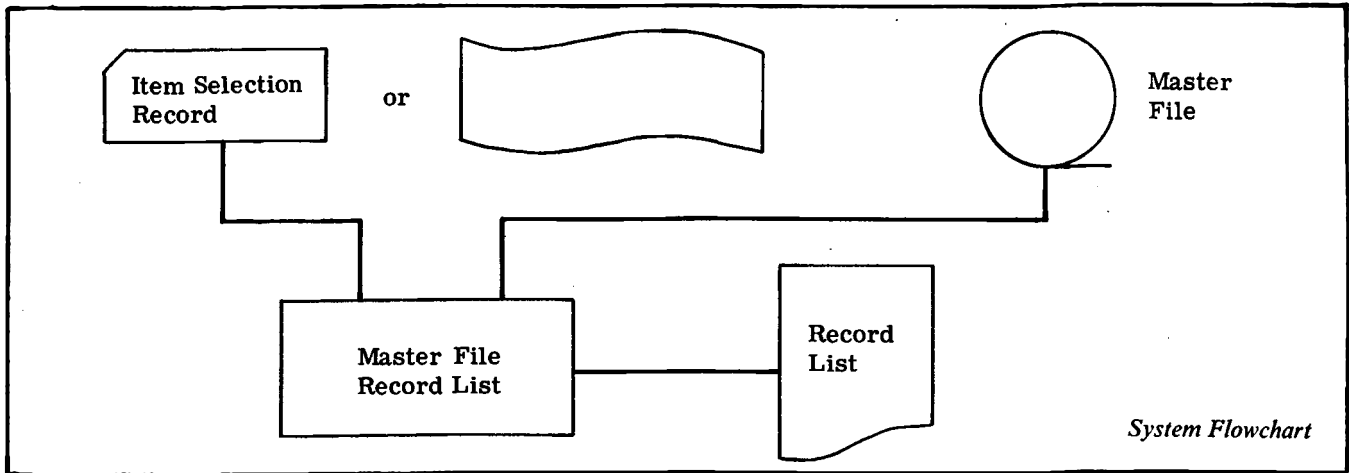
Demand History magnetic tape file (see Chapter 2 for a description of the situations affecting the use of this program).

Peripherals

- 1 card or paper tape reader (optional)
- 2 or 3 magnetic tape units

Source Language

PLAN 3



I.C.T. SCAN SYSTEM LISTING													DATE		
DEMAND HISTORY FILE													01/07/67		
ITEM NUMBER	0111					DESCRIPTION	QTBS J HAIG								
CLASS CODE	A1					LOCATION CODE	15					UNIT OF MEASURE	EACH		
COST PRICE	1.992					SALES PRICE	2.142					ORDERING COST	0.000		
LEADTIME	2.00					AVERAGE DEMAND	511.365					STD. DEVIATION OF DEMAND	0.000		
DESEASONALIZED FORECAST	267.171					CUMULATIVE SUM OF ERRORS	22.625					STD. DEVIATION OF ERRORS	0.000		
SMOOTHED ERROR	15.218					SMOOTHED M.A.D. OF ERRORS	35.938					CLOSING STOCK	963		
SERVICE LEVEL GROUP	1					ORDERING INTERVAL	1					INVESTMENT RATE GROUP	0		
SYSTEM MARKER	1					C.P.P.R. INCLUSION MARKER	1					SERIES LENGTH	104		
FORECAST INTERVAL	1					FORECAST INTERVAL COUNT	0								
CYCLE BASE	52					CYCLE BASE COUNT	20								
FACTOR ONE	0.10					FACTOR TWO	0.00								
SEASONAL FACTORS															
	P	FACTOR	P	FACTOR	P	FACTOR	P	FACTOR	P	FACTOR	P	FACTOR	P	FACTOR	
1	1.97	2	1.99	3	2.08	4	2.40	5	2.74	6	2.99	7	2.83	8	2.52
9	2.25	10	2.22	11	2.00	12	1.69	13	1.39	14	1.44	15	1.34	16	1.04
17	1.00	18	1.08	19	1.12	20	1.41	21	1.47	22	1.51	23	1.50	24	1.57
25	1.78	26	1.84	27	1.95	28	1.82	29	1.59	30	1.57	31	1.49	32	1.34
33	1.34	34	1.30	35	1.15	36	1.20	37	1.06	38	1.07	39	1.33	40	1.19
41	1.92	42	1.14	43	1.14	44	1.19	45	1.35	46	1.42	47	1.29	48	1.71
49	1.82	50	1.83	51	1.64	52	2.33								
DEMAND HISTORY															
	P	DEMAND	P	DEMAND	P	DEMAND	P	DEMAND	P	DEMAND	P	DEMAND	P	DEMAND	
1	556	2	568	3	600	4	700	5	939	6	1100	7	1017	8	858
9	802	10	798	11	750	12	749	13	633	14	600	15	550	16	350
17	280	18	317	19	323	20	350	21	382	22	395	23	400	24	450
25	576	26	600	27	678	28	600	29	593	30	581	31	550	32	450
33	449	34	439	35	420	36	400	37	415	38	421	39	450	40	500
41	509	42	520	43	509	44	450	45	448	46	500	47	514	48	527
49	550	50	552	51	580	52	650	53	675	54	677	55	700	56	800
57	772	58	768	59	750	60	718	61	603	62	590	63	500	64	308
65	237	66	298	67	287	68	300	69	345	70	360	71	375	72	530
73	540	74	550	75	540	76	530	77	540	78	550	79	540	80	409
81	400	82	396	83	380	84	384	85	386	86	376	87	295	88	347
89	244	90	246	91	378	92	244	93	691	94	190	95	200	96	293
97	356	98	388	99	288	100	536	101	588	102	594	103	446	104	806

Figure 8 Master File Record List - Demand History File

I.C.T. SCAN SYSTEM LISTING													DATE	
STOCK MASTER FILE													01/07/67	
ITEM NUMBER	0111					DESCRIPTION	QTBS J HAIG							
CLASS CODE	A1					LOCATION CODE	15					UNIT OF MEASURE	EACH	
COST PRICE	1.992					SALES PRICE	2.142					PURCHASE TAX	0.000	
LEADTIME	2.000					UNIT WEIGHT/TIME	0.000					SET UP TIME	0.000	
DISCOUNT CODE	70					SUPPLIER CODE	2376					SCRAP FACTOR %	0	
MINIMUM ORDER QUANTITY	48					MAXIMUM ORDER QUANTITY	0					CYCLE BASE	52	
BIN LOCATION	3721					SYSTEM MARKER	1					MINIMUM STOCK LEVEL	100	
REORDER POINT	2161					REORDER QUANTITY	774					MAXIMUM STOCK LEVEL	2000	
CLOSING STOCK	963					FORWARD DEMAND BALANCE	974					PERIOD DEMAND	597	
BACKORDERS	0					STOCK ON ORDER BALANCE	576					CUMULATIVE DEMAND	6093	
CUMULATIVE RECEIPTS	7152					CUMULATIVE SCRAP	0					CUMULATIVE BACKORDERS	9	
RECEIPTS COUNT	12					STOCK-OUT COUNT	1					NON-MOVE COUNT	0	

Figure 9 Master File Record List - Stock Master File

Objective

To permit inspection of one, or more, selected item record details from either the Demand History magnetic tape file, or the Stock Master magnetic tape file.

Input

- 1 Demand History magnetic tape file - see Section 5.5.1, or Stock Master magnetic tape file - see Section 5.5.2
- 2 One, or more, punched cards (or paper tape blocks) with the item number punched in the first 16 columns - see Section 5.6.4.

Processing

Selection of the appropriate magnetic tape file is by console instruction (entry point). Item numbers in the punched medium must be in the same sequence as those in the master file. When a match is obtained between item numbers, the record details are printed. After the last card (or paper tape block) is processed the input file is rewound.

Output

Printed report of selected item details

1 per page - Demand History file

4 per page - Stock Master file.

Peripherals

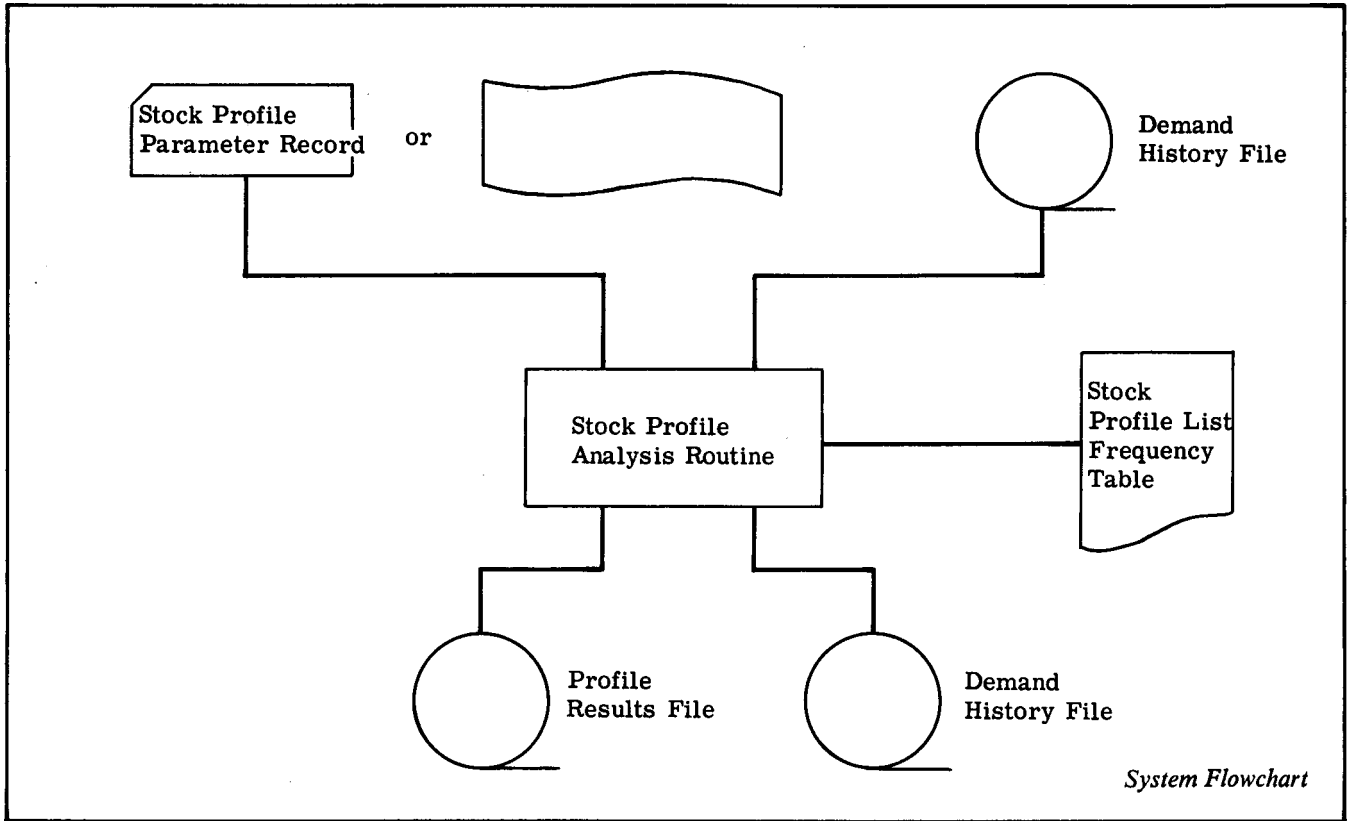
1 card or paper tape reader

1 magnetic tape

1 line printer.

Source Language

PLAN 3.



Stock Profile Analysis Routine**3.5.1****Objectives**

To examine the historical demands for each inventory item and determine a recommended minimum time interval at which a forecast should be made, based on frequency of movement.

To evaluate for each item, total average annual sales value, current stock value and average annual marginal value.

To provide a 'profile' of the total inventory within each recommended forecast interval.

To provide an entry point to the ABC Analysis routine see Section 3.5.2.

Input**1 Stock Profile Parameter Record**

Four parameters are required for this record:

Selective listing

Frequency table

Profile Results

Currency unit.

Selective Listing parameter: If this parameter is set, only those stock items with a movement frequency greater than or equal to the equivalent value of the parameter will be output on the Stock Profile list. The value of this parameter is the selected forecast interval. If set to 27 or over, all stock items will be listed; if zero, the list is suppressed.

Frequency Table parameter: If this parameter is set to '0' the four unit totals together with the frequency table, as illustrated by Figure 10, will be accumulated and output in addition to the Stock Profile List.

If set to '1', the Stock Profile List only will be printed according to 'Selective Listing' above.

Profile Results parameter: If this parameter is set to '0', no Profile Results magnetic tape file is produced.

If set to '1', the Profile Results magnetic tape file is output.

Currency Unit parameter: This is used as a literal for printer output, e.g. £ or FR.

2 Demand History Magnetic Tape File - see Section 5.5.1.

The only fields used in this program are as follows:

Item number

Cost price

Sales price

Closing stock-on-hand

Demand history

Series length

Description

Processing

The Stock Profile Parameter record is read into store and a switch set by operator control if a Demand History magnetic tape file is required as output.

Each item record on the Demand History file is scanned and the following calculations performed:

1 Frequency of movement = movement count ÷ demand history length (series length).

Note: Movement count is the number of basic time units, in each of which a demand has occurred, and is obtained by scanning the demand history array.

2 The total demand is summed over the demand history provided and the sales value (at sales price) and gross margin (at difference between cost and sales prices) is calculated, based on the average annual demand, i.e. the total demand is divided by the number of demand points provided and multiplied by the number of demand points in a year (52 for weekly data, 13 for 4 weekly data and 12 for monthly data)

3 The stock value = closing stock quantity × cost price.

The forecast interval is related to the frequency of movement as follows (the alternatives in column 3 are for basic time intervals of one week and one month respectively):

<i>Probability of at least one movement per basic time interval or unit</i>	<i>Forecast Interval</i>	<i>Time Period between Successive forecasts</i>
≥ 0.5	1	Week or Month
≥ 0.25	2	Fortnight or Two Months
≥ 0.125	4	Month or Four Months
≥ 0.0385	13	Other
> 0	26	

Reference should be made to Section A.3.1 of Appendix A.

Output

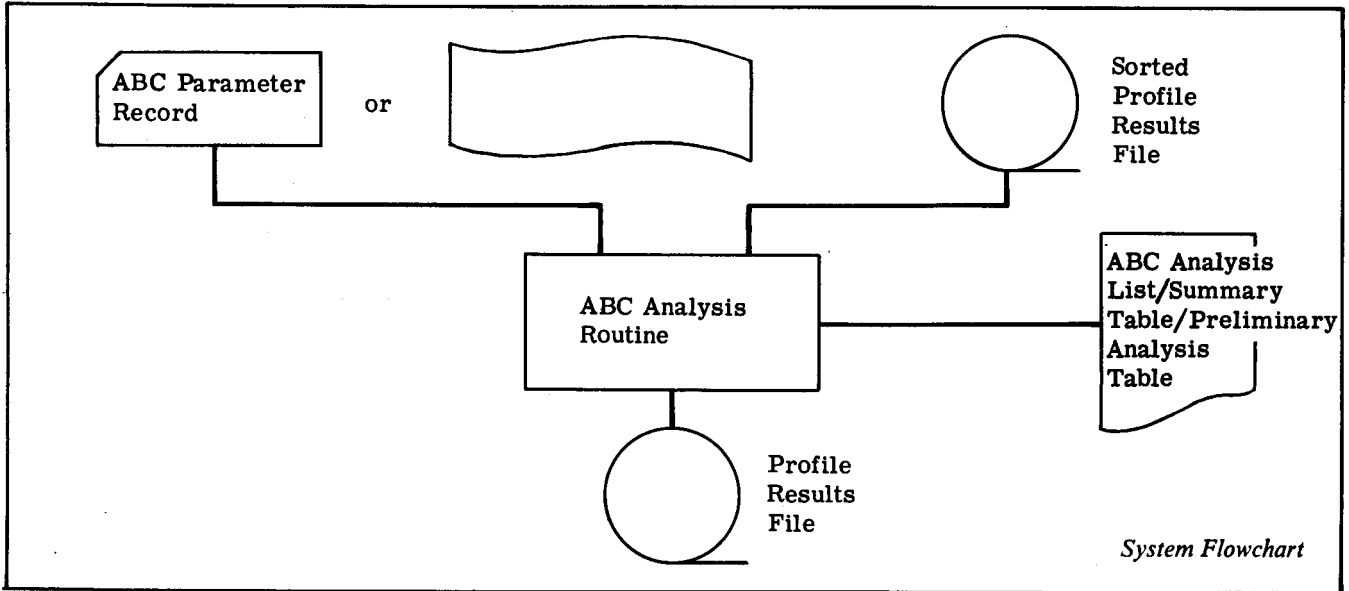
- 1 Demand History magnetic tape files (format as Input (2)). This is an optional file and, if output, will include the minimum forecast interval computed for each item.
- 2 Profile Results magnetic tape file - see Section 5.5.4. This is also an optional file, but, if ABC Analysis is required, it must be output. See Profile Results Parameter.
- 3 Stock Profile list - optional - see Selective Listing Parameter. As illustrated below: this list may contain all items with a forecast interval equal to or less than that specified by input parameter, or it may contain all items on the input file.
- 4 Frequency Analysis. This is obtained by setting the appropriate parameter value - see Frequency Table Parameter.

Peripherals

- 1 card or paper tape reader
- 1 to 3 magnetic tape units (see Output section)
- 1 line printer

Source Language

PLAN 3



A.B.C. ANALYSIS			DATE 01/07/67		PAGE 1									
ITEM NUMBER	DESCRIPTION	UNIT OF MEAS	C	L S	ANNUAL USAGE	STOCKHOLDING	GROSS MARGIN	ITEM COUNT	CUMULATIVE USAGE	STOCK VALUE	PERCENTAGES MARGIN	ITEM COUNT		
					UNITS	£	UNITS	£						
A10J	CHUNKY MARMALADE 15 ST. MARTIN	CASE	A1	01 104	9632	25043	872	1831	4816	1	1.2	1.2	2.1	.1
A103	FLOUR PLAIN MCDUGALLS 1S	CASE	A1	01 104	8931	22550	885	1770	4465	2	2.3	2.4	4.1	.3
A105	FLOUR S.R. MCDUGALLS 1S	CASE	AT	01 104	8879	21753	821	1724	3107	3	3.4	3.5	5.5	.5
A109	FLOUR S.R. MCDUGALLS 3S	CASE	A1	01 104	5028	20112	416	1456	2514	4	4.3	4.5	6.6	.7
C008	NESCAFE SACHETS	GRSS	A1	01 104	8260	19824	772	1621	2478	5	5.3	5.6	7.7	.8
C109	NESCAFE 20Z	CASE	A1	01 104	973	14595	83	1037	2432	6	6.0	6.3	8.8	1.0
C390	NESCAFE 80Z	CASE	A1	01 104	2572	12860	217	911	2057	7	6.6	6.9	9.7	1.2
C821	NESCAFE 1 1/2 LBS	CASE	A1	01 104	1101	11560	110	946	2091	8	7.2	7.5	10.6	1.3
C001	NESCAFE 40Z JAR	CASE	A1	01 104	1296	11534	121	943	1425	9	7.8	8.1	11.2	1.5
C010	NESCAFE CONTINENTAL 2 OZ	CASE	A1	01 104	1838	11028	158	742	2389	10	8.3	8.6	12.3	1.7
C007	NESCAFE CONTINENTAL 4 OZ	CASE	A1	01 104	1757	10717	147	837	703	11	8.8	9.2	12.6	1.8
C100	INSTANT COFFEE 4 OZ	CASE	A1	01 104	3261	10435	197	492	2282	12	9.3	9.5	13.6	2.0
D002	NESQUICK STRAWBERRY 8 OZ	CASE	A1	01 104	8962	9858	693	623	1792	13	9.8	9.9	14.4	2.2
S100	MARIE ELIZABETH SARDINES	CASE	A1	01 104	3897	9742	340	612	2727	14	10.3	10.3	15.6	2.3
A028	STEWED STEAK IRISH 15 1/2 OZS	CASE	A1	01 104	1387	7212	118	566	554	15	10.6	10.7	15.8	2.5
P311	KENNAMEAT SMALL	CASE	A1	01 104	1953	6835	163	440	1562	16	11.0	11.0	16.5	2.7
P102	KATTOMEAT SMALL	CASE	A1	01 104	1875	6750	165	462	1500	17	11.3	11.3	17.2	2.9
D801	TIDYSAN 13 X 10	CASE	A1	01 104	8581	6006	721	288	2574	18	11.6	11.5	18.3	3.0
P101	TOP CAT HANDY	CASE	A1	01 104	4076	5298	376	338	1630	19	11.8	11.7	19.0	3.2
LIST TOTALS					2057891		150491	226368						

Figure 11 ABC Analysis List

Objectives

- 1 To enable Management to classify their inventory into three categories according to sales value and three independent categories by frequency of movement of demand, giving a maximum of nine classifications, any one of which will apply to each stock item.
- 2 To provide a guide to Management to select the final percentages in which to group the three categories based on sales value.
- 3 To provide the entry point to the automatic Control System Selection routine, if required.
- 4 To provide a listing of items in the sequence: stock value, gross margin, item number or class code.

Input

- 1 Profile Results magnetic tape file - see Section 5.5.4.
- 2 A Parameter Card (or paper tape block) containing six options as follows:

Print option: this allows selective listing of the ABC analysis:

- fast movers only
- medium movers only
- slow movers only
- high value items only
- medium value items only
- low value items only
- a complete list of all items
- a preliminary analysis table only

An ABC analysis summary table is printed with each of the above selections except the last.

File Sequence indicator: this indicates to the program which sequence must be checked.

- descending sequence of sales value
- descending sequence of stock value
- descending sequence of gross margin
- ascending sequence of item number
- ascending sequence of class code

Class 'A' Limit: this is used only when the Profile Results file is in descending sequence of sales value. If the parameter has a zero value no ABC classification will be performed. This will produce a preliminary analysis table only.

Any other value of this parameter will set the limit for classifying the class 'A' items, e.g. 20 would progressively classify each item as 'A' items until the first 20% of total sales value had been reached.

Class 'B' Limit: this delimits the percentage of total sales within which the items will be classified as 'B', e.g. 60 would progressively classify each item as 'B' items from the 'A' limit until the first 60% of sales had been reached. It is ignored if the Class A Limit parameter is zero.

All items beyond this limit will be classified as 'C' items.

Output File Control: an output Profile Results file identical to the input file but containing the ABC classifications may be written, if the ABC Analysis is carried out during the run.

Medium Mover Limit: this delimits the forecast interval used to divide items between medium and slow movers. Fast movers (class 1) will always be classified as those items having a forecast interval of 'one'. This parameter specifies the maximum forecast interval for medium movers.

A.B.C. ANALYSIS			DATE 01/07/67				PAGE 51	
CLASS CODE	ANNUAL USAGE		STOCKHOLDING		GROSS MARGIN		ITEM COUNT	
	£	CUM %	£	CUM %	£	CUM %	UNITS	CUM %
A1	830937	40.4	68548	45.5	81980	36.2	75	12.6
A2	397213	59.7	28721	64.6	41237	54.4	88	27.3
A3	13716	60.3	1092	65.4	1583	55.1	5	28.2
B1	679631	93.4	40732	92.4	85328	92.8	339	85.1
B2	87291	97.6	7016	97.1	10921	97.7	48	93.1
B3	1525	97.7	130	97.2	185	97.7	1	93.3
C1	45727	99.9	3842	99.7	4931	99.9	38	99.7
C2	960	99.9	180	99.8	105	99.9	1	99.8
C3	891	100.0	230	100.0	98	100.0	1	100.0
TOTALS	2057891		150491		226368		596	

Figure 12 ABC Analysis Summary Table

A.B.C. ANALYSIS			DATE 01.07.67				PAGE 1		
PERCENTAGE	ANNUAL USAGE	ANNUAL USAGE		STOCKHOLDING		GROSS MARGIN		ITEM COUNT	
		£	CUM %	£	CUM %	£	CUM %	UNITS	CUM %
5	109282	5.3	8402	5.6	17380	7.7	5	.8	
10	102329	10.3	7143	10.3	17898	15.6	9	2.3	
15	102123	15.3	7318	15.2	12003	20.9	9	3.9	
20	101072	20.2	7526	20.2	9927	25.3	9	5.4	
25	101578	25.1	7412	25.1	6529	28.2	10	7.0	
30	102837	30.1	7521	30.1	6219	30.9	10	8.7	
35	102973	35.1	11631	37.8	6828	33.9	11	10.6	
40	103221	40.1	11258	45.3	5087	36.2	11	12.5	
45	103118	45.1	7501	50.3	9937	40.6	18	15.1	
50	102966	50.1	7488	55.3	10869	45.4	20	18.8	
55	102998	55.1	7475	60.3	11621	50.5	24	22.8	
60	102793	60.1	7301	65.1	10032	54.9	28	27.5	
65	102985	65.1	7218	69.9	12938	60.6	35	33.4	
70	102894	70.1	6817	74.4	14892	67.2	42	40.4	
75	101262	75.0	5838	78.3	14999	73.8	50	48.8	
80	103116	80.1	5488	81.2	14582	80.3	55	58.1	
85	103005	85.1	7458	86.9	13923	86.4	57	67.6	
90	102816	90.1	7215	91.7	12268	91.8	71	79.5	
95	101936	95.0	5053	95.0	9268	95.9	65	90.4	
100	102587	100.0	7428	100.0	9168	100.0	57	100.0	
TOTALS	2057891		150491		226368		596		

Figure 13 ABC Analysis Preliminary Analysis Table

Processing

The parameter record is read into store and the input magnetic tape file scanned to give the results required according to the parameter settings described above.

If the preliminary analysis table is required first (to provide a guide to the selection of the A and B limits) the program aggregates the sales, stock and marginal values in 5% increments and prints the preliminary analysis table. No output Profile Results file is produced with this table and the input file must be in descending sales value sequence.

If the ABC list and classification is required, the input Profile Results file must be in descending sequence of sales value, and the input parameters set to the appropriate values.

The program will classify each item, print the ABC Analysis list and summary and may produce an output Profile Results file for entry to the next routine, see Control System Selection.

The ABC Analysis Summary table is printed to give a summary of each of the classes A1, A2, A3, B1, etc; Sales Value, Stockholding, gross margins and item counts are accumulated for each class, including cumulative percentages.

Output

- 1 Profile Results magnetic tape file (format as Input (1)). This is optional, unless the next program is required (Control System Selection).
- 2 ABC Analysis list - optional
- 3 ABC Analysis Summary table (with list)
- 4 Preliminary Analysis table - optional

Each of the above reports is illustrated below:

Peripherals

- 1 card or paper tape reader
- 2 magnetic tape units
- 1 line printer

Source Language

1900 Compact COBOL

Objective

To provide Management with the facility to allocate automatically any one of four control systems to each item in the inventory.

Input

- 1 Stock Master magnetic tape file - see Section 5.5.2 in Item Number sequence.
- 2 Profile Results magnetic tape file - see Section 5.5.4 - in same sequence as (1).
(Output from the ABC Analysis routine and containing ABC classification in each item record.)
- 3 A punched card (or paper tape block) containing nine numbers selected to define with the control system marker allocated to the nine item classifications.

Note: The nine numbers may be selected from the list given below. The same control system may be applied to more than one classification.

0 = fixed re-order point, random ordering.

1 = variable re-order point, random ordering, using Box-Jenkins two-point predictor.

5 = fixed re-order point, cyclical ordering.

6 = variable re-order point, cyclical ordering, using Box-Jenkins two-point predictor.

See Chapter 4, Implementation, for suggested control system selection.

Processing

The Control System Selection parameter record is read into store, after which the Profile Result magnetic tape file is examined, record by record.

Each corresponding record on the Stock Master magnetic tape file is written to an output file to include the ABC classification and the corresponding selected system marker as determined by the input parameter card.

A printed list of each item giving the classifications etc., may be output if required.

Output

- 1 Stock Master magnetic tape file - format as Input (1) - containing ABC classifications and selected system markers.
- 2 Inventory list as illustrated below - optional.

Peripherals

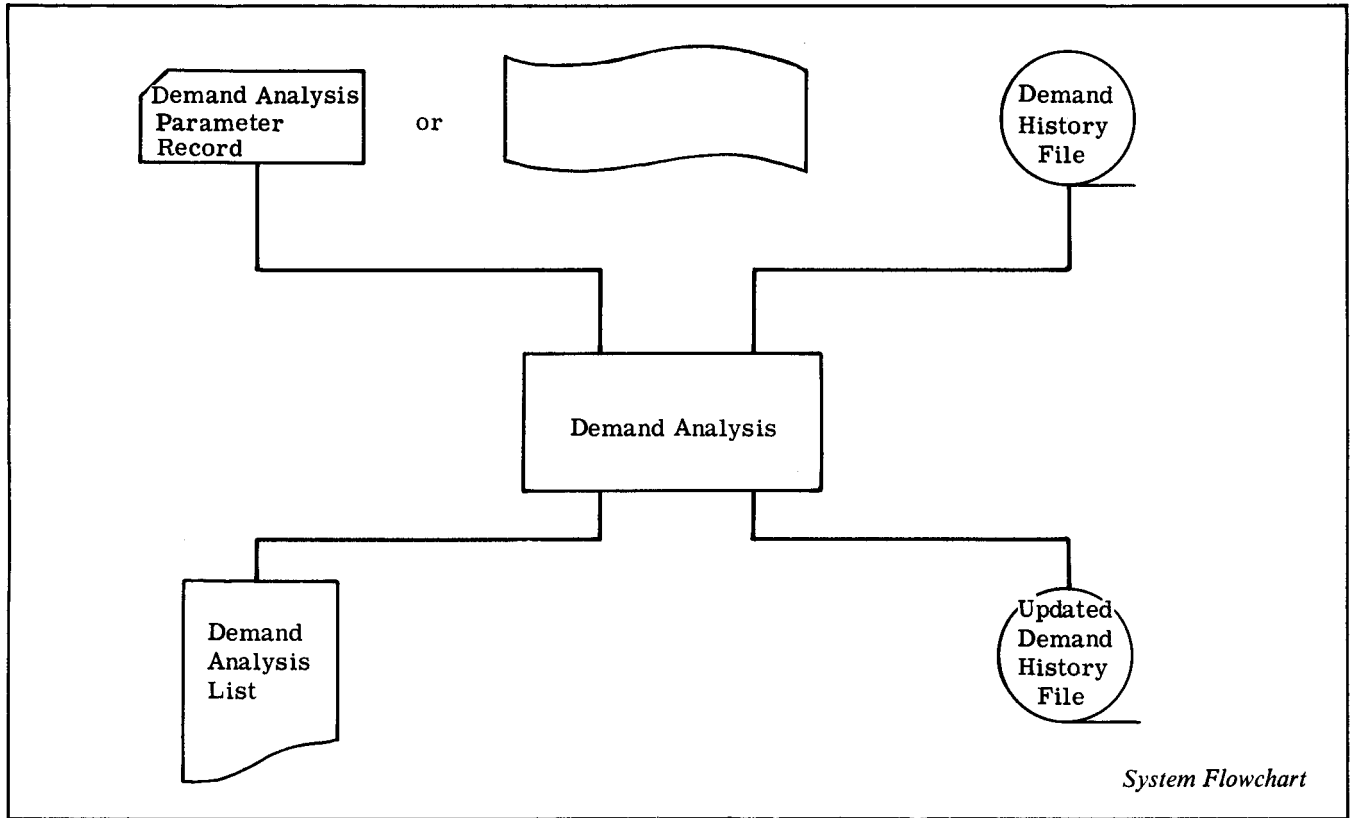
1 card or paper tape reader

3 magnetic tape units

1 line printer

Source Language

1900 Compact COBOL



Objective

To determine statistical demand characteristics, for each item selected for further analysis, providing that the system marker is 1 or 6.

Input

- 1 Demand History file. As defined in Section 5.5.1.

Note: A minimum of about 24 demand points is recommended for initial analysis. If seasonality is to be investigated, two years' data are required.

- 2 Demand Analysis Parameter record. This record contains the following options for the demand analysis:

Limit of forecast base or interval

Confidence limit for significance test

List format parameter

Processing parameter for the Optimal Prediction Parameter routine.

Limit of forecast base: The value of this parameter decides which items from the Demand History file will be processed in this routine, and can have the value 1, 2, 4, etc., to correspond with a forecast interval - see Section A.3.1.

Confidence limit for significance test: The value of this parameter will represent the upper level of confidence to be applied to the single tail normal distribution test (see Section A.3.4.).

List format parameter: If this parameter is set to '0' an abbreviated print format will be output on the printer. If set to '1', the full print format will be output (see Output, below).

Processing parameter for Optimal Prediction Parameter routine: If set to '0' only those items having either a cycle base or trend indicator determined from the Demand Analysis will have an indicator set in the output Demand History file.

If set to '1' all items with the required forecast base for processing through this routine will have an indicator set in the output Demand History file.

This indicator determines which items are processed in the Optimal Prediction Parameter routine.

Processing

For each item the following computations are performed:

- 1 Minimum forecast interval, (as in the Stock Profile Analysis).
- 2 The arithmetic mean of demand (\bar{y}).
- 3 Box-Jenkins proportional control parameter (γ_0) from an analytical formula (see Section A.3.2, equation 13) and selected to give minimum λ .
- 4 Lambda (λ) the ratio of error variance (associated with the selected value of γ_0) to the demand variance.
- 5 Serial correlation coefficients of demands with lags, 1, 2, 3 and yearly (for use in 3 above) and in the test for seasonality.
- 6 Significance factors derived from the single tail normal distribution test (see Section A.3.4) which determine if there is either seasonality or trend in the demand history.
- 7 The OPRR Inclusion Marker is set to '1' and the Cycle Base set equivalent to one year in the output Demand History file if:

the serial correlation coefficient for lag one year is ≥ 0.5 and is significant by test 6, or

the serial correlation coefficient for lag 1 is ≥ 0.5 and is significant AND $\lambda \leq 0.5$.

DEMAND ANALYSIS				DATE 01/07/67				PAGE 2				
ITEM NUMBER	MINIMUM FORECAST INTERVAL	DEMAND SERIES LENGTH	UNIT OF MEASURE	AVERAGE DEMAND	GAMMA ZERO	LAMDA	SERIAL CORR. COEFFICIENTS R1	RM	TAU 1	TAU M	CYCLE BASE	TREND IND.
12041	1	104	EACH	4.51	0.65	0.81	0.55	-0.03	5.62-0.98			*
12086	4	104	EACH	1.53	0.05	1.03	-0.01	0.24	0.03	1.18		
13150	1	104	EACH	985.18	0.85	0.28	0.84	0.86	8.68	6.08	52	
14921	2	104	EACH	3.11	1.00	0.30	0.84	0.84	6.30	5.77	26	
15006	4	104	EACH	1.53	0.05	1.00	0.16	0.89	1.02	4.61	13	
15008	1	104	DOZ	20.75	0.70	0.45	0.73	-0.50	7.91-6.14			*
15389	1	104	GRSS	115.22	0.05	1.01	0.06	-0.07	1.04-0.95			

Figure 15 Demand Analysis - Full Printer Output

DEMAND ANALYSIS				DATE 01/07/67				PAGE 2				
ITEM NUMBER	MINIMUM FORECAST INTERVAL	DEMAND SERIES LENGTH	UNIT OF MEASURE	AVERAGE DEMAND	GAMMA ZERO	CYCLE BASE	TREND INDICATOR					
12041	1	104	EACH	4.51	0.65		*					
12086	4	104	EACH	1.53	0.05							
13150	1	104	EACH	985.18	0.85	52						
14921	2	104	EACH	3.11	1.00	26						
15006	4	104	EACH	1.53	0.05	13						
15008	1	104	DOZ	20.75	0.70		*					
15389	1	104	GRSS	115.22	0.05							

Figure 16 Demand Analysis - Abridged Printer Output

The OPPR Inclusion Marker is set to '1' and the Cycle Base set to unity in the output Demand History file if the serial correlation coefficient for lag one year is non-significant AND:

the serial correlation coefficient for lag 1 is >0.5 , and is significant

AND $\gamma_0 \geq 0.3$, or

processing parameter for OPPR (see above) is set to '1' on input to this routine.

The first of these cases causes the trend indicator to be set.

The OPPR Inclusion Marker is set to '0' and the Cycle Base set to unity in all other cases.

Output

- 1 Demand History file. An updated Demand History file (format as Input (1)) containing, in addition to the updated fields, indicators set to determine which items will be processed in the Optimal Prediction Parameters routine.
- 2 Demand Analysis list. Either a full or abbreviated list format may be output on the printer by setting the appropriate parameter (see Figures 15 and 16).

Peripherals

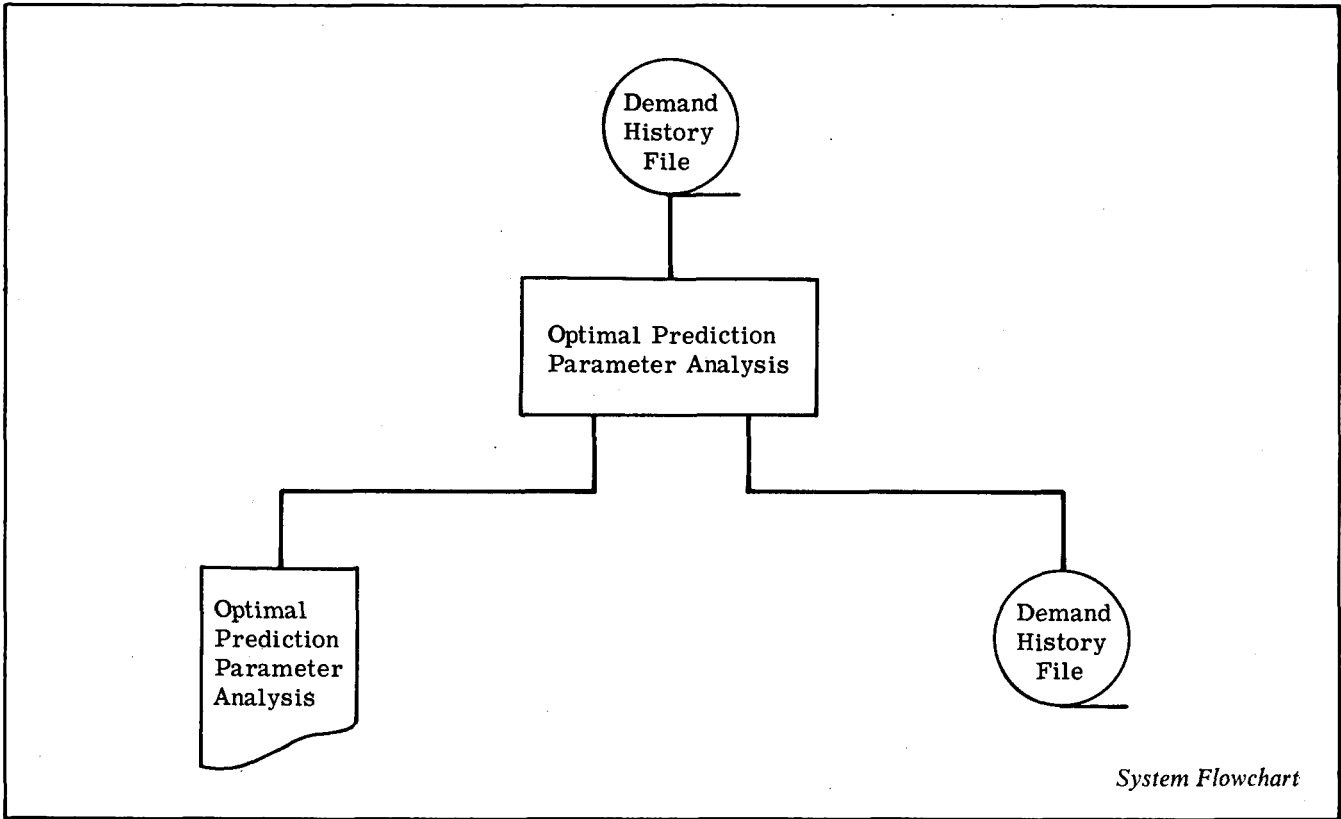
1 card or paper tape reader

2 magnetic tape units

1 line printer

Source Language

PLAN 3 and 1900 FORTRAN



Objectives

For items having system marker 1 or 6:

- 1 To calculate seasonal factors (where appropriate) to determine, for each selected item, the optimal pair of prediction parameters and to calculate for all items the values required by the System Performance Estimation routine (Section 3.5.6), and the initial (starting) values required by the Stock Forecasting and Monitoring routine (Section 3.6.6), or
- 2 To re-calculate seasonal factors (where appropriate) on a routine basis where revision of prediction parameters is not required.

Input

Demand History file (as defined in Section 5.5.1) previously output from last run of:

- 1 Demand Analysis routine (see Section 3.5.4) if Objective (1) required - indicated by Switch 23 OFF - or
- 2 Stock Forecasting and Monitoring routine (Section 3.6.6) if Objective (2) required - indicated by Switch 23 ON.

Processing

If switch 23 ON; compute, for each item with Cycle Base >1 the following:

- 1 Reduced demand series, e.g. if Forecast Interval were '4' each successive four demand points are summed such that a series with 104 demand points would be reduced to a series of 26 points.
- 2 A new set of seasonal factors using the partial sums method - see Appendix A, Section A.3.3.

If switch 23 OFF; compute, for each item with OPPR Inclusion Marker = 1, the following:

- 3 Reduced demand series, as Processing (1) above.
- 4 Seasonal factors as Processing (2) if cycle Base >1.
- 5 The sum of squares of prediction errors for successive pairs of prediction parameters (γ_0 and γ_1) in a progressive box search - see Notes below. Seasonal factors are applied if calculated in (4).

The pair of prediction parameters giving the smallest sum of squares of errors is chosen as optimal. If OPPR Inclusion Marker = 0, the value of γ_0 computed in the Demand Analysis routine is selected and γ_1 set to zero.

Compute the following for all items in the input file, using prediction parameters chosen in the manner described:

- 6 Standard deviation of errors (σ_e)
- 7 Mean error (\bar{e})
- 8 The ratio of error variance to demand variance: $\lambda = \sigma_e^2 / \sigma_y^2$
- 9 Final deseasonalized demand forecast (\hat{x}_T) which is used as initial forecast in Stock Forecasting and Monitoring routine.
- 10 Smoothed mean absolute deviation of errors (\hat{d}) and smoothed error (\hat{e}). These are calculated as

$$\hat{d} = \frac{\sigma_e}{1.25} \quad \hat{e} = \frac{\hat{d}}{2}$$

Notes

- 1 Unless it is required only to recompute seasonal factors (Objective 2), this program must be run in conjunction with, and after the Demand Analysis routine.
- 2 For each item to be treated as seasonal, a Cycle Base (>1) will always be recorded in the input item record, but note that items with less than two years demand history cannot be treated as seasonal in the analytical routines.
- 3 Non-seasonal items are output with a single seasonal factor of 1.00 in the magnetic tape file record.

OPTIMAL PREDICTION PARAMETER ANALYSIS						DATE 01/07/67				PAGE 5									
ITEM NUMBER	GAMMA ZERO	GAMMA ONE	SIGMA ERROR	LAMBDA	MEAN ERROR	CYCLICAL FACTORS													
						P	F	P	F	P	F	P	F	P	F				
12041	0.70	0.00	3.8	0.81	0.1														
13150	0.50	0.00	140.0	0.14	-21.9	1	1.15	2	1.17	3	1.31	4	1.31	5	1.44				
						6	1.44	7	1.56	8	1.56	9	1.68	10	2.00				
						11	1.93	12	1.92	13	1.77	14	1.63	15	1.61				
						16	1.60	17	1.60	18	1.62	19	1.64	20	2.10				
						21	1.82	22	2.17	23	2.10	24	1.87	25	2.46				
						26	1.96	27	2.59	28	1.75	29	1.80	30	2.15				
						31	1.92	32	1.96	33	1.91	34	2.67	35	3.05				
						36	2.66	37	2.57	38	3.36	39	3.40	40	3.56				
						41	3.73	42	3.61	43	3.52	44	3.52	45	3.36				
						46	3.35	47	3.13	48	3.13	49	2.90	50	1.15				
						51	1.00	52	1.00										

Figure 17 Optimal Prediction Parameter Analysis - Printer Output

- 4 The Cycle Base is always the number of forecast intervals in a year, e.g. a seasonal item with a forecast interval of '2' will have a cycle base of '26' if weekly data are recorded in the Demand History file and a cycle base of '6' if monthly data are recorded.

The search for optimal prediction parameters (Processing (5)) starts with γ_0 set to the value derived in the Demand Analysis routine, and γ_1 set to zero. The forecasting process is simulated over the reduced demand series - see Processing (3) - taking account of seasonal factors if cycle base > 1 . The sum of squares of forecast errors is computed.

This process is then repeated successively for the pairs of values $[\gamma_0, \gamma_1]$: $[(G_0 - 0.1), G_1]$, $[(G_0 - 0.1), (G_1 + 0.1)]$, $[G_0, (G_1 + 0.1)]$, $[(G_0 + 0.1), (G_1 + 0.1)]$, $[G_0 + 0.1, G_1]$, $[(G_0 + 0.1), (G_1 - 0.1)]$, $[G_0, (G_1 - 0.1)]$ and $[(G_0 - 0.1), (G_1 - 0.1)]$, with the restriction that γ_0 may not have a value outside the range 0.05 to 1.0 and γ_1 a value outside the range 0 to 1.0. G_0 and G_1 are the values of γ_0 and γ_1 respectively, used in the previous paragraph and are thus the co-ordinates of the centre of a 'box' of which the co-ordinates listed in this paragraph represent the mid-points of the sides and the corners, enumerated clockwise starting with the mid-point of the left-hand side.

The sum of squares of errors is computed for each of these pairs of values. If any is less than that computed for the centre of the box (G_0, G_1), the pair of values giving the lowest sum of squares of errors is selected as the centre of a new box and the process repeated, except that pairs of values used in the previous box are not used again. The search ends when the centre of the box gives the lowest sum of squares of errors and the corresponding values of γ_0 and γ_1 are selected as optimal.

Output

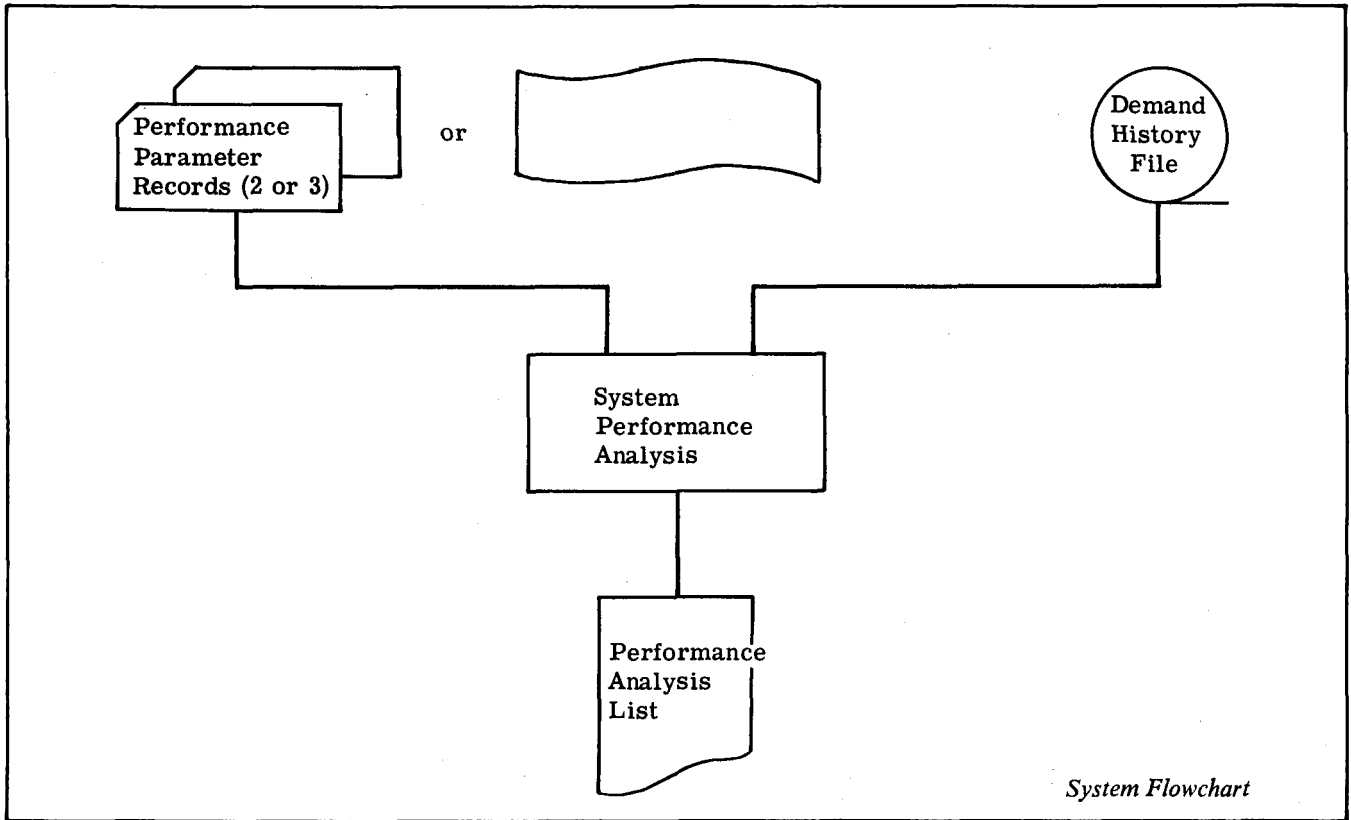
- 1 An updated Demand History file now containing revised seasonal factors if (Objective (2)); or the selected pair of prediction parameters (γ_0 and γ_1), seasonal factors where appropriate and the values computed in Processing 6 to 9 if (Objective (1)).
- 2 Optimal Prediction Parameter Analysis list (Objective (1) only) giving key information about each item for which the OPPR Inclusion Marker was set in the input Demand History file - see Figure 17. Items not so covered are omitted from the list.

Peripherals

- 2 magnetic tape units
- 1 line printer

Source Language

PLAN 3 and 1900 FORTRAN



SYSTEM PERFORMANCE ANALYSIS				DATE 01/07/67				PAGE 4		
ITEM NUMBER / DESCRIPTION	UNIT OF MEASURE	SERVICE LEVEL %	ORDER INT.	AVERAGE STOCK QUANTITIES			AVERAGE ORDER QUANTITIES	ECONOMIC ORDER QUANTITY	ORDERING COST \$	INV. RATE
				MINIMUM	AVERAGE	MAXIMUM				
12041 SPEEDOMETER UNIT	EACH	95.0	1	6	8	10	4	28	0.75	15.0
			2	10	15	9				
			3	12	19	13				
			4	15	24	18				
			5	19	33	27				
			6	20	34					
12086 REAR AXLE UNIT	EACH	95.0	1	3	4	4	0	9	0.75	15.0
			4	4	5	1				
			6	5	6	2				
			8	5	7	3				
			12	6	8	4				
				8	13					
13150 OIL FILTER	EACH	95.0	1	202	700	1187	985	1135	0.75	15.0
			2	770	1337					
			3	1187	2172	1970				
			4	1680	3158	2955				
			6	2172	4143	3940				
				3158	6113	5911				
14921 LIMITED SLIP DIFFERENTIAL UNIT	EACH	95.0	1	0	1	2	1	6	0.75	15.0
			2		2	4	3			
			3		3	5	4			
			4		4	7	6			
					4	7	6			
			6		5	10	9			

Figure 18 System Performance Analysis - Item List

Objective

To determine the expected performance of the adaptive control system from demand and prediction statistics derived in the preceding analysis routines and, in general, to act as a guide to Management for selection of an acceptable inventory policy.

Input

- 1 Demand History file. This file should have been processed and updated through at least two of the preceding analysis routines in order to obtain prediction and demand statistics for items selected for inclusion in an adaptive control system. Each item record may contain one of four Service Level Group codes, one of ten Investment Rate Group codes and an individual Order Cost. The last two apply only if Performance Parameter Record 3 is effective.
- 2 Performance Parameter records. Two or three cards or paper tape blocks are required as input.

Record 1 contains the following parameters:

Currency unit: (maximum four characters).

Ordering cost: expressed in the same units as sales and cost prices and indicated by currency unit. If set to '0', no economic re-order quantity calculations will be performed except under control of Record 3 - see below.

Investment rate selected (expressed as decimal fraction): this permits a blanket rate to be applied to the total inventory. It must be zero if Record 3 is to be effective.

Preferred ordering interval parameter: intended for use prior to the selection of individual item ordering intervals. In addition to the preferred interval, expected stockholding details for two ordering intervals above and below are printed.

List selection parameter: if set to '0' both the summary table and the list will be printed (see Figures 18 and 19) based on the selected order interval for each item. If set to '1', only the summary table (Figure 19) will be printed, based on the preferred order interval indicated on the parameter record (see above).

Limit of forecast base: the value of this parameter decides which items from the Demand History file will be processed in this routine, and can have the value 1, 2, 4, etc., to correspond with a forecast interval, e.g. a value of '4' excludes all items with a forecast interval greater than 4.

Record 2 contains four customer service levels chosen by Management and expressed as percentages, together with their associated factors (*K*) drawn from a normal distribution (see table, Appendix B).

The appropriate service level is selected by the service level group field in the Demand History file record.

Record 3 contains ten investment rates for the ten permitted Investment Rate Groups. It is read only if the Investment Rate in record 1 is zero. Individual order costs apply if a blanket ordering cost is not present on the first card.

Processing

ITEM LIST REQUIREMENTS (see Section A.8)

For each item selected for analysis compute:

- 1 Expected minimum, average and maximum stock levels for the ordering interval selected and at the selected customer service level (see Section A.4).
- 2 The average order quantity for the selected ordering interval.
- 3 The economic order quantity if desired (see Performance Parameter Records 1 and 3).

SUMMARY TABLE 1 REQUIREMENTS (see Section A.8)

- 1 Accumulate the following quantities within each selected customer service level group and the total for all items:

Number of items.

Safety stock value at cost, i.e. minimum expected stock.

SYSTEM PERFORMANCE SUMMARY TABLE 1		DATE 01/07/66				PAGE 8
SERVICE LEVEL GROUP		1	2	3	4	TOTAL
SERVICE LEVEL %		90.0	95.0	97.0	99.0	
NUMBER OF ITEMS IN GROUP		123.0	788.0	98.0	18.0	1027.0
SAFETY STOCK						
SAFETY STOCK AT COST	£	893.1	6967.2	685.5	139.1	8684.9
AVERAGE ANNUAL SALES AT COST	£	79188.3	653586.4	69527.2	15881.8	818183.7
SAFETY STOCK TURNOVER RATIO		88.7	93.8	101.4	114.2	94.2
TOTAL CURRENT STOCK HOLDING	£	3521.2	29388.0	2870.8	583.8	36363.8
AT MINIMUM STATISTICAL ORDERING INTERVAL						
TOTAL AVERAGE STOCK	£	1731.2	13413.0	1403.8	301.5	16849.5
TURNOVER RATIO		45.7	48.7	49.5	52.7	48.6
NUMBER OF ORDERS PER YEAR		5821.0	40001.0	4753.0	883.0	51458.0
AT PREFERRED ORDERING INTERVAL						
TOTAL AVERAGE STOCK	£	1931.2	15112.7	1576.3	301.5	18921.7
TURNOVER RATIO		41.0	43.2	44.1	52.7	43.2
NUMBER OF ORDERS PER YEAR		4691.0	31615.0	3853.0	883.0	41042.0
USING ECONOMIC REORDER QUANTITY FORMULA; BASED ON INVESTMENT RATE OF 20.0% AND ORDERING COST OF £ .20						
TOTAL AVERAGE STOCK	£	2932.8	22715.8	2687.9	487.3	28823.8
TURNOVER RATIO		27.0	28.8	25.9	32.6	28.4
NUMBER OF ORDERS PER YEAR		2040.0	15749.0	2002.0	348.0	20139.0
SUM OF ROOT (YBAR X COST PRICE)		2884.6	22272.1	2831.8	482.5	28481.0

Figure 19 System Performance Analysis - Summary Table 1

SYSTEM PERFORMANCE SUMMARY TABLE 2		DATE 01/07/7		PAGE 9
THE FOLLOWING TABLE SHOWS THE EFFECT ON TOTAL STOCK OF VARIOUS STOCKHOLDING COSTS, BASED ON AN ORDERING COST OF £ .20				
INVESTMENT RATE	TOTAL STOCK VALUE	£	ANNUAL NUMBER OF ORDERS	
5.0	48957.0		10071.0	
7.5	41552.0		12332.0	
10.0	37525.9		14241.0	
12.5	34158.3		15921.0	
15.0	31939.6		17442.0	
17.5	30213.7		18840.0	
20.0	28823.8		20139.0	
22.5	27576.3		21361.0	
25.0	26699.1		22517.0	
END OF RUN				

Figure 20 System Performance Analysis - Summary Table 2

Average annual turnover value at cost.

Total current stock holding value at cost.

- 2 Depending upon the value of the List Selection parameter (Performance Parameter record 1 above) accumulate:

Total average stock value.

Number of orders per year within the selected customer service levels, and summarize under the following headings:

Minimum statistical ordering interval i.e. basic time period chosen - week, month etc.

Preferred order interval chosen from either the input record or parameter record according to the List Selection parameter setting.

Economic re-order quantity using a selected investment rate and ordering cost.

- 3 Calculate the stock turnover ratio for each service level group and the total stock for each of the summary tables above.
- 4 For the economic re-order quantity summary calculate the quantity $\sqrt{Y C_p}$ for each item and accumulate for each service level group and the total stock. This is omitted if more than one Investment Rate is applicable. Refer to equations (45) and (48), Section A.8.

SUMMARY TABLE 2 REQUIREMENTS

- 1 Compute the total stockholding value which would result from each of a range of investment rates commencing at 5%, incremented by $2\frac{1}{2}\%$ to a maximum of 25%, based on the ordering cost specified and using the economic re-order quantity formula. (See Section A.8, equation 45.)
- 2 Calculate the number of orders required for each of the values in 1 above. (See Section A.8, equation 48.)

Summary Table 2 calculations are omitted if more than one Investment Rate is applicable

Output

Item list and two summary tables - see Figures 18 to 20.

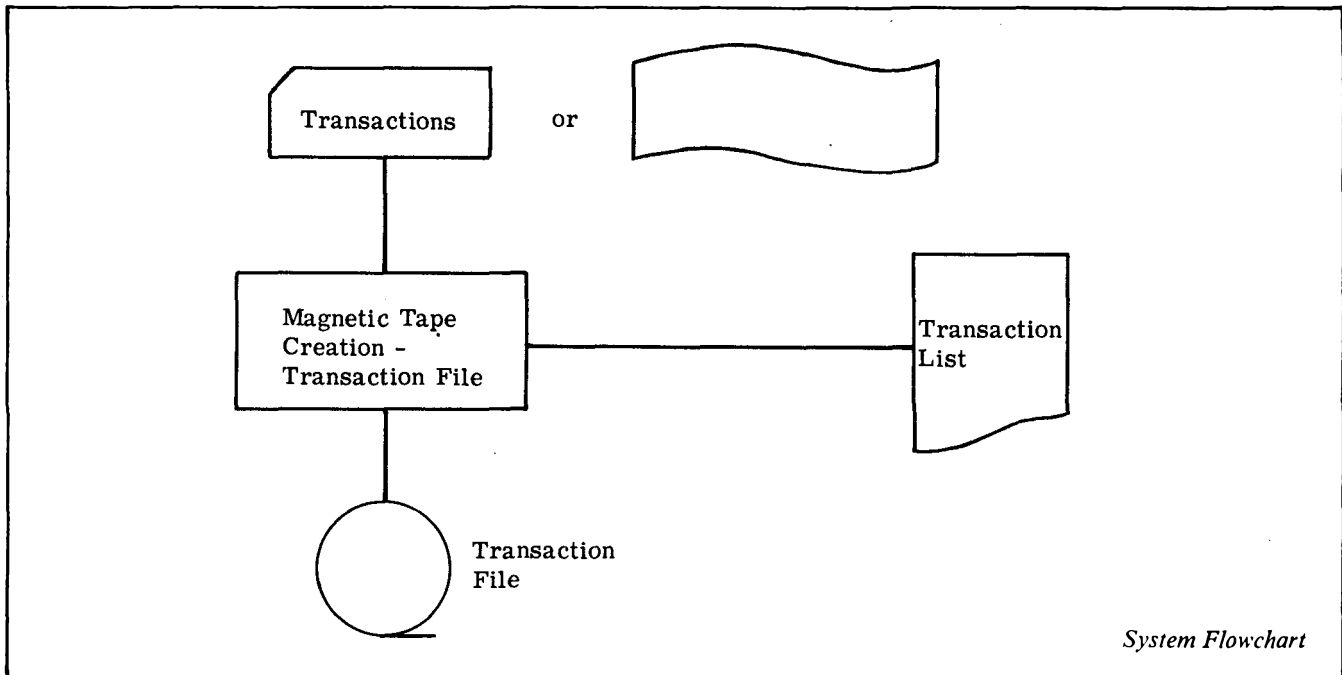
The item list and summary tables may be selected or omitted by appropriate parameter settings (see Input Performance Parameter Record 1). Summary Table 2 is omitted if more than one Investment Rate is used.

Peripherals

- 1 card or paper tape reader
- 1 magnetic tape unit
- 1 line printer

Source Language

PLAN 3 and 1900 FORTRAN



STORES TRANSACTIONS LIST										DATE: 28/02/67	PAGE 1
TRANS TYPE	LOC CODE	LEDGER A/C NO.	INT. ORDER REFERENCE	DATE	ITEM NO.	U.O.M.	QUANTITY-1	QUANTITY-2	SECOND DOC. REF	DUE DATE	PRIORITY
11	15		A1311	280267	0111	EACH	963				
12	15		C921	280267	0111	EACH	17		87		
13	15	2376	16098	270267	0111	EACH	798	18	87		
17	15	A731	15937	270267	0111	EACH	17	17	11839		
21	15	A831		280267	0111	EACH	83		19327	170467	01
21	15	A785		280267	0111	EACH	37		1A732	120467	01
21	15	A797		280267	0111	EACH	42		83112	150367	02
21	15	A731		280267	0585	EACH	25		18721	120367	01
21	15	A831		280267	0586	EACH	13		19211	120367	03
19	15	A732	18576	260267	0731	EACH	50				
15	15	A731	B7218	280267	0112	EACH	17		93		
14	15	A932	18736	280267	0112	EACH	15		G7318		
20	15	A797		270267	0738	EACH	25		2A837	120367	01
21	15	A831		280267	0111	EACH	10		19732	180367	01
12	15		C936	280267	0591	EACH	8		88		
11	15		A1312	280267	0631	EACH	1027				
13	15	2478	16095	270267	0112	EACH	256		85		
13	15	2581	16003	270267	0136	EACH	523		85		
17	15	A831	16021	280267	0111	EACH	5		11837		
21	15	A731		280267	0287	EACH	215		29871	070367	02
					314	19	4087	35			
99			956	010367	334	20	4112	35			
21	16	A931		280267	0110	EACH	36		18732	100367	01
.
.
.
END OF RUN					317 TRANSACTIONS						

Figure 21 Transaction File Creation - Transaction List

OPERATIONAL ROUTINES

3.6

Magnetic Tape Creation Routine - Transaction File

3.6.1

Objective

To create a magnetic tape file of stores transactions.

Input

One or more batches of transactions (punched on either cards or paper tape) separated by batch control total records if desired.

Note: Subsequent programs in I.C.T. SCAN System 1 process the following types of transactions:

- Audit requests
- Stock adjustments
- Stock receipt and scrap
- Returns outwards
- Unscheduled issues
- Returns inwards
- Replenishment order balance adjustments
- Demands

Refer to: Chapter 2, Section 2.2.3 for a description of these transactions,
Chapter 5, Section 5.3 - for the record formats.

Processing

Each transaction record is written to an output magnetic tape file after performing validity checks on the type of field content. At the same time a listing of each transaction is printed.

No transactions with an invalid transaction code will be accepted.

Batch control records, if present, will cause accumulated totals of the transaction codes and quantity fields to be printed, as well as the contents of the batch control record, before resuming the transaction listing.

Note: It is not necessary to sort transactions prior to processing; once the magnetic tape file has been created, standard I.C.T. Sort software may be used.

Output

- 1 Transactions magnetic tape file - see Section 5.5.3
- 2 Transaction List - see Figure 21.

Peripherals

- 1 card or paper tape reader
- 1 magnetic tape unit
- 1 line printer

Source Language

PLAN 3

Notes

- 1 Provision has been made within this program for a user to insert his own CHECKDIGIT subroutine for item numbers.
- 2 The presence of an asterisk on the list indicates an error in the transaction record. This record is not written to the output magnetic tape.

Sort

The Transactions magnetic tape file output from the previous program may be in any sequence.

Standard I.C.T. Sort software may be used to sort the file according to the preferred sequence.

Provision has been made to allocate a priority code to each demand. This allows important demands to receive priority allocation, especially useful if the stock is limited. The highest assignable priority is 99: the minimum is zero. Priority codes may be allocated only to Demand Transactions.

Due date may be used also to assign priority allocation.

If due date overrides priority code (i.e. priority codes choose only between demands due on the same day) the Transaction file will be sorted to:

Item number/Transaction code/Due date/Priority,

where the first key is the most significant. Overdue demands (back-orders) will then take precedence over Priority code.

If priority is to override the due date, even if the item is overdue and has already been back-ordered, both the Transaction file and Recirculating file (see next program) must be sorted to:

Item number/Priority code/Transaction code/Due date.

If priority code is not used, it will be necessary only to sort the Transaction file by

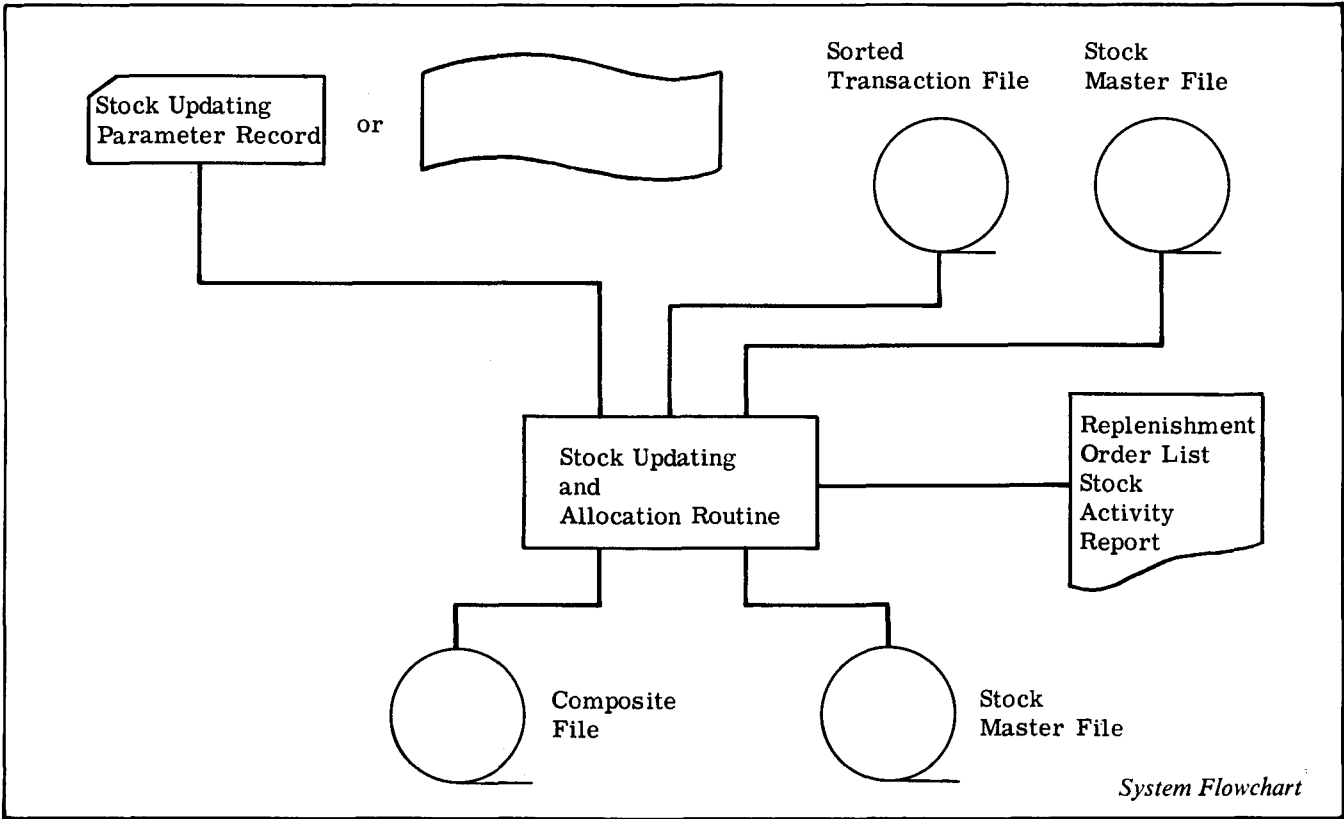
Item number/Transaction code/Due date.

All the above keys are ascending sequences except priority code which is descending sequence.

Merge

The sorted Transaction file may have to be merged with a recirculating Composite file (in the same record format). Standard I.C.T. Merge software may be used, and care must be taken that both files are in the same sequence as the required merge keys.

The magnetic tape file output from the 'Merge' will contain stock transactions in a sequence suitable for processing in the next program; see Stock Updating and Allocation Routine.



Objectives

- 1 To update the stock position and maintain stock balance records.
- 2 To allocate physical stock to each demand in an agreed priority sequence
- 3 To issue a report of all stock items requiring replenishment.
- 4 To provide a link to other commercial system areas.
- 5 To provide the facility for a continuous stock audit on selected items.
- 6 To apply re-order point control to all stock items.
- 7 To provide control information on an exceptions basis.

Input

- 1 Stock Master magnetic tape file - see Section 5.5.2.
- 2 Transactions magnetic tape file - see Section 5.5.3.
- 3 Parameter record (punched card or paper tape) - see Section 5.6.14.

Processing

Items are processed serially in ascending sequence of item reference number. One, or more, transactions may be in various sequences within each item number.

The normal sequence is (the first key is the most significant):

- Item number (ascending)
 - Transaction code (ascending)
 - Due date (ascending)
 - Priority (descending)
- but see Section 3.6.2 for other possible sequences.

Unmatched records in the Stock Master are written to the updated Stock Master file unchanged.

Unmatched records on the Transaction file are notified by error message.

For each item the processing is as follows:

- 1 AN AUDIT REQUEST, Transaction Code '11', if present, is processed first. This will generate an output record on the Composite magnetic tape file, containing the 'counted' stock balance (if present in the input record) together with the file record on-hand opening stock balance. The priority code field is changed to '300' upon output.

Subsequent transactions affecting the stock-on-hand balance for this item will be output with a priority code equal to '200' provided that the audit request is present. If an audit request is input with a priority code of '300', no further action is taken, except to write the record directly to output. However, all new transactions for that item will be processed and then output with a priority code equal to '200'. Resubmitted Audit Transaction records (priority code '250') are copied through to the output Composite file.

A later user routine must extract all such audit records and associated transactions from the Composite file for reconciliation by the Stores Auditor. If the user fails to extract such records the recirculating Composite file will continue to collect transaction records affecting the item.

- 2 The following transactions, if present, will be processed next; but see reference to priority codes below:

Stock adjustment: (Code 12) - this will alter the stock-on-hand balance.

Stock receipt and scrap: (Code 13) - the quantity good will be added to the stock-on-hand balance and to the cumulative receipts balance and deducted from the stock-on-order balance. Scrap will be deducted from the stock-on-order balance and added to the scrap accumulator. A unit is added to the receipts count for each receipts transaction.

Returns outward: (Code 14) - this is processed as though it was a negative receipt, except that the receipts count is not adjusted.

Unscheduled issues: (Code 15) - this is deducted from the stock-on-hand balance and added to both the period demand accumulator and the cumulative demand to date.

Returns inwards: (Code 17) - this is processed as though it was a negative issue (see Section 4.4.2.).

Replenishment order adjustment: (Code 19) - this simply adjusts the stock-on-order balance.

After the above transactions have all been processed the stock is ready for allocation, if required.

All of the above transactions, with the exception of transaction code 19, are output to the composite file with certain data added from the Stock Master file record and with the priority code set to '150' except where an audit request is present, in which case the priority code is set to '200'.

Note: Certain Transaction records are expected to be recirculated back to the Stock Updating routine and these are merged with the new Transaction file before it is presented to the next updating run. The system is able to recognize these recirculated records as such. However, other types of output Transaction records should never be re-presented to the Stock Updating routine. Normally, these are removed by subsequent of the SCAN system programs, but if inadvertently this were not done they would be re-submitted to the Stock Updating routine. To avoid errors that would otherwise result, the priority codes of these records are set to either 150 or 200 (depending on the circumstances) when they are first output from the Stock Updating routine. If they are subsequently re-submitted to this routine they are copied through to the output Composite file, but no other action is taken with them.

- 3 Allocation of stock against demand is on a 'first come, first served' basis in the Stock Updating routine, the correct sequence of presentation of the demands having already been secured - see Section 3.6.2. The process of allocation reduces the stock balance and, therefore, employs a system of pre-posting of issues. Where post-posting is required of some, or all issues *Unscheduled Issues* (Transaction Code 15 - see paragraph (2) above) are used. These are posted to the stock records before allocation against demand is attempted.

The user may permit part-shipments, in which case the physical stock is allocated to each demand in turn until the stock is exhausted. The balance of the demands which cannot be satisfied is back-ordered. However, if part-shipments are not allowed, an allocation will be made only if there is enough stock to cover the full demand: either the demand for that item on the one customer order is satisfied in full, or the full amount is back-ordered.

This choice is fixed for the run and is expressed by input parameter.

At the first attempt to allocate stock to a new demand, an *Allocated Demand Transaction* record (Transaction Code 18) is always output to show the quantity allocated (which may be zero) and the quantity to follow. If this latter quantity is non-zero, a *Back-order Transaction* record (Transaction Code 20) is also output.

When this back-order (it retains its original priority code) is re-presented to the Stock Updating routine, an *Allocated Demand Transaction* record is output only if at least some stock can be allocated. Meanwhile, it continues to circulate back to this routine.

When demand is back-ordered the *Back-order Balance* is incremented accordingly; when a back-order is satisfied, the amount allocated is deducted from this balance.

Future demands (i.e. advance warning of demand) may be admitted to the system. If the due date is more than a lead time away, the Transaction record will merely be copied to the output Composite file without any other action.

If or when the due date comes within a lead time, the demand quantity is added to the *Forward Demand Balance* and this fact noted by duplication of the quantity required in both quantity fields of the output Transaction record.

The user has the facility of specifying (by input parameter) a future date which is the expected issued, or despatch date for to-day's allocations. This allows for the situation where it takes several days to deal with the orders once they have passed through the SCAN system, e.g. central processing for remote warehouses or use of the system for manufacturing order control when it is necessary to test availability of stock by allocation a few days ahead of requirement date.

If or when the demand due date is equal to or earlier than this allocation date, allocation of stock is attempted in the manner already described. If the demand were previously a forward demand, as indicated by a non-zero second quantity field in the record, this quantity is deducted from the Forward Demand Balance. The demand now generates an Allocated Demand record, and a Back-order record if there is insufficient stock to cover the full amount.

The Period Demand Accumulator is updated the first time the demand is inspected with a due date not more than a lead time away. In this way the forward demand is allowed to influence forecasting at the earliest reasonable date. When allocation of part or all of the demand occurs, the full demand is added to Cumulative demand to date.

When Allocated Demand Transaction records are created by the Stock Updating routine they are all given a priority code of 150 or 200, irrespective of the priority allocated to the original demand. The reasons for this have already been explained in the note to paragraph (2) above.

4 After updating and allocating stock the following control action is performed:

- (a) If either stock on hand or stock on order is negative, an error report is printed and the field is zeroized. These conditions should be investigated by the user as they may indicate submission of an invalid transaction.
- (b) For randomly ordered items the re-order point or level is compared with the available stock (i.e. sum of stock on hand, plus stock on order, less back orders) and, if the re-order point is lower, no action is taken. Otherwise, a replenishment order record is written to the output composite file and details printed on the replenishment order list.

Note: the normal replenishment order quantity is the system re-order quantity plus the re-order point less the available stock, increased by the scrap factor percentage - see Section A.2.3, Appendix A.

A switch within the program (see parameter record) will allow ordering for those items selected for cyclical ordering, only during the time the switch is set. If the switch is set, for those items having an order interval count of zero an order is calculated which is equal to the reorder point minus the available stock. The order interval count is then set to minus one to inhibit further small orders in the same system time period. If the available stock is greater than the reorder point, no order is calculated but the Count field is still set to minus one since sufficient available stock exists to last until the end of the next order interval. Items selected for random ordering are not affected by this switch.

- (c) The computed re-order quantity is then compared with the minimum order quantity and, if less, the minimum order quantity is output. Otherwise, if the minimum order quantity is not unity (a zero minimum is assumed to mean unity) the computed order quantity is increased to an integer multiple of the former. The new order quantity is then compared with the maximum order quantity and, if greater, is reduced to the latter. The excess quantity is noted on the replenishment order list as well as the amount actually ordered. The stock on order balance is increased by the order quantity finally output, but not the excess.
- (d) Stock on hand less back-orders is then compared with the minimum stock level. If the former is greater than the latter no action is taken; otherwise, an Under Minimum record is output to the Composite file. This will always include shortages. An Under Minimum record is also output if the Available Stock (on-hand plus on-order minus back-orders) does not exceed the Forward Demand Balance, unless this balance is zero.
- (e) If stock on hand is greater than the maximum stock level, an Over Maximum record is output to the Composite file.

After all items have been processed a stock activity report is printed giving details of opening and closing balances and transactions within the headings, demands, new orders, receipts and scrap.

Notes

- 1 Re-order point, or level, is the expected demand over the next replenishment delivery time (lead time) plus safety stock.
- 2 Re-order quantity is the expected demand over the subsequent replenishment order interval plus the re-order point less available stock.

REPLENISHMENT ORDER LIST										DATE 01/07/67		PAGE 1		
ITEM NUMBER/ DESCRIPTION	CC	LC	S M	UOM	FORWARD DEMAND	STOCK ON ORDER	STOCK ON HAND	BACK ORDERED	REORDER POINT	ORDER QUANTITY	LOAD INDEX	LEAD TIME	SUPPLIER CODE	
CHARAPYNE	A001	B1	01	1	CASE	10	68	482	0	642	492	2952.00	1.0	20064
LASSIE LARGE	A006	A1	01	1	CASE	0	15	132	0	228	201	1005.00	1.0	19588
TRILL BUDGIE SEED SMALL	A013	A1	01	1	CASE	0	11	168	0	193	158	711.00	1.0	18732
PAL MEAT LARGE	A019	A1	01	1	CASE	0	23	113	0	198	163	2037.50	1.0	19721
STEWED STEAK IRISH 15 1/2 OZS	A028	A1	01	1	CASE	46	38	372	0	481	125	2062.50	4.0	20122
CREAM STERILISED NESTLES 4 OZS	A035	A1	01	1	CASE	12	71	128	0	228	139	1772.25	1.0	18655
SHAPES SPILLERS SMALL	A048	A1	01	1	CASE	0	85	228	0	399	163	2200.50	2.0	19633
.
.
.

Figure 22 Stock Updating and Allocation - Replenishment Order List

STOCK ACTIVITY REPORT (BY VALUE)				DATE 01/07/67	
	TOTAL	STOCK ON HAND	STOCK ON ORDER	UNALLOCATED DEMAND	
OPENING BALANCES		125281	9278	85	
ADJUSTMENTS		32	85		
RECEIPTS	8871	8802	8871	69	
NEW DEMAND	12382	12382		0	
NEW ORDERS	6237		6237		
SCRAP	0		0		
CLOSING BALANCES		121733	6729	16	
END OF RUN					

Figure 23 Stock Updating and Allocation - Stock Activity Summary

Output

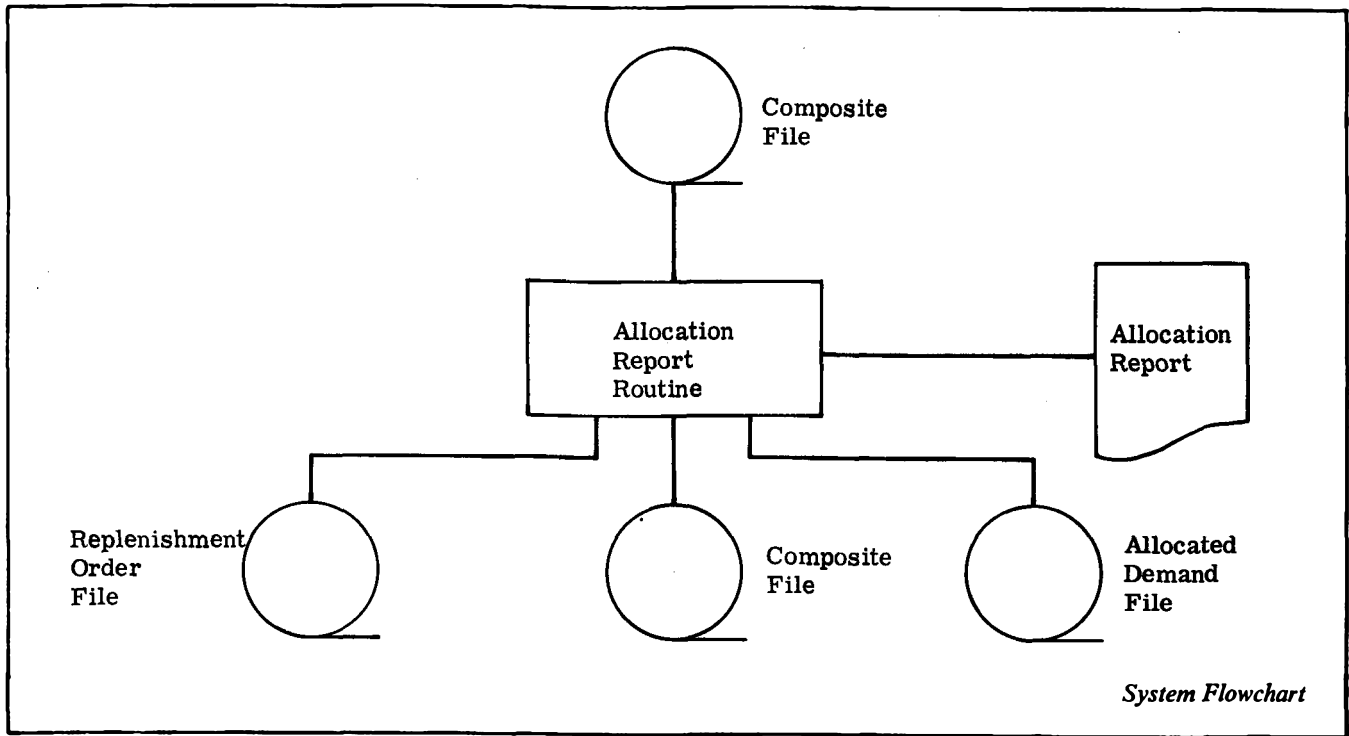
- 1 Updated Stock Master magnetic tape file
- 2 Composite magnetic tape file - see Section 5.5.5., containing the following types of records
 - Audit requests
 - Stock adjustments
 - Stock receipts
 - Returns outwards
 - Unscheduled issues
 - Returns inwards
 - Backorders
 - Allocated demands
 - Replenishment orders
 - Demands
 - Under minimum records
 - Over maximum records
- 3 Replenishment Order List - see Figure 22.
- 4 Stock Activity Summary - see Figure 23.

Peripherals

- 1 card or paper tape reader
- 4 magnetic tape units
- 1 line printer

Source Language

PLAN 3



ALLOCATION REPORT						DATE 01/07/67	PAGE 1				
ITEM NO	CLASS	LOC CODE	SYST MARK	UOM	DESCRIPTION	BACK ORDERED	ALLOC DEMAND	ORDER NO	DUE DATE	CUSTOMER CODE	
A001	B1	01	1	CASE	CHARAPYNE		15	2789	04/07/67	87	
A001	B1	01	1	CASE	CHARAPYNE		27	A371	04/07/67	23	
A001	B1	01	1	CASE	CHARAPYNE		72	93182	07/07/67	59	
							114				
A002	B1	01	1	CASE	SODA THAWPIT		28	5721	04/07/67	25	
A002	B1	01	1	CASE	SODA THAWPIT		35	A371	04/07/67	23	
A002	B1	01	1	CASE	SODA THAWPIT		15	9978	06/07/67	81	
A002	B1	01	1	CASE	SODA THAWPIT		69	1281	07/07/67	59	
							147				
A003	A1	01	1*	CASE	LEMON DRINK SUMMER GOLD		21	A371	04/07/67	23	
							21				
A004	A1	01	1*	CASE	ORANGE DRINK SUMMER GOLD		87	A371	04/07/67	23	
A004	A1	01	1*	CASE	ORANGE DRINK SUMMER GOLD		39	87132	06/07/67	61	
A004	A1	01	1*	CASE	ORANGE DRINK SUMMER GOLD		18	2789	07/07/67	87	
							144				
.	
.	
B008	A1	01	1	CASE	CHOC DROPS FOR DOGS		32	1681	04/07/67	31	
B008	A1	01	1	CASE	CHOC DROPS FOR DOGS		76	9721	04/07/67	33	
B008	A1	01	1	CASE	CHOC DROPS FOR DOGS	27	5	A371	04/07/67	23	
B008	A1	01	1	CASE	CHOC DROPS FOR DOGS	35		8218	05/07/67	58	
							62	113			
.	
.	
END OF ALLOCATION REPORT. NUMBER OF BACKORDERS						8.	NUMBER OF ALLOC. DEMANDS		153.	NUMBER OF ITEM NOS. 51.	

An asterisk next to the system marker denotes a seasonal item (see Section 5.5.3.).

Figure 24 Allocation Report

Objectives

- 1 To print a list of all demands allocated and unallocated during the previous Stock Updating and Allocation program.
- 2 To provide an entry point to invoicing/credit note procedures.
- 3 To provide an entry point to purchase order control procedures.

Input

Composite magnetic tape file - see Section 5.5.5., output from Stock Updating and Allocation routine.

Processing

The Composite magnetic tape file is scanned and all Replenishment Order records (Transaction Code 23) are written to an output Replenishment Orders magnetic tape file.

Similarly, all Allocated Demand records (giving details of both allocated and unallocated demands) are both printed and written to an Allocated Demands magnetic tape file (Transaction Code '18'). All Unscheduled Issues (Code 15) and Returns Inwards (Code 17) are written to the same output Allocated Demands file for use in user's invoicing procedures.

Exceptions to this are:

- 1 Where the incoming records have a priority code of '250'. No action is taken except to write the records to the output composite magnetic tape file.
- 2 Where the incoming records have a priority code of '200' (denoting new records with an Audit Request present). In this case the records are processed as above and, in addition, identical records are written to the Composite tape file. All other records with transaction codes other than 15, 17, 18, 23 are written directly to the output Composite magnetic tape file.

Output

- 1 Composite magnetic tape file (format as input file) excluding:
 - replenishment orders (Code 23),
 - allocated demands (Code 18),
 - returns inwards (Code 17), and
 - unscheduled issues (Code 15)(see Processing, paragraphs (1) and (2).
- 2 Allocated Demands magnetic tape file - see Section 5.5.5., containing:
 - Allocated Demands (Code 18),
 - Returns Inwards (Code 17), and
 - Unscheduled Issues (Code 15).
- 3 Replenishment Orders magnetic tape file - see Section 5.5.3.
- 4 Allocation Report - see Figure 24.

Peripherals

- 4 magnetic tapes
- 1 line printer

Source Language

1900 Compact COBOL

Objectives

- 1 To print a report of all items whose physical stock less back-orders is equal to or less than a preset Minimum Stock level, or whose Available Stock is equal to or less than the Forward Demand Balance.
- 2 To print a report of all items whose physical stock is greater than a preset maximum stock level.
- 3 To provide entry points to Costing and Purchase Invoice Control routines.

Input

- 1 Composite magnetic tape file - see Section 5.5.5 (output from previous program - Allocation Report routine).
- 2 Over Maximum magnetic tape file (produced by first run of this routine).

Processing

The Composite file is scanned and all 'Over Maximum' records (Code 25) are written to an output Over Maximum magnetic tape. Similarly all Receipts (Code 13), Stock Adjustments (Code 12) and Returns Outwards (Code 14) are written to a Priced Receipts magnetic tape as an entry point to costing and invoice checking procedures.

Under minimum stock level records are printed (Code 24).

If input records with a priority code of '250' are detected, they are written to the output Composite magnetic tape file, unprocessed.

In the case of records written to the Priced Receipts tape, if they have a priority code of '200', identical records are written to the output Composite tape but with the priority code changed to '250'.

Other records with a priority code of '200' are written to the output Composite tape with the priority code changed to '250'.

All input records with the exception of Transaction Codes 24, 25, 12, 13, 14 are written directly to the output Composite tape.

After processing the input Composite file, the magnetic tape containing the Over Maximum Stock Level items is rewound and a list printed giving details of each record.

Output

- 1 Over Maximum Stock Level items magnetic tape file - see Section 5.5.5.
- 2 Priced Receipts magnetic tape file - see Section 5.5.5.
- 3 Composite file magnetic tape (format as Input (1)) excluding:
 - Receipts (Code 13),
 - Stock Adjustments (Code 12),
 - Returns Outwards (Code 14),
 - Under Minimum records (Code 24),
 - Over Maximum records (Code 25).
- 4 Under Minimum Stock Level Report - see Figure 25.
- 5 Over Maximum Stock Level Report - see Figure 26.

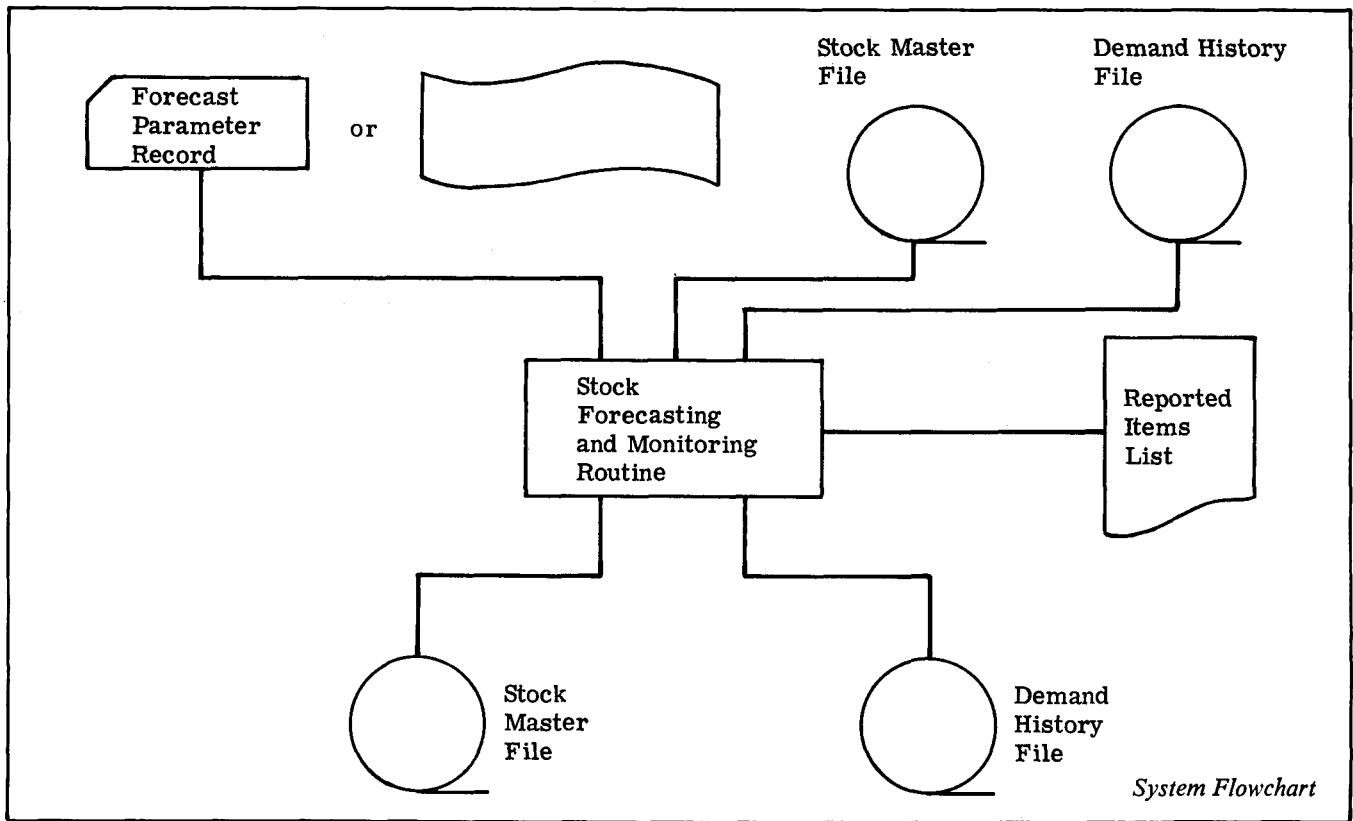
Peripherals

4 magnetic tape units

1 line printer

Source Language

1900 Compact COBOL



REPORTED ITEMS LIST		DATE 01/07/67				PAGE 1	
ITEM NUMBER	DESCRIPTION	STOCK ON HAND	STOCK ON ORDER	DEMAND LAST PERIOD	FORECAST LAST PERIOD	FORECAST INTERVAL	SYSTEM MARKER
A007	LASSIE SMALL	408	15	381	128	1	1
A011	SWOOP WILD BIRD FOOD	159	97	126	69	2	1
A018	KIT-E-KAT HANDY	188	45	187	45	1	1
B008	CHOC DROPS FOR DOGS	0	327	178	108	1	1
C001	NESCAFE 4 OZS JAR	101	49	120	83	1	1
D002	NESQUICK STRAWBERRY 8 OZS	587	87	382	148	1	1
D801	TIDYSAN 13 X 10	758	58	487	351	1	1
.
.

END OF RUN

Figure 27 Stock Forecasting and Monitoring - Reported Items List

Objectives

- 1 To estimate future demands for selected items by adaptive forecasting techniques.
- 2 To recalculate the re-order point and re-order quantities for these items.
- 3 To monitor the system performance and provide control information on an exceptions basis.
- 4 To update demand history and system counts.

Input

- 1 Demand History magnetic tape file - see Section 5.5.1., containing all necessary fields to produce period ahead demand forecasts.
- 2 Stock Master magnetic tape file - see Section 5.5.2., containing updated stock positions and period demand data from previous stock Updating and Allocation runs.
- 3 Forecast parameter record - see Section 5.6.15.

The following Management parameters are held in this record:

- (a) *Four customer service levels:* chosen by Management (expressed as percentages) and their associated factors (*K*) (see Appendix B). The appropriate service level factor is selected from the service level group field in the Demand History file item record.
- (b) *Ordering cost selected.*
- (c) *Investment rate:* (expressed as a percentage) selected.
- (d) *The investment rate:* (as (c)) for each of ten investment rate groups - any one of which is held in the Demand History file item record.
- (e) *Cumulative control parameter:* (γ_1) to be used for any item in the control system as an emergency measure when loss of prediction optimality is detected by the Tracking Signal.

Note: Parameters (b) and (c) are used as 'blanket' values in the formula for economic order quantities (see Section A.7 equation 34). If (c) is set to zero parameter (d) is used provided that the ordering cost field in the item record is not zero, otherwise no economic order is computed for that item. If the parameter (c) is non-zero, parameter (d) is not necessary and the third card or paper tape block (see Section 5.6.15) is omitted.

Processing

Unmatched item records on the input Stock Master file are written directly to an output Stock Master file.

Unmatched item records on the input Demand History file are notified by error message and written directly to an output Demand History file.

For all matched item records processing depends upon the control system marker present in each record as follows:

System Marker value '0': This means fixed re-order point control with random ordering. The only processing performed is to place the period demand from the input Stock Master file item record in the demand history array held on the output Demand History file - item record and update the series length, closing stock and non-move count.

System Marker value '1': This means adaptive control with random ordering and using the two-point Box-Jenkins prediction technique - see Section A.3.2.

- 1 All system control counts are updated, e.g.

Forecast interval count	}	increased by 'one'
Cycle base count		
Non-move count		

- 2 The demand array length (series length) is updated and the latest demand placed in its correct position in the demand array.
- 3 The closing stock-on-hand is transferred from the input Stock Master to the output Demand History item record.

If the forecast interval equals the forecast interval count, reset it to zero and compute:

- 4 Smoothed forecast error (equation 28, Section A.6).
- 5 Smoothed mean absolute deviation of errors (equation 29, Section A.6).
- 6 The tracking signal and compare it against statistical limits (see Section A.6).
If the limit is exceeded, details are printed in the Reported Item list and the cumulative control parameter (γ_1) from parameter card is brought into use if normal $\gamma_1 = 0$.
- 7 The next period's forecast of demand (see equation 7, Section A.3.3).
- 8 The new re-order point, using the input parameter customer service level appropriate to the item (see equation 27, Section A.5). In this calculation the decimal parts of reorder point and reorder quantity are rounded up to the next integer.

- 9 Input parameter (b) is examined.

If it is zero, the ordering cost field in the item record is examined.

If this is zero, an order quantity is computed based on the preferred ordering interval and the demand forecast extrapolated over the order interval (taking account of seasonal factors, if appropriate).

If either parameter (b), or the ordering cost field is non-zero an economic order quantity is computed using either:

- (a) the input parameter (c) as the investment rate for the item (blanket value for the whole inventory) or, if this value is zero,
- (b) the value of input parameter (d) corresponding to the investment rate group for that item.

If parameter (b) and the Ordering Cost field in the item record in the Demand History file are both non-zero, the former takes precedence. If an economic order quantity is calculated, the order quantity corresponding to the preferred order interval is also calculated and the larger of the two quantities output as the system re-order quantity. Refer to Section A.7. In all methods of calculating the reorder quantity the decimal parts of the quantity are rounded up to the next integer.

If the preferred order interval is zero, a value of unity is assumed.

- 10 If γ_1 was amended, reset it to zero.

System Marker value '5': This means fixed re-order point control with cyclical ordering.

Processing is identical to System marker '0' above but, in addition, the order interval count is updated (reset if negative).

System Marker value '6': This means adaptive control with cyclical ordering, and using the Box-Jenkins two-point predictor.

Processing is identical to System marker value '1' above except that the re-order point calculation is based on the lead time plus the preferred ordering interval in place of the lead time, the re-order quantity is set to zero and the order interval count is updated (reset if negative).

In all cases the period demand accumulator in the output Stock Master file is zeroized. For System Markers '1' and '6' the re-order point and re-order quantity fields in this file are updated with the newly calculated values.

No System Marker other than 0, 1, 5 and 6 is permitted in SCAN System 1.

It is advisable at the commencement of operational running to initialize the Stock Master file using the forecasting routine. This ensures that a reorder point and a reorder quantity are present on the Stock Master file for all forecast items before stock updating is attempted. If the user has put his own estimates of these quantities on the file for any item these will not be altered. If this has been done for all items, the initializing run is not required.

Output

- 1 Updated Demand History magnetic tape file - format as Input (1).
- 2 Updated Stock Master magnetic tape file - format as Input (2).

3 Reported Items List - see Figure 27.

Peripherals

4 magnetic tape units

1 card or paper tape reader

1 line printer

Source Language

PLAN 3 and 1900 FORTRAN

Stock Forecasting and Monitoring Routine (16K processor)

The large processor version of the forecasting program (X42V) incorporates all the features of the program described in section 3.6.6 (X42K) but has the following additional features which take advantage of the extra processor space available.

- 1 Seasonal factors are automatically recalculated at the end of the year, that is, when the cycle base equals the cycle base count. This avoids the necessity of entering the analysis routines.
- 2 The magnetic tape files are double buffered to shorten the processing time for each item.
- 3 A larger block size is specified for the Stock Master file (256 words) to enable user data to be accommodated at the end of each record if required.

Chapter 4 System Implementation and Integration

GENERAL

4.1

The magnetic tape creation routine makes it possible for a user to obtain a magnetic tape in the format required to process demand data through one or more of the analytical routines, thus directly using the available programs to derive the control parameters best suited to each item's demand pattern. Fixed file formats are used by the operational routines. Where these are acceptable to the associated commercial routines, or can be provided by inter-linking routines, the operational routines may be used unmodified. All programs are written so that input, output and processing features are contained in separate sections.

It may be possible for a user to write input/output sections to suit his total system requirements but incorporate the processing sections available - thus reducing the period required to produce an operational program. Total integrated business system concepts may be such that a user may prefer to write operational programs to suit his needs, whilst still using the logic contained in this manual.

The rest of this chapter will deal with problems of data collection, basic data required, internal and external system relationships and operational control.

DATA COLLECTION

4.2

The record formats provided for Master file creation in this system are subdivided so that each relevant department within the business may provide its own data as follows:

Stock Master File: normally the first file created for an operational system.

The punching document for this file is designed such that the Stores, Purchasing and Sales departments may each add data to the document in specific areas - see Figure 31.

Demand History File: required for analysis and forecasting.

The punching document for this file is designed so that generalized item details are recorded in one area - see Figure 30.

Supplementary item data, demands, seasonal factors are each recorded in other areas corresponding to separate punched cards/paper tape blocks which need not be present if no data is available.

For a valid analysis by statistical methods not less than 24 data points, i.e. period demands, should be included in the demand history. These could be either weekly or monthly periods. Two years' monthly or weekly data is necessary for the analysis to detect seasonality.

If there is initially insufficient data available, it would be advisable to omit the analysis routines, set arbitrary control factors, accumulate demand history by using the automatic demand history updating feature, and perform analysis when sufficient data is available.

This will not, in general, give the best results possible, but if the choice of control parameters gives rise to excessive forecast errors the automatic monitoring feature will detect this state and output details so that the control parameters can be modified to give acceptable results.

Thus there is no reason why the control system cannot be implemented regardless of data availability.

Transaction File: required for day to day stock transactions.

Each transaction type is recorded on a separate record with a common format. The transaction (or records) code identifies the type of transaction - see Section 4.4.2. A planning aid (Figure 32) will assist experimental runs, but routine punching will usually be from original documents.

1 For an initial analysis of demand history the following fields are required in the Demand History file:

- Record length
- Item number
- Cost price
- Sales price
- Service level group
- Closing stock on hand
- Demand history length
- Demand history
- Selected lead time
- * Description of product
- * Unit of measure
- * Store location

Note: If closing stock data is not provided, the Stock Profile List will print zero against the headings Stock Quantity and Stock Value.

2 After analysis, all control factors will be written to magnetic tape, although any changes in field content will have to be made by Management and a file maintenance program used to enter the appropriate values. This program would normally be written by a user to suit his special requirements.

If the control system is implemented without prior analysis the following values are recommended for the control factors:

<i>Field</i>	<i>Initial Value</i>
Forecast base (or interval)	1
Cyclical (or seasonal) values	1
† Cycle base (or season length)	
Box-Jenkins proportional control parameter	γ_0 0.1
Box-Jenkins cumulative control parameter	γ_1 0.1
Deseasonalized demand forecast	Latest demand or best estimate
Cumulative sum of errors	0
Smoothed forecast error	0
Mean absolute deviation of errors	1

3 Lead times. If lead times (or replenishment delivery times) are fixed or firmly promised, then the value appropriate to a given supplier for that item is used. More often, lead times are variable.

There are two recommended approaches to this problem:

- (a) Use the maximum known lead time.
- (b) Perform a distribution (or frequency) analysis of the lead time history and compute a value corresponding to one or two standard deviations above the mean value.

* These fields are for identification and may be omitted.

† The value for season length will be either 1 for non-seasonal items or 1 year, e.g. 12, 13 or 52 for seasonal items depending on the forecast interval.

The first choice may give rise to higher stock holdings depending upon the difference between the lowest and highest value of the lead time, but will increase the customer service level. Where there is wide variation in lead times the second choice is recommended, i.e. one standard deviation above the mean value of the distribution is equivalent to saying that approximately 84% of all lead times encountered in practice will be covered by this value. Similarly, mean plus two standard deviations will cover up to 98% of all lead times. This method eliminates the extremely long lead time from consideration.

Any other value acceptable to Management and giving the desired customer service may be used.

INTERNAL SYSTEM RELATIONSHIP

4.4

The analysis routines require only one magnetic tape file - the Demand History file - although if automatic control system selection is used, the Stock Master file is required.

The operational routines require the Stock Master file to be created initially and the Transaction file to be created prior to stock updating. Thereafter, all files used in the system are generated by the relevant program.

Figure 28 indicates the sequence of routines for both analysis and operation of the system.

Chapter 2 describes the use of each program in general terms but the following notes may be regarded as useful supplementary comments.

File Creation Routines: the programs are described in Chapter 2, and the input record formats in Chapter 5.

A comprehensive Master File Create/Maintenance program is provided and the only function which requires extra careful attention is the 'AMEND' function. It is imperative that the correct field location reference (word number) is used.

Analysis Routines

4.4.1

Irrespective of the type of inventory control system to be established, these programs improve on the traditional ABC Analysis since they take account of the frequency of movement of each item. Annual usage value has always been a valuable criterion to guide selection of the stores items first to be subjected to a computer based system of inventory control, but it is the fast moving items that will respond soonest to control action. It is better, therefore, to use frequency of movement and annual usage value as joint criteria in the making of this selection.

It is recommended that adaptive control be applied only to those items with a frequency of movement of at least one demand in eight weeks. This limit corresponds to a forecast interval of four weeks or one month.

If weekly demand data are presented to the Stock Profile Analysis program, the first selection will, therefore, be those items with recommended forecast intervals of 1, 2 and 4. The Frequency Analysis table shows what this means in terms of annual sales (or usage value), gross margin and stock-holding values relative to the total of items included for analysis.

The demand history presented to the Stock Profile Analysis program should refer to a constant number of demand points if possible, so that all items are comparable, although the program will adjust to give the annual demand in any case.

The Stock Profile Analysis may be used to review the control performance by comparing with reports produced during the previous analyses. This comparison shows:

- 1 how the balance of stock-holding has changed in relation to annual sales value.
- 2 how the stock turnover ratio has changed for each section of the inventory,
- 3 how the stock-holding and number of non-moving or slow-moving items has changed.

The ABC Analysis program provides the user with a preliminary analysis table in 5% steps to enable a close estimate to be made of the desired high and medium usage value groupings.

Having thus established classes of inventory items based on the combination of usage value and frequency of movement, the user may then apply automatic control system selection based on the following suggested table:

Class	System Marker	
	Random Ordering	Cyclical Ordering
A1	1	6
A2	1	6
A3	0	5
B1	1	6
B2	1	6
B3	0	5
C1	0	5
C2	0	5
C3	0	5

Operational Routines

4.4.2

Transaction File Creation

Data for each transaction type (see Section 5.3) is punched into a separate record, which contains two quantity fields.

Both these fields may not always be used but each may be negative. The negative sign is contained in the first character position of the field, a space indicating a positive figure. All the fields used in SCAN System 1 are right-justified unless otherwise stated.

Only integer values are allowed for quantities.

The date is always punched as day, month, year and is converted in this program to year, month, day in two words, right-justified.

Priority codes will only be used in Demands (Transaction Code 21). All other transaction types will be output on magnetic tape with a priority of 100 except for Audit requests (transaction code 11), which will have a priority code of '200'. In the case of a blank priority code field in the Demand transaction, zero will be assumed.

Batch control records may be used, but must be in the same record format as the transactions. (See Section 5.3.)

Audit Requests: (Transaction Code 11) If a system of continuous stock auditing is used it is highly likely that the time at which the stock is counted is not coincident with the time at which stock is balanced in the Stock Updating routine.

If a transaction affecting the stock balance occurs between the two times, the stock count will not agree with the computer balance. The two figures must then be reconciled by the stores auditor. To assist this the system will output a file of transactions covering the period of time between the stock count and the nearer balancing date or time.

It is assumed that the Stores Auditor will draw up a list of items to be checked between successive updatings. This list could be drawn up in arrears provided that the list is available in time to feed details to the Stock Updating run immediately following the stock count of the selected items.

The presence of an audit request will cause the system to circulate all transactions affecting the stock of that item. Normally, these transactions would be removed from the system before entering the next stock updating run, although the system caters for items recirculating.

If the user does not wish to use this facility no audit request will be submitted.

Note: Demands are pre-posted as issues when stock is allocated. If the resultant issues do not occur the same day, account must be taken of this in the timing of the audit request.

Stock Adjustment: (Transaction Code 12) If the stock-on-hand balance is found to be in error for any reason, a stock adjustment record may be used to correct the balance (possibly following an audit).

Stock Receipt and Scrap: (Transaction Code 13) A receipt (i.e. quantity good of a total receipt) is recorded in the first quantity field. However, if any quantity is rejected for replacement or rework, this quantity will be punched as scrap in the second quantity field only if it is desired to record the rejects in the Stock Master file or if it helps the users Invoice Checking routines. If this is so recorded an Order Adjustment record (Transaction Code 19) must be raised from the documents returning the rejects to the supply source for replacement.

If the above requirements do not apply, the quantity rejected will be omitted and only the good stock recorded and any genuine scrap which will not be replaced.

Returns Outward: (Transaction Code 14) This transaction will be used for items in stock which are returned to the supply source for some reason. It will not be used for rejects which have not been posted as receipts.

Unscheduled Issue: (Transaction Code 15) When unplanned stores issues are made or where an issue is made urgently and the normal system is bypassed, the Stock Master record must be updated in arrears.

The transaction will still be treated as a demand for pre-posting except that the allocation of stock will be assumed successful.

Returns Inwards: (Transaction Code 17) This transaction is treated as though it were a negative issue, but will update both the stock-on-hand and the cumulative demand to date, unless the second quantity field is non-zero, in which case it will also update the Period Demand Accumulator. Normally, it will be used to record the return of an unscheduled issue, the return of goods from a Customer for credit or the cancellation of an allocated demand before despatch.

If the goods were returned for replacement and are to be scrapped a Stock Adjustment record (Transaction Code 12) must also be prepared to write the goods off and be available for the user's Costing routine.

If the original demand was received in a previous period, the second quantity field will be left blank.

If it is necessary to correct the demand history this will be effected by use of the File Maintenance program.

Replenishment Order Balance Adjustment: (Transaction Code 19) This will simply be used to adjust the stock on order balance for a given item. It may be created directly or as a result of a user's Purchase order procedures.

Demands: (Transaction Code 21) These records represent new demands, which may or may not be required for immediate allocation.

There is a facility provided (see page 68) to enable the user to specify a time interval (from the current date) which will allow all demands with a due-date coming within this time interval to have stock allocated against them.

Demands not due for allocation are classed as:

- (a) Forward demands if their due date is beyond the time interval specified but within a lead time from the current date
- (b) Future demands if their due date falls outside the lead time plus current date.

As stated elsewhere, the transactions are written to a magnetic tape file in the sequence in which they are presented, and a subsequent sort places the records in the sequence for further processing.

Stock Updating and Allocation

As stated, not all demand is for immediate satisfaction and, where this occurs, the issue must not be pre-posted until the item is due for despatch. It is, however, desirable to know this future commitment and, where demand is forecast automatically to set the re-order level, this demand should be recorded as soon as it is received. Demand should, therefore, be advised to the system as soon as it is known.

When the demand becomes due, it will automatically be deducted from the Forward Demand balance and be available for immediate allocation.

The stores handling time varies from user to user. If, for example, it takes an average of three days to service a demand, a demand due in three days' time must now be allocated and pre-posted as an issue if stock is available or back-ordered if stock is not available.

This facility may also be used for manufacturing order control. Constituent requirements for planned manufacture may be fed to the Stock Updating program as forward demand. Stock will be allocated for all demands for, say, the next 14 days and shortages reported as back-orders.

To avoid the inclusion of very long term demand in the Forward Demand balance, a forward demand will be ignored until the due date is within one lead time from the current date. However, the demand will be recirculated on magnetic tape until action is required.

Unallocated demands are the due and overdue demand which cannot be met from stock and which have, therefore, been back-ordered.

Transactions records for back-orders will be recirculated until stock is received and the demands can then be met.

A user option (specified by parameter) decides if part shipment is permitted. If it is, all physical stock available will be allocated to the demand as it is received. If part shipment is not allowed, stock will be allocated only if the demand may be satisfied in full.

Stock on order is the total quantity of outstanding orders to replenish the stock. Orders are requisitioned by the system automatically and will be assumed to be placed immediately. Any variation in quantity between that requisitioned and that actually ordered must be reported to the system as soon as possible. The same remarks apply if there is likely to be a serious delay in placing the order.

The total quantity received will be assumed to be in satisfaction of outstanding orders, i.e. all rejects will be assumed to be scrapped. Any rejects returned for replacement, or re-work, must be re-entered to the system by means of an Order Adjustment.

If more is received than the quantity ordered, the order balance will be understated and may go negative. If the excess quantity is accepted, an order adjustment must be entered to correct the order balance (unless the excess is credited to a following order). Similarly, if less than the quantity ordered is accepted in full satisfaction of the order, an Order Adjustment must be entered to clear the balance of that order from the order balance in the Stock Master record.

The Demand Accumulator accepts all demands due within one lead time from the current date. Periodically, by use of the Forecasting routine, this accumulated demand is entered into the Demand History file and the accumulator zeroized.

Other Balances are as follows:

Cumulative Receipts to date: all receipts less returns outwards are added to this accumulator. It is available to the user in conjunction with the Scrap balance.

Cumulative Scrap to date: this is used to accumulate the total scrap reported when goods are received.

Cumulative Demand to date: this records the total demands and unscheduled issues since the accumulator was last zeroized.

Cumulative Back orders to date: read in conjunction with the cumulative demand it gives one indication of customer service.

Receipt Count: incremented by one every time a receipt occurs.

Back order Count: incremented by one every time a quantity is added to the cumulative back order accumulator.

Non-move Count: incremented by one each time the Demand accumulator is transferred to the Demand History file, provided the balance is zero.

It is assumed that the last seven balances listed will be zeroized by the user routine which produces the annual stock listing.

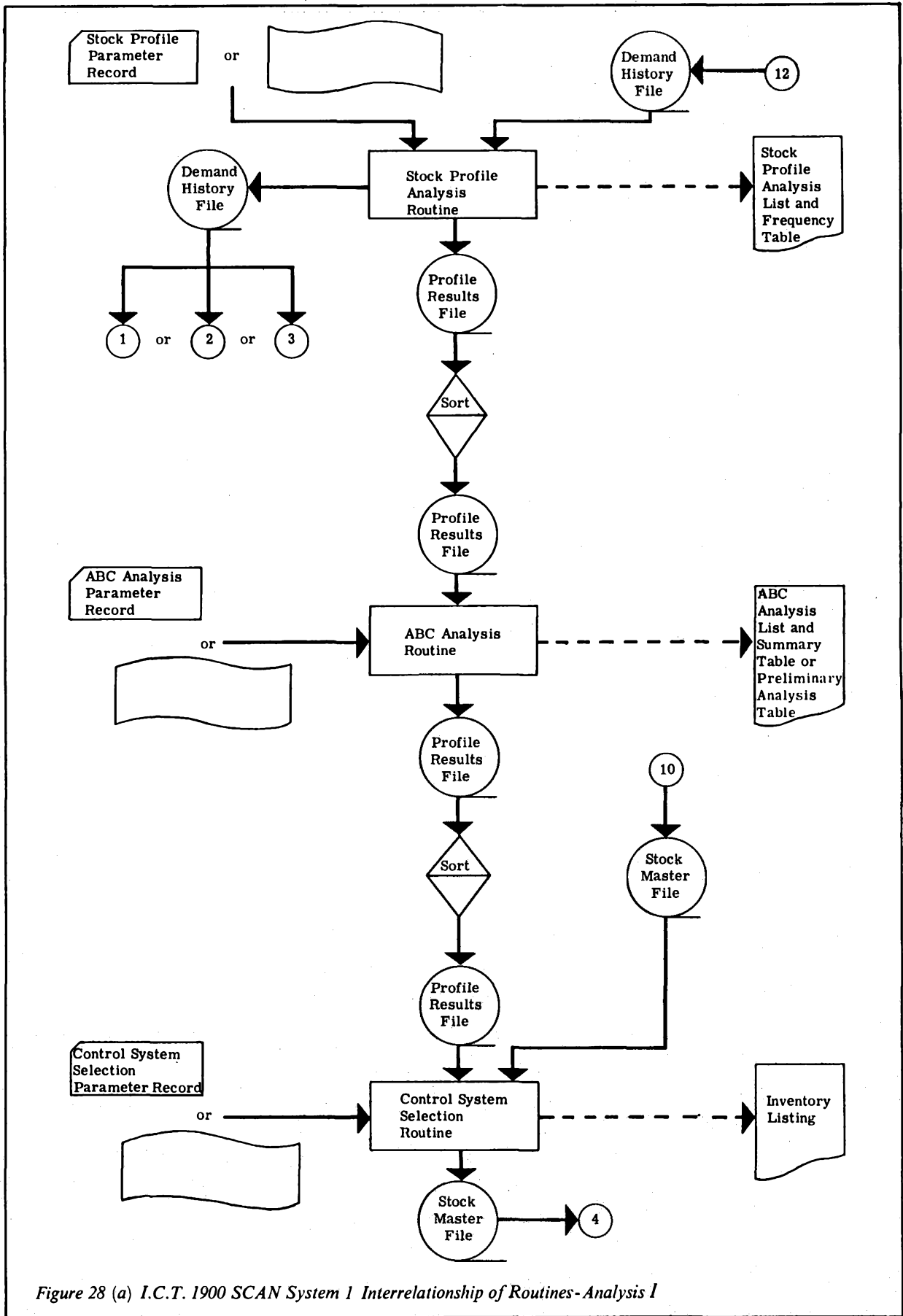
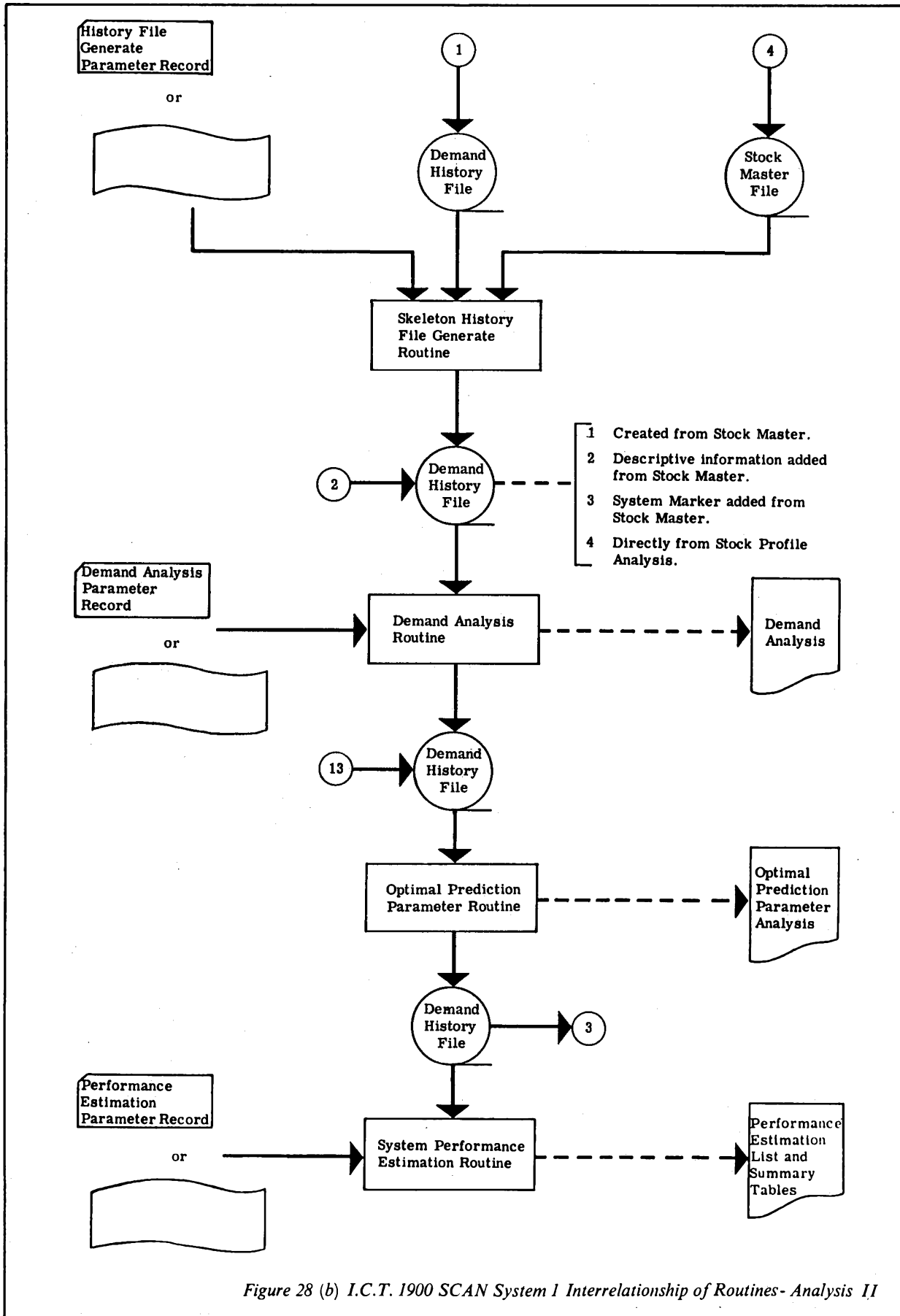


Figure 28 (a) I.C.T. 1900 SCAN System 1 Interrelationship of Routines - Analysis I



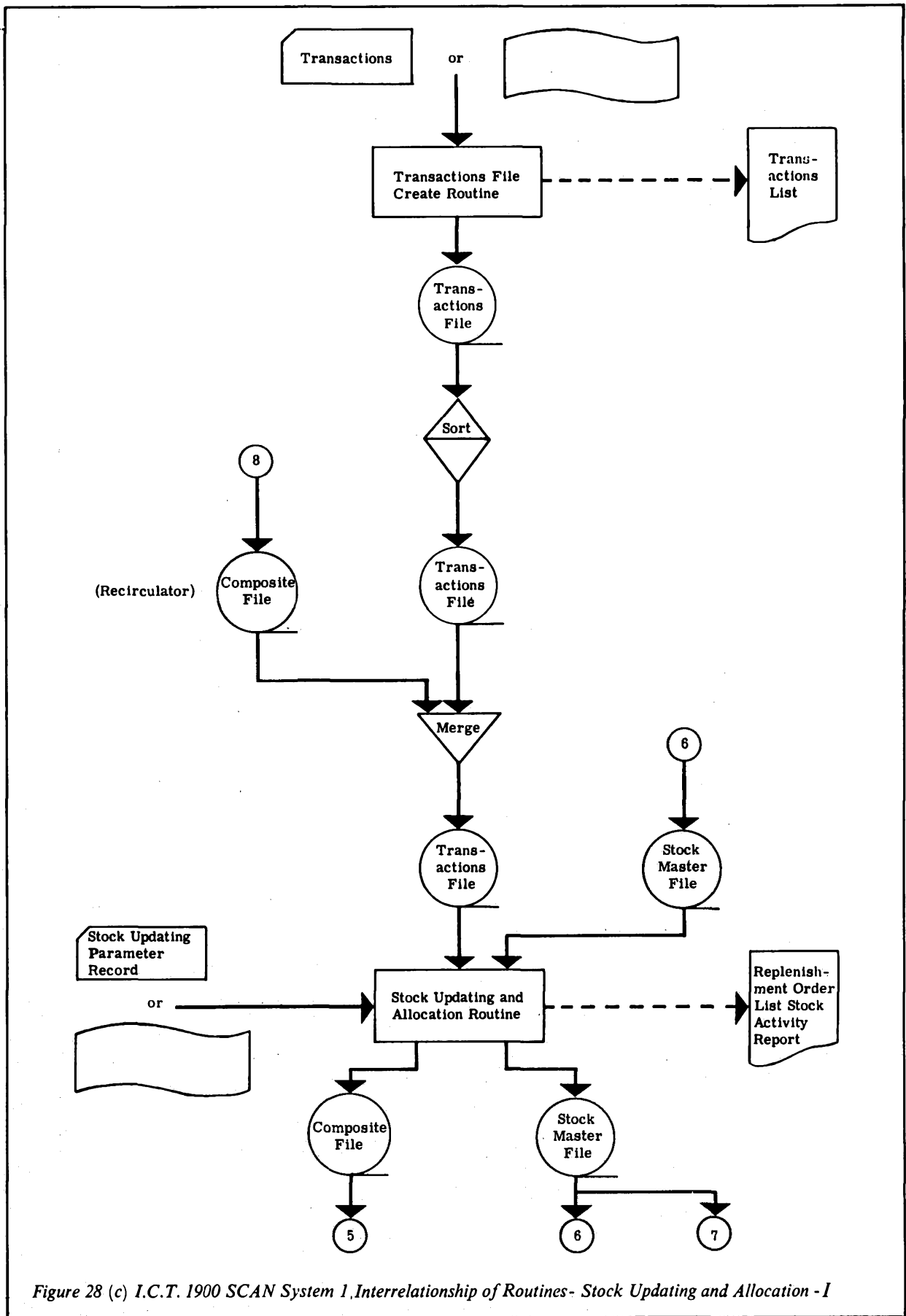


Figure 28 (c) I.C.T. 1900 SCAN System 1, Interrelationship of Routines - Stock Updating and Allocation - I

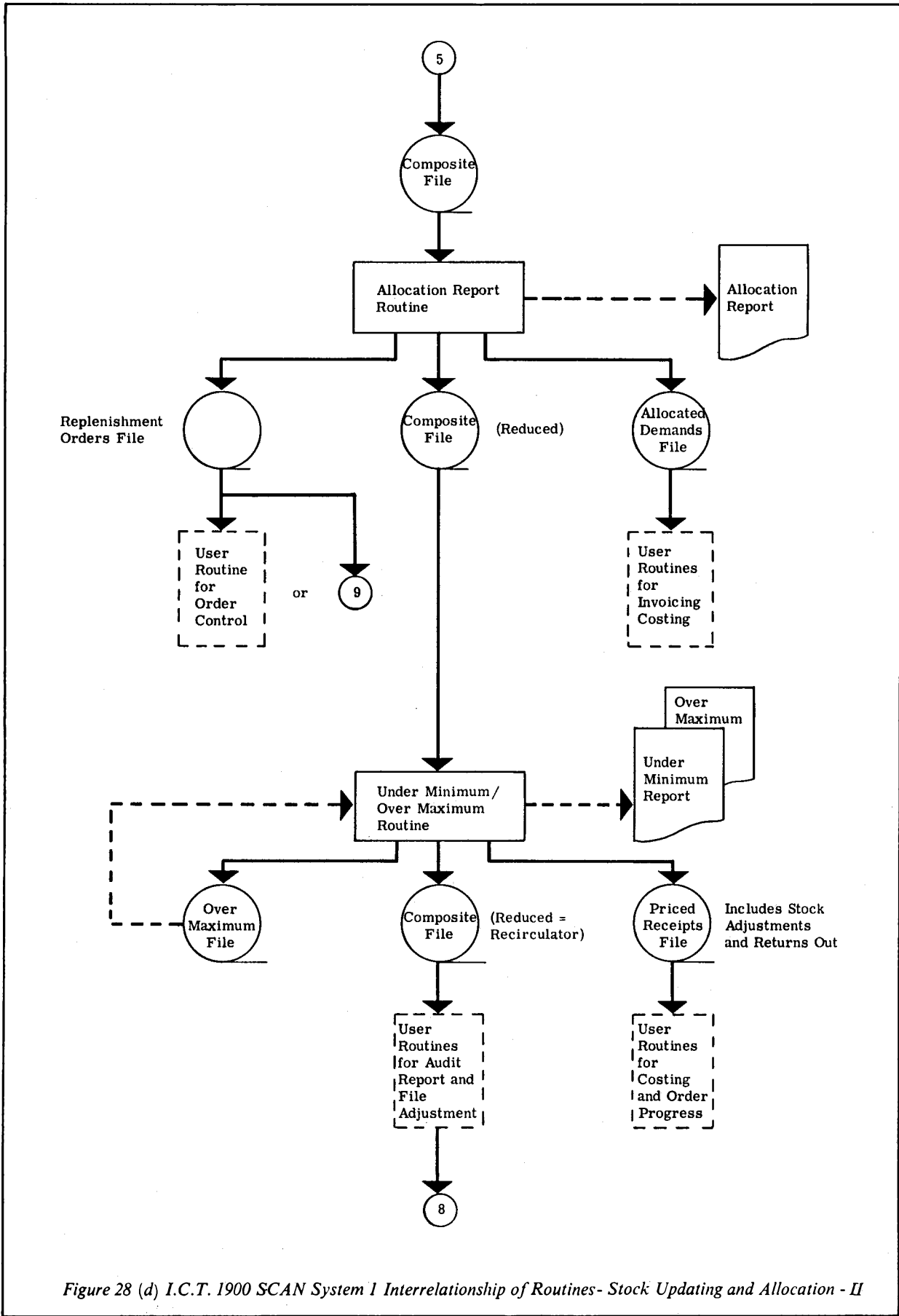


Figure 28 (d) I.C.T. 1900 SCAN System 1 Interrelationship of Routines- Stock Updating and Allocation - II

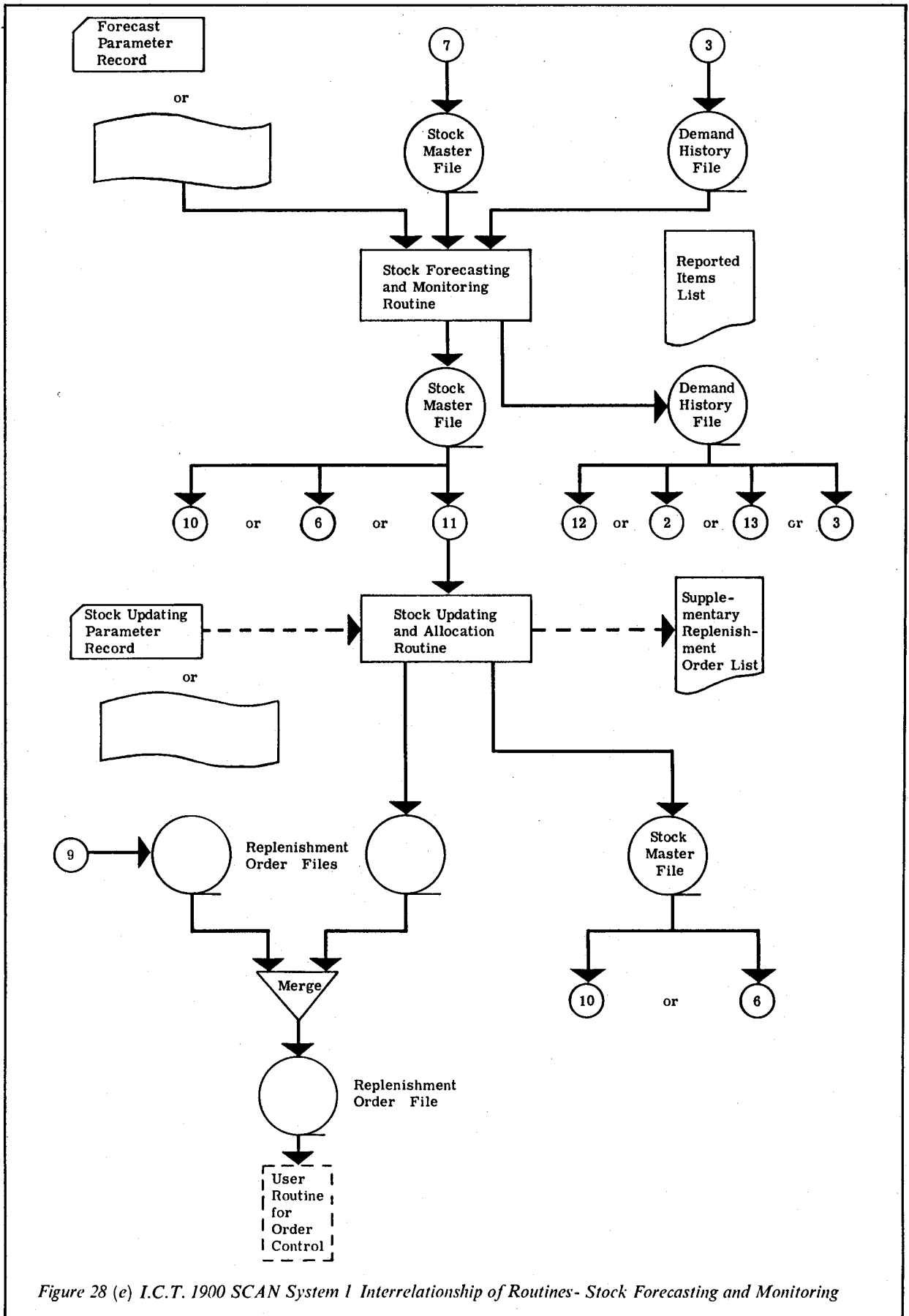


Figure 28 (e) I.C.T. 1900 SCAN System I Interrelationship of Routines- Stock Forecasting and Monitoring

Allocation Report Routine and Under Minimum/Over Maximum Report Routine

Two programs supplementary to the main Stock Updating routine are used to provide control information and entry points to other system areas.

A composite magnetic tape file output from the Stock Updating run contains the results of the processing which are progressively 'split-off' to the reports and entry points described in Chapter 3. This file is finally recirculated back into the system containing back-orders, forward and future demands and possibly audit records (if not extracted).

Stock Forecasting and Monitoring Routine

Two basic methods of control are permissible.

- (a) Adaptive control with variable re-order points and variable re-order quantities.
- (b) Fixed re-order point, fixed re-order quantity.

Either of these systems may operate with cyclical ordering. In this case the order cover will be increased each time to a lead time plus an ordering interval.

The function of this routine is to make a forecast of demand for the next time period for those items selected for adaptive control. Re-order points and quantities are then adjusted in line with this forecast.

To provide some measure of control over the forecasting efficiency an automatic monitoring feature is built into the system. The safety stock (and hence customer service) is computed to consider the forecast errors.

The re-order point contains the safety stock allowance determined from the service level desired by Management. The system order quantity may be based on the demand forecast extrapolated over the ordering interval (considering seasonal factors) or it may be an economic order quantity computed to conform to parameters set by Management.

Monitoring is based on calculating a tracking signal from the errors and comparing it with pre-set limits (see Section A.6, Appendix A).

Fixed re-order points and quantities will be decided by Management and entered during file creation/maintenance.

All items held on the Demand History file will automatically collect demand data from the Stock Master file during the running of the Forecasting routine.

If the new forecast results in the re-order points, rising to, or above the available stock, it may be necessary to run the Stock Updating routine (with no Transaction File present) in order to generate new replenishment orders, but only if significant time will elapse before the next Stock Updating run. This delay is likely to be significant if it were more than about a quarter of the ordering interval, or of the lead time.

EXTERNAL SYSTEM RELATIONSHIP

4.5

The I.C.T. SCAN System provides a framework upon which an integrated commercial data processing system may be developed. Control of stock is a major factor in a company's profitability and ability to give prompt, efficient service where needed, at the time it is needed.

The following charts (Figure 29) give a suggested expansion of the entry points provided by this system into other commercial areas.

The Stock Updating and Allocation routine provides a printed report of all order requisitions which, it is expected, will be validated by the Buying department before final Purchase Orders are printed. Any amendments must be advised to the system.

Invoicing may easily be effected by User routine using the allocated demands magnetic tape file produced during the Allocation Report routine.

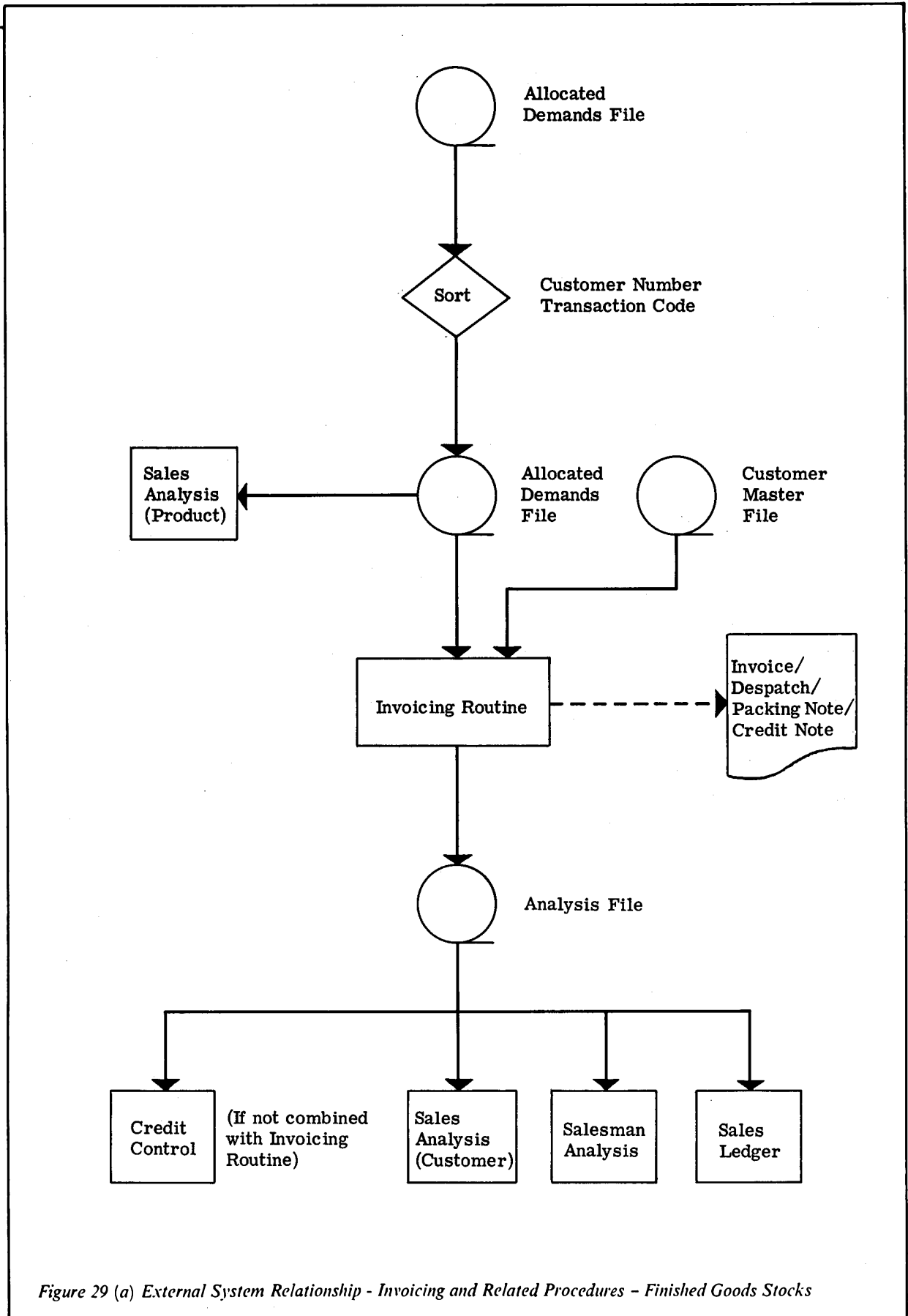


Figure 29 (a) External System Relationship - Invoicing and Related Procedures - Finished Goods Stocks

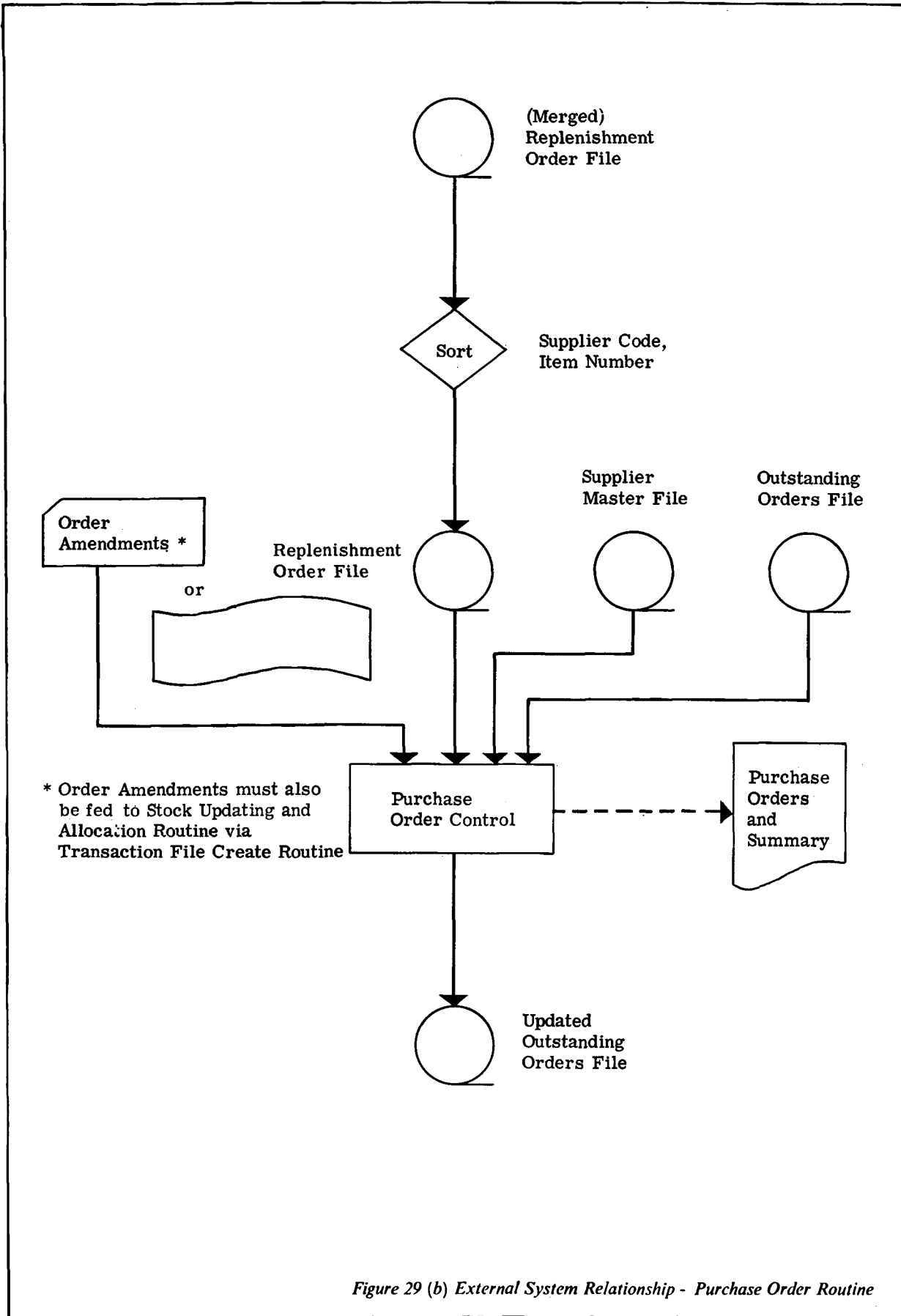


Figure 29 (b) External System Relationship - Purchase Order Routine

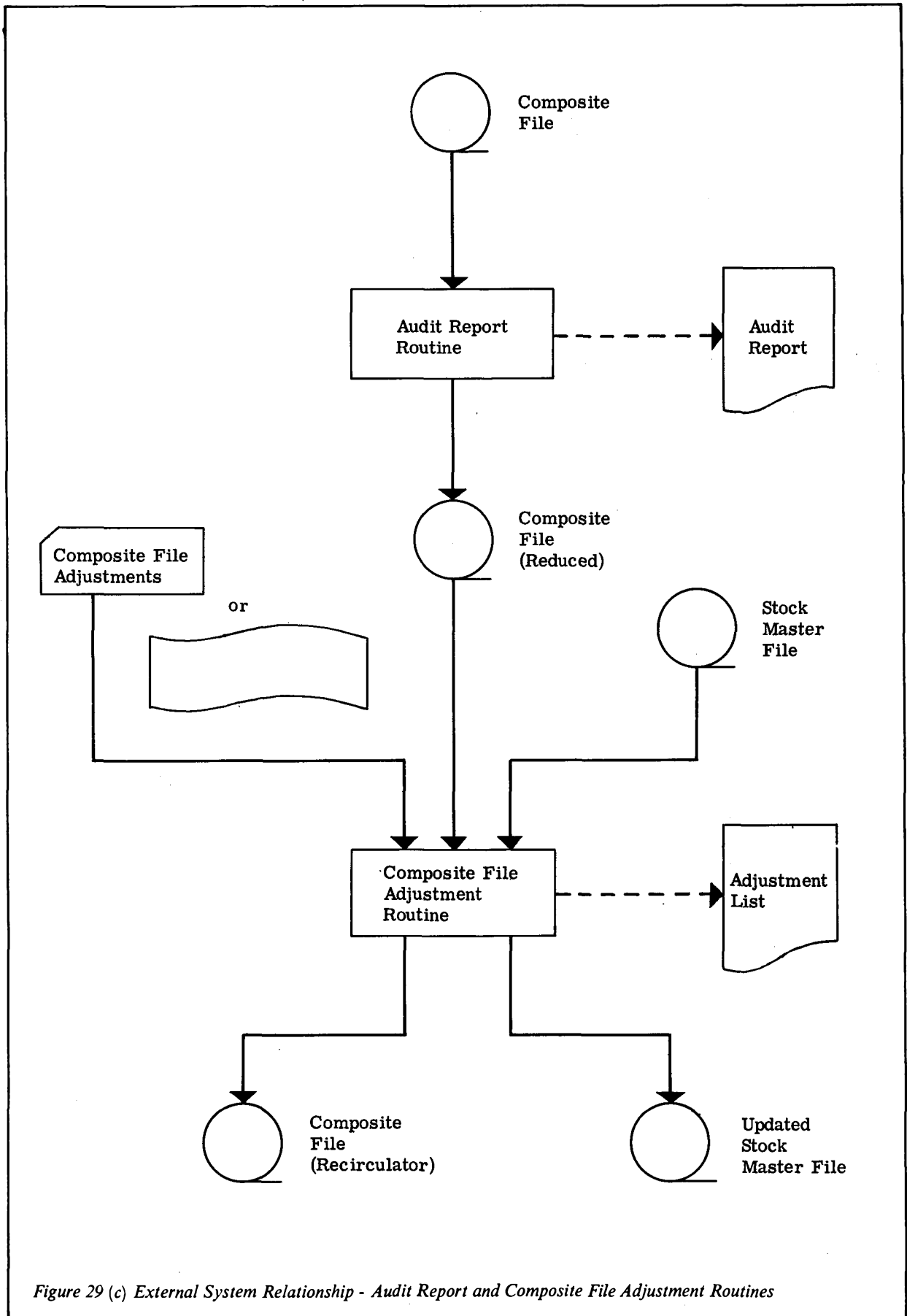


Figure 29 (c) External System Relationship - Audit Report and Composite File Adjustment Routines

A typical invoice set consists of:

- invoice copy
- daybook copy (accounts)
- production control copy (progressing order) - if appropriate
- consignment note copy - with goods to customer
- advice note copy - by post to customer.

The allocated demand record contains the following data pertinent to invoicing:

- Customer number and/or code
- Internal order or batch reference number
- Date of demand
- Item number
- Unit of measure
- Quantity allocated
- Quantity unallocated (to follow)
- Date required
- Cost price
- Sales price
- Purchase tax
- Discount code
- Bin location (store reference location)
- Unit weight

An Allocated Demand (Transaction Code 18) would be processed to provide an invoice; an Unscheduled Issue (Transaction Code 15) may require an invoice.

A Returns Inwards (Transaction Code 17) would be processed to provide a credit note.

Any of the above transactions may be held on the Allocated Demands tape file and there are several ways in which the file may be sorted prior to processing.

- 1 A straightforward invoice/credit note procedure normally requires a sort by customer number/item number/transaction code.

This tape would be matched against a customer master file containing names and addresses, credit control details, special discount terms, etc.

Invoice sets would be prepared and an output tape written containing credit note details and invoice records.

Upon completion of invoicing, the credit note tape would be rewound and matched against the Customer Master file (also rewound) to print the credit notes.

- 2 The unit weights extended by quantity may be used in conjunction with route numbers (held on the Customer Master file) to schedule deliveries and vehicles (by User program).

For the simplest approach to this, the credit notes would be printed first and an output tape containing extended invoices together with the transport route numbers produced. This tape would be sorted by transport route number and the invoice sets printed. Concurrently the total weights could be aggregated in approximate vehicle loads.

Development of sales statistics depends entirely upon the needs of the user but generally falls within two broad classifications.

- 1 Customer sales statistics which might reflect year-to-date (YTD) sales in total and/or by department including percentage changes in previous year's performance.

Another useful measure is customer sales and profit to company by product group as monthly and YTD figures, with perhaps a comparison with last year's corresponding figures.

- 2 Product statistics which reflect sales by product including number of times sold, bought, balance, profit, interest on stock value etc.

Either the Allocated Demands, or the Invoice files, or both would be used.

Note: The foregoing discussion is included simply to suggest how the SCAN system may be linked with other commercial routines. Obviously, circumstances will determine the complexity of invoicing, sales analysis, production scheduling, purchase control, credit control and other related routines.

Monitoring of Forecasting

4.5.1

If errors between predicted and actual demands are excessive, the monitoring feature will detect this and output details. Excessive errors may be due to one of the following causes:

- 1 Large orders for an item or items, the magnitude of which was not previously included in the original demand history used to derive control factors.

These may be sporadic. If a large order were expected, then a dummy product should be set up outside the control system and stocks built up separately so that normal demands for that item are not influenced. If this large order were not expected then it is too late to build up stocks and the tracking signal limits are exceeded.

Management must then determine if there is a likelihood of this occurring again and set their safety stock at a higher level to cope with the situation. If there is no expectancy of such an event recurring, the control factors may be left unaltered.

- 2 Combination of two or more products causing changes in the market demand pattern for each individually. It could be regarded as a new product for purposes of analysis.
- 3 Marketing activity causing erratic trends in the demand pattern which were not present in the Original Demand history

Both (2) and (3) may necessitate removing the items from the control system and exercising tighter manual control until the demand has stabilized, whereupon the analysis could be performed prior to their inclusion back in the system.

A unique feature of the Stock Forecasting routine is that a parameter is provided, on punched card/paper tape input, which will be used with the increasing sum of forecast errors to adjust the forecast, if the error limits are exceeded, until such time as either Management intervenes or the errors reduce to acceptable limits.

The Y_0' value (Box-Jenkins proportional control parameter), which is used to smooth errors, and in computing, the tracking signal is fixed at 0.17. This has been found empirically to give a control system which responds quickly to real changes in error level without being too sensitive to random variations in error.

Other reports that a user may wish to include in the operational routines are:

- 1 Notification of items not previously included in the control system, but which have an increased demand frequency such that the items should now be included.
- 2 Similarly, notification of items included in the system that are now in the slow moving category.
This can be achieved by utilizing the non-move count in the Stock Master file and by writing either a segment to produce the report in the Stock Forecasting routine, or a separate program.
- 3 By modifying the idea of the non-move count, a program could be written to produce a static inventories list, as a further by-product of the system.

FREQUENCY OF PROCESSING

4.6

Analytical Routines

4.6.1

If demand history is available for analysis, two or more of these routines will be used *at least* once in order to derive initial values for the control factors.

Subsequently the routines may be used as desired by Management for review purposes or to establish new control factors for:

- 1 New items (where demand history is available).
- 2 Items previously excluded from the control system.
- 3 Items included in the control system whose control factors are no longer valid because of radical changes in the demand pattern, causing excessive forecast errors (see Section 4.5.1).

Operational Routines

4.6.2

This is entirely at the user's discretion, but Stock Updating must be processed at least as often as the Stock Forecasting routine.

If the demand data is aggregated on a weekly basis and the recommended minimum forecast interval is '1', the Stock Forecasting routine should be processed weekly and Stock Updating possibly daily. It may be desirable, because of data collection/preparation problems, to process the Stock Forecasting routine once a month and update stock balances as a weekly routine (see Section A.2.)

Demand data would be aggregated on a monthly basis, thus allowing time for data communication from remote warehouses, stores etc., to a centralized computer.

In general, the response to monthly forecasting is not as good as for weekly forecasting, although the more uniform monthly demand data may compensate since it may lead to more uniform sized orders on a supplier, or on a production line where the facility of manufacturing in batches is available.

OPERATIONAL CONTROL

4.7

The I.C.T. SCAN System may produce up to seven schedules which relate only to these items requiring attention (except in the case of the transaction list, allocation report and stock activity report).

Transaction list

Replenishment Order list

Stock Activity report

Allocation report

Under Minimum report

Over Maximum report

Reported Items list

Transaction List

4.7.1

This is a listing of each transaction detail as it is written to magnetic tape and is produced each time the Transaction file is created.

Items in error are indicated with an asterisk on the printed report as well as an error type message reference together with the item number on the console typewriter. Batch controls are admitted, if desired, computed on the transaction codes and both quantity fields.

Replenishment Order List

4.7.2

This report is produced by the Stock Updating and Allocation routine and is a request to the user to place a replenishment order for a specified minimum quantity; it also provides the necessary information for validation by the Purchasing Department prior to their proceeding with ordering. In general, all the order requisition magnetic tapes produced by the Allocation Report routine must be merged, sorted and updated (if necessary) before implementing the Purchase Order Control routine - written by the user.

The load index has two uses:

- 1 If the 'set-up time' field in the Stock Master item record has a value (other than zero), the load index expresses the total time required to set-up and manufacture the replenishment order, i.e. order quantity times unit time, plus set-up time.
- 2 If the 'set-up time' field has zero value and unit weight is entered instead of unit time, the load index expresses the total weight of the replenishment order.

Stock Activity Report

4.7.3

Also produced during the Stock Updating run, it summarizes all transactions in terms of opening, processed and closing balances (by value at cost price).

Allocation Report

4.7.4

Produced during the Allocation Report routine, this is a listing of all demands allocated during the previous Stock Updating and Allocation routine. It also includes the amounts unallocated (if appropriate).

Under Minimum Report

4.7.5

The minimum stock level may be set by Management or left at zero.

In the first case the report will contain a list of all items whose physical stock less backorders is below or equal to the minimum level that Management wishes to tolerate. In the second case, if the backorders exceed the physical stock a report of all stock shortages will be produced. It is, essentially, a progress document and may be used by the progress chaser in conjunction with a list of individual orders placed during the Purchase Order routines.

Over Maximum Report

4.7.6

The maximum stock level set by Management may represent a maximum financial limit to the physical stock (or, alternatively the stock quantity representing a fixed warehouse area limit). However set, if the physical stock exceeds the maximum level, a report will be produced. If the level is left at zero, no report is produced.

Reported Items List

4.7.7

This report is produced during the stock forecasting routine and indicates those items under adaptive control for which errors between predicted and actual demands exceeded preset limits.

The report cannot say why this event occurred: Management must investigate the reason and decide what action, if any, to take.

PARALLEL RUN

4.8

It is strongly recommended that before attempting to control stocks using the SCAN system a pilot or parallel run be effected alongside the existing system for a period sufficiently long to allow:

- 1 control factors and computed demand forecasts, re-order points, re-order quantities etc. to be realistic.
- 2 personnel to become familiar with the necessary procedures and the system.
- 3 any errors to be eliminated from the User linking programs, before accepting results as valid.
- 4 the monitoring feature to detect obviously incorrect choices of prediction parameters.

The period involved could be from 6 to 20 weeks depending on difficulties encountered.

Implementation of a control system could result in a reduction in stock holding value of 30% or more, and in all cases reduces the major part of the control activity to a machine function, enabling Management to have more time to solve problems of controlling slow moving items.

If a more detailed study of the action of the system is to be undertaken, the System Simulator may be used - see Chapters 7 to 9. This simulation program is particularly valuable for studying the control response for selected very important items in the inventory.

Initializing the System

4.8.1

The recommended method of initializing the system is to run the Stock Updating and supporting programs for the whole of the first forecasting interval (either one or several runs), then enter the forecasting routine.

Until the latter has been run the re-order point will be zero (unless a figure is entered via file creation/maintenance) and no orders will be generated.

For the first forecasting run a switch must be set (see Operating Instructions, Chapter 6) otherwise only those items with a forecast interval equal to '1' will have their re-order points and quantities revised. The switch will cause all items selected for adaptive control to have their re-order points and quantities revised - for use in subsequent Stock Updating runs.

Chapter 5 File Formats

DEMAND HISTORY FILE

5.1

Four Analytical routines and the Stock Forecasting and Monitoring routine require a Demand History file as input. This may be created from either

- 1 punched cards or paper tape (see Figure 30), or
- 2 a Stock Master magnetic tape file, if it is desired to reduce key punching and, incidentally transcription errors.

In the latter situation, a 'skeleton' Demand History file is created with data common to both files. It is then necessary to amend the file with additional data before full advantage may be taken of the facilities offered by this file. Chapter 3 describes the program which creates the 'skeleton' Demand History file - see Section 3.4.2.

In the former situation, a record for one item in the Demand History file may be created by cards or paper tape of four codes as follows:

Record Code 1 - Item Details

Item Number: this field must contain the item reference number in alphanumeric form. If the item number is less than the 16 characters shown on the standard punching form, care must be taken to punch one or more preceding zeros so that a correct item number sequence is obtained in Sort routines.

Service Level Group (S.L.G.): punched as 1, 2, 3 or 4, depending on which service level category the item falls (see Section 5.6.11.). The program inserts a value 1 if a quantity outside the range 1 to 4 is specified.

Ordering Interval: selected to give the appropriate average number of periods between orders; maximum value of 27.

Investment Rate Group: punched as a number in the range 0 to 9. This number associates the item with a selected investment rate used in the Performance Estimation and Stock Forecasting and Monitoring routines (see Section 5.6.11.).

Ordering Cost: right-justified with a decimal point punched followed by a zero or decimal fraction. The value shown here should be in terms of the currency unit at the head of the sheet.

Note: Ordering cost is used as a parameter in the economic order quantity formula. If either a blanket ordering cost or no economic ordering is required, this field may be left blank.

System Marker: punched as a number in the range 0 to 9. This field indicates the control system to be applied to this item. If analysis is intended, this field may be left blank. During operational control the selected number must agree with a similar field in the Stock Master file (see Section 3.5.3.).

Forecast Interval: this may be selected by Management, or if analysis is preferred, left blank. It is used to indicate the time interval, in terms of the basic time unit of the system, between each forecast of demand. This applies only to those items included in the adaptive control system.

Factor One: proportional prediction parameter (γ_0) for these 'included' items. This is a numeric field, right-justified with a floating decimal point. Leave blank if value is to be selected by inventory analysis.

Factor Two: cumulative prediction parameter (γ_1): punching format as Factor One. Leave blank if value is to be selected by inventory analysis.

Unit of Measure: alphanumeric field. Must always be identical wherever used in the system. Normally, it indicates the standard measure of the item i.e. feet, dozen, gross, etc.

Deseasonalized Demand Forecast: this field may be left blank if the item is not to be subjected to forecasting or is to be analyzed. However, if the item is to be forecast without pre-analysis, an 'educated guess' should be made as to the likely value initially. This will reduce the initial error in making a forecast before the system settles down. The estimate must relate to selected Forecast Interval.



1900 SCAN system for inventory management

Company name J. SOAP CO. LTD.
 Part Number 0111
 Currency unit £
 Time unit WEEKLY DATA

Demand history record

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40	1	2	3	4	5	6	7	8	9	50	1	2	3	4	5	6	7	8	9	60	1	2	3	4	5	6	7	8	9	70	1	2	3	4	5	6	7	8	9	80
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----

Card code	Item number	S.L.G.	Order Int.	I.R.G.	Ordering Cost	S.M.	Forecast Int.	Factor one	Factor two	Unit of measure	Deseasonalised forecast	Cost price	Sales price	Lead-time	Closing stock	Series length	Cycle base
01		01111	10			01	10	100	00	EACH	267.17101	99202.142		2	96310452		

Card code	Item number	Class code	Loc'n code	Description
02		0111A	115	RTBTS J HAIG

Card code	Item number	No. of previous items	DEMAND HISTORY (Last data item must be followed by field terminator and 999999.)															
03		0000	556	568	600	700	939	1100	1017	858	802	798	750	749	633	600		
03		0145	550	350	280	317	323	350	382	395	400	450	576	600	678	600		
03		0285	93	581	550	450	449	439	420	400	415	421	450	500	509	520		
03		0425	69	450	448	500	514	527	550	552	580	650	675	677	700	800		
03		0567	72	768	750	718	603	596	500	308	237	208	287	300	345	360		
03		0703	75	530	540	550	540	530	540	550	540	409	400	396	380	384		
03		0843	86	376	295	347	244	244	378	244	691	190	200	293	356	388		
03		0982	88	536	588	594	446	806	99999									

Card code	Item number	No. of previous factors	SEASONAL FACTORS (Last factor must be followed by field terminator and 999999.)															
04		0000	1.97	1.99	2.08	2.40	2.74	2.99	2.83	2.52	2.25	2.22	2.00					
04		0111	1.69	1.39	1.44	1.34	1.04	1.00	1.08	1.12	1.41	1.47	1.51					
04		0221	1.50	1.57	1.78	1.84	1.95	1.62	1.59	1.57	1.49	1.34	1.34					
04		0331	1.30	1.15	1.20	1.06	1.07	1.33	1.19	1.92	1.14	1.14	1.19					
04		0441	1.35	1.42	1.29	1.71	1.82	1.83	1.64	2.33	99999							

FORM 14/36/3 (5.67)

© International Computers and Tabulators Limited 1967 Printed in Great Britain

Figure 30 Data Sheet - Demand History File Record

Cost Price and Sales Price: right-justified numeric fields with a floating decimal point (as for ordering cost). The value shown here must be in terms of the currency unit at the head of the sheet.

Lead Time: selected by Management to represent the expected replenishment delivery time. Again, this is a right-justified, floating decimal, numeric field and must be in terms of the basic time unit of the system, i.e. if demand is accumulated in weekly aggregates, the lead time must be in weeks.

Closing Stock: the stock-on-hand balance for that item (this must not be a negative quantity).

Series Length: the number of demand points in the demand history provided (maximum of 104). If no demand points are entered, a single demand point of zero is included on the record by program and the series length is set to 1.

Cycle Base: the time interval between a repeat of the seasonal cycle. If an item is not subject to seasonal influence in its demand pattern, this field must be punched with '1', right-justified. If analysis is to be performed, the field must be left blank (see Record Code 4).

Record Code 2 - Item Supplementary Details

Item Number: as for Record Code 1

Class Code: alphanumeric field, may be left blank if analysis is intended.

Location Code: alphanumeric field intended as reference to stock location i.e. warehouse or store number; may be left blank.

Description: alphanumeric field

Record Code 3 - Demand History Details

Item Number: as for Record Code 1

Number of previous demand points: the number of previous demand points on preceding cards (or paper tape blocks), e.g. 000 as shown for first card. If this first card contained ten demands, then the field in the second Code 3 card would be 010. If this second card also contained ten demands, then the field in the third card would be 020.

Demand History: variable length demand fields separated by a space, and terminated by 999999 following the last demand. Only integer values are allowed.

Record Code 4 - Seasonal Factor Details

As Demand History cards but containing seasonal factors (or Management weighting factors): decimal fractions permitted.

Note: If there are no seasonal factors this card may be omitted. If analysis is to be performed, seasonal factors will be calculated automatically. If they are entered on Record Code 4, the number of factors must equal the number of Forecast Intervals in a year. This number must be present in the cycle base field of Record Code 1.



1900 SCAN system for inventory management

Company name: J. SOAP CO. LTD.

Part numbers: 0111

Currency unit: £

Time unit: WEEKLY DATA

Stock master records

1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40	1	2	3	4	5	6	7	8	9	50	1	2	3	4	5	6	7	8	9	60	1	2	3	4	5	6	7	8	9	70	1	2	3	4	5	6	7	8	9	80
---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---	----

STORES DETAIL CARD

Card code	Item number	Loc'n code	Bin location	Unit of measure	Re-order point	Minimum stock level	Maximum stock level	Re-order quantity	Closing stock	S.M.
0 5	0111115		3721	EACH	2161	100	2000	774	9631	

SUPPLY DETAIL CARD

Card code	Item number	Class code	Supplier code	Lead-time	Cost price	Minimum order qty	Maximum order qty	Stock on order	Unit weight or time	Set-up time	Scrap factor
0 6	0111111	41	2376		201.992	48	0	576	0	0	

SALES DETAIL CARD

Card code	Item number	Disc. code	Sales price	Purchase Tax	Description							Cycle base
0 7	0111170	02	.142	0	97975 5 1114							52

STORES DETAIL CARD

Card code	Item number	Loc'n code	Bin location	Unit of measure	Re-order point	Minimum stock level	Maximum stock level	Re-order quantity	Closing stock	S.M.
0 5										

SUPPLY DETAIL CARD

Card code	Item number	Class code	Supplier code	Lead-time	Cost price	Minimum order qty	Maximum order qty	Stock on order	Unit weight or time	Set-up time	Scrap factor
0 6											

SALES DETAIL CARD

Card code	Item number	Disc. code	Sales price	Purchase tax	Description							Cycle base
0 7												

FORM 14/36/1 (5.87)

© International Computers and Tabulators Limited 1967

Printed in Great Britain

Figure 31 Data Sheet - Stock Master File Records

STOCK MASTER FILE

5.2

To implement the operational routines a Stock Master magnetic tape file must be created. The user may write a conversion program to provide a magnetic tape with the record formats required by SCAN System 1 if a user file already exists. If this course of action is not desired, the Stock Master file may be created directly from punched cards or paper tape using all three of the codes as follows (see Figure 31). All three card codes must be present for each item.

Record Code 5 - Stores Details

Item Number: as for Record Code 1

Location Code: as for Record Code 2

Bin Location: alphanumeric field. Normally used to indicate the actual location reference of stock within the warehouse or store.

Unit of Measure: as for Record Code 1

Re-order Point: the level of stock at which a replenishment order should be issued. In the case of these items selected for variable re-order point control this field is continually updated by the Stock Forecasting and Monitoring program to adjust for variations in demand.

Minimum Stock: a level of stock on hand, set by Management, at or below which a report is generated.

If this field is left blank, zero will be inserted in the corresponding field in the magnetic tape record.

Maximum Stock: a level of stock-on-hand, set by Management, over which a report is generated. If this field is left blank, zeros will be inserted in the corresponding field in the magnetic tape record.

Re-order Quantity: the amount of stock required to be placed on order. In the case of items selected for variable re-order point control this field will be updated by the Stock Forecasting and Monitoring program to adjust for variations in demand.

Closing Stock (on-hand) Balance: as for Record Code 1

System Marker: as for Record Code 1

Record Code 6 - Supply Details

Item Number: as for Record Code 1

Class Code: as for Record Code 2

Supplier Code: alphanumeric field. Normally used for purchase order control routines.

Lead Time: as for Record Code 1

Cost Price: as for Record Code 1

Minimum Order Quantity: the lowest order quantity permitted by the system. May be set at unity or used by Management to ensure that multiples of a given batch size are ordered. If left blank unity will be assumed.

Maximum Order Quantity: the maximum sized order permitted by the system. This may represent a production capacity or transport constraint.

On-order Balance: the stock on order at the time of file creation.

Unit Weight or Time: either the weight of a single stock unit or the time taken to produce a single stock unit.

Set-up Time: the time required to set-up/tear-down a production unit for the given item.

Scrap Factor Percentage: a factor used to increase the replenishment order quantity to account for possible scrap. If left blank, zero will be assumed.

Record Code 7 - Sales Details

Item Number: as for Record Code 1

Discount Code: alphanumeric field for use in user's invoicing procedures.

Sales Price: as for Record Code 1

Purchase Tax: for use in user's invoicing routines.

Description: as for Record Code 2.

Cycle Base: as for Record Code 1.

TRANSACTION FILE

5.3

This file is the entry point to the operational control system and consists of eight different transaction types which, collectively, embrace most of those commonly met in a stock and order processing system. The file may be created directly from punched cards or paper tape as follows:

Audit Request

Columns

- 1 and 2 Record Code 11 - Audit Request
- 3 and 4 Location Code - as for Record Code 2.
- 13 to 20 Document Reference - alphanumeric field used to enter audit authority reference
- 21 to 26 Date - date of audit request (DDMMYY)
- 27 to 42 Item Number - as for Record Code 1
- 43 to 46 Unit of Measure - as for Record Code 1
- 47 to 53 Stock Count - actual physical (on hand) stock balance. May be left blank.

Stock Adjustment

Columns

- 1 and 2 Record Code 12 - Stock Adjustment
- 3 and 4 Location Code - as for Record Code 2
- 13 to 20 Authority Reference - alphanumeric field
- 21 to 26 Date - as for record code 11
- 27 to 42 Item Number - as for record code 1
- 43 to 46 Unit of Measure - as for record code 1
- 47 to 53 Adjustment Quantity - Amount by which stock-on-hand is to be adjusted. The leftmost position is used for the sign: blank positive, minus negative.
- 61 to 68 Cost Code - a reference for accounting purposes

Stock Receipt and Scrap

Columns

- 1 and 2 Record Code 13 - Stock Receipt and Scrap
- 3 and 4 Location Code - as for Record Code 2
- 5 to 12 Supplier or Department Code - as for Record Code 6
- 13 to 20 Order or Batch Number - alphanumeric field used as reference to order placed originally on a supplier
- 21 to 26 Date or Receipt - punched as DDMMYY
- 27 to 42 Item Number - as for Record Code 1
- 43 to 46 Unit of Measure - as for Record Code 1
- 47 to 53 Quantity Good - right-justified numeric field
- 54 to 60 Quantity Scrap - right-justified numeric field
- 61 to 68 Cost Code or GRN - alphanumeric field which may be used as either a reference for accounting purposes or for the goods received note or other document reference.

Returns Outward

Columns

- 1 and 2 Record Code 14 - Returns Outward
- 3 and 4 Location Code - as for Record Code 2
- 5 to 12 Supplier or Source Code - as for Record Code 6
- 13 to 20 Order Number - Alphanumeric field. Normally used as reference to original order placed on supplier.
- 21 to 26 Date of Issue - punched as DDMMYY
- 27 to 42 Item Number - as for Record Code 1
- 43 to 46 Unit of Measure - as for Record Code 1
- 47 to 53 Quantity Returned - right-justified numeric field
- 61 to 68 Advice Note Number - alphanumeric field used as reference if appropriate

Unscheduled Issue

Columns

- 1 and 2 Record Code 15 - Unscheduled Issue
- 3 and 4 Location Code - as for Record Code 2
- 5 to 12 Customer or Department Code - Alphanumeric field. Normally used for invoicing procedures.
- 13 to 20 Internal Order Reference Number - alphanumeric field used as authority for issue
- 21 to 26 Date of Issue - punched as DDMMYY
- 27 to 42 Item Number - as for Record Code 1
- 43 to 46 Unit of Measure - as for Record Code 1
- 47 to 53 Quantity Issued - right-justified numeric field
- 61 to 68 Cost Code - as for Record Code 12

Returns Inward

Columns

- 1 and 2 Record Code 17 - Returns Inward
- 3 and 4 Location Code - as for Record Code 2
- 5 to 12 Customer or Department Code - as for Record Code 15
- 13 to 20 Order Number - or other internal reference
- 21 to 26 Date of Return - punched as DDMMYY
- 27 to 42 Item Number - as for Record Code 1
- 43 to 46 Unit of Measure - as for Record Code 1
- 47 to 53 Quantity - right-justified numeric field. Normally used for credit note procedures.
- 54 to 60 Adjustment - right-justified numeric field. Used to adjust the demand accumulator for the current period. If the 'return' is related to a previous demand period, this field is left blank and adjustment to the appropriate period demand must be effected through the use of file maintenance.
- 61 to 68 Customer Order Number - Alphanumeric field used either as reference for adjustment to a previously allocated demand or as a goods received note reference.

Note If scrap is included in the return it should be recorded on a Stock Adjustment card (Record Code 12) in order to reduce the stock balance.

Replenishment Order Adjustment

Columns

1 and 2	Record Code 19 - Replenishment Order Adjustment
3 and 4	Location Code - as for Record Code 2
5 to 12	Supplier Code - as for Record Code 6.
13 to 20	Order Number - alphanumeric field used to reference original order placed in the supplier.
21 to 26	Date of Order - punched as DDMMYY
27 to 42	Item Number - as for Record Code 1
43 to 46	Unit of Measure - as for Record Code 1
27 to 53	Quantity - amount by which on-order balance is to be adjusted.
69 to 74	Due Date - punched as DDMMYY. Usually refers to the date that receipt of original order was expected.

Note If the user has catered for this transaction in his own Purchase Order Print routine, it will not be necessary to use the above card type.

Demand

Columns

1 and 2	Record Code 21 - Demand
3 and 4	Location Code - as for Record Code 2
5 to 12	Customer Code - alphanumeric user code identifying customer for invoicing etc., procedures.
13 to 20	Internal Order or Batch Reference - alphanumeric field
21 to 26	Date of Demand - punch as DDMMYY
27 to 42	Item Number - as for Record Code 1
43 to 46	Unit of Measure - as for Record Code 1
47 to 53	Quantity - amount of demand
61 to 68	Customer Order Number - alphanumeric customer reference
69 to 74	Date Required - punched as DDMMYY and refers to delivery date (due date).
75 and 76	Priority Code - numeric field used to arrange demands for the same item in a particular sequence so that allocation of available physical stock to a particular customer is given priority over the remaining demands.

Batch Control Record - Optional record

Columns

1 and 2	Record code '99' - batch control
3 to 12	Blank
13 to 20	Batch Number
21 to 26	Date
27 to 36	Blank
37 to 42	Sum of Transactions Codes in batch
43 to 46	Number of Transactions in batch
47 to 53	Sum of Quantity - 1 field
54 to 60	Sum of Quantity - 2 fields

Note: Any of these fields may be left blank except columns 21 to 26, 37 to 42.

End of Run Record

Columns

1 to 4 '****' This record must be inserted at the back of the transaction pack.

PAPER TAPE FORMATS

5.4

Paper tape formats for the Demand History, Stock Master and Transaction File records must be identical to the corresponding card formats, with the addition that a Newline character must be punched at the position which would be occupied by column 81 on each card.

In addition to creating three magnetic tape files by using the Master File Create/Maintenance and Transaction File Create routines, the system itself will create a further five magnetic tape files. The file formats for all eight magnetic tapes are given below.

All magnetic tapes defined in the system contain:

- Header label
- Qualifier block
- Data blocks
- Trailer label

Multi-reel files are permitted.

Demand History File 'STATISTICAL'

5.5.1

Record length from 63 to 217 words

Block length 1 record (minimum); 4 records (maximum),

The first data block contains 88 words:

Word	Field Content	Comments
0	88	Record length
1 to 4	0	
5 to 24	I.C.T. 1900 SCAN system Run on dd/mm/yy with fortnightly demand data	Note: 'Fortnightly' may be 'Weekly' or 'Monthly' at user's choice – located in word 18 (character 3), 19, 20, 21 (characters 0, 1)
25	52	Numbers of time periods in year (could be 12 or 13)
26	£ (for example)	Currency unit
27 to 87		Field type location table for use in file maintenance

Subsequent records contain fields in the following sequence:

Field	Words	Type	Word Number
S Record length	1	Integer	0
C Item Number	4	Character	1 to 4
XC Class Code (e.g. A1)	1	Character	5
C Description	8	Character	6 to 13
C Location Code	1	Character	14
C Unit of Measure	1	Character	15
C Cost Price (C_p)	2	Decimal (24.24)	16 and 17
C Sales Price	2	Decimal (24.24)	18 and 19
Order Cost (C_o)	2	Decimal (24.24)	20 and 21
OC Lead Time (L)	2	Decimal (24.24)	22 and 23
Average demand (\bar{y})	2	Decimal (24.24)	24 and 25
Standard deviation of demand (σ_y)	2	Decimal (24.24)	26 and 27
Deseasonalized demand forecast (\hat{X}_T)	2	Decimal (24.24)	28 and 29

	<i>Field</i>	<i>Words</i>	<i>Type</i>	<i>Word number</i>
	Cumulative sum of errors (Σe)	2	Decimal (24.24)	30 and 31
	Standard deviation of errors (σ_e)	2	Decimal (24.24)	32 and 33
	Smoothed forecast errors (\hat{e}_T)	2	Decimal (24.24)	34 and 35
S	Mean absolute deviation of errors (\hat{d}_T)	2	Decimal (24.24)	36 and 37
XC	Closing Stock Balance (S_T)	1	Integer	38
S	Service Level Group	1	Integer	39
	Ordering Interval (W)	1	Integer	40
	Investment Rate Group	1	Integer	41
XC	System Marker	1	Character	42
	OPPR Inclusion Marker	1	Integer	43
S	Demand history length (series length) (N)	1	Integer	44
	Forecast Interval (T)	1	Integer	45
	Forecast Interval Count	1	Integer	46
S	Cycle Base (seasonal length) (M)	1	Integer	47
	Cycle Base count	1	Integer	48
	Factor One (γ_0)	1	Decimal (8.16)	49
	Factor Two (γ_1)	1	Decimal (8.16)	50
	Spare	10		51 to 60
S	Cycle (seasonal) factors (s)	1 to 52	Decimal (16.8)	61 to 112
S	Demand History (y)	1 to 104	Integer	113 to 216
	Total	63 to 217 words		

Note: Spare words are reserved for I.C.T. use.

Field types designated e.g. (24.24) refer to the bit position of the binary point of the number. The position of the demand history series is variable depending on the number of seasonal factors present.

When using X42B, fields marked with S are set by X42B; fields marked with C are copied from the Stock Master file.

When using forecasting, fields marked X are copied across from the Stock Master file and are used in the forecast run. The field marked O is used from Stock Master file but is not copied across.

Stock Master File 'STOCK MASTER'

5.5.2

Record length 64 words

Block length 2 or 4 records (see note 5)

The first data block contains 91 words:

Word	Field Content	Comments
0	91	Record length
1 to 4	0	
5 to 24	I.C.T. 1900 SCAN system Run on dd/mm/yy with fortnightly demand data	Note: 'Fortnightly' may be 'Weekly' or 'Monthly' at user's choice - located in words 18 (character 3), 19, 20, 21 (characters 0, 1).
25	52	Number of time periods in year
26	£	Currency unit
27 to 90		Field type location table for use in File Maintenance

Subsequent records contain fields in the following sequence:

Field	Words	Type	Word Number
Record length	1	Integer	0
Item Number	4	Character	1 to 4
Class Code (e.g. A1)	1	Character	5
Description	8	Character	6 to 13
Location Code	1	Character	14
Unit of Measure	1	Character	15
Cost Price (C_p)	2	Decimal (24.24)	16 and 17
Sales Price	2	Decimal (24.24)	18 and 19
Purchase Tax	2	Decimal (24.24)	20 and 21
Lead Time (L)	2	Decimal (24.24)	22 and 23
Unit weight or time	2	Decimal (24.24)	24 and 25
Set-up time	1	Decimal (16.8)	26
Discount Code	1	Character	27
Supplier Code	2	Character	28 and 29
Minimum Order Quantity (R_M)	1	Integer	30
Maximum Order Quantity (R_{MAX})	1	Integer	31
Scrap Factor %	1	Integer	32
Spare	4		33 to 36
Bin Location	2	Character	37 and 38
System Marker	1	Character	39
Re-order Point (P_T)	1	Integer	40
Minimum stock level (S_{MIN})	1	Integer	41
Maximum stock level (S_{MAX})	1	Integer	42
Re-order Quantity (R_T)	1	Integer	43
X Cycle Base (seasonal length) (M)	1	Integer	44
Stock on hand Balance ($C(t')$)	1	Integer	45
Forward Demand Balance	1	Integer	46

<i>Field</i>	<i>Words</i>	<i>Type</i>	<i>Word Number</i>
Back-order Balance ($U(t')$)	1	Integer	47
Stock on Order Balance ($O(t')$)	1	Integer	48
Period Demand accumulator	1	Integer	49
Cumulative Receipts to date (ΣD)	2	Integer	50 and 51
Cumulative Scrap to date	2	Integer	52 and 53
Cumulative Demands to date (Σy)	2	Integer	54 and 55
Cumulative Back-orders to date	2	Integer	56 and 57
Receipts count	1	Integer	58
Back-orders count	1	Integer	59
Non-move count	1	Integer	60
Ordering Interval count	1	Integer	61
Spare	2		62 and 63
Total	64	words	

Notes

- 1 The record may be expanded to a maximum of 128 words if the user writes his own Stock Master create program.
All I.C.T. SCAN system programs which update this file will transfer extra words to the output file without amendment. The user will make his own arrangements for file amendment of the extra data beyond word 63. Spare words in the above format are reserved for future I.C.T. use.
- 2 If the user writes his own create program the first 64 words must be in the format shown above.
- 3 During forecasting the field marked X is overwritten from the Statistical file.
- 4 If the record is expanded by user data, forecasting can only be carried out using the forecast program X42V. This program requires a 16K processor.
- 5 All programs which process the Stock Master file produce 128 word blocks if switch 16 is set, and 256 word blocks otherwise.

Transaction File 'TRANSACTIONS'

5.5.3

Record length 50 words

Block length 5 records

All transactions will have a common record format including certain records created during the Stock Updating and Allocation routines, intended to recirculate back into the system.

The basic record format is as follows:

<i>Field</i>	<i>Words</i>	<i>Type</i>	<i>Word Number</i>	<i>Source</i>
Record length	1	Integer	0	FC
Transaction Code	1	Integer	1	FC/SU
Item Number	4	Character	2 to 5	FC
Class Code (e.g. A1)	1	Character	6	SMR
Description	8	Character	7 to 14	SMR
Location Code	1	Character	15	FC
Unit of Measure	1	Character	16	FC
Cost Price	2	Decimal (24.24)	17 and 18	SMR
Sales Price	2	Decimal (24.24)	19 and 20	SMR
*Purchase Tax	2	Decimal (24.24)	21 and 22	SMR
*Discount Code	1	Character	23	SMR
*Customer/Supplier Code	2	Character	24 and 25	FC
*Bin Location	2	Character	26 and 27	SMR
*1st Document Reference	2	Character	28 and 29	FC
Transaction date	2	Character (00YYMMDD)	30 and 31	FC
Quantity 1	1	Integer	32	FC
Quantity 2	1	Integer	33	FC/SU
*2nd Document Reference	2	Character	34 and 35	FC
Date Required	2	Character (00YYMMDD)	36 and 37	FC
Priority	1	Character	38	FC
Spare	3		39 to 41	
System Marker/Cycle Indicator	1	Character	42	SMR
Spare	7			
Total	50			

Note: Source key refers to media from which field is obtained.

FC = File Create stage,

SU = Stock Updating routine,

SMR = Stock Master record.

Certain fields marked '*' are not used by the I.C.T. SCAN System but will be transferred untouched to the appropriate entry points for other commercial routines.

1st Document Reference contains data transferred from input card columns 13 to 20.

2nd Document Reference contains data transferred from input card columns 61 to 68.

Quantity 1 contains data transferred from input card columns 47 to 53 and Quantity 2, data from columns 54 to 60.

During stock updating, Quantity 1 and Quantity 2 fields may be altered. (See Chapter 3.)

Replenishment Order Requisition Records
(created during the Stock Updating and Allocation program)

<i>Field</i>	<i>Words</i>	<i>Type</i>	<i>Word Number</i>
Record length	1	Integer	0
Transaction Code	1	Integer	1
Item Number	4	Character	2 to 5
Class Code	1	Character	6
Description	8	Character	7 to 14
Location Code	1	Character	15
Unit of Measure	1	Character	16
Cost Price	2	Decimal (24.24)	17 and 18
Lead Time	2	Decimal (24.24)	19 and 20
Spare	3		21 to 23
Supplier Code	2	Character	24 and 25
Bin Location	2	Character	26 and 27
Spare	2		28 and 29
Date (order generated)	2	Character (00YYMMDD)	30 and 31
Re-order Quantity	1	Integer	32
Spare	3		33 to 35
Due Date	2	Character (00YYMMDD)	36 and 37
Spare	12		38 to 49
	Total	50 words	

Under Minimum/Over Maximum Records
(created during the Stock Updating and Allocation program)

<i>Field</i>	<i>Words</i>	<i>Type</i>	<i>Word Number</i>
Record length	1	Integer	0
Transaction Code	1	Integer	1
Item Number	4	Character	2 to 5
Class Code	1	Character	6
Description	8	Character	7 to 14
Location Code	1	Character	15
Unit of Measure	1	Character	16
Cost Price	2	Decimal (24.24)	17 and 18
Lead Time	2	Decimal (24.24)	19 and 20
Spare	3		21 to 23
Supplier Code	2	Character	24 and 25
Spare	4		26 to 29
Date generated	2	Character (00YYMMDD)	30 and 31
Maximum/Minimum Stock Level	1	Integer	32
Free Stock (Available Stock minus Forward Demand)	1	Integer	33

<i>Field</i>	<i>Words</i>	<i>Type</i>	<i>Word Number</i>
Spare	4		34 to 37
Stock on hand	1	Integer	38
Forward Demand Balance	1	Integer	39
Unallocated Demand Balance	1	Integer	40
Stock on Order Balance	1	Integer	41
System Marker/Cycle Indicator	1	Integer	42
Spare	7		43 to 49
	<hr/>		
Total	50		

Profile Results File 'PROFILE PRSLT'

5.5.4

Created initially by the Stock Profile Analysis routine

Record length 28 words

Block length 9 records

Data Records: (except last)

<i>Field</i>	<i>Words</i>	<i>Type</i>	<i>Word Number</i>
Record length	1	Integer	0
Item Number	4	Character	1 to 4
Class Code	1	Character	5
Description	8	Character	6 to 13
Location Code	1	Character	14
Unit of Measure	1	Character	15
Series Length	1	Integer	16
Forecast Interval	1	Integer	17
Annual Demand	2	Integer	18 and 19
Annual Sales	2	Integer	20 and 21
Closing Stock Balance	2	Integer	22 and 23
Stock Value	2	Integer	24 and 25
Gross Annual Margin	2	Integer	26 and 27
	Total		28 words

Last Data Record

<i>Field</i>	<i>Words</i>	<i>Type</i>	<i>Word Number</i>
Record length	1	Integer	0
Spare (contains zeros)	14		1 to 14
Currency	1	Character	15
Item count	1	Integer	16
Spare (contains zeros)	3		17 to 19
Total annual sales	2	Integer	20 and 21
Spare (contains zeros)	2		22 and 23
Total stock value	2	Integer	24 and 25
Total gross margin	2	Integer	26 and 27
	Total		28 words

The last data record contains accumulated totals as a result of processing during the Stock Profile Analysis; subsequent use of this file will place this record in the first data record position.

Composite File 'COMPOSITE ∇∇∇ '

5.5.5

(output from the Stock Updating and Allocation routine)

This file contains various record types as a result of processing - all identical to the Transaction File record formats, where applicable, or created during the Stock Updating and Allocation routine.

These record types are progressively extracted from the Composite File, during the next two routines, to form the following output files intended as entry points to user routines.

<i>Replenishment Order Requisition File 'REPLENFILE ∇∇'</i>	}	from the Allocation Report routine
<i>Allocated Demands File 'ALLOCFILE ∇∇∇'</i>		
<i>Priced Receipts File 'RECEIPTSFILE'</i>	}	from the Under Minimum/Over Maximum routine
<i>Over Maximum Stock Level File 'OVERMAXFILE ∇'</i>		

The balance of the Composite file is recirculated back into the system with Unallocated Demand (back-order), Forward Demand, and Audit records (if present).

Note: The Audit records may be extracted from the Recirculating File in a user Audit Report routine.

All programs referred to in this manual require one or more parameter records with the exception of:

- #X42C Magnetic Tape Creation routine - Transaction File
- #X42G Optimal Prediction Parameter routine
- #X42L Allocation Report routine
- #X42P Under Minimum/Over Maximum List routine

Run Parameter Record

5.6.1

Used in the Master File Creation/Maintenance routine - program #X42A.

This record must contain at least four fields, each terminated by a comma. The first and second fields give the input file names and the third and fourth fields the output file names.

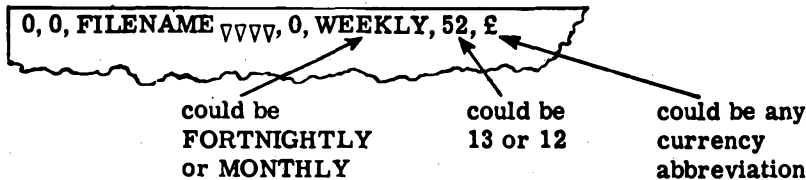
File names must be twelve characters long but, if any file is not present, (when there is only one input file, for example) the appropriate field must contain a single zero. It should be noted that, for the file creation function, additional parameter fields will be punched immediately following the four file name fields. The following are the file descriptions for the different functions:

Magnetic tape creation	0, 0, FILENAME _{vvvv} , 0,
Merge	FILENAME _{vvvv} , FILENAME _{vvvv} , FILENAME _{vvvv} , 0,
Insert	} FILENAME _{vvvv} , 0, FILENAME _{vvvv} , 0,
Amend	
Delete	
Extract	FILENAME _{vvvv} , 0, FILENAME _{vvvv} , FILENAME _{vvvv} ,

Note: FILENAME_{vvvv} is either
 STATISTICAL_v for the Demand History file, or
 STOCK_vMASTER for the Stock Master file.

The following additional fields must be punched on the Run Parameter record for the CREATE function:

- basic time unit of data e.g. WEEKLY, or MONTHLY etc. (maximum 11 characters).
- number of time intervals in a year e.g. 52 or 13 or 12 (maximum 2 characters)
- currency unit literal e.g. £, \$, DM, FR etc. (maximum 4 characters).



Field Type Table Records

5.6.2

Used in Master file creation/Maintenance routine - program #X42A, 'CREATE' function only - and are placed behind the Run Parameter Record - see Section 5.6.1.

Also used in the Skeleton History File Generate routine - program #X42B - if NO input Demand History file is present. In this case, no Run Parameter record is required.

The format is fixed for I.C.T. SCAN System 1 and for the appropriate master file must be punched exactly as illustrated. Their purpose is to indicate the size and type of field for file maintenance purposes and the table is held on the first data block on each master file - see Sections 5.5.1 and 5.5.2.

Used in the Master File Creation/Maintenance routine - program #X42A for the functions: INSERT, AMEND, DELETE and EXTRACT. In any one run only one of these functions may be used for a particular item record, but they may all be used in the same run. The functions may be applied to either the Stock Master file, or the Demand History file, but not both in the one run.

The Function records indicate the action to be taken: a set of function records, in Item Number sequence, follow the Run Parameter record defined in Section 5.6.1.

Each Function record must refer to only one of the four functions listed above, and to only one item record in the master file. The Function record may consist of one or more cards (or 80-character paper tape blocks). Every card (or block) must contain the function code in columns 1 and 2 and the item number in columns 3 to 18. Spare columns at the end of each card must be left blank: spare positions at the end of a paper tape block may be omitted if the Newline character is punched immediately after the last significant character in the block; this latter character will be a blank, a comma, or an asterisk, depending upon the circumstances.

The function codes are as follows:

Insert	Code 31
Amend	Code 32
Delete	Code 33
Extract	Code 34

INSERT Function Record (Code 31)

1	2	3	18
'31'		Item Number	

Each Insert Function record must be followed by a set of data cards - either card codes 1 to 4 for the Demand History file (see Section 5.1) or card codes 5 to 7 for the Stock Master file (see Section 5.2). Each set of amendment records must be followed by a record containing the number 99 punched in the first two positions.

AMEND Function Record (Code 32)

A Function record type 32 allows any word in a record in the master file to be amended (except Record Length and Item Number). Each Amend Function record contains all the amendments to be made to a particular item record in that run. The punching format depends upon the data format in the master file (integer, character or binary fraction) and the position in the item record of the field to be amended - see Section 5.5.1 (Demand History file) and Section 5.5.2 (Stock Master file).

The word number in the file format is used to identify the field to be amended: usually this is the word number of the first (most significant) word of a multi-word field, but there are certain exceptions to this and these are discussed below. The word number reference for the first amendment specified in an Amend Function record is punched in columns 19 to 21 of the first (or only) card of the record. Other amendments relating to the same item record may be punched in the same card and additional cards may be used if necessary. All the cards comprising the Function record must be punched with the Function Code and the Item Number (columns 1 to 18) and a word number reference must always be punched in columns 19 to 21.

The word number reference is always a three digit field and non-significant zeros must be punched.

Integer Fields: the full amendment facility is only available for one word integer fields. In this case, the word reference is punched as described above and is immediately followed by the new value and then a comma. The whole of this data must be contained within one record. The new value may consist only of the decimal digits 0 to 9; non significant zeroes need not be punched and a zero value may be punched as a single zero.

In the case of two word integer fields, the field can be modified by referencing each word separately. This will usually mean, however, that modification is restricted to zeroizing the field unless the new value to be entered can be completely contained in the least significant word.

Character Fields: if the whole of a character field is to be amended, the word number reference must be that of the first word of the field. However, an amendment may start at character position 0 of any word of the field and the start word address is the word number reference of the first word to be amended. The amendment must always extend to character position 3 of the last (least significant) word of the field and must, therefore, always contain an integer multiple of four characters.

Some single word character fields do not use all four character positions in the word. These fields are right justified at the time of file creation and if any is to be amended, the 'new' value must contain blank characters in the unused positions to the left of the significant characters. The System Marker field is the exception to this rule - the new value in an amendment to this field must be zero filled in character positions 0, 1 and 2.

The amendment to a character field must be punched as a continuous field:

Word number reference New value Comma

and the whole of this contained within one card. The full 1900 printable character set and the blank are permitted characters as far as the Amendment routine is concerned, but other routines may impose restrictions, e.g. the Class Code may contain only two characters of which the first is restricted to one of the three characters: A, B, or C and the second is restricted to one of the three digits: 1, 2, or 3.

The Item Number field may not be amended by means of the Amend function. If this field is incorrect, the item record must be deleted and a correctly referenced item record inserted.

Decimal Fields: the word number reference must always be that of the most significant word of the field. If the new value has a zero decimal fraction, it may be punched as an integer without the decimal point, with the decimal point or with the decimal point and one following zero, i.e. 15.0 may be punched as 15 15. or 15.0 but the recommended form is 15.0 since this will make it easier to check the punching document prepared by the control clerk for the Parameter records.

Similarly, a zero value may be punched in any of the above forms, but 0.0 is the one preferred.

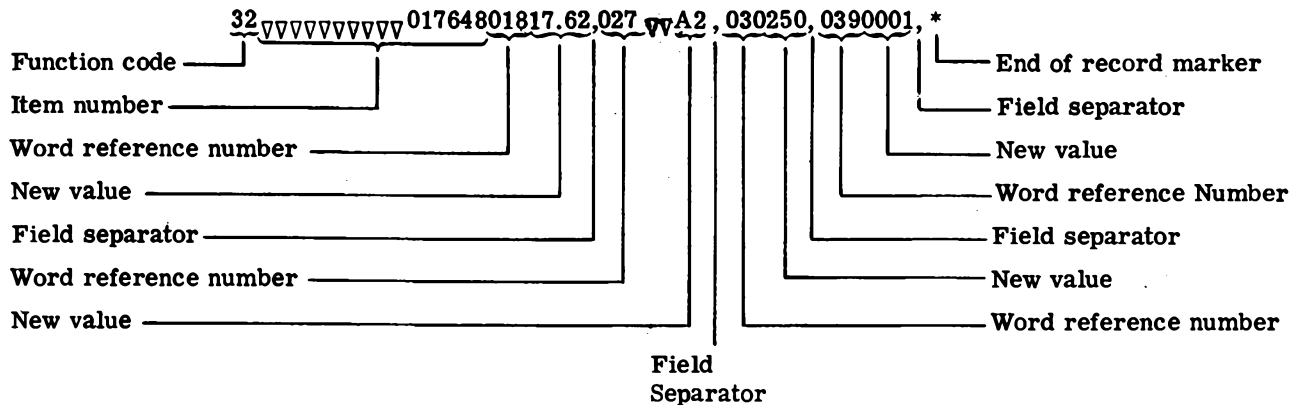
In all other cases the decimal point and at least one following digit must be punched.

Amendment to a decimal field must be punched:

Word number reference New value Comma

as a continuous field contained within the one card.

The following example will illustrate the method of amending the types of field discussed so far. Amendments to seasonal factors and demand history points in the Demand History file require special treatment and these are considered subsequently.



The above amendment will change:

- Sales price (word 18) to 17.62
- Discount code (word 27) to A2
- Minimum order quantity (word 30) to 250
- System marker (word 39) to 1

in the record for Item Number 17648 in the Stock Master file.

Seasonal Factors (Demand History file only) - extreme care must be exercised on the rare occasions when the seasonal factors require manual amendment. This should never be attempted without the Item record in question being first printed, using Master File Record List routine (see Section 3.4.3).

It cannot be assumed that the seasonal factor array in the item record represents the same time span for every item - the current period's seasonal factor will be found at position (Cycle Base Count + 1) in the printed array and in word (61 + Cycle Base Count) in the item record.

If the Forecast Interval is greater than '1' it is also necessary to look at (Forecast Interval Count + 1) to check how much of the current period remains before the seasonal factors can be pegged to the calendar.

It should also be remembered that the number of seasonal factors must equal the Cycle Base and that this, in turn, must equal the length of the year divided by the Forecast Interval. The length of the year is specified in the first block on the Demand History file - see Section 5.5.1.

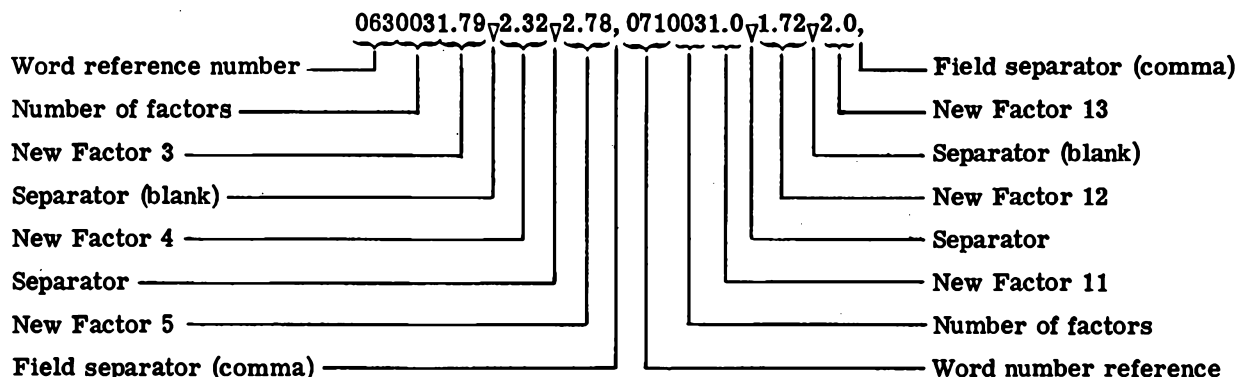
The seasonal factors are expressed as ratios in such a way that the smallest non-zero factor is unity - see Equation 16, Appendix A. Any amendment to the seasonal factors must not destroy this relationship.

The three cases considered below will probably cover most of the situations that are likely to arise in practice. They are:

- 1 The amendment to a few seasonal factors
- 2 The replacement of the complete array of seasonal factors.
- 3 The insertion of a complete array of seasonal factors into the record of an item previously treated as non-seasonal

Note that file amendment is required only when manually calculated seasonal factors are to be inserted into the record or amended. The automatic recalculation of seasonal factors can be performed by use of the Optimal Prediction Parameter routine (described in Section 3.5.5).

- 1 The factors requiring amendment must first be identified in the seasonal factor array in the manner already discussed. The following example assumes that Factors 3, 4 and 5 and 11, 12 and 13 require amendment. The corresponding amendment field in the Amend Function record should be punched as follows:



The seasonal factor array starts in word 61 of the item record. Thus, seasonal Factors 3, 4, and 5 will be stored in words 63, 64 and 65, whilst words 71, 72 and 73 will hold Factors 11, 12 and 13.

It will be noted that each group of new factors is considered as a separate amendment field terminating in a comma. The first three digits give the word number reference as before, the next three digits the number of factors to be amended by that field, followed immediately by the first of the new values. All of the new values, except the last, is followed by a blank: the last factor in the group is followed by a comma.

A group of factors may overrun from one card to the next provided that the first factor in the group is not separated from the opening six digits of reference data and that the last factor on the first card is followed by at least one blank. The word number reference of the first factor in the second card must be punched in columns 19 to 21 and followed immediately by the new value of that factor.

- 2 To exemplify the replacement of a complete array of seasonal factors it is assumed that there are 13 factors to be inserted and that they have been calculated so that the first of the new array refers to the current period. The word number reference of the current period is always (Cycle Base Count + 61), e.g. if the Cycle Base Count were '7', the word number reference of the current period, would be 68. The opening six digits of the amendment field would then be 068013 to indicate

that 13 new factors are to be inserted starting in word 68 in the record. The insertion of the new factors is 'circular' such that the sixth new factor will be inserted in word 73 (Factor 13 of the array) and the seventh factor in word 61 (Factor 1 of the array).

The punching format is otherwise as for case (1).

- 3 To change an item from non-seasonal to seasonal, the Cycle Base must be amended from unity to the correct value (equal to the number of factors to be inserted). The Cycle Base Count is always zero for a non-seasonal item, but in case of error in the record it should always be zeroized in this circumstance. If the new factors are arrayed as for case (2) the word number reference is then 061. Otherwise the punching format is the same as for case (2).

Demand History Points (Demand History file only) - irrespective of the number of seasonal factors present in the record, the word number reference of the first demand point is always 113. If some demand points are to be amended, the punching format is the same as for seasonal case (1). If the complete demand history is to be changed (an unlikely amendment) seasonal case (2) punching format applies, but note that any change in the number of demand points must be matched with a corresponding change in the Demand History Length in word 44 of the item record. Revised demand data must be entered in integer form.

Note that the number of demand points in the record may vary from item to item and it is essential that a record list print of the item record be obtained before amendment of the demand history is attempted. The last demand point of the array always refers to the time interval between the last two forecasting runs. The demand since the last forecasting run is only to be found in word 49 of the Stock Master file. Note also that each demand point in each item record is the demand in the system's minimum forecasting interval: it is not dependent on the forecast interval of the item.

General Comment: Each field in the Amend Function record is concerned with the amendment to a single field in the item record in the master file, except in the case of amendments to seasonal factors and demand history in the Demand History file, when the amendment is concerned with a contiguous group of items. Every amendment field in the function record starts with a three digit word number reference and ends with a comma. The first field in each card starts with its word number reference in columns 19 to 21. If more than one card is required for one amendment record, the break from one card to the next must follow a comma or a blank (array amendments only).

The word number references within a single amendment record must be in ascending sequence.

The final comma in the record must be followed immediately by an asterisk. This latter must be on the same card as the last amendment field or the last new value of an array amendment.

DELETE Function Record (Code 33)

1	2	3	18	
'33'		Item Number		

If duplicate records occur on a main file, either of them may be deleted at the User's choice. To delete the first record, the standard deletion function is used. To delete the second record, the amendment function is used on the first record, any field of which may be "amended" to its existing value (for example, if the cost price is 1.5, amend to 1.5). This is followed by a deletion function.

EXTRACT Function Record (Code 34)

1	2	3	18	
'34'		Item Number		

Item Selection Record

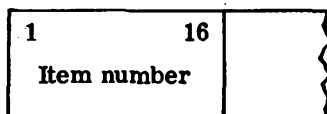
5.6.4

Used for the Master File Record List routine - program #X42S.

Each item record that is required to be listed is matched from the appropriate Master file with the item number held on the Item Selection record.

These records must be in the same sequence as the master file.

The item number must be punched exactly as the item number held on the Master file record.



The last card contains **** in columns 1 to 4. (A Newline character separates each item number in paper tape.)

Note: One punched card (or paper tape block) is required for each item record to be listed.

Stock Profile Analysis Parameter Record

5.6.5

Used in the Stock Profile Analysis routine - program #X42D

Four parameters are required for this record:

Columns 1 and 2 Selective listing, e.g.

if 04, all items with a forecast interval of 1, 2 and 4 will be listed.

Column 3 Frequency table

If value = 0, Frequency table and four unit totals will be output on printer.

If value = 1, Stock Profile list only will be printed (in conjunction with selective listing above)

Column 4 Profile Results

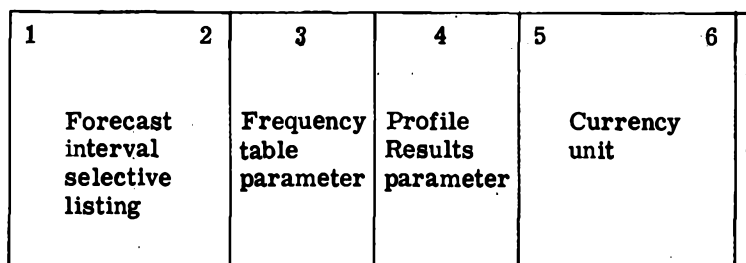
If value = 0, Profile Results magnetic tape file is suppressed.

If value = 1, Profile Results file output.

Columns 5 and 6 Currency Unit

Used as literal for printer output, e.g.

∇£ or FR etc.



SORT(Input to ABC Analysis)

5.6.6

The Profile Results magnetic tape file output from the Stock Profile Analysis Routine - program #X42D - may be sorted in one of several different sequences depending upon Management use of the ABC Analysis.

If the ABC classification is to be performed, the only permissible sequence is descending sales value.

Parameters for #XSMC Magnetic Tape Sort

Card		Field		Paper Tape	
No.	Columns	Name	Contents	Block	Position
1	1 to 4	Identity	SORT	1	1 to 4 N/L
1	5 to 10	Current date	ddmmyy	2	1 to 6 N/L
1	11	Card number	1	-	
1	12 to 23	File name	PROFILE▽RSLT	3	1 to 12 N/L
1	24 to 29	Input tape { Reel sequence number	000000	4	1 to 6 N/L
1	30	File Generation Number check Indicator	1	5	1 N/L
1	31 to 37	File Generation Number	EEEEEEE	6	1 to 7 N/L
1	38 to 49	File name	PROFILE▽RSLT	8 *	1 to 12 N/L
1	50 to 55	Output file { Reel sequence Number	000000	9	1 to 6 N/L
1	56 to 58	Maximum block length	256	10	1 to 3 N/L
1	59	Number of Tape decks	3 or 4	7 *	1 N/L
1	60 to 80		Ignored		
2	1 to 4	Identity	SORT	-	
2	5 to 10	Current date	ddmmyy	-	
2	11	Card number	2	-	
2	12 to 23	Input tape { File name	PROFILE▽RSLT	-	
2	24 to 29	Reel sequence number	000000	-	
2	30	Number of keys	1	11	1 N/L
For sort in descending order of ANNUAL SALES VALUE continue:					
2	31	Key type	2	12	1 N/L
2	32	Direction of sequencing	1	13	1 N/L
2	33 to 35	Key position	020	14	1 to 3 N/L
2	36 to 38	Key length	000	15	1 to 3 N/L
2	39 to 80		Ignored	-	
OR, for sort in descending order of STOCK VALUE continue:					
2	31	Key type	2	12	1 N/L
2	32	Direction of sequencing	1	13	1 N/L
2	33 to 35	Key position	024	14	1 to 3 N/L
2	36 to 38	Key length	000	15	1 to 3 N/L
2	39 to 80		Ignored	-	
OR, for sort in descending order of GROSS ANNUAL MARGIN VALUE continue:					
2	31	Key type	2	12	1 N/L
2	32	Direction of sequencing	1	13	1 N/L
2	33 to 35	Key position	026	14	1 to 3 N/L
2	36 to 38	Key length	000	15	1 to 3 N/L
2	39 to 80		Ignored	-	
OR, for sort in ascending order of CLASS CODE continue:					
2	31	Key type	0	12	1 N/L
2	32	Direction of sequencing	0	13	1 N/L
2	33 to 35	Key position	020	14	1 to 3 N/L
2	36 to 38	Key length	004	15	1 to 3 N/L
2	39 to 80		Ignored	-	
OR, for sort in ascending order of ITEM NUMBER continue:					
2	31	Key type	0	12	1 N/L
2	32	Direction of sequencing	0	13	1 N/L
2	33 to 35	Key position	004	14	1 to 3 N/L
2	36 to 38	Key length	016	15	1 to 3 N/L
2	39 to 80		Ignored	-	

* Note block number sequence

ABC Analysis Parameter Record

5.6.7

Used in the ABC Analysis routine - program #X42Q.

Six parameters are required for this record:

1 COLUMN 1 PRINT OPTION

- 1 = fast movers only
- 2 = medium movers only
- 3 = slow movers only
- A = high value items only
- B = medium value items only
- C = low value items only
- L = complete list of all items
- T = preliminary analysis table only

2 COLUMN 2 SEQUENCE INDICATOR

- 0 = descending sequence of sales value
- 1 = descending sequence of stock value
- 2 = descending sequence of gross margin
- 3 = ascending sequence of class code
- 4 = ascending sequence of item number

3 COLUMNS 3 and 4 CLASS 'A' LIMIT

Two-digit number representing percentage of Total Sales up to which items will be classified as high value 'A' items.

Note: If the value = 0, no ABC classification will be performed and Parameter 1 must be set to 'T'.

This, with the appropriate file sequence setting, will then produce a Preliminary Analysis table.

4 COLUMNS 5 and 6 CLASS 'B' LIMIT

Two-digit number representing percentage of total sales up to which items will be classified as medium value - from the 'A' limit.

Note: If the value is set equal to the 'A' limit no 'B' classes will be produced and the classification will be high and low value items only, i.e. 'A' and 'C'.

5 COLUMN 7 OUTPUT FILE CONTROL

0 = no Profile Results magnetic tape file required as output

1 = Profile Results file required, containing the ABC classification.

6 COLUMNS 8 and 9 MEDIUM MOVER LIMIT

Two-digit number used to specify the boundary between medium and slow moving items in terms of the forecast interval, e.g. 04 means that medium movers will include those items with a forecast interval of 2 and 4. Slow movers would have a forecast interval greater than 4.

1	2	3	4	5	6	7	8	9
Print option	File sequence indicator	Class 'A' limit		Class 'B' limit		Output file control	Medium mover limit	

SORT (Input to Control System Selection Routine)

5.6.8

The Profile Results magnetic tape file output from the ABC Analysis routine - program #X42Q - must be sorted to the same sequence as the Stock Master file used as input to the Control System Selection routine - program #X42R. Normally, the Stock Master file is in ascending item number sequence.

The sort parameter format is identical to that illustrated in Section 5.6.6 but uses the ascending item number sequence only.

Control System Selection Parameter Record

5.6.9

Used in the Control System Selection routine - program #X42R

- 1 The first nine columns (positions) must be used to allocate system markers to each item classification.
- 2 The numbers may be selected from the list given in Section 3.5.3.
- 3 Some, or all, of the numbers may be identical i.e. the same control systems may be applied to more than one classification.
- 4 Blanks are valid in the appropriate position if it is known that a particular classification has been suppressed, e.g. no 'B' items.

1	2	3	4	5	6	7	8	9
A1 marker	A2 marker	A3 marker	B1 marker	B2 marker	B3 marker	C1 marker	C2 marker	C3 marker

e.g. the A1 marker is set by punching a number in the range 0 to 9 in column 1.

Used in Demand Analysis routine (#X42F) and consisting of one card/paper tape block containing:

- 1 Limit of forecast interval, columns 1 and 2. The value of this parameter decides which items will be processed and output. Recommended values are 1, 2 or 4, assuming weekly demand data:
 - 1 for all items to be forecast weekly,
 - 2 for all items to be forecast fortnightly,
 - 4 for all items to be forecast monthly.

If set to zero, all items except those which are static (i.e. no movements in history provided) will be processed.

- 2 Confidence limit for significance test, columns 3 to 6. The value of this parameter will represent the upper level of confidence to be applied to the single tail normal distribution test. The factor to be inserted for any desired level may be read from Appendix B.
- 3 List format parameter, column 7.
 - 1 = full print
 - 0 = abbreviated print
 } (See Section 3.5.4)
- 4 Processing parameter for Optimal Prediction Parameter routine, column 8.
 - 1 = all items will be processed in O.P.P.R.
 - 0 = only items selected by this program will be processed in O.P.P.R. (See Section 3.5.4).

1.	2	3	6	7	8	
Limit of Forecast interval		Confidence limit		List format	Processing parameter	

- 5 Newline character, character position 9 (paper tape only).

Performance Estimation Parameter Record

5.6.11

Used in System Performance Estimation routine (#X42H) and consisting of three cards/paper tape blocks as follows:

Card		Field		Paper Tape	
No.	Columns	Name	Contents	Block	Position
1	1 to 4	Currency unit, e.g. pounds sterling or francs. See Note (1).	e.g. ∇∇∇£ or FRCS	1	1 to 4
1	5 to 9	Cost of placing an order (C_o) in terms of above currency unit. See Note (2).	e.g. ∇1.25	1	5 to 9
1	10 to 13	Investment rate percentage (I_r). See Notes (3) and (9).	e.g. 15.0 or ∇∇15 or 0015	1	10 to 13
1	14 and 15	Preferred ordering interval (W). See Note (4).	e.g. ∇6 or 06	1	14 and 15
1	16	List selection parameter. See Note (5).	0 = list required 1 = no list required	1	16
1	17 and 18	Limit of forecast interval. See Note (6).	e.g. ∇4 or 04	1	17 and 18 N/L
2	1 to 4	Service level percentage corresponding to Service Level Group 1. See Note (7).	e.g. 90.0 or ∇∇90	2	1 to 4
2	5 to 8	Service level factor, Group 1. See Note (8).	e.g. 1.28	2	5 to 8
2	9 to 12	Service level percentage, Group 2.	as columns 1 to 4	2	9 to 12
2	13 to 16	Service level factor, Group 2.	as columns 5 to 8	2	13 to 16
2	17 to 20	Service level percentage, Group 3.	as columns 1 to 4	2	17 to 20
2	21 to 24	Service level factor, Group 3.	as columns 5 to 8	2	21 to 24
2	25 to 28	Service level percentage, Group 4	as columns 1 to 4	2	25 to 28
2	29 to 32	Service level factor, Group 4	as columns 5 to 8	2	29 to 32 N/L
3	1 to 4	Investment rate percentage (I_r) corresponding to Investment Rate Group 1. See Note (9).	e.g. 15.0 or ∇∇15 or 0015	3	1 to 4
3	5 to 8	Ditto, Group 2.	ditto	3	5 to 8
3	9 to 12	Ditto, Group 3	ditto	3	9 to 12
3	13 to 16	Ditto, Group 4	ditto	3	13 to 16
3	17 to 20	Ditto, Group 5	ditto	3	17 to 20
3	21 to 24	Ditto, Group 6	ditto	3	21 to 24
3	25 to 28	Ditto, Group 7	ditto	3	25 to 28
3	29 to 32	Ditto, Group 8	ditto	3	29 to 32
3	33 to 36	Ditto, Group 9	ditto	3	33 to 36
3	37 to 40	Ditto, Group 0	ditto	3	37 to 40 N/L

				1				4					5				8	9	Parameter Card 3.																			
				Investment Rate for IRG '1' e.g. 15.0 = 15%				Investment Rate for IRG '2'				ETC.																										
				1				4	5				8	9	12			13			16	17	Parameter Card 2															
				Service Level 1				Factor 1				Service Level 2				Factor 2				ETC.																		
1				4					5					9				10				13			14			15			16			17			18	Parameter Card 1
Currency Unit				Cost of Ordering				Investment rate				Preferred Ordering interval				List parameter				Forecast interval																		

Notes: These notes must be read in conjunction with the description of the System Performance Estimation routine - see Section 3.5.6. References to the Demand History file are to the input magnetic tape file to this program - format as Section 5.5.1.

- 1 *Currency Unit*: all money values throughout the SCAN system must be in terms of this unit which must agree with word 26 of the first data record of the Demand History file.
- 2 *Cost of placing an order*: a non-zero value for this parameter overrides the Ordering Cost in words 20 to 21 of the individual item records in the Demand History file. If both fields are zero, the calculation of Economic Order Quantity is omitted for that item. If the value of this parameter includes a decimal fraction, the decimal point and at least one following digit must be punched.
- 3 *Investment rate percentage*: a non-zero value of this parameter overrides parameter card/paper tape block - see Note (9) below. The comment on punching format in Note (2) applies here also. The % symbol must not be punched.
- 4 *Preferred ordering interval*: a non-zero value for this parameter overrides the equivalent value in word 40 of the individual item records of the Demand History file. This parameter must be punched as an unsigned integer of value not greater than 27.
- 5 *List selection parameter*: used to suppress the item listing (Figure 18) from the System Performance Estimation routine. Summary Table 1 (Figure 19) is always produced by this program. Summary Table 2 (Figure 20) may be suppressed if Parameter Card 3 is effective - see Note (9) below.
- 6 *Limit of forecast interval*: the System Performance Estimation routine ignores all items with a forecast interval greater than that specified by this parameter. A value of zero includes all items, although those with zero demand history will contribute only to Actual Stock value in Summary Table 2.
- 7 *Service level percentage*: each item in the Demand History file may be classified into one of four groups, the group number being specified in Word 39 of the item record. A different service level percentage may be specified for each group by means of Parameter Card 2. The value of this parameter is the percentage of the total number of replenishment deliveries which, it is required, will be delivered before demand overruns the physical stock. The comment on punching format in Note (2) applies here also.
- 8 *Service level factor*: the factor taken from Appendix B and corresponding to the service level percentage chosen for that group. The decimal point and at least one following digit must always be punched. The fields in this parameter card which correspond to groups not present in the Demand History file may be omitted.
- 9 *Investment rate percentage*: each item in the Demand History file may be classified into one of ten Investment Rate Groups (IRG's) the group number being specified in Word 41 of the item record. Parameter Card 3 specifies the investment rate to be applied to the items in each group in the calculation of economic order quantities. This card should be omitted, if the investment rate percentage in Parameter Card 1 is non-zero. If Parameter Card 3 is included, the fields corresponding to unused Investment Rate Groups may be left blank (punched with blanks in the case of paper tape except that the block may end with a Newline character following the last significant field). IRG '0' may conveniently be reserved for items for which economic order quantities are not to be used. Zero, or blank fields in columns 10 to 13 of Parameter Card 1 and in columns 37 to 40 of Card 3 will achieve this if non-zero values are given to the other IRG's used in the Demand History file. The comment on punching format in Note (2) applies here.

SORT(Transaction File)

5.6.12

The Transaction magnetic tape file, output from the Transaction File Creation routine - program #X42C - must be sorted, normally by:

- Item number
- Transaction code
- Due date
- Priority sequence

The sort parameter format for the above sequence is as follows:

Parameters for #XSMC Magnetic Tape Sort

Card		Field		Paper Tape	
No.	Columns	Name	Contents	Block	Position
1	1 to 4	Identifier	SORT	1	1 to 4 N/L
1	5 to 10	Current date	ddmmyy	2	1 to 6 N/L
1	11	Card number	1		
1	12 to 23	Input File name	TRANSACTIONS	3	1 to 12 N/L
1	24 to 29	Input Reel sequence number	000000	4	1 to 6 N/L
1	30	F.G.N. check indicator	1	5	1 N/L
1	31 to 37	Input F.G.N.	ggggggg	6	1 to 7 N/L
1	38 to 49	Output File name	TRANSACTIONS	8 *	1 to 12 N/L
1	50 to 55	Output Reel sequence number	000000	9	1 to 6 N/L
1	56 to 58	Maximum block size	256	10	1 to 3 N/L
1	59	Number of tape decks	3 or 4	7 *	1 N/L
1	60 to 68		Ignored	-	
2	1 to 4	Identifier	SORT	-	
2	5 to 10	Current date	ddmmyy	-	
2	11	Card number	2	-	
2	12 to 23	Input File name	TRANSACTIONS	-	
2	24 to 29	Input Reel Sequence number	000000	-	
2	30	Number of Keys	4	11	1 N/L
2	31	Key type	0	12	1 N/L
2	32	Direction of sequencing	0	13	1 N/L
2	33 to 35	Position of key	008	14	1 to 3 N/L
2	36 to 38	Length of key (chs)	016	15	1 to 3 N/L
2	39	Key type	1	16	1 N/L
2	40	Direction of sequencing	0	17	1 N/L
2	41 to 43	Position of key	001	18	1 to 3 N/L
2	44 to 46	Length of key (chs)	VVV	19	1 to 3 N/L
2	47	Key type	0	20	1 N/L
2	48	Direction of sequencing	0	21	1 N/L
2	49 to 51	Position of key	144	22	1 to 3 N/L
2	52 to 54	Length of key (chs)	008	23	1 to 3 N/L
2	55	Key type	0	24	1 N/L
2	56	Direction of sequencing	1	25	1 N/L
2	57 to 59	Position of key	152	26	1 to 3 N/L
2	60 to 62	Length of key (chs)	004	27	1 to 3 N/L

* Note block number sequence.

MERGE (Transactions)

5.6.13

The Sorted Transaction magnetic tape file, output from #XSMC, must normally be merged with a recirculating Composite file in the same record format, prior to its use as input to the Stock Updating and Allocation routine.

The merge parameter format is as follows:

Parameters for #XSMM Tape Merge

Card		Field		Paper Tape	
No.	Columns	Name	Contents	Block	Position
1	1 to 4	Output file	Identity	XSMC	1 1 to 4
1	5 to 10		Current date	ddmmyy	1 5 to 10
1	11		Card type number	1	-
1	12		Number of input files	2	1 11
1	13 to 24		File name	TRANSACTIONS	1 12 to 23
1	25 to 30		Reel sequence number	000000	1 24 to 29
1	31 to 37		Generation number	ggggggg	1 30 to 36
1	38 to 43		Retention period	000100	1 37 to 42
1	44 to 46		Maximum block size	256	1 43 to 45 N/L
1	47 to 80			Blanks	-
2	1 to 4	For 1st key	Identity	XSMC	-
2	5 to 10		Current date	ddmmyy	-
2	11		Card type number	2	-
2	12		Number of keys	4	2 1
2	13		Key type	0	2 2
2	14		Direction of sequencing	0	2 3
2	15 to 18		Key Position	0008	2 4 to 7
2	19 to 21		Key length	016	2 8 to 10
2	22		Key type	0	2 11
2	23		Direction of sequencing	0	2 12
2	24 to 27		Key position	0004	2 13 to 16
2	28 to 30		Key length	004	2 17 to 19
2	31		Key type	0	2 20
2	32		Direction of sequencing	0	2 21
2	33 to 36		Key position	0144	2 22 to 25
2	37 to 39		Key length	008	2 26 to 28
2	40		Key type	0	2 29
2	41		Direction of sequencing	0	2 30
2	42 to 45		Key position	0152	2 31 to 34
2	46 to 48		Key length	004	2 35 to 37 N/L
2	49 to 80		Blank	-	
3	1 to 4	First input file	Identity	XSMC	-
3	5 to 10		Current date	ddmmyy	-
3	11		Card type number	3	-
3	12		File Generation Number check indicator	1	3 1
3	13 to 24		File name	COMPOSITEvvv	3 2 to 13
3	25 to 30		File reel sequence number	000000	3 14 to 19
3	31 to 37		File Generation number	ggggggg	3 20 to 26 N/L
3	38 to 80			Blank	-
4	1 to 4	Second input file	Identity	XSMC	-
4	5 to 10		Current date	ddmmyy	-
4	11		Card type number	3	-
4	12		File Generation Number check indicator	1	4 1
4	13 to 24		File name	TRANSACTIONS	4 2 to 13
4	25 to 30		File reel sequence number	000000	4 14 to 19
4	31 to 37		File Generation number	ggggggg	4 20 to 26 N/L
4	38 to 80			Blank	-

Stock Updating Parameter Record

5.6.14

Used in the Stock Updating and Allocation routine - program #X42J

This record consists of four parameters, each expressing a Management option as follows:

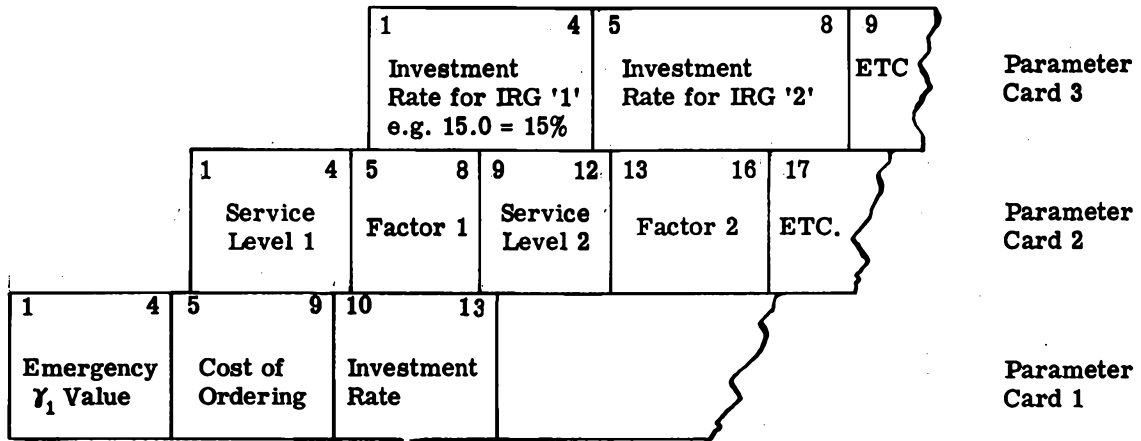
	<i>Value</i>	
Column 1	1	Part allocation allowed
	0	No part allocation
Column 2	1	Cyclical ordering required
	0	Cyclical ordering not required
Column 3	1	Supplementary ordering required (omit Transaction file input)
	0	Normal stock updating
Columns 4 to 6	'n'	Time interval, where 'n' is the number of days from current date - see Section 3.6.3.

Forecast Parameter Record

5.6.15

Used in Stock Forecasting and Monitoring routine (#X42K) and consisting of three cards/paper tape blocks as follows:

<i>Card</i>		<i>Field</i>		<i>Paper Tape</i>	
<i>No.</i>	<i>Columns</i>	<i>Name</i>	<i>Contents</i>	<i>Block</i>	<i>Position</i>
1	1 to 4	Emergency γ_1 value	e.g. 0.30 or $\surd 0.3$	1	1 to 4
1	5 to 9	Cost of placing an order (C_0) in terms of currency unit contained on the Master file. See Note (2).	e.g. $\surd 1.25$	1	5 to 9
1	10 to 13	Investment rate percentage (I_r). See Notes (3) and (6).	e.g. 15.0 or $\surd \surd 15$ or 0015	1	10 to 13 N/L
2	1 to 4	Service level percentage corresponding to Service Level Group 1. See Note (4).	e.g. 90.0 or $\surd \surd 90$	2	1 to 4
2	5 to 8	Service level factor, Group 1. See Note (5).	e.g. 1.28	2	5 to 8
2	9 to 12	Service level percentage, Group 2	as columns 1 to 4	2	9 to 12
2	13 to 16	Service level factor, Group 2	as columns 5 to 8	2	13 to 16
2	17 to 20	Service level percentage, Group 3	as columns 1 to 4	2	17 to 20
2	21 to 24	Service level factor, Group 3	as columns 5 to 8	2	21 to 24
2	25 to 28	Service level percentage, Group 4	as columns 1 to 4	2	25 to 28
2	29 to 32	Service level factor, Group 4	as columns 5 to 8	2	29 to 32 N/L
3	1 to 4	Investment rate percentage (I_r) corresponding to Investment Rate Group 1. See Note (6).	e.g. 15.0 or $\surd \surd 15$ or 0015	3	1 to 4
3	5 to 8	Ditto, Group 2	ditto	3	5 to 8
3	9 to 12	Ditto, Group 3	ditto	3	9 to 12
3	13 to 16	Ditto, Group 4	ditto	3	13 to 16
3	17 to 20	Ditto, Group 5	ditto	3	17 to 20
3	21 to 24	Ditto, Group 6	ditto	3	21 to 24
3	25 to 28	Ditto, Group 7	ditto	3	25 to 28
3	29 to 32	Ditto, Group 8	ditto	3	29 to 32
3	33 to 36	Ditto, Group 9	ditto	3	33 to 36
3	37 to 40	Ditto, Group 0	ditto	3	37 to 40 N/L



Notes: These notes must be read in conjunction with the description of the Stock Forecasting and Monitoring routine - see Section 3.6.6. References to the Demand History file are to the input magnetic tape file to this program-format as Section 5.5.1.

- 1 *Emergency γ_1 value:* this is the value of the Box Jenkins cumulative control parameter which is used if an out of control situation develops for an item which has a zero file value of γ_1 .
- 2 *Cost of placing an order:* a non-zero value for this parameter overrides the Ordering Cost in words 20 and 21 of the individual item records in the Demand History file. If both fields are zero, the calculation of Economic Order Quantity is omitted for that item. If the value of this parameter includes a decimal fraction, the decimal point and at least one following digit must be punched.
- 3 *Investment rate percentage:* a non-zero value of this parameter overrides parameter card/paper tape block 3 - see Note (6) below. The comment on punching format in Note (2) applies here also. The % symbol must not be punched.
- 4 *Service level percentage:* each item in the Demand History file may be classified into one of four groups, the group number being specified in Word 39 of the item record. A different service level percentage may be specified for each group by means of Parameter Card 2. The value of this parameter is the percentage of the total number of replenishment deliveries which, it is required, will be delivered before demand overruns the physical stock. The comment on punching format in Note (2) applies here also.
- 5 *Service level factor:* the factor taken from Appendix B and corresponding to the service level percentage chosen for that group. The decimal point and at least one following digit must always be punched. The fields in this parameter card which correspond to groups not present in the Demand History file may be omitted.
- 6 *Investment rate percentage:* each item in the Demand History file may be classified into one of ten Investment Rate Groups (IRG's) the group number being specified in Word 41 of the item record. Parameter Card 3 specifies the investment rate to be applied to the items in each group in the calculation of economic order quantities. This card should be omitted, if the investment rate percentage in Parameter Card 1 is non-zero. If Parameter Card 3 is included, the fields corresponding to unused Investment Rate Groups may be left blank (punched with blanks in the case of paper tape, except that the block may end with a Newline character following the last significant field) IRG '0' may conveniently be reserved for items for which economic order quantities are not to be used. Zero, or blank fields in columns 10 to 13 of Parameter Card 1 and in columns 37 to 40 of Card 3 will achieve this if non-zero values are given to the other IRG's used in the Demand History file. The comment on punching format in Note (2) applies here.

Chapter 6 Operating Procedures

This chapter gives the key specification details and run instructions for all of the programs in the I.C.T. SCAN System 1, except for the Simulator which is dealt with separately in Chapters 7 to 9.

Note that all programs assume the use of standard 11-inch printer stationery.

MASTER FILE CREATION/MAINTENANCE ROUTINE

6.1

This routine incorporates six separate functions, namely:

- CREATE master file
- MERGE part files
- INSERT records
- AMEND fields
- DELETE records
- EXTRACT records

The CREATE and MERGE functions must each be used alone in separate runs. INSERT, AMEND, DELETE and EXTRACT may be used together in one run, but only one function may be used for each item to be processed.

Only one master file format may be handled in one run. Reference should be made to Chapter 5 for details of formats, as follows:

- Section 5.1 Data record - Demand History file - used in CREATE and INSERT functions.
- Section 5.2 Data record - Stock Master file - used in CREATE and INSERT functions.
- Section 5.5.1 Demand History magnetic tape file - used in all functions.
- Section 5.5.2 Stock Master magnetic tape file - used in all functions.
- Section 5.6.1 Run Parameter record - used in all functions.
- Section 5.6.2 Field Type Table record - used in CREATE function.
- Section 5.6.3 Function record - used in INSERT (Code 31), AMEND (Code 32), DELETE (Code 33) and EXTRACT (Code 34) functions.

To avoid needless repetition, punched input data are described as being in punched cards, but in all cases punched paper tape may be used as an alternative input medium (the choice is under operator control): a paper tape block then replaces each punched card.

Program #X42A

Priority 70

Hardware Requirement 5,632 words of core store
 1 line printer (120 print positions)
 1 card/paper tape reader
 1 magnetic tape unit

Use of Peripherals All peripherals are allotted by program

Description See Section 3.4.1.

Input

- 1 Run Parameter record: one punched card
- 2 Field Type Table record: two punched cards
- 3 Data records: a set of punched cards for each item to be written to the output magnetic tape file.

Run Terminator Final card with '****' in columns 1 to 4

Output

- 1 Magnetic tape file: either Demand History (name 'STATISTICAL') or Stock Master (name 'STOCKMASTER')
 Relative deck address: 2
 File generation number: 1
- 2 List of input records - see Figure 6.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load one scratch tape.	
2 Load program #X42A.	
3 Load Run Parameter record, Field Type Table record, Data records and Run Terminator card on input peripheral.	
4 Start program by typing for paper tape input: for punched card input:	GO #X42A 20 GO #X42A 21
5 At end of run the program will halt and type:	0#X42A HALTED EN

Exception Conditions See Section 6.18.

<i>Program</i>	#X42A
<i>Priority</i>	70
<i>Hardware Requirement</i>	5,632 words of core store 1 card/paper tape reader 3 magnetic tape units
<i>Use of Peripherals</i>	All peripherals are allotted by program. Card/paper tape reader used, initially, to input Run Parameter record and released immediately.
<i>Description</i>	See Section 3.4.1.
<i>Input</i>	<ol style="list-style-type: none"> 1 Run Parameter record 2 Two magnetic tape master files in which no item record is duplicated in the other file: either two Demand History files (names 'STATISTICAL∇') or two Stock Master files (names 'STOCK∇MASTER') <p>Relative deck addresses: 0, 1 File generation numbers: various Note: Input files must be in ascending sequence of Item Number.</p>
<i>Output</i>	<ol style="list-style-type: none"> 1 One magnetic tape master file (same name, format and sequence as input files) containing all records from two input files <p>Relative deck address: 2 File generation number: greater of input F.G.N. + 1</p>

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load one scratch tape.	
2 Load program #X42A.	
3 Load two input tapes (both Demand History, or both Stock Master files).	
4 Load Run Parameter record on input peripheral.	
5 If the input file generation numbers are to be checked, alter word 5 to the F.G.N. of the input file on relative deck address 0 by typing: (where n = input F.G.N.)	AL #X42A 5 n
6 If the input file generation numbers are to be checked, alter word 6 to the F.G.N. of the input file on relative deck address 1 by typing: (where n = input F.G.N.)	AL #X42A 6 n
7 Start program by typing for paper tape input: for punched card input:	GO #X42A 20 GO #X42A 21
8 At end of run the program will halt and type:	0#X42A HALTED EN

Exception Conditions

See Section 6.18.

<i>Program</i>	#X42A
<i>Priority</i>	70
<i>Hardware Requirement</i>	5,632 words of core store 1 line printer (120 print positions) 1 card/paper tape reader 2 magnetic tape units - unless EXTRACT function present in run, when 3 magnetic tape units are required.
<i>Use of Peripherals</i>	All peripherals are allotted by program.
<i>Description</i>	See Section 3.4.1.
<i>Input</i>	<ol style="list-style-type: none"> 1 Run Parameter record 2 INSERT items: Function record (Code 31) Set of Data records Card punched with '99' in columns 1 and 2. 3 AMEND items: Function record (Code 32) 4 DELETE items: Function record (Code 33) 5 EXTRACT items: Function record (Code 34) <p>Note: Items to be in ascending sequence of Item Number.</p> <ol style="list-style-type: none"> 6 For all items: Master magnetic tape file: either Demand History file (name 'STATISTICAL∇'), or Stock Master file (name 'STOCK∇MASTER') Relative deck address: 0 File generation number: various Sequence: ascending Item Number
<i>Run Terminator</i>	Final card with '*****' in columns 1 to 4
<i>Output</i>	<ol style="list-style-type: none"> 1 One master magnetic tape file (same name, format and sequence as input file) containing all items except EXTRACTED and DELETED items. Relative deck address: 2 File generation number: input F.G.N. + 1 2 A second master magnetic tape file (same name, format and sequence as input file) containing all EXTRACTED items. Relative deck address: 3 File generation number: input F.G.N. + 2 Note: this file will not be opened if no Code '34' Function records are present in the run. 3 List for record - see Figure 7.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load one scratch tape.	
2 Load second scratch tape if EXTRACT function present.	
3 Load program #X42A.	
4 Load input data tape (either Demand History, or Stock Master file).	
5 Load Run parameter record, Function and Data records and Run Terminator card on input peripheral.	
6 If the input file generation number is to be checked, alter word 5 to the F.G.N. of the input file on relative deck address 0 by typing: (where n = input F.G.N.)	AL #X42A 5 n
7 Start program by typing for paper tape input: for punched card input:	GO #X42A 20 GO #X42A 21
8 At end of run the program will halt and type:	0#X42A HALTED EN
<i>Exception Conditions</i>	See Section 6.18.

Program #X42B

Priority 70

Hardware Requirement 2,752 words of core store
 1 card/paper tape reader
 2 or 3 magnetic tape units.

Use of Peripherals All peripherals are allotted by program. Card/paper tape reader used, initially, to input parameters and released immediately.

Description See Section 3.4.2.

Input

- 1 Stock Master magnetic tape file (name: 'STOCKMASTER') - see Section 5.5.2.
 Relative deck address: 0
- 2 Demand History Magnetic tape file (name: 'STATISTICAL') - see Section 5.5.1.
 Relative deck address: 1
 Note: This is an optional input file.
- 3 Field Type Table records: two punched cards or paper tape blocks - see Section 5.6.2.
 Note: Only required if NO input Demand History file present.

Output

- 1 Demand History magnetic tape file (name: 'STATISTICAL').
 Relative deck address: 2
 Generation number: as input Stock Master file unless input Demand History present, when F.G.N. = input Demand History F.G.N. + 1.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load one scratch tape	
2 Load program #X42B	
3 Load one or two input tapes	
Stock Master file - mandatory	
Demand History file - optional, see Section 3.4.2	
4 Load Field Type Table records on card or paper tape reader if NO input Demand History file present.	
5 If NO input Demand History file present, alter word 30 to octal 4000 by typing:	AL #X42B 30 #4000 (or ON #X42B 12)
6 If the input Stock Master file generation number is to be checked, alter word 5 to the F.G.N. of the input file on relative deck address 0 by typing: (where n = input F.G.N.)	AL #X42B 5 n

<i>Narrative</i>	<i>Console Message</i>
7 If the input Demand History file generation number is to be checked, alter word 6 to the F.G.N. of the input file on relative deck address 1 by typing: (where n = input F.G.N.)	AL #X42B 6 n
8 Start program by typing for paper tape input: for punched card input:	GO #X42B 20 GO #X42B 21
9 At the end of run the program will halt and type:	0#X42B HALTED EN
<i>Exception Conditions</i>	See Section 6.15.

Program **#X42S**

Priority 70

Hardware Requirement 4,032 words of core store
 1 line printer (120 print positions)
 1 card/paper tape reader
 1 magnetic tape unit

Use of Peripherals All peripherals are allotted by program

Description See Section 3.4.3.

Input

- 1 Either
 - Stock Master magnetic tape file (name: 'STOCKMASTER') - see Section 5.5.2.
 - Relative deck address: 0, or
 - Demand History magnetic tape file (name: 'STATISTICAL') - see Section 5.5.1.
 - Relative deck address: 0
- 2 Item Selection records: one, or more, punched cards or paper tape blocks - see Section 5.6.4.

Output 1 Master File Record list - see Figures 8 and 9.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load program #X42S	
2 Load one input tape (either Stock Master or Demand History file)	
3 Load Item Selection records on card or paper tape reader. If the complete main file is to be listed without using Item selection records, type:	ON #X42S17
4 Start program by typing	
for paper tape input:	GO #X42S 20
for punched card input:	GO #X42S 21
5 The program signifies correct CR or TR allocation by typing:	0 #X42S HALTED 01
6 If the input file generation number is to be checked alter word 5 to the F.G.N. of the input file on relative deck address 0 by typing: (where n = input F.G.N.)	AL #X42S 5n
7 Select correct input Master file by typing	
for Demand History file:	GO #X42S 22
for Stock Master file:	GO #X42S 23
8 At the end of run the program will halt and type:	0 #X42S HALTED EN

Exception Conditions See Section 6.18.

Narrative

- 8 At the end of run the program will halt and type:

Exception Conditions

Console Message

0 #X42D HALTED END OF STOCK PROFILE ANALYSIS

See Section 6.18.

Program **#XSMC**

Priority 50

Hardware Requirement 5,056 words of core store
 3 or 4 magnetic tape units
 1 card/paper tape reader

Use of Peripherals All peripherals are allotted by program. Card/paper tape reader used, initially, to input sort parameters and released immediately.

Description See Sections 3.5.2, and 5.6.6.

Input 1 Profile Results magnetic tape file, output from #X42D, (name: 'PROFILEγRSLT') - see Section 5.5.4.
 2 SORT Parameter record - see Section 5.6.6. for format.

Output 1 Sorted Profile Results magnetic tape file (name: 'PROFILEγRSLT').
 Generation number: see SORT parameters.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load #XSMC.	
2 Load input magnetic tape without write permit ring.	
3 Load n - 1 scratch tapes (where n = total number of tape decks specified).	
4 Load sort parameter records on card or paper tape reader.	
5 Start program by typing for paper tape input:	GO #XSMC 21
for punched card input:	GO #XSMC 20
6 Program will halt and type:	0 #XSMC REMOVE INPUT REEL FROM UNIT XX
7 Replace input reel with a scratch tape.	
8 After continuing, program will, at end of run, type:	0 #XSMC END OF SORT, FINAL O/P REEL ON UNIT YY
9 The program will delete itself.	

Note: For a full description see I.C.T. 1900 series Library Specifications for Magnetic Tape. Any amendments to the standard software will, of course, affect the appropriate sections of this manual, including core store requirements.

Program **#X42Q**

Priority 70

Hardware Requirement 5,440 words of core store
 1 line printer (120 print positions)
 1 card/paper tape reader
 2 magnetic tape units.

Use of Peripherals All peripherals are allotted by program. Card/paper tape reader used, initially to input parameters and released immediately.

Description See Section 3.5.2.

Input

- 1 Sorted Profile Results magnetic tape file (name: 'PROFILE ∇ RSLT') - see Section 5.5.4 sorted to a sequence indicated in Section 3.5.2, and originally output from #X42D.
 File number: 1
- 2 ABC Analysis Parameter record: one punched card or paper tape block - see Section 5.6.7.

Output

- 1 Profile Results magnetic tape file (name: 'PROFILE ∇ RSLT').
 File number: 2
 Generation number: as specified
- 2 ABC Analysis List - see figure 11.
- 3 ABC Analysis Summary table - see figure 12.
- 4 Preliminary Analysis table - see figure 13.

Note: The Output Profile Results file and the above reports are optional and may be suppressed by input parameter - see Section 5.6.7.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load one scratch tape (optional)	
2 Load program #X42Q	
3 Load input tape (Profile Result File)	
4 If the magnetic tape file generation number checks are to be omitted:	ON #X42Q 0
5 If the number of lines per page is to be other than 60:	ON #X42Q 2
6 Start program by typing:	
for paper tape parameter	GO #X42Q 20
for card parameter	GO #X42Q 21
7 If switch 2 was set on the program halts:	HALTED COBOL ACCEPT (SEE JOB SHEET) nnnnn 1
8 Alter word 0 to the number of lines (<i>nn</i>) of print required per page and restart program	AL #X42Q 0 <i>nn</i> GO #X43Q

<i>Narrative</i>	<i>Console Message</i>
9	HALTED:-LOAD FILE ⁽⁰³⁾ ₍₀₄₎ ON unit no.
10 Load parameters on unit indicated and restart program.	GO #X42Q
11	HALTED:- LOAD FILE 00 ON unit no.
12 Set up stationery and restart program.	GO #X42Q
13 If switch 0 was set messages 14 to 17 will be suppressed and zero generation numbers will be assumed.	
14	HALTED SET FILE 01 GENERATION NO. IN WORD 0
15 Alter word 0 to the input Profile Results generation number (<i>n</i>) and restart program.	AL #X42Q 0 <i>n</i> GO #X42Q
16	HALTED SET FILE 02 GENERATION NO. IN WORD 0
17 If required, alter word 0 to the output Profile Results generation number (<i>n</i>) and restart program.	AL #X42Q 0 <i>n</i> GO #X42Q
18 At end of run the program halts:	HALTED END OF RUN
<i>Exception Conditions</i>	See Section 6.18

<i>Program</i>	#XSMC
<i>Priority</i>	50
<i>Hardware Requirement</i>	As Section 6.5.
<i>Use of Peripherals</i>	As Section 6.5.
<i>Description</i>	See Sections 3.5.3, and 5.6.8
<i>Input</i>	Profile Results magnetic tape file, output from #X42Q (name: 'PROFILE ∇ RSLT') - see Section 5.5.4. SORT Parameter record - see Section 5.6.7. for format.
<i>Output</i>	As Section 6.5.
<i>Run Instructions</i>	As Section 6.5.

<i>Program</i>	#X42R
<i>Priority</i>	70
<i>Hardware Requirement</i>	5,312 words of core store 1 line printer (120 print positions) 1 card/paper tape reader 3 magnetic tape units
<i>Use of Peripherals</i>	All peripherals are allotted by program. Card/paper tape reader used, initially, to input parameter and released immediately.
<i>Description</i>	See Section 3.5.3.
<i>Input</i>	1 Stock Master magnetic tape file (name: 'STOCK▽MASTER') - see Section 5.5.2. File number: 1 2 Sorted Profile Results magnetic tape file, format as described in Section 5.5.4, output from #X42Q and sorted (name: 'PROFILE▽RSLT') - see Section 6.7. File number: 2 3 Control System Selection Parameter record: one punched card or paper tape block - see Section 5.6.9.
<i>Output</i>	1 Stock Master magnetic tape file (name: 'STOCK▽MASTER'). File number: 3(128 Word Blocks) or 4 (256 Word Blocks) Generation number: as specified 2 Inventory list - see figure 14. Note: The list is optional and may be suppressed by console switch.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load scratch tape	
2 Load program X42R	
3 Load input tapes (Stock Master and Profile Results files).	
4 If magnetic tape file generation number checks are to be omitted:	ON #X42R 0
5 If the number of lines per page is to be other than 60:	ON #X42R 2
6 If Output Stock Master file is to have short blocks:	ON #X42R 16
7 If reports of unmatched records are not required:	ON #X42R 22
8 If the inventory list is not required:	ON #X42R 23
9 Start program by typing:	
for paper tape parameter	GO #X42R 20
for card parameter	GO #X42R 21

<i>Narrative</i>	<i>Console Message</i>
10 If switch 2 was set on the program will halt:	HALTED:- COBOL ACCEPT (SEE JOB SHEET) nnnnnn 1
11 Alter word 0 to the number of lines (<i>nn</i>) of print required per page add restart program.	AL #X42R 0 <i>nn</i> GO #X42R
12	HALTED:- LOAD FILE $\left\{ \begin{matrix} 05 \\ 06 \end{matrix} \right\}$ ON unit no.
13 Load parameters on unit indicated and restart program.	GO #X42R
14	HALTED:- LOAD FILE 00 ON unit no.
15 Set up stationery and restart program.	GO #X42R
16 If switch 0 was set messages 17 to 22 will be suppressed and zero generation numbers assumed.	
17	HALTED SET FILE 01 GENERATION NO. IN WORD 0
18 Alter word 0 to the input Stock Master file generation number (<i>n</i>) and restart program.	AL #X42R 0 <i>n</i> GO #X42R
19	HALTED SET FILE 02 GENERATION NO. IN WORD 0
20 Alter word 0 to the input Profile Results file generation number (<i>n</i>) and restart program.	AL #X42R 0 <i>n</i> GO #X42R
21 If required, alter word 0 to the output Stock Master file generation number (<i>n</i>) and restart program.	HALTED SET FILE $\left\{ \begin{matrix} 03 \\ 04 \end{matrix} \right\}$ GEN. NO. IN WORD 0 AL #X42R 0 <i>n</i> GO #X42R
22 At end of run, the program will halt:	HALTED:- END OF RUN.
<i>Exception Conditions</i>	See Section 6.18

<i>Program</i>	#X42F
<i>Priority</i>	50
<i>Hardware Requirement</i>	5,612 words of core store 1 line printer (120 print positions) 1 card/paper tape reader 2 magnetic tape decks Floating point facilities (hardware, or extracode)
<i>Use of Peripherals</i>	All peripherals are allotted by program. Card/paper tape reader used, initially, to input parameters and then released immediately.
<i>Description</i>	See section 3.5.4.
<i>Input</i>	1 Demand History magnetic tape file (name: 'STATISTICAL γ ') - see Section 5.5.1. Relative deck address: 0 2 Demand Analysis Parameter record: one punched card/paper tape block - see Section 5.6.10.
<i>Output</i>	1 Updated Demand History magnetic tape file (name: 'STATISTICAL γ ') Relative deck address: 1 Generation number: Input F.G.N. + 1 2 Full Demand Analysis list - see Figure 15 - or Abridged Demand Analysis list - see Figure 16 - as selected by input parameter.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load one scratch tape.	
2 Load Demand History magnetic tape file.	
3 Load program #X42F.	
4 Load Demand Analysis Parameter record into input peripheral.	
5 If parameters on paper tape, type:	ON #X42F 23
6 If input file generation number is to be checked, alter word 5 to F.G.N. of input Demand History file, i.e. type: (where n = F.G.N.)	AL #X42F 5 n
7 Activate by message:	GO #X42F 20
8 At end of run, program is suspended:	0 #X42F HALTED - END OF DEMAND ANALYSIS

Exception Conditions

See Section 6.18.

Program **#X42G**

Priority 50

Hardware Requirement 5,246 words core store
 1 line printer 1 line printer (120 print positions)
 2 magnetic tape units
 Floating point facilities (hardware, or extracode)

Use of Peripherals All peripherals are allotted by program.

Description See Section 3.5.5.

Input Demand History magnetic tape file (name: 'STATISTICAL η ') - see Section 5.5.1.
 Relative deck address: 0

Output 1 Updated Demand History magnetic tape file (name: 'STATISTICAL η ').
 Relative deck address: 1
 Generation number: Input F.G.N. + 1
 2 Optimal Prediction Parameter Analysis list - see Figure 17.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load one scratch tape.	
2 Load Demand History magnetic tape file.	
3 Load Program #X42G.	
4 If only recalculation of seasonal factors required, type:	ON #X42G 23
5 If input file generation number is to be checked, alter word 5 to F.G.N. of input Demand History file, i.e. type: (where n = F.G.N.)	AL #X42G 5 n
6 Activate by means of message:	GO #X42G 20
7 At end of run program is suspended:	0 #X42G HALTED - END OF OPPR ANALYSIS

Exception Conditions Nil

Program #X42H

Priority 50

Hardware Requirement 5,522 words of core store
 1 line printer (120 print positions)
 1 card/paper tape reader
 1 magnetic tape deck
 Floating point facilities (hardware, or extracode)

Use of Peripherals All peripherals are allotted by program. Card/paper tape reader used, initially, to input parameters and then released immediately.

Description See Section 3.5.6.

- Input**
- 1 Demand History magnetic tape file (name: 'STATISTICAL') - see Section 5.5.1
 Relative deck address: 0
 - 2 Performance Estimation Parameter record: two (or three) punched cards/paper tape blocks - see Section 5.6.11.
- Output**
- 1 System Performance Analysis - Item list - see Figure 18 - if specified by input parameter.
 - 2 System Performance Analysis - Summary Table 1 - see Figure 19.
 - 3 System Performance Analysis - Summary Table 2 - see Figure 20 - only in certain circumstances (see input parameter details).

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load Demand History MT file.	
2 Load program #X42H.	
3 Load Performance Estimation parameter record into input peripheral.	
4 If parameters are on paper tape:	ON #X42H 23
5 If input file generation number is to be checked, alter word 5 to F.G.N. of input Demand History file, i.e. type: (where n = F.G.N.)	AL #X42H 5 n
6 Activate by message:	GO #X42H 20
7 At end of run, program is deleted:	0 #X42H HALTED EN

Exception Conditions See Section 6.18.

Program **#X42C**

Priority 70

Hardware Requirement 1,858 words of core store
 1 line printer (120 print positions)
 1 card/paper tape reader
 1 magnetic tape unit

Use of Peripherals All peripherals are allotted by program.

Description See Section 3.6.1.

Input 1 Transaction records, as described in Section 5.3, on punched cards or paper tape. (Last card contains '****' in columns 1 to 4.)

Output 1 Transaction magnetic tape file (name: 'TRANSACTIONS') - see Section 5.5.3.
 Relative deck address: 0
 Generation number: 1
 2 Transaction list - see Figure 21.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load one scratch tape.	
2 Load program #X42C.	
3 Load Transaction records on card/paper tape reader.	
4 Start program by typing	
for paper tape input:	GO #X42C 20
for punched card input:	GO #X42C 21
5 At end of run the program will halt and type:	0 #X42C HALTED EN

Exception Conditions See Section 6.18.

SORT/MERGE ROUTINES (OPERATIONAL)

6.13

SORT Routine (Input to MERGE and/or Stock Updating and Allocation Routine)

6.13.1

<i>Program</i>	#XSMC
<i>Priority</i>	50
<i>Hardware Requirement</i>	As Section 6.5
<i>Use of Peripherals</i>	As Section 6.5
<i>Description</i>	See Section 3.6.2.
<i>Input</i>	<ol style="list-style-type: none">1 Transaction magnetic tape file, format as described in Section 5.5.3, output from #X42C (name: 'TRANSACTIONS').2 SORT Parameter records - see Section 5.6.12 for format.
<i>Output</i>	<ol style="list-style-type: none">1 Sorted Transaction magnetic tape file (name: 'TRANSACTIONS') Generation number: see SORT parameters.
<i>Run Instructions</i>	As Section 6.5.

<i>Program</i>	#XSMM
<i>Priority</i>	70
<i>Hardware Requirement</i>	3,072 words of core store 1 card/paper tape reader 3 or 4 magnetic tape units
<i>Use of Peripherals</i>	As Section 6.5.
<i>Description</i>	See Section 3.6.2.
<i>Input</i>	1 Sorted Transaction magnetic tape file (name: 'TRANSACTIONS') - see Section 5.5.3, output from #XSMC. 2 Composite Magnetic tape file (name: 'COMPOSITE _{γγγ} ') - see Section 5.5.5. 3 MERGE Parameter records see Section 5.6.13 for format.
<i>Output</i>	1 Merged Transaction magnetic tape file (name: 'TRANSACTIONS') Generation number: as specified on SORT parameters.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load program #XSMM	
2 Start the program by typing for paper tape input: for punched card input:	GO #XSMM 21 GO #XSMM 20
3 Load MERGE parameters on card or paper tape reader as indicated by console typewriter.	
4 Switch unit on-line to read parameters.	
5 Remove MERGE Parameter records from appropriate peripheral when unit released.	
6 Load two input tapes (Composite and Transactions files).	
7 Load one scratch tape.	
8 Continue program.	
9 At end of run program will halt and type:	0 #XSMM FINISHED FINAL OUTPUT REEL ON UNIT ZZ FILE NAME: ABCDEFGHJKL REEL NO: XXXXXX

For fuller details of these programs see 1900 series Library Specification for Magnetic Tape. Any amendments to standard software will, of course, affect the appropriate sections of this manual, including the core store requirements.

<i>Program</i>	#X42J
<i>Priority</i>	70
<i>Hardware Requirement</i>	5,632 words of core store (to be advised) 1 line printer (120 print positions) 1 card/paper tape reader 4 magnetic tape units
<i>Use of Peripherals</i>	All peripherals are allotted by program. Card/paper tape reader used, initially, to input parameters and released immediately.
<i>Description</i>	See Section 3.6.3.
<i>Input</i>	<ol style="list-style-type: none"> 1 Stock Master magnetic tape (or cassette) file (name: 'STOCKMASTER') - see Section 5.5.2. Relative deck address: 0 2 Transaction magnetic tape file (name: 'TRANSACTIONS') - see Section 5.5.3. Relative deck address: 1 3 Stock Updating Parameter record: one punched card or paper tape block - see Section 5.6.14.
<i>Output</i>	<ol style="list-style-type: none"> 1 Stock Master magnetic tape file (name: 'STOCKMASTER'). Relative deck address: 2 Generation number: input F.G.N. + 1 2 Composite magnetic tape file (name: 'COMPOSITE') - see Section 5.5.5. Relative deck address: 3 Generation number: 1 3 Replenishment Order list - see Figure 22. 4 Stock Activity summary - see Figure 23.

Run Instructions:

<i>Narrative</i>	<i>Console Message</i>
1 Load two scratch tapes	
2 Load program #X42J	
3 Dismount MLT if four tape units only are available.	
4 Load two input tapes (Stock Master and Transaction files).	
5 Load Stock Updating Parameter record on card/paper tape reader.	
6 If only 8K store is available, type:	ON #X42J 16
7 If input Stock Master file generation number is to be checked, alter word 5 to F.G.N. of input file on relative deck address 0 by typing: (where n = F.G.N.)	AL #X42J 5 n

Narrative

Console Message

- | | | |
|----|--|----------------------------|
| 8 | If input Transaction file generation number is to be checked, alter word 6 to F.G.N. of input file on relative deck address 1 by typing:
(where n = input F.G.N.) | AL #X42J 6 n |
| 9 | Start program by typing
for paper tape input:
for punched card input: | GO #X42J 20
GO #X42J 21 |
| 10 | At end of run program will halt and type: | 0 #X42J HALTED EN |

Exception Conditions

See Section 6.18

ALLOCATION REPORT ROUTINE

Program #X42L

Priority 70

Hardware Requirement 5,312 words of core store
1 line printer (120 print positions)
4 magnetic tape units

Use of Peripherals All peripherals are allotted by program

Description See Section 3.6.4.

Input Composite magnetic tape file (name: 'COMPOSITE▽▽▽') - see Section 5.5.5 - output from #X42J.
File number: 1

Output

- 1 Composite magnetic tape file (name: 'COMPOSITE▽▽▽').
File number: 2
Generation number: as specified
- 2 Allocated Demand magnetic tape file (name: 'ALLOCFILE▽▽▽') - see Section 5.5.5.
File number: 3
Generation number: as specified
- 3 Replenishment Order magnetic tape file (name: 'REPLENFILE▽▽▽') - see Section 5.5.5.
File number: 4
Generation number: as specified
- 4 Allocation report - see Figure 24.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load three scratch tapes.	
2 Load program #X42L.	
3 Load input tape (composite file).	
4 If the magnetic tape file generation number checks are to be omitted:	ON #X42L 0
5 If the number of lines to be printed per page is to be other than 60:	ON #X42L 2
6 If the Replenishment Order file is not required:	ON #X42L 22
7 If the Allocated Demand file is not required:	ON #X42L 23
8 Start program by typing:	GO #X42P 20
9 If switch 2 was set on the program halts:	HALTED:- COBOL ACCEPT (SEE JOB SHEET) nnnnnn 1
10 Alter word 0 to the number of lines (<i>nn</i>) of print required per page and restart program.	AL #X42L 0 <i>nn</i> GO #X42L
11 The program will halt:	HALTED:- LOAD FILE 00 ON unit no.

<i>Narrative</i>	<i>Console Message</i>
12 Set up stationery and restart program.	GO #X42L
13 If switch 0 was set on, messages 14 to 21 will be suppressed and zero generation numbers will be assumed.	
14	HALTED SET FILE 01 GENERATION NO. IN WORD 0
15 Alter word 0 to the input Composite file generation number (<i>n</i>) and restart program.	AL #X42L 0 <i>n</i> GO #X42L
16	HALTED SET FILE 02 GENERATION NO. IN WORD 0
17 If required, alter word 0 to the output Composite file generation number (<i>n</i>) and restart program.	AL #X42L 0 <i>n</i> GO #X42L
18	HALTED SET FILE 03 GENERATION NO. IN WORD 0
19 If required, alter word 0 to the output Allocated Demand file generation number (<i>n</i>) and restart program.	AL #X42L 0 <i>n</i> GO #X42L
20	HALTED SET FILE 04 GENERATION NO. IN WORD 0
21 If required, alter word 0 to the output Replenishment Orders file generation number (<i>n</i>) and restart program.	AL # X42L 0 <i>n</i> GO #X42L
22 At end of run, the program halts:	HALTED END OF RUN
<i>Exceptions Conditions</i>	See Section 6.18

Program #X42P

Priority 70

Hardware Requirement 5,248 words of core store
 1 line printer (120 print positions)
 4 magnetic tape units

Use of Peripherals All peripherals are allotted by program

Description See Section 3.6.5.

Input Composite magnetic tape file (name: 'COMPOSITE▽▽▽') - see Section 5.5.5.
 File number: 1

Output

- 1 Composite magnetic tape file (name: 'COMPOSITE▽▽▽')
 File number: 2
 Generation number: as specified
- 2 Priced Receipts magnetic tape file (name 'RECEIPTSFILE') - see Section 5.5.5.
 File number: 3
 Generation number: as specified
- 3 Over Maximum magnetic tape file (name: 'OVERMAXFILE') - see Section 5.5.5.
 File number: 4
 Generation number: 0
 Note: This file is rewound during the program to produce the Over Maximum list.
- 4 Under Minimum list - see Figure 25.
- 5 Over Maximum list - see Figure 26.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load three scratch tapes.	
2 Load program #X42P.	
3 Load input tape (Composite file).	
4 If the magnetic tape file generation number checks are to be omitted:	ON #X42P 0
5 If the number of lines to be printed per page is other than 60:	ON #X42P 2
6 If the Priced Receipts file is not required:	ON #X42P 23
7 Start program by typing:	GO #X42P 20
8 If switch 2 was set on the program will halt:	HALTED:- COBOL ACCEPT (SEE JOB SHEET) nnnnn 1
9 Alter word 0 to the number of lines (nn) of print required per page and restart program:	AL #X42P 0 nn GO #X42P
10 The program will halt:	HALTED:- LOAD FILE 00 ON unit no.

<i>Narrative</i>	<i>Console Message</i>
11 Set up stationery and restart program.	GO #X42P
12 If switch 0 was set on messages 13 to 17 will be suppressed and zero generation numbers will be assumed.	
13 Alter word 0 to the input Composite file generation number (<i>n</i>) and restart program.	HALTED SET FILE 01 GENERATION NO. IN WORD 0 AL #X42P 0 <i>n</i> GO #X42P
14	HALTED SET FILE 02 GEN. NO. IN WORD 0
15 If required, alter word 0 to the output Composite file generation number (<i>n</i>) and restart program.	AL #X42P 0 <i>n</i> GO #X42P
16	HALTED SET FILE 03 GEN. NO. IN WORD 0
17 If required, alter word 0 to the output Priced Receipts file generation number (<i>n</i>) and restart program.	AL #X42P 0 <i>n</i> GO #X42P
18 If an Over Maximum file is produced this file is closed and re-opened during the program.	
19 The program halts:	HALTED END OF RUN
<i>Exception Conditions</i>	See Section 6.18

<i>Program</i>	#X42K
<i>Priority</i>	50
<i>Hardware Requirement</i>	5,549 words of core store 1 line printer (120 print positions) 1 card/paper tape reader 4 magnetic tape units
<i>Use of Peripherals</i>	All peripherals are allotted by program. Card/paper tape reader used, initially, to input parameters and released immediately.
<i>Description</i>	See Section 3.6.6.
<i>Input</i>	<ol style="list-style-type: none"> 1 Demand History magnetic tape file (name: 'STATISTICAL∇') - see Section 5.5.1. Relative deck address: 0 2 Stock Master magnetic tape file (name: 'STOCK∇MASTER') - see Section 5.5.2. Relative deck address: 2 3 Forecast Parameter record: two (or three) punched cards or paper tape blocks - see Section 5.6.15.
<i>Output</i>	<ol style="list-style-type: none"> 1 Updated Demand History magnetic tape file (name: 'STATISTICAL∇') Relative deck address: 1 Generation number: input F.G.N. + 1 2 Updated Stock Master magnetic tape file (name: 'STOCK∇MASTER'). Relative deck address: 3 Generation number: input F.G.N. + 1 3 Reported Items list - see Figure 27.
<i>Run Instructions</i>	
<i>Narrative</i>	<i>Console Message</i>
1 Load two scratch tapes	
2 Load program #X42K.	
3 Dismount MLT if four tape units only are available.	
4 Load two input tapes (Demand History and Stock Master files).	
5 Load Forecast Parameter record on card/paper tape reader.	
6 For the initial run of the System, <i>only</i> , type: ON #X42K 22	
7 If the input parameters are on paper tape, type:	ON #X42K 23
8 If input Demand History file generation number is to be checked, alter word 5 to F.G.N. of input file on relative deck address 0 by typing: (where n = input F.G.N.)	AL #X42K 5 n

Narrative

Console Message

9 If input Stock Master file generation number is to be checked, alter word 6 to F.G.N. of input file on relative deck address 2 by typing:
(where n = input F.G.N.)

AL #X42K 6 n

10 Start program by typing:

GO #X42K 20

11 At end of run the program will halt and type:

0 #X42K DELETED EN

Exception Conditions

See Section 6.18.

Note: the forecasting routine #X42K will accept only a Stock Master file containing short blocks; long blocks cause HALTED HD (see page 170). If this routine is being used it is imperative that any SCAN processing of the Stock Master file immediately prior to forecasting using #X42A, #X42B or #X42R should have switch 16 set. If more than one of these routines precedes forecasting, only the last in the sequence need have the switch set.

Program **#X42V**

Priority 50

Hardware Requirement 7,680 words of core store
 1 line printer (120 print positions)
 1 card/paper tape reader
 4 magnetic tape units

Use of Peripherals All peripherals are allotted by program. Card/paper tape reader used, initially, to input parameters and released immediately.

Description See Section 3.6.6.

Input

- 1 Demand History magnetic tape file (name: 'STATISTICAL ∇ ') - see Section 5.5.1.
Relative deck address: 0
- 2 Stock Master magnetic tape file (name: 'STOCK ∇ MASTER') - see Section 5.5.2.
Relative deck address: 2
- 3 Forecast Parameter record: two (or three) punched cards or paper tape blocks - see Section 5.6.15.

Output

- 1 Updated Demand History magnetic tape file (name: 'STATISTICAL ∇ ')
Relative deck address: 1
Generation number: input F.G.N. + 1
- 2 Updated Stock Master magnetic tape file (name: 'STOCK ∇ MASTER').
Relative deck address: 3
Generation number: input F.G.N. + 1
- 3 Reported Items list - see Figure 27.

Run Instructions

<i>Narrative</i>	<i>Console Message</i>
1 Load two scratch tapes	
2 Load program #X42V	
3 Dismount MLT if four tape units only are available.	
4 Load two input tapes (Demand History and Stock Master files).	
5 Load Forecast Parameter record on card/paper tape reader.	
6 For the initial run of the System, <i>only</i> , type:	ON #X42V 22
7 If the input parameters are on paper tape, type:	ON #X42V 23
8 If input Demand History file generation number is to be checked, alter word 5 to F.G.N. of input file on relative deck address 0 by typing: (where n = input F.G.N.)	AL #X42V 5 n

Narrative

Console Message

9 If input Stock Master file generation number is to be checked, alter word 6 to F.G.N. of input file on relative deck address 2 by typing:
(where n = input F.G.N.)

AL #X42V 6 n

10 Start program by typing:

GO #X42V 20

11 At end of run the program will halt and type:

0 #X42V DELETED EN

Exception Conditions

See Section 6.18.

- (a) Two or three character error codes have been used wherever possible throughout the system, and, where possible, errors common to two or more programs have the same code.
- (b) The error codes, definitions and action to be taken are as follows:

<i>Message</i>	<i>Reason</i>
HALTED AA	Sequence error - Stock Master file
HALTED AB	Invalid file description
HALTED AC	Incorrect file generation number
HALTED AE	Incorrect file name
HALTED AI	Incorrectly punched parameter record
HALTED BB	Sequence error - transactions
HALTED CC*	Sequence error - class code
HALTED CR**	Card reader not available
HALTED DD	Sequence error - Demand History file
HALTED DR	Data remaining in reader
HALTED GM*	Sequence error - Gross Margin
HALTED LP**	Line printer not available
HALTED NN*	Sequence error - Item Number
HALTED PP*	Parameter card invalid or out of sequence
HALTED SS*	Sequence error - Sales Value
HALTED TR**	Tape reader not available
HALTED TT*	Sequence error - Stock Value
HALTED XX*	File not classified

Action

Except where indicated by asterisks abandon run, correct error and re-run.

After one of the halts indicated '*', the following action can be taken:

- (a) Type 'GO' to close files and abandon run, or
- (b) GO at n (n = one more than the value in word 8) to ignore halt and continue run.

After one of the halts indicated '**' the peripheral should be allotted by the operator and program restarted.

DISPLAY AG	(Item Number)	Series length incorrect
DISPLAY AH	(Item Number)	Cycle base incorrect
DISPLAY AI	(Item Number)	Invalid character
DISPLAY AJ	(Item Number)	Invalid record type
DISPLAY AK	(Item Number)	Card (block) missing
DISPLAY AL	(Item Number)	Invalid function
DISPLAY AN	(Item Number)	Item number for deletion not present
DISPLAY AO	(Item Number)	Incorrect Demand History file
DISPLAY AP	(Item Number)	Cycle base and forecast interval incompatible
DISPLAY AQ	(Item Number)	Factor sequence check failure
DISPLAY AR	(Item Number)	Incorrect number of seasonal factors input

DISPLAY	AS	(Item Number)	Incorrect word number following seasonal factors
DISPLAY	AT	(Item Number)	Insufficient demand factors
DISPLAY	AU	(Item Number)	Excess demand factors
DISPLAY	AV	(Item Number)	Card (or block) out of sequence
			Item not on file (during file amendment)
			Item already on file (during item insertion)
DISPLAY	AW	(Item Number)	Item on demand history file not on Stock Master file (occurs during X42B operations)
DISPLAY	AX	(Item Number)	Item numbers equal on merging
DISPLAY	ER1	(Item Number)	Incorrect transaction item number
DISPLAY	ER2	(Item Number)	Incorrect audit record sequence
DISPLAY	SM	(Item Number)	Item not on Profile Results file

Action

Displays do not cause program halts but usually the error will require correcting upon completion of the run.

GENERAL INFORMATION

The following magnetic tape housekeeping error halts can occur while the SCAN programs are being used. In each case the program is non-restartable.

<i>Message</i>	<i>Cause</i>
HALTED HA	Record larger than maximum block size (writing)
HALTED HB	Parity error (writing)
HALTED HC	Block count discrepancy (reading)
HALTED HD	Long block (reading)
HALTED HE	Parity error (reading)

Chapter 7 SCAN System I Simulator

GENERAL

7.1

The routines described in detail in Chapter 3 provide all the elements essential to the setting up of a soundly based computer system for adaptive inventory control. The analysis routines, which form an important and integral part of the I.C.T. SCAN System, cater for the initial processing which should, desirably, precede putting the control system to work. They may be used again for review purposes.

In addition, these analysis routines may be used in a pilot study as part of a feasibility study which includes consideration of the adoption of improved control by the I.C.T. SCAN System 1. At the mere cost of collecting sufficient data and of a small amount of 1900 computer time, a representative sample of items (say 50 to 100) may be analyzed to see how the essential features of each individual demand pattern are isolated and how the control system is likely to affect stock levels. The financial implications of various operating policies will be seen and this processing will demonstrate the potential of the system not only for assisting stricter management control of inventory, but also for achieving closer integration of inventory management policy with the overall financial policy of the company.

At times, a deeper study of the action of the system may be required. For this purpose a simulation program has been provided. This program simulates the action of the control system over a selected period of immediate past history (preferably not less than 24 demand points) and computes an estimate of the stock levels, week by week, or month by month, which would have resulted from the use of the SCAN system during this period. The actual stock levels may also be computed and the two sets of results printed in tabular form for direct comparison and detailed study. Usually such simulation will need to be applied to only a few selected key items in the inventory, but the program does not impose any limitation on the number of items which may be studied in this way. Prior use of the analytical routines on demand data drawn from an adequate length time period immediately preceding that studied by the simulator is assumed, but may be avoided in certain circumstances.

The routines described in Chapter 3 provide all the basic elements for efficient inventory control, but it will readily be appreciated that the simulator provides a valuable supplementary routine when circumstances warrant a deeper study of the action of the system in specific cases. The use of the simulator will also be found invaluable to those wishing to obtain a better understanding of how the I.C.T. SCAN System works in practice.

INPUT SECTION

7.2

The program accepts data in punched card form, each group of cards (forming one input record for one stores item) being fully processed before the next input record is read. A separate, similar program accepts punched paper tape input. Chapter 8 gives details of input file formats.

PROCESSING SECTION

7.3

Processing is performed in serial mode, on a record by record basis. The number of records which may be processed in a single pass, is, therefore, unlimited, although it will not normally be required to process more than a few records, say, less than twenty.

The program comprises three main segments, namely:

- 1 Input, validation and control,
- 2 Simulation,
- 3 Performance analysis.

Input, Validation and Control

7.3.1

This segment is responsible for reading and checking the simulator file and for the overall control of the program. A record is read and its contents are checked for correct format and sequence; they are then listed for record and for visual check if required. If the data fail the computer checks, no further processing is performed on that item and the next record is read. Otherwise, entry is made to the simulation segment.

Simulation

7.3.2

The process of stock updating, forecasting, ordering and system monitoring is reproduced on a diminished time scale. Time is advanced in the simulator in discrete steps. At each step, a delivery table is scanned and closing stock is updated by receipts. The demand series is then scanned, demand is allocated from stock and closing stock is again updated. If there is insufficient stock to meet demand, the latter is assumed to be back-ordered, i.e. placed on shortage to be satisfied as soon as further receipts are encountered.

If the current period being examined marks the end of a forecast interval, a new demand forecast is made using the Box-Jenkins two-point predictor. Re-order point, re-order quantity and monitoring signal are computed.

For random re-ordering (System Marker 1 Card type '01', Section 8.3) the re-order point calculation is based on the Re-order Point Lead time (card type '03', Section 8.5) rounded up to an integer multiple of the forecast interval. The order quantity calculation is based on either the Ordering Interval (card type '01', Section 8.3) rounded up in the same way, or on the Economic Order Quantity (which overrides if non-zero values are specified for both Order Cost and Stock-holding Cost - card type '01', Section 8.3).

For cyclical re-ordering (System Marker 6) the re-order point calculation is based on Re-order Point Lead time plus Order Interval, the sum being rounded up as above. The order quantity is set to zero. Economic order quantities cannot be used with cyclical re-ordering, although an Order Interval approximating E.O.Q. may be chosen.

If the current period is not the end of a forecast interval, the re-order point and re-order quantity last calculated are used.

For random re-ordering, the available stock is then compared with the re-order point and if it is insufficient, the raising of a new order is simulated and the delivery table is updated accordingly.

For cyclical re-ordering, the re-order point and available stock are compared only at the end of each Order Interval. A new order is raised and the delivery table updated to increase the available stock (physical stock plus stock-on-order minus back-orders) to cover the estimated demand in a lead time plus an ordering interval.

If details of actual receipts have been provided, closing stock which was actually experienced is calculated.

If the monitoring signal is found to be outside the control limits set, an asterisk is output to signal this. If this occurs consecutively more than a number of occasions set by parameter, an emergency value of γ_1 (also set by parameter), is brought into use until the monitoring signal returns within limits.

Information on the state of the system as at the end of the current period is then reported and the processing cycle repeated for the next period's data.

Initial Conditions

7.3.3

In practice, when a new control system is brought into use, there will be a period of parallel running while the new system settles down. It will then assume control smoothly. The length of time devoted to parallel running will depend on the circumstances.

There may be outstanding replenishment orders 'in the pipeline' at the time of the handover. The opening stock figure may, or may not be appropriate to current needs when judged by the criteria used in SCAN System 1.

To make the maximum use of the data available to the Simulator, the latter tries to accelerate this settling down process.

Initial Forecast: the demand in the first forecast for seasonal items only. For non-seasonal items the average demand in the lead time is used as the first forecast.

Initial M.A.D: if the setting up instructions are followed correctly, the Error Step entered on the Control Parameter card - see Section 8.5 - will be approximately half the standard deviation of forecast errors. The error step is used by the Simulator to derive an initial estimate of mean absolute deviation of forecast errors from which the initial safety stock is then calculated - see equation (25) Appendix A.

From these two initial values, an initial re-order point is calculated - see equation (27) Appendix A.

Outstanding Replenishment Orders: the demand in the first lead time is summed and a single delivery scheduled into period 1 so that the amount delivered plus the opening stock covers that demand. If the opening stock is enough to cover this demand, no delivery is scheduled.

This ensures that an inadequate opening stock is brought up to the required level as the simulation starts - this is particularly useful if no opening stock is specified. If, however, the opening stock is excessive, no attempt is made to reduce this artificially - thereby the run down of stock by the system is seen in the simulation. This very roughly accords with practice: early system action may correct any stock deficiency by a single replenishment order (assumed to have been placed before the simulation starts) whereas excessive stock can only be used up. All the control system can do in the latter situation is prevent further orders being placed. If actual receipts and orders are present the system is initialized by taking the receipts in the 'actual lead time + 1 period'.

Performance Analysis

7.3.4

At the end of the simulation, a summary of operational statistics is made and reported in tabular form.

OUTPUT SECTION

7.4

The output for each item comprises three printed reports, namely:

- 1 Parameter Check List,
- 2 Simulation Report,
- 3 Performance Analysis Report.

Parameter Check List

7.4.1

The Parameter Check List provides the opportunity for visual checking of the simulator file, it is available for reference during study of the reports and it provides a permanent record of the parameters and data on which the simulation was based: see Figure 33.

Simulation Report

7.4.2

The Simulation Report comprises a chronological table of which each line represents a time period. It includes details of the system quantities, of stock, receipts, orders, forecast demand and the monitoring signal (where appropriate). Actual demand is also shown together with actual stock for comparison (if the input data included action details). Refer to Figure 34.

Performance Analysis Report

7.4.3

The Performance Analysis report comprises a table summarizing the results of the simulation and quotes totals and averages, with their associated standard deviations, for the most important quantities in the Simulation report: see Figure 35.

The Performance Analysis report is, in the main, self explanatory but one point is worthy of mention. In the two frequency tables, all the abscissae except the last represent the inclusive upper limits of their respective cells. The last value in each case represents the exclusive lower limit of the cell.

1. 7.67. RUN 1.

1900 INVENTORY MANAGEMENT SIMULATOR

PAGE 1

ITEM AB12345C SAMPLE DATA

PARAMETER CHECK LIST

	ITEM	DESCRIPTION	SAFE	OI	FB	OO	CP	CO	CS	CB	CI	SM						
CARD 1	AB12345C	SAMPLE DATA	X.XX	XX	XX	XXXXXXXX	XXXXX.XXX	XX.XXX	XX.XX	XX	X	X						
		ITEM S	CYCLICAL FACTORS:															
CARD 2	AB12345C	1	XXXX.XX	XXXX.XX	XXXX.XX	XXXX.XX	XXXX.XX	XXXX.XX	XXXX.XX	XXXX.XX	XXXX.XX	XXXX.XX						
CARD 2	AB12345C	2	XXXX.XX	XXXX.XX	XXXX.XX	.00	.00	.00	.00	.00	.00	.00						
		ITEM	L	AL	SL	BSE	DEM	STEP	BSE	ERROR	STEP	GO	GI	GMI	GP	GE	CL	STCK
CARD 3	AB12345C	XX	XX	XXX	XXXXXXXX	XXXXXX	XXXXXX.XX	XXXXX.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	XXXXXX		
		ITEM	PER	L	DEMAND	RECPTS	ORDERS	L	DEMAND	RECPTS	ORDERS							
CARD 4	AB12345C	XXX	XX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX							
CARD 4	AB12345C	XXX	XX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX							
CARD 4	AB12345C	XXX	XX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX							

CARD 4	AB12345C	XXX	XX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XX	XXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX
--------	----------	-----	----	----------	----------	----------	----	----------	----------	----------	----------

CONTROL TOTALS	AB12345C	SAMPLE DATA			
ACCUMULATED CONTROLS	XXXXXXXX	XXXXXXXX	XXXXXXXX		
CONTROLS PUNCHED	XXXXXXXX	XXXXXXXX	XXXXXXXX		
DIFFERENCE	0	0	0		

- Notes
1. Cyclical factor cards only appear where cyclical data is indicated. In the case above, the period of the cycle is 12; hence only 12 cyclical factors are present. Note that the remaining space on the second cyclical factor card is filled with zeros.
 2. The Control Totals Report and the Steering Line always appear, whether or not a check list is specified.

Figure 33 Simulator Parameter Check List - Print Format

1. 7.67. RUN 1.

1900 INVENTORY MANAGEMENT SIMULATOR

PAGE 3

ITEM AB12345C SAMPLE DATA

PERFORMANCE ANALYSIS

MEAN DEMAND	XXXXXXXX.X	MEAN ERROR	XXXXXXXX.XX
STD DEV OF DEMAND	XXXXXXXX.X	STD DEV OF ERROR	XXXXXXXX.XX
		MEAN ABS DEVIATION	XXXXXXXX.XX

DEMAND	FREQUENCY	ERROR	FREQUENCY
XXXXXXXX	XXX	XXXXX.XX	XXX
XXXXXXXX	XXX	XXXXX.XX	XXX
XXXXXXXX	XXX	XXXXX.XX	XXX

XXXXXXXX	XXX	XXXXX.XX	XXX
XXXXXXXX	XXX	XXXXX.XX	XXX
	SYSTEM		ACTUAL
TOTAL DEMAND	XXXXXXXX		XXXXXXXX
% MET EX STOCK	XX.XX		XX.XX
SERIES LENGTH	XXX		XXX
TOTAL STOCKOUTS	XXX		XXX
ALARM SIGNALLED	XXX		--

	SYSTEM		ACTUAL	
	MEAN	STD DEV	MEAN	STD DEV
TOTAL STOCK	XXXXXXXX.X	XXXXXXXX.X	XXXXXXXX.X	XXXXXXXX.X
ORDER SIZE	XXXXXXXX.X	XXXXXXXX.X	XXXXXXXX.X	XXXXXXXX.X
QTY. BACKORDERED	XXXXXXXX.X	XXXXXXXX.X	XXXXXXXX.X	XXXXXXXX.X
SAFETY STOCK	XXXXXXXX.X	XXXXXXXX.X	---	---

Figure 35 Simulator Performance Analysis -Print Format

Chapter 8 Simulator Input File Formats

THE SIMULATOR FILE

8.1

This file may be punched card or paper tape. In the interests of avoiding unnecessary duplication the following descriptions refer to the punched card record. However, it should be remembered that paper tape formats are identical in every respect, the paper tape being punched in 80-character blocks, each block corresponding to one card, with a Newline character in position 81.

It should be noted that all fields having the value of zero should be punched with a zero: a blank space is not acceptable. Moreover, all blank spaces remaining at the end of the card should be zero filled.

The Simulator file is opened by a header card: it is followed by any number of item records and closes with a trailer card.

HEADER CARD

8.2

This card opens the Simulator file and must appear as the first card in the deck. It is identified by a card code '90' and holds the following information:

Current Date: the current date, appearing in this field, is output on the title line of each page output. It should be punched in numeric form, with the format: dd mm yy.

Run Number: the run number appearing in this field is output on the title line of each page output.

Page Length: the size in lines of the stationery in use. This should be 66 for 11 inch stationery.

Run Abstract: a short description of the run, output on the title page.

Header Card Format

<i>From Column</i>	<i>To Column</i>	<i>Field Length</i>	<i>Field Description</i>	<i>Remarks</i>
1	2	2	Card Code	'90'
3	4	2	Day	Integer
5	6	2	Month	Integer
7	8	2	Year	Integer
9	10	2	Run Number	Integer
11	12	2	Page Length	Integer
13	16	4	Space	Leave
17	80	64	Run Abstract	Alphanumeric

PRINCIPAL PARAMETER CARD

8.3

The card, which is identified by a card code of '1', heads each item record. It bears the following information:

Item Number: the item reference number is in alphanumeric or plain numeric form, and may be up to eight characters long. This appears on every card in the record and is sequence checked. It also appears on the output headings.

Item Description: this appears in the headings which identify the output. It may be up to 16 characters in length.

Service Level Factor: this determines the amount of safety stock held consistent with the desired level of service for that item. A table of values of this factor appears in Appendix B.

Ordering Interval: this determines the approximate average number of periods, up to a maximum of 27, between orders. This should be selected by Management.

Forecast Interval: this determines the frequency of forecasting. It should be such that the probability of a stock movement during a forecast period is at least 0.5.

Ordering Unit: the minimum quantity that can be ordered. Orders are assumed to be made in integer multiples of this quantity.

Cost Price: the unit cost per item as used in the Economic Order Quantity (EOQ) formula. Sterling must appear in decimal format. Nine characters are allowed for this field, of which up to three may be the decimal fraction. If the figure entered has less than three places of decimals, the decimal point must be punched. If EOQ is not required, this field may be omitted.

Order Cost: the order cost per item as used in the EOQ formula. As before, sterling must appear in decimal format. Six characters are allowed for this field of which up to three may be the fraction. If the figure entered has less than three decimal places the decimal point must be punched. If EOQ is not required this field should be omitted.

Stockholding Cost: expressed as the annual percentage rate of average stock value as used in the EOQ formula. Five characters are allowed for this field, of which up to two may be the decimal fraction. If the figure entered has less than two places of decimals, the decimal point must be punched. If EOQ is not required this field should be omitted.

Annual Time Base: the number, in integer format, of *forecast* periods in a calendar year. If a cycle is present this figure also represents the number of cyclical factors to be expected.

Cycle Indicator: this parameter is used to indicate the presence of a cycle in the data for the current item. If a cycle is indicated the program expects cyclical factor cards. If a cycle is not indicated, the program assumes that cyclical factor cards are absent.

This parameter should be set to *zero* if a cycle is *present*, and *unity* if a cycle is *absent*.

System Marker: enter '1' for random re-ordering or '6' for cyclical re-ordering.

Principal Parameter Card Format

From Column	To Column	Field Length	Field Description	Remarks
1	2	2	Card Code	'01'
3	10	8	Item Number	Alphanumeric
11	26	16	Item Description	Alphanumeric
27	30	4	Service Level Factor	X.XX (See Appendix B)
31	32	2	Order Interval	Integer
33	34	2	Forecast Interval	Integer
35	40	6	Order Unit	Integer
41	49	9	Unit Cost per Item	XXXXX.XXX (Only if EOQ.)
50	55	6	Order Cost per Item	XX.XXX (Only if EOQ.)
56	60	5	Stockholding Cost	XX.XX (Only if EOQ.)
61	62	2	Annual Time Base	Integer
63	63	1	Spare	Zero Filled
64	64	1	Cycle Indicator	Unity if cycle absent, zero if cycle present.
65	65	1	System Marker	Unity or six - see text.
66	80	15	Spare	Zero Filled.

CYCLICAL FACTOR CARDS

8.4

These cards, which are only necessary if a cycle is present in the data, bear the set of cyclical factors as are applicable in the current case. Normally, these would be those calculated at the analysis stage during the Optimal Prediction Parameter routine.

Cyclical factor cards, which are identified by a card code of '2' bear the following information:

Item Number: this must agree with that punched on the principal parameter card.

Sequence Number: each cyclical factor card is numbered to ensure that cyclical factors are input in the correct sequence. Data out of sequence are rejected.

Cyclical Factors: as calculated during analysis by the Optimal Prediction Parameter routine. Seven characters are allowed for each factor, of which up to two may be decimal fractions. Note that if the figure entered contains *less* than two places, the decimal point must be punched.

Up to nine factors in their correct time sequence may appear on each card. If the sequence ends in mid-card, the remaining fields must be filled with zeros.

The number of cyclical factors which appear must agree with the time base of the annual cycle as entered on the principal parameter card. Otherwise, the data may be rejected.

Cyclical Factor Card Format

From Column	To Column	Field Length	Field Description	Remarks
1	2	2	Card Code	'02'
3	10	8	Item Number	As on Principal Parameter Card
11	11	1	Card Sequence Number	Must exceed predecessor Integer
12	18	7	Cyclical Factor	XXXX.XX
19	25	7	Cyclical Factor	XXXX.XX
26	32	7	Cyclical Factor	XXXX.XX
33	39	7	Cyclical Factor	XXXX.XX
40	46	7	Cyclical Factor	XXXX.XX
47	53	7	Cyclical Factor	XXXX.XX
54	60	7	Cyclical Factor	XXXX.XX
61	67	7	Cyclical Factor	XXXX.XX
68	74	7	Cyclical Factor	XXXX.XX
75	80	6	Spare	Zero Filled

CONTROL PARAMETER CARD

8.5

This card, which is identified by a card code of '3' bears the following information:

Item Number: this must agree with that punched on the Principal Parameter card.

Re-order Point Lead Time: the length of time that is likely to elapse after raising of an order, before it is actually received. This value is used as the basis for the calculation of the Re-order Point throughout the simulation. It should be distinguished from the Lead Time used to schedule deliveries see Section 8.6.

Alarm Limit: the number of forecast periods over which the system may be allowed to continue to depart from prediction optimality before emergency action is undertaken.

In a real situation, emergency action would depend on a management appreciation of the circumstances, but in the simulator, a rule of thumb measure is taken.

Gamma one is set to an emergency value when the alarm limit is reached and continues in use until control is regained, when this parameter is reset to zero and the simulation proceeds as normal.

If the forecasting model for the current item uses a non-zero value of gamma one, a higher value should be chosen for Emergency Gamma One.

Total Series Length: the total number of demand points in the data series, including data to be ignored as well as data for simulation. The maximum permissible value of this item is 312.

Base Demand: demands are classified during simulation for output during Performance Analysis in the form of a frequency table. This field holds the starting value of demand from which 20 equal steps are made to form the 21 cells into which demands are classified and counted. The value entered in this field must be a positive integer.

Demand Step: the cell separation in the demand frequency table. 20 Steps are made starting at the base value mentioned above. The value entered in this field must be a positive integer.

Base Error: errors are similarly classified during simulation for output during Performance Analysis. This field holds the starting value of the forecasting error from which 20 equal steps are made to form the 21 cells into which errors are classified and counted.

Errors tend to be spread evenly about zero. The base error should therefore, be ten 'steps' below zero - see 'Error Step', below. If this parameter is set to zero, the base error is computed by program on this basis.

Seven characters are allowed for this parameter of which up to two may be the decimal fraction. The decimal point must be included. Note also that, for negative values, the minus sign must be punched.

Error Step: the cell separation in the Error Frequency Table. 20 Steps are made starting at the base value mentioned above. The step size should approximate to one half the standard deviation of forecast errors. The I.C.T. SCAN analysis programs (Optimal Prediction Parameter routine) compute the standard deviation of forecast errors. If this parameter is set to zero, the program will use the Demand Step, but this should be avoided if the data are seasonal.

Six characters are allowed for this field, of which up to two may be the decimal fraction. The decimal point must be included.

Control Parameters: the values of the control parameters used in the forecasting model and the system monitoring equations. The former should normally be those values determined during analysis by the Demand Analysis or Optimal Prediction Parameter routines, while the latter should take the values recommended in Chapter 4.

Note that in all cases, four characters are allowed for each parameter, of which up to two may be the decimal fraction. If less than two places appear, the decimal point must be included.

Gamma Zero: the proportional control parameter in the Box-Jenkins forecasting model.

Gamma One: the cumulative control parameter in the Box-Jenkins forecasting model.

Gamma Minus One: the difference control parameter in the Box-Jenkins forecasting model. This is not included in SCAN System 1 and should normally be set to zero.

The inclusion of this parameter, however, provides the facility for experimenting with non-zero values.

Gamma Prime: the smoothing parameter used in the calculation of the smoothed mean error, smoothed mean absolute deviation of the error and the Tracking Signal. A value of 0.17 is recommended.

Emergency Gamma One: when the number of consecutive alarms reaches the alarm limit, this emergency value of gamma one is brought into use.

It continues in use until such time as control is regained, when the emergency value is dropped and gamma one reverts to normal. The value selected will depend on circumstances, but normally it should not exceed unity. Generally speaking, a high value will bring back control sooner, but a high value is dangerous if gamma zero is also high. For most purposes a value of 0.20 is suitable, but see Alarm Limit, above.

Initial Closing Stock: physical closing stock as at the end of the period immediately preceding the first period simulated.

Control Parameter Card Format

From Column	To Column	Field Length	Field Description	Remarks
1	2	2	Card Code	'03'
3	10	8	Item Number	As on Principal Parameter Card
11	12	2	Re-order Point Lead Time	Integer
13	14	2	Alarm Limit	Integer
15	17	3	Spare	Zero Filled
18	20	3	Total Series Length	Integer (≤ 312)
21	27	7	Base Demand	Integer
28	33	6	Demand Step	Integer
34	40	7	Base Error	XXXX.XX
41	46	6	Error Step	XXX.XX
47	50	4	Gamma Zero (γ_0)	X.XX
51	54	4	Gamma One (γ_1)	X.XX
55	58	4	Gamma Minus One (γ_{-1})	X.XX
59	62	4	Gamma Prime (γ'_0)	X.XX
63	66	4	Emergency Gamma One	X.XX
67	73	7	Initial Closing Stock	Integer
74	80	7	Spare	Zero Filled

DEMAND DATA CARDS

8.6

These cards give details of demand, orders and receipts and constitute the input signal to the forecasting process. Two time periods are covered per card.

Demand data cards are identified by a card code of '4' and hold the following information:

Item Number: this must agree with that punched on the Principal Parameter card.

Period Number: the date of the first set of data appearing on the current card. This item is sequence checked. The period number of the first data point on the first Demand Data card should be unity.

Lead Time: the time interval which must elapse between the raising of an order and its receipt, as it stands at the current date. This value controls only the scheduling of deliveries. The Re-order Point calculation is based on the value in the Control Parameter card.

The Lead Time must be entered for every time period. A zero, or blank will result in immediate delivery of any order raised at that time.

Demand: the actual demand experienced in the current period, the date of which is given by the period number above.

Receipts: actual stock received during the current period. This is assumed to take place in a single delivery at the beginning of the period. If this information is not available it may be omitted, but it should be noted that this omission may render a comparison of the system with actual experience impossible. If receipts are entered, the first few receipts are assumed to exist as outstanding orders at the beginning of the simulation.

Orders: the actual orders placed in the current period. The orders are assumed to be placed as a single order at the end of the period.

Lead Time, Demand, Receipts, Orders: the same information as above, but relating to the period following that covered by the first half of the card. If that period was the final one of the data provided this second set of fields should be punched with zeros.

Demand Data Card Format

<i>From Column</i>	<i>To Column</i>	<i>Field Length</i>	<i>Field Description</i>	<i>Remarks</i>
1	2	2	Card Code	'04'
3	10	8	Item Number	As on Principal Parameter card
11	13	3	Period Number (t)	Integer
14	15	2	Lead Time (t)	Integer
16	22	7	Demand (t)	Integer
23	29	7	Receipts (t)	Integer
30	36	7	Orders (t)	Integer
37	38	2	Lead Time ($t+1$)	Integer
39	45	7	Demand ($t+1$)	Integer
46	52	7	Receipts ($t+1$)	Integer
53	59	7	Orders ($t+1$)	Integer
60	80	21	Spare	Zero Filled

CONTROL TOTALS CARD

8.7

This card, which marks the end of an item record, bears control totals of demand, orders and receipts accumulated over the whole data series for that item. These totals are checked by program and control lines are output giving the results of the control check. If the control totals do not agree, an error message is output, and simulation is not undertaken. In this case, the program goes on to deal with the next item.

The Control Totals card is identified by a class of card code of '5' and bears the following information:

Item Number: this must agree with that punched on the Principal Parameter card.

Total Demand: the total accumulated over the data series of the current item.

Total Receipts: the total accumulated over the data series of the current item.

Total Orders: the total accumulated over the data series of the current item.

Note: if totals are entered as zero, no check is made.

Control Totals Card Format

<i>From Column</i>	<i>To Column</i>	<i>Field Length</i>	<i>Field Description</i>	<i>Remarks</i>
1	2	2	Class of Card	'05'
3	10	8	Item Number	As on Principal Parameter card
11	17	7	Total Demand	Integer
18	24	7	Total Receipts	Integer
25	31	7	Total Orders	Integer
32	80	49	Spare	Zero Filled

TRAILER CARD

8.8

This card marks the end of the Simulator file. When it is detected, the program is brought to a halt, printing the message on the console typewriter: HALTED 1.

The trailer card is identified by a card code of '99' punched in columns 1 and 2. This card bears no further information.

Trailer Card Format

<i>From Column</i>	<i>To Column</i>	<i>Field Length</i>	<i>Field Description</i>	<i>Remarks</i>
1	2	2	Class of Card	'99'

Paper Tape

When paper tape is being used this record will have 99 punched in columns 1 and 2, and then zeros or blanks to column 80 with a Newline character in column 81.

Chapter 9 Running the Simulator

PROGRAM SUMMARY

9.1

<i>Program</i>	#X42M (punched card input) #X42N (paper tape input)
<i>Priority</i>	50
<i>Hardware Requirement</i>	9,088 words of core store 1 line printer (120 print positions) 1 card/paper tape reader Floating point facilities (hardware or extracode).
<i>Use of Peripherals</i>	All peripherals are allotted by program. They are required for the whole of the program.
<i>Description</i>	See Chapter 7.
<i>Input</i>	Simulator file in punched cards or paper tape - see Chapter 8.
<i>Output</i>	1 Parameter check list (Figure 33) 2 Simulation report (Figure 34) 3 Performance Analysis (Figure 35) All are described and illustrated in Chapter 7.
<i>Running Time</i>	1 second per time period on 1903 0.4 second per time period on 1905

RUN INSTRUCTIONS

9.2

<i>Narrative</i>	<i>Console Message</i>
1 Load input peripheral with simulator file	
2 Load program #X42M (punched card input) or #X42N (paper tape input).	
3 If input on punched cards, activate by message:	GO #X42M 20
if input on paper tape, activate by message:	GO #X42N 20
4 At end of run, program is suspended with message:	0 #X42M HALTED 1 or 0 #X42N HALTED 1

Invalid input data is reported on the line printer in the Parameter Check list. Each report gives details of the item number and the type of error as follows:

Card Sequence Error: item records are input in card code sequence beginning with code '1' and ending with code '5'. Any departure from this sequence brings about a sequence error.

Sequence errors may be due to mispunching, transposition, omission or any combination of these.

It should be noted that cyclical factor cards must appear only when a cycle is indicated. Any departure from this rule causes a sequence error.

A sequence error may also be caused when the number of demand data cards is greater or less than the number indicated by the series length parameter on the Control Parameter card.

In the case of both cyclical factor and demand data cards, it is advisable to zero fill all zero or unused fields to column 78 as one sequence error may cause others in succeeding cards even though those cards in themselves may be correct.

Item Sequence Error: each card in each record is identified on alphanumeric item number. The item number on each card is checked against the item number entered on card 1. Any departure from exact identity is rejected.

Cyclical Factor Sequence: the sequence number entered on each cyclical factor card should exceed that of its predecessor. This prevents cyclical factors going into the machine in the wrong order.

Series Length Omitted: if the series length is omitted from the control parameter card, the program is unable to handle the demand data cards which follow, and this report is output.

Period Number Sequence: the period number entered on each demand data card should exceed that of its predecessor. This prevents the demand series going into the machine in the wrong order.

Length of Data Series Exceeds 312: the simulator is limited to 312 points of demand data and a series length in excess of this figure is unacceptable.

Insufficient Parameters: this report is output if any of the following items of data is absent:

Annual Time Base,

Forecast Base,

All of the Box-Jenkins Control Parameters.

Control Errors: if the control totals entered on the Control Totals card do not agree with those calculated by machine, a non-zero difference is reported and simulation will not proceed.

Certain other reports may occur during running, after the Parameter Check List stage, as follows:

Field Overflow: where an item of data for output exceeds the space available to accommodate it, its space is filled with asterisks. This means that the data used is too great for the simulator to cope with and must be scaled down before re-running.

Note: the asterisk that appears alongside the tracking signal is the alarm signal and not an overflow.

End of Cycle - Re-analysis Required: where data is cyclical, this report is output at the end of each cycle to indicate that a re-analysis is necessary. Simulation does not stop, however, and no re-analysis actually takes place. The report merely indicates what should be done in a true operational environment.

Alarm Limit Reached - Emergency cum Control Parameter in Operation: this report may appear during simulation where the number of consecutive alarms exceeds the Alarm Limit. Simulation continues using the emergency value until control is regained.

Very often, the Alarm Signal 'fires' consecutively during the initial stages of simulation, but this need cause no concern as the system may take a certain amount of time to 'warm up'.

Appendix A Mathematical Description

GENERAL

A.1

The logical procedures described in Chapter 3 provide the basic organization of an adaptive inventory control system which seeks to minimize stock holdings consistent with the current level of demand and with Management policy on provisioning and customer service level. Each stores item is treated individually and the system includes routines which are used by Management to assist in determining operating policy.

This chapter states the mathematical structure of the system and discusses the theoretical foundation of the techniques employed. Stated in these terms, the system is independent of the machine configuration on which it is applied.

Those readers wishing to make a more detailed study of modern inventory control techniques, should refer to the bibliography of original sources which appears in Appendix C.

The basis of the I.C.T. SCAN System 1 is an automatic forecasting process which regularly formulates a new estimate of future demand for each item in the inventory. This process requires information on actual demand at fixed, constant time intervals. Moreover, the demand must be expressed in relation to a constant time period. This latter is the basic time period of the system: operationally, it is the interval between successive runs of the forecasting routine. Whatever the basic time period chosen, all other time intervals used by the system must be expressed as integer multiples of it.

In most cases, a basic time period of one week is to be preferred, but a two- or four-week period may be used on occasion. The use of the calendar month is to be avoided whenever possible unless the demand on the inventory is geared to the calendar month itself rather than the number of working days in the month. An accounting structure linked to the calendar month need, and should, have no influence on the basic period chosen for the inventory control system.

It is a system requirement that the updating interval (the interval between successive stock updating runs) shall be no longer than the basic time period and that the two shall be in phase, i.e. the end of each basic time period shall coincide with the end of a stock updating interval. Overall system considerations generally decide the stock updating interval (within these limitations).

The terms 'Movement' and 'Stores Movement' are used in the general sense of meaning any event which, when recorded, will result in a change in one of the balance quantities in the Stock Master record for the item concerned, e.g. a demand on unscheduled issue, a replenishment order, a stock receipt or an adjustment entry. 'Orders' relate to orders for stock replenishment: 'demand' is demand on the inventory for the supply of a quantity of an item: it is assumed to be satisfied immediately, or back-ordered if not covered by the stock in hand.

The 1900 SCAN System offers a choice between random and cyclical re-ordering. The former allows replenishment orders to be requested by any stock updating run; the latter confines re-ordering to one selected updating run in each basic time interval. Operational requirements will usually determine the preferred method but if the updating interval is a week or longer, and if the lead time or the order cycle time is short, technical considerations will suggest cyclical re-ordering.

Demand may be notified to the system either prior to the issue of stock to satisfy that demand (pre-posting of issues) or in arrears of the issue (post-posting of issues). Elsewhere these two types of transaction are distinguished as Demands and Unscheduled Issues, but in this Appendix they are both regarded as Demand.

Where random re-ordering, or post-posting of issues is used, the updating interval should be kept as short as possible.

The system assumes that all stock replenishment orders requested will be placed immediately and for the quantity stated. Any variation on quantity must be reported back as an adjusting entry. The replenishment delivery or lead time (L) is the time required to secure delivery into stores counted from the point when the system requested the order (plus one stock updating interval if random re-ordering is used).

STOCK UPDATING ROUTINE

A.2

The inventory control system must be fed with data on an organized basis. In the practical situation it is convenient for the Stock Updating routine to perform this function.

This routine is also the point of action of the control system: it tests the available stock against the re-order point and issues requests for any replenishment orders required.

For each item in the Stock Master Record file let, for any stock updating interval (t'):

$$\left. \begin{aligned} y(t') &= \text{demand} \\ D(t') &= \text{stores receipts} \\ R(t') &= \text{orders placed other than by the system} \end{aligned} \right\} \text{ during interval } t'$$

The above quantities will include any adjustment entries.

$$\text{Let } \left. \begin{aligned} C(t') &= \text{physical (bin) stock} \\ O(t') &= \text{outstanding order balance} \\ U(t') &= \text{unallocated demand, or back-order balance} \end{aligned} \right\} \text{ at end of interval } t'$$

Let $C(t'-1)$, $O(t'-1)$ and $U(t'-1)$ have equivalent meanings as at the start of interval t' (i.e. the end of interval $t'-1$).

Note that $I(t')$ (the length of the updating interval) must not be confused with $I(t)$ (the length of the basic time unit of the control system). $I(t') \leq I(t)$ and $I(t)/I(t')$ is an integer.

Then:

Closing Stock**A.2.1**

$$S(t') = C(t'-1) - U(t'-1) + D(t') - y(t') \quad (1)$$

If $S(t') < 0$,

$$C(t') = 0 \text{ and } U(t') = -S(t')$$

Otherwise

$$C(t') = S(t') \text{ and } U(t') = 0$$

Available Stock ***A.2.2**

$$A(t') = S(t') + O(t'-1) + R(t') - D(t') \quad (2)$$

Re-order Quantity ***A.2.3**If $P_{T+1} \geq A(t')$,

$$R = R_M \left[\text{Integral part of } \frac{R_{T+1} + P_{T+1} - A(t')}{R_M} + 1 \right] \quad (3)$$

unless $\left[\frac{R_{T+1} + P_{T+1} - A(t')}{R_M} \right]$ is an integer, when

$$R = R_{T+1} + P_{T+1} - A(t') \quad (3A)$$

If $P_{T+1} < A(t')$,

$$R = 0 \quad (3B)$$

where P_{T+1} = Re-order point (see equation 27). R_{T+1} = System re-order quantity (see equations 37, 37A). R_M = Unit order size such that quantity ordered must be integer multiple of R_M . If not applicable, $R_M = 1$.and R = Quantity to be ordered.

* Quantities marked thus are appropriate only to stores items controlled on a re-order point basis. The stock record updating process must, however, deal with all items in the inventory.

Notes:

- 1 Equation 3 is used for both cyclical and random re-ordering. In the former case, it increases the order cover to one lead time plus one ordering interval; in the latter case it prevents another replenishment order from following quickly after the current one if a large demand has depleted that stock well below the re-order point.
- 2 If a maximum order quantity has been specified for the item, R will not be allowed to exceed this. If the maximum is less than the calculated value, the reduction imposed on R is reported for Management information.
- 3 If cyclical ordering is used for the item, R will not be calculated unless permitted by run parameter. When such permission is given, the system will respond only if the item is at the end of its ordering cycle. If permission for cyclical re-ordering is given twice in the same basic time interval, the second occasion will be ignored by the system.

Outstanding Order Balance

A.2.4

$$O(t') = O(t'-1) + R(t') - D(t') + R \tag{4}$$

DEMAND FORECASTING

A.3

Forecast Interval

A.3.1

It is desirable that the demand is relatively homogeneous with respect to the forecast interval (T) since short-term forecasting techniques are not appropriate to an item which 'moves' infrequently. The forecasting system treats the total demand in each forecast interval as a single item of data. Consequently, extending the forecast interval increases the frequency of movement as seen by the forecasting system. The observed demand in each forecast interval (T) is a sample taken from the demand time series $\{y_T\}$. Increasing the forecast interval increases the sample size and hence stabilizes $\{y_T\}$. At the same time, the speed of response of the system to real changes in demand is reduced. A balance between the two effects must be achieved by selection of a suitable $I(T)$, the length of the forecast interval, for each item.

The criterion used is:

Select $I(T)/I(t) = 1, 2, 4, 13, 26$ to satisfy:

$$P(y_T > 0) \geq 0.5 \tag{5}$$

where $I(t) =$ basic time unit of the system (usually one week).

$P(y_T > 0) =$ probability that demand y_T in forecast interval T is not zero.

Thus the length of the forecast interval is chosen to secure at least one movement in each two intervals e.g. (T) and ($T+1$). This is the minimum forecast interval: overall system considerations may require a longer interval

The above rule is generally sufficient for $I(T) \leq 4$ weeks. If $I(T) > 4$ weeks, it is recommended that an alternative method of control be applied. This is not a theoretical necessity, however, and any item may be included in the adaptive control system (subject to observance of 5 above) if other considerations demand it.

Adaptive Prediction Techniques

A.3.2

The traditional method of demand forecasting is the moving average, defined as:

$$\hat{y}_{T+1} = \frac{1}{N} \sum_{i=1}^N y_{T-N+i} \quad (6)$$

where \hat{y}_{T+1} is the one-period ahead forecast made at time (T)

$NI(T)$ = the time base period of the moving average

y_j = the demand in period j , $j = T - N + i$

This method is reasonably satisfactory if the demand is stable, or changes only slowly with time, and it has some advantages in dealing with cyclical variations in demand, provided that N is chosen to correspond to the base period of the cycle and that there is no large change in mean level of demand between one cycle and the next.

However, unless N is small, the moving average is sluggish in responding to step changes in demand and in following trends. Whilst the effect of an impulse (a single large demand) is minimized by large N , this effect is retained in the forecast for a full N periods. Moreover, it is difficult to change the sensitivity of the system (N must be changed to do this) and almost impossible to do so if cyclical variations in demand are present.

To overcome these disadvantages, considerable research has been conducted into short-term forecasting techniques in recent years, the work by Brown (1959 and 1963) on exponential smoothing being the most widely known. The latter technique employs the classical approach of assuming a fixed time-series model, giving for the linear case a one-period ahead prediction as:

$$\hat{y}_{T+1} = U_T + b_T/p \quad (7)$$

where Average Value $U_T = py_T + (1-p) U_{T-1}$ (8)

and Trend Value $b_T = q(U_T - U_{T-1}) + (1-q) b_{T-1}$ (9)

with $0 < p \leq 1$ and $0 \leq q \leq 1$ (7A)

A predictor is unbiased when $\bar{e} = 0$ (e = forecast error) and is assumed to be optimal when Σe^2 is a minimum. Minimum Σe^2 is preferred to minimum σ_e^2 (σ_e^2 = error variance) as a criterion of optimality because the former, used as a sole criterion, is not influenced by bias in the error.

Use of exponential smoothing in practice generally requires a computer simulation using historic y_T to find appropriate p and q for optimal forecasting in a manner similar to that discussed later in connection with the Box-Jenkins predictor.

Box and Jenkins (1962) have developed a generalized adaptive prediction technique, derived from automatic control theory, which gives a one-period ahead forecast (\hat{y}_{T+1} made at time T for period $T+1$) as:

$$\hat{y}_{T+1} = \hat{y}_T + \gamma_{-1} \Delta e_T + \gamma_0 e_T + \gamma_1 \sum_{j=1}^T e_j \quad (10)$$

where \hat{y}_T = forecast for period (T) made at time ($T-1$)
 e_T = forecast error at time (T) ($e_T = y_T - \hat{y}_T$)
 y_T = demand in period (T)
 $\Delta e_T = e_T - e_{T-1}$

and γ_{-1} , γ_0 and γ_1 are prediction parameters.

The second, third and fourth terms of the R.H.S. of equation 10 are known as the difference, proportional and cumulative control terms respectively, and correspond to the differential, proportional and integral terms, respectively, in automatic control theory.

It has been shown (Ward 1963) that equation 10 is equivalent to equation 7 when

$$\begin{aligned} \gamma_{-1} &= 0 \\ \gamma_0 &= p + q - pq \end{aligned} \quad (11)$$

$$\text{and } \gamma_1 = pq \quad (12)$$

It is apparent from equations 11 and 12 that p and q are interchangeable and may, therefore, be interchanged in the set of equations 7, 8 and 9. It follows that there is no practical advantage to be gained from these equations for the condition $q > p$. This reduces the useful range of p and q from that stated at equation 7A to

$$0 < p \leq 1 \text{ and } 0 \leq q \leq p \quad (7B)$$

No such restriction applies to the relative values of γ_0 and γ_1 in the Box-Jenkins equation and, in fact, it has been shown that the latter is stable over a wider range of values for the prediction parameters than exponential smoothing.

Exponential smoothing is thus a restricted special case of the Box-Jenkins predictor. Moreover, the latter is computationally simpler - this is particularly important when simulation is used to select optimal values for the prediction parameters - and requires no assumptions to be made concerning a basic time-series model.

Box and Jenkins (op. cit. page 314) state that the difference control term is not generally required for prediction purposes. γ_0 and γ_1 which minimize Σe^2 may be found by simulation with an appropriate grid of values (using historic y_T) but it is a faster process to use a ranging search technique which simulates the forecasting process with successive pairs of values for γ_0 and γ_1 chosen to follow a descending path across the response surface of Σe^2 until a minimum is found.

In practice, optimal γ_1 is often found to be zero, and this implies that real changes in the level of demand are no greater than the random element. Because of this, the one-point Box-Jenkins predictor (using proportional term only) may be used extensively. Optimal γ_0 may then be estimated from the following formula developed by Kay (then of Management Sciences Ltd.):

$$\lambda = \sigma_e^2 / \sigma_y^2 = \left[2 / (2 - \gamma_0) \right] \left[1 - \gamma_0 \sum_{j=0}^{\infty} (1 - \gamma_0)^j r_{j+1} \right] \quad (13)$$

where σ_e^2 = error variance

σ_y^2 = demand variance

r_{j+1} = serial correlation coefficient of the demand series for lag $(j+1)$

and $0 < \gamma_0 \leq 1$

Experience has shown equation 13 to give a good approximation of γ_0 , although it uses σ_e^2 in place of the preferred criterion Σe^2 . It is usually sufficient to consider only $j = 0, 1, 2$.

Where analysis of historic demand data suggests the use of a single point Box-Jenkins predictor it is convenient to set an emergency value for γ_1 which will be brought into use automatically when prediction optimality is lost.

Since Σe would be automatically accumulated as well, but normally multiplied by zero γ_1 the developing bias in successive forecasts will give a powerful response as soon as the emergency γ_1 is brought into use, if loss of optimality is due to a rapidly developing real change in demand.

When the use of zero γ_1 again produces acceptable forecasting, the system can revert to normal.

The tracking signal (see Section A.6 below) used to test system optimality is the trigger which brings the emergency γ_1 into use and subsequently abandons it.

If the introduction of the emergency γ_1 fails to restore system optimality, fuller investigation is necessary before the prediction parameters can safely be changed.

Cyclical Variation in Demand

A.3.3

This occurs when the demand tends to vary according to a repeating cycle of values. In practice the most common form which this takes is an annual seasonal variation in demand. The amplitude of the variation may change from cycle to cycle and the period of peak demand may alter in length and position within the complete cycle. It is a fundamental requirement of an inventory control system that stocks of seasonal items shall be increased in the early stages of the seasonal peak, and then maintained at this higher level until the demand starts to fall off, when stocks must be reduced so that only minimal stocks, if any, are carried during the slack season. This requirement may be critical.

Unaided, the Box-Jenkins predictor will track a cyclically varying demand closely when appropriate prediction parameters are used: but the system may have to forecast demand over several future periods. In these circumstances there is no known successful method of forecasting which does not take the seasonal demand profile into account. Moreover, whilst many workers have treated the subject

of seasonal fluctuations, no precise mathematical treatment which is of general application has yet been developed.

Seasonal variations may be further complicated by the presence of a trend component, but Kendall (1953) suggests that the classical method of attempting to separate long term and short term movements is unjustified.

A pragmatic treatment of seasonal demand variation has been adopted. By the use of a simple ratio transformation of historic demand data the relative magnitude of the demand in each period of the cycle is derived. The resulting cyclical profile represents the effect of all causal influences acting on the demand within the short period of one cycle - usually one year. The seasonal profile is derived again at the end of each cycle.

Demand Partial Sum

$$s_i = \sum_{j=0}^{n-1} y_{i+jM'} \quad (14)$$

where i = positional count within cycle in terms of $I(T)$.

M' = cycle length, or base, in terms of $I(T)$,

i.e. $M' = M I(t)/I(T)$. M must be an integer.

M = cycle length in units of $I(t)$, the basic time unit of the system.

n = number of complete cycles in demand data analyzed (usually two), i.e. n = integral part of N'/M' .

N' = number of forecast intervals covered by demand data analyzed, i.e. N' = integral part of $N I(t)/I(T)$.

N = number of demand points of data originally provided in terms of $I(t)$.

Factor Base

$$s_{min} = \text{Minimum } s_i > 0 \quad (15)$$

Seasonal Factor

$$s_T = s_i / s_{min} \quad T = i + jM' \quad (16)$$

Applying this transformation to equation 10 for $\gamma_{-1} = 0$, gives

$$\hat{y}_{T+1} = \hat{y}_T s_{T+1} / s_T + \gamma_0 e_T + \gamma_1 \sum_{j=1}^T e_j \quad (17)$$

Also

$$\sum_{j=1}^{L'} \hat{y}_{T+j} = (\hat{y}_{T+1} / s_{T+1}) \sum_{j=1}^{L'} s_{T+j} \quad (18)$$

L' as defined by equation 26.

It would be a sufficient test of the significance of cyclical variations present in a demand series that correction for them gave better forecasting, i.e. smaller safety stocks. However, to test the demand history of every inventory item in this way would require a long simulation which should be avoided wherever possible, since there are many inventories in which only a small proportion of the items show significant cyclical variation in demand. Simulation is used to select optimal prediction parameters only when seasonality (or trend - see below) is detected, and an initial screening is made so that usually only a small proportion of the items need be subjected to this more detailed examination.

The serial correlation coefficients of a demand series respond to the presence of cyclical variations if the time lag for which the coefficient is calculated is small, or is approximately equal to the cycle base (M') which is the length of the cycle. Where r_k = serial correlation coefficient for lag k , it is therefore, necessary to test $r_{M'}$ for significance. For reasons explained later, r_1 is also examined in the same way.

The test used is a non-parametric one which has the effect of studying the distribution of the correlation coefficients (for constant k) arising from all possible arrangements of the demand points and deciding (at a pre-set level of confidence - 90% is suggested) if the actual r_k could have been due to chance causes. If the demand pattern is such that it could be explained by a model containing both trend and cyclical components, $r_{M'}$ may, because of the nature of the test used, appear to be non-significant. Since r_1 is generally found to be significant if either trend, or cyclical variation, or both are present r_1 is subjected to the same test.

For computational convenience, the circular form of the serial correlation coefficient is used, and of this, only the cross product term need be examined because the other terms (see equation 20) would not change if the sequence of demand points were re-arranged.

Serial Correlation Coefficient

$$r_k = \frac{\sum_{i=1}^{N'-k} x_i y_i - (N'-k)\bar{x}\bar{y}}{(N'-k) \sigma_x \sigma_y} \quad \text{standard form} \quad (19)$$

$$r_k = \frac{\sum_{i=1}^{N'} x_i y_i - N'\bar{x}\bar{y}}{N' \sigma_x \sigma_y} \quad \text{circular form} \quad (20)$$

- where $k = \text{lag} = 1, 2, 3, \dots, M'$
- $y_i = \text{demand in period } i = 1, 2, 3, \dots, N'$
- $x_i = y_{i+k} \quad (i \text{ to modulo } N')$

Significance Test

Only the cross product term $\sum_{i=1}^{N'} x_i y_i$ in equation 20 need be considered as noted above.

If $r'_k = \sum_{i=1}^{N'} x_i y_i$ it has been shown that

$$\bar{r}'_k = \frac{S_1^2 - S_2}{N' - 1} = \text{mean}(r'_k) \quad (21)$$

and
$$\sigma^2(r'_k) = \frac{S_2^2 - S_4}{N' - 1} + \frac{S_1^4 - 4S_1^2 S_2 + 4S_1 S_3 + S_2^2 - 2S_4}{(N' - 1)(N' - 2)} - \bar{r}'_k{}^2 \quad (22)$$

$$= \text{variance}(r'_k)$$

where
$$S_i = \sum_{j=1}^{N'} y_j^i$$

Then
$$\tau_k = \frac{r'_k - \bar{r}'_k}{\sigma(r'_k)} \quad (23)$$

and for the 90% confidence level, $\tau_k \geq 1.28$

For other confidence levels, the limiting value of τ_k may be taken from the normal probability table—see Appendix B. Further details of this test will be found in Hoel (1965, pp. 343-345).

If either r_1 , or r_M , is found to be significant, or if $\gamma_0 \geq 0.3$ (from equation 13) a simulation over the demand history for that item is used to determine optimal prediction parameters. Seasonality is ignored unless r_M is significant, or r_1 is significant and $\lambda \leq 0.5$ (see equation 13) when seasonality is taken into account. Whichever pair of γ_0 and γ_1 gives lower Σe^2 is accepted.

SAFETY STOCK

A.4

It is fundamental to a re-order point control system that an estimate be made of the maximum demand which may be satisfied during the replenishment delivery time (L'). If available stock is not greater than this, a stock replenishment order must be issued. This estimate of maximum demand is, in fact, the re-order point for the item in question.

The forecasting process estimates the mean level of demand, but because a random component is found in the demand patterns for most stores items, this forecast must be qualified to allow for this when the re-order point is calculated. The qualification used is to include a safety stock component in the re-order point. The safety stock provides protection against running out of stock should the demand exceed the forecast while fresh supplies are awaited: it is computed for a specific risk of stock-out.

which must be specified by management. The risk of stock-out is:

$$P(S_{T+L}, < 0)$$

where S_{T+L} , is the available stock immediately prior to the delivery of fresh supplies and is assumed to take a negative value when demand is greater than the stock available to meet it. Its complement, $P(S_{T+L}, \geq 0)$ expressed as a percentage, is the customer service level.

If the incidence of demand for a stores item is considered as a continuing process which is observed at discrete time intervals, observation of the process level (the true demand) is obscured by the random element. In continually providing a latest best estimate of the process level, the forecasting system filters out the random element, which is transferred to the forecast error ($e_T = y_T - \hat{y}_T$).

The tolerance on the forecast (\hat{y}_T) to contain the demand (y_T) to satisfy the specified $P(S_{T+L}, \geq 0)$ is, therefore, a function of σ_e , the standard deviation of forecast errors.

Brown (1959, page 93) shows that σ_e may be estimated from

$$\sigma_e \approx (\pi/2)^{\frac{1}{2}} \hat{d}_{T+1} \approx 1.25 \cdot \hat{d}_{T+1} \quad (\bar{e} = 0) \quad (24)$$

where \hat{d}_{T+1} = the smoothed mean absolute error computed at time (T),

and this may be used to compute the safety stock.

The forecasting system adapts to changes in the demand process level, but while such changes are occurring, a transient bias may develop in the forecast, although the mean forecast error $\bar{e} \rightarrow 0$ over time. When such a bias develops, equation 24 will tend to overstate σ_e because now local $\bar{e} \neq 0$. When demand is changing, therefore, there is an automatic increase in safety stock to provide additional protection against stock-out until the process has again stabilized at a new level.

The tolerance on the demand over the replenishment delivery time is obtained from the following, only the upper limit being of interest:

$$S_s = K \cdot 1.25 \hat{d}_{T+1} (L')^{\frac{1}{2}} \quad (25)$$

where S_s = safety stock

and K = the percentage point of the normal distribution curve corresponding to $P(S_{T+L}, \geq 0)$ where S_{T+L} , is the stock at the end of the replenishment delivery time prior to the receipt of the new order.

The most likely values of K may be taken from the following table, which also shows the relative effect of customer service level on the resulting size of safety stock, the safety stock for the 95% level being taken as 100. A more detailed table is given in Appendix B.

<i>Service Level (%)</i>	<i>K</i>	<i>Relative Size of Safety Stock</i>
80	0.84	51
85	1.04	63
90	1.28	78
95	1.64	100
96	1.75	107
97	1.88	115
98	2.05	125
99	2.33	142
99.9	3.09	188

The interpretation of customer service level as used here is the percentage number of the ordering intervals during which a stock-out will not occur, e.g. for an ordering interval of one month and a 95% service level, say, a stock-out may be expected to occur once in 20 months.

The setting of the value K in equation 25 provides Management with the facility for tuning the system when it is wished to change the customer service level for a particular item. Normally, however, the same service level will be adopted for large groups of items and provision is made for four such groups. Consequently, during the early stages of running the system, the service level for a complete group can be changed by a simple amendment to a run parameter.

In general, the slower an item moves the better will be the protection against stock-out provided by the cycle stock (i.e. the stock in excess of the safety stock) because slow moving items tend to be re-ordered infrequently in comparison with fast moving items. The value of K chosen for the slow movers will, therefore, tend to be lower than that selected for the fast movers.

The replenishment delivery time (L') in equation 25 is in terms of the forecast interval ($I(T)$) for the item concerned. All times are, however, advised to the system in terms of $I(t)$, the basic time period of the system. The automatic conversion from L to L' when $I(T) > I(t)$ is:

$$L' = [\text{integral part of } L I(t)/I(T)] + 1 \quad (26)$$

unless $L I(t)/I(T)$ is an integer, when

$$L' = L I(t)/I(T) \quad (26A)$$

If cyclical ordering is to be used, substitute $(L+W)$ for L in equations 26 and 26A.

W = ordering interval in basic time periods $I(t)$.

Variability of Replenishment Delivery Times

A.4.1

Equation 25 takes no account of possible variation in the replenishment delivery time (L). In the general case there are two practical difficulties which make it unwise to adjust automatically for this.

(a) Supply sources may not stay stable over long periods of time and any analysis of delivery times

should be based on recent history. Unless the item is ordered frequently, there will thus tend to be insufficient data for a reliable statistical analysis if each item is considered independently.

- (b) It cannot safely be assumed that the causal influences on demand and on delivery times are independent, but they may be in some cases. Theoretically, a different treatment is required for each of the two cases.

In the absence of reliable information to the contrary, the safe course is to group items which have similar lead times and which may be expected to have much the same lead time variability, and to analyze experience over, say, the preceding six months; hence to derive a reasoned estimate of L to be used in the system.

RE-ORDER POINT

A.5

The operational rule of the re-order point inventory control system is:

Order a new supply if, and only if, the available stock is not greater than the re-order point.

Effect is given to this rule in equations 3, 3A and 3B.

The re-order point is thus the maximum expected consumption of stock in the replenishment delivery time, appropriate to the selected level of customer service. The re-order point may therefore be derived from equations 18 and 25, thus:

$$P_{T+1} = (\hat{y}_{T+1}/s_{T+1}) \sum_{j=1}^{L'} s_{T+j} + 1.25 K \hat{d}_{T+1} (L')^{\frac{1}{2}} \quad (27)$$

Note that P_{T+1} is recomputed each forecasting interval, but the above operational rule is applied at the end of each updating interval (t') throughout period ($T+1$). It may also have to be applied immediately after the forecasting process has been used to revise P_{T+1} , since P_{T+1} may thereby be increased above the available stock (A_T). If system considerations warrant it, however, this check may be left until the next subsequent stock updating run.

There is a minimum order quantity required to maintain system stability (see equation 36) but if this is satisfied there is no other limit on the number of orders which may be raised in one replenishment delivery time. This is achieved by controlling on available stock ($A(t')$) instead of physical stock ($S(t')$). To prevent the same order being requested twice in two successive updating runs, the on-order balance is updated immediately a replenishment order is requested by the system - see equation 4. If Management intervenes to withhold an order, or to vary the quantity, this must be reported to the system - see $R(t')$ in equation 2.

CONTROL OF PREDICTION OPTIMALITY

A.6

Clearly, for minimum stock holding, P_{T+1} must be a minimum consistent with the customer service level required by Management. This implies that the safety stock must also be a minimum which occurs when $\{ |e_T| \} \rightarrow 0$. The magnitude of e_T however, depends upon the prediction parameters used in equation 17 and it is obvious from equation 25 that minimizing \hat{d}_{T+1} results in a reduction of safety stocks with corresponding reduction in stock holding costs. The selection of optimal γ_0 and γ_1

values is, therefore, of fundamental importance to inventory control. Considerable increases in the cost of holding safety stock may arise from the use of non-optimal prediction parameters.

The method of monitoring prediction optimality proposed by Trigg (1964) is the most suitable available.

Smoothed Error

(28)

$$\hat{e}_{T+1} = \hat{e}_T + \gamma_0'(e_T - \hat{e}_T)$$

Mean Absolute Deviation

$$\hat{d}_{T+1} = \hat{d}_T + \gamma_0'(|e_T| - \hat{d}_T) \quad (29)$$

Tracking Signal

$$\tau = \hat{e}_{T+1} / \hat{d}_{T+1} \quad (30)$$

Whenever $|\tau| > 2.4\gamma_0' / (2\gamma_0' - \gamma_0'^2)^{\frac{1}{2}}$ an indicator denoting departure from prediction optimality (control indicator) is output. At the same time if the currently used value of γ_1 is zero, γ_1 is temporarily reset to the value input by parameter and the forecasting process uses this, γ_1 then being reset to zero. This process is repeated each forecast interval until its use results in an acceptable value of the tracking signal. The control indicator is output each time the tracking signal falls outside limits. When this happens a number of times in succession, arrangements should be made to re-analyze the demand history when sufficient data representative of any new demand pattern has been accumulated. If γ_1 already has a non-zero value, an alternative value for γ_1 is not used.

It has been found experimentally that γ_0' used in equations 28 and 29 gives best results with a value of 0.17 and it is recommended that this value be used.

REPLENISHMENT ORDER QUANTITY

A.7

Ideally, any inventory control system should ensure that total operating costs (C_h) are kept to a minimum over time. Assuming that the cost of stock holding is a linear function of the average stock value and that the cost of ordering is some function of the order quantity (R), then:

$$\begin{aligned} \text{Stock holding cost} &= I_r C_p (R/2 + S_s) \\ \text{Ordering cost} &= F(R) \\ \text{Hence} \quad C_h &= I_r C_p (R/2 + S_s) + F(R) \quad (31) \\ \text{where} \quad R &= \text{re-order quantity} \\ C_p &= \text{unit cost price of item} \\ S_s &= \text{safety stock quantity} \\ I_r &= \text{stock holding cost such that } I_r C_p = \text{the annual cost of stocking one unit.} \end{aligned}$$

$$R/2 = \text{cycle stock}$$

$$R/2 + S_s = \text{average stock}$$

It follows from equation 31 that for minimum C_h :

$$dC_h/dR = I_r C_p/2 + dF(R)dR = 0 \quad (32)$$

From which, R that minimizes C_h can be obtained provided that $F(R)$ can be differentiated and that the safety stock (S_s) is computed from equation 25 when it is independent of R .

If Y = annual demand rate, and

C_0 = the total costs arising from placing an order for the item

then, for minimum C_h

$$R = (2C_0 Y / C_p I_r)^{1/2} \quad (33)$$

If \hat{Y}_{T+1} = current estimate of Y made at time (T)

and E_{T+1} = current estimate of R ,

then $\hat{Y}_{T+1} = (\hat{y}_{T+1} / s_{T+1}) \sum_{j=1}^{M'} s_{T+j}$ (1 year = M' × forecast interval)

and $E_{T+1} = (2C_0 \hat{Y}_{T+1} / C_p I_r)^{1/2} \quad (34)$

Whilst equation 34 allows for seasonal variation in demand in the calculation of \hat{Y}_{T+1} it will give only approximate results for all cases other than a constant demand. Where strong seasonality is present in the demand pattern of an item, the equation should be used with discretion.

Tate (1964) has discussed the validity of economic replenishment order quantities. Hadley and Whitin (1963) give a detailed description of their derivation.

A practical alternative to equation 34 is the selection of order quantities such that the ordering interval is approximately constant. If the ordering interval is $W I(t)$, then the order quantity (Q_{T+1}) is given by:

$$Q_{T+1} = (\hat{y}_{T+1} / s_{T+1}) \sum_{j=1}^{W'} s_{T+L'+j} \quad (35)$$

where $W' = [\text{integral part of } W I(t)/I(T)] + 1$

unless $W I(t)/I(T)$ is an integer, when

$$W' = W I(t)/I(T)$$

Note that the new delivery is assumed to be available from the start of the period $T+L'+1$.

Equation 35 is not affected by a non-constant demand pattern, but is likely to give higher C_h than equation 34 if C_0 and I_r can be accurately determined for the latter.

If cyclical ordering is to be used, equation 34 is not appropriate, although it may be used to help choose W for use in equations 26 and 26A.

Minimum Order Quantities

A.7.1

There are two minimum order quantities which the system may have to recognize. One of these - the statistical minimum order quantity - is imposed by the system itself, and must always be observed: the second may be imposed by the supply source when orders must be placed in terms of a quantity unit larger than that used for recording and issuing stock. Equation 3 takes account of this latter minimum quantity.

The operational system uses data aggregated in terms of time units $I(T)$ the forecast interval. Unless further analysis is undertaken, the system can derive no information on the demand in any smaller time unit. For example, the whole of the demand forecast for a particular (T) might arise in the first day of that period, there being no further demand during the period. Consequently, in order to maintain system stability, it is a system requirement that the minimum order quantity (Q_{min}) shall satisfy the following:

$$Q_{min} = (\hat{y}_{T+1} / s_{T+1}) s_{T+L'+1} \tag{36}$$

This is derived from equation 35 for $W' = 1$

For random re-ordering the system computes both Q_{T+1} and E_{T+1} and selects the larger for use in equations 3, 3A and 3B thus:

If $Q_{T+1} \geq E_{T+1}$,

$$R_{T+1} = Q_{T+1} \tag{37}$$

Otherwise

$$R_{T+1} = E_{T+1} \tag{37A}$$

If fixed interval ordering is preferred, W is set to the appropriate value in equation 35 and C_0 is set to zero in equation 34. 35 will then override 34 and still satisfy 36.

If use of the economic order quantity formula in equation 34 is preferred, the appropriate parameters are set in this and W in 35 is set to 1 so that 36 will still be observed.

For cyclical re-ordering, $E_{T+1} = 0$. This in conjunction with equations 26, 26A, 27, 3, 3A and 3B ensures that a regular order increases the order cover to $(L + W)$ basic time periods each time, i.e. once every W periods.

PERFORMANCE ESTIMATION

A.8

Assuming fixed \bar{y} (over the demand history examined) then, for any order interval W in terms of $I(t)$:

Average Minimum Stock

$$\bar{S}_{min} = (L')^{\frac{1}{2}} K \sigma_e \quad (38)$$

Average Stock

$$\bar{S}_{av} = \bar{S}_{min} + W\bar{y}/2 \quad (39)$$

Average Maximum Stock

$$\bar{S}_{max} = \bar{S}_{min} + W\bar{y} \quad (40)$$

Average Replenishment Order Size

$$\bar{R} = W\bar{y} \quad (41)$$

The inventory may be subdivided into four sections, and a different service level applied to each for the calculation of safety stock, which is the minimum stock in equation 38.

Equations 38 to 41 are applied to five values of W for each item, disposed two on each side of the preferred interval. Equations 38 to 41 are then repeated using the economic order quantity in place of $W\bar{y}$.

$$E = (2C_o \bar{Y} / C_p I_r)^{\frac{1}{2}} \quad (42)$$

Total Average Safety Stock Value

$$C_s = \sum_{i=1}^N (S_{min})_i (C_p)_i \quad N = \text{number of items} \quad (43)$$

Total Average Cycle Stock Value

$$C_c = \frac{1}{2} \sum_{i=1}^N W_i \bar{y}_i (C_p)_i \quad \text{using preferred ordering interval} \quad (44)$$

or
$$C_c = \left(\frac{1}{2} C_o / I_r \right)^{\frac{1}{2}} \sum_{i=1}^N \left[(\bar{Y})_i (C_p)_i \right]^{\frac{1}{2}} \quad \text{using economic order quantities} \quad (45)$$

Total Stock Value

$$C_I = C_s + C_c \quad (46)$$

Number of Orders a Year

$$H = M \sum_{i=1}^N 1/W_i \quad \text{using preferred ordering interval with } M I(t) = 1 \text{ year} \quad (47)$$

or

$$H = \left(\frac{1}{2} I_r / C_0 \right)^{\frac{1}{2}} \sum_{i=1}^N \left[(\bar{Y})_i (C_p)_i \right]^{\frac{1}{2}} \quad \text{using economic order quantities} \quad (48)$$

Stock Turnover Ratio

$$B = \left[\sum_{i=1}^N (\bar{Y})_i (C_p)_i \right] / C_I \quad (49)$$

SUPPLEMENTARY FORMULAE

A.9

A number of equations omitted from the foregoing discussion are included here for reference.

Mean Demand

$$\bar{y} = \frac{1}{N} \sum_{i=1}^N y_i \quad (50)$$

Standard Deviation of Demand

$$\sigma_y = \left[\frac{1}{N} \sum_{i=1}^N y_i^2 - (\bar{y})^2 \right]^{\frac{1}{2}} \quad (51)$$

Forecast Error

$$e_T = y_T - \hat{y}_T \quad (52)$$

Mean Error

$$\bar{e} = \frac{1}{N} \sum_{i=1}^N e_i \quad (53)$$

Standard Deviation of Error

$$\sigma_e = \left[\frac{1}{N} \sum_{i=1}^N e_i^2 - (\bar{e})^2 \right]^{\frac{1}{2}} \quad (54)$$

Appendix B Normal Probability Table

%	Factor	%	Factor
80.0	0.84	90.0	1.28
80.5	0.86	90.5	1.31
81.0	0.88	91.0	1.34
81.5	0.90	91.5	1.37
82.0	0.91	92.0	1.41
82.5	0.93	92.5	1.44
83.0	0.95	93.0	1.48
83.5	0.97	93.5	1.51
84.0	0.99	94.0	1.55
84.5	1.02	94.5	1.60
85.0	1.04	95.0	1.64
85.5	1.06	95.5	1.69
86.0	1.08	96.0	1.75
86.5	1.10	96.5	1.81
87.0	1.13	97.0	1.88
87.5	1.15	97.5	1.96
88.0	1.17	98.0	2.05
88.5	1.20	98.5	2.17
89.0	1.23	99.0	2.33
89.5	1.25	99.5	2.58
		99.9	3.09

Appendix C Bibliography

Box, G.E.P., and Jenkins, G.M. (1962)

"Some statistical aspects of adaptive optimization and control"
J.R. Statist. Soc. (B)., vol. 24, No. 2, pp. 297 - 343 (with discussion).

* Brown, R.G. (1959)

Statistical Forecasting for Inventory Control McGraw-Hill: New York.

(1963)

Smoothing, Forecasting and Prediction of Discrete Time-series Prentice-Hall: NJ.

Brown, R.G., and Meyer. R.F. (1961)

"The fundamental theorem of exponential smoothing"
J. Op. Res. Soc. Am., vol. 9, No. 5, pp. 673 - 687.

* Coutle, G.A. *et al.*, (1964)

Short-term Forecasting I.C.I. Monograph No. 2. Oliver & Boyd: Edinburgh

Cox, D.R. (1961)

"Prediction by exponentially weighted moving averages and related methods"
J.R. Statist. Soc. (B)., vol. 23, No. 2, pp. 414 - 422.

Hadley, G., and Whitin, T.M. (1963)

Analysis of Inventory Systems. Prentice-Hall: NJ.

Hannan, E.J. (1960)

Time Series Analysis Methuen: London.

Hoel, P.G. (1965)

Introduction to Mathematical Statistics Wiley: New York.

Holt, C.C. (1957)

"Forecasting seasonals and trends by exponentially weighted moving averages"
Off. Naval Res. Research Memorandum No. 52.

Kay, E., and Hampton, J.S. (1963)

"An experiment in short-term forecasting"
Proc. 3rd. Int. Conf. on Op. Res. pp. 120 - 141 (with discussion).

Kendall, M.G. (1953)

"The analysis of economic time-series - Part I: Prices"
J. R. Statist. Soc. (A) vol. 116, No. 1, pp. 11-34.

Leong, Y.S. (1962)

"The use of an iterated moving average in measuring seasonal variations"
J. Amer. Stat. Assoc., vol. 57, pp. 149 - 171.

* Muir, A. (1958)

"Automatic sales forecasting"
Comp. J., vol. 1., No. 3, pp. 113 - 116.

Shiskin, J., and Eisenpress, H. (1958)

Seasonal Adjustments by Electronic Computer Methods
Nat. Bur. Econ. Res., Technical paper No. 12.

Tate, T.B. (1964)

"In defence of the economic batch quantity"
Operat. Res. Quart., vol. 15, No. 4, pp. 329 - 340.

Trigg, D.W. (1964)

"Monitoring a forecasting system"
Operat. Res. Quart., vol. 15, No. 3, pp. 271 - 274.

Vassian, H.J. (1955)

"Application of discrete variable servo theory to inventory control"
J. Op. Res. Soc. Am., vol. 3, No. 3., pp. 272 - 282.

Ward, D.H. (1963)

"Comparison of different systems of exponentially weighted prediction"
The Statistician, vol. 13, No. 3., pp. 173 - 185.

Whittle, P. (1963)

Prediction and Regulation by Linear Least-square Methods
The English Universities Press: London.

* Winters, P.R. (1960)

"Forecasting sales by exponentially weighted moving averages"
Mang. Sci., vol. 6, No. 3, pp. 324 - 342.

* These references are particularly recommended to any reader wishing to make a deeper non-technical study of the subject.

A more extensive bibliography is given by Brown (1963, pp. 453 - 462).

