D E V E L O P M E N T O F A C O M P U T E R I S E D W O R K S H O P M A N A G E M E N T P R O G R A M

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Declaration

I declare that this project report is my own, unaided work. It is being submitted for the degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

H Bamlab

23rd day of October 1991

Abstract

It is generally accepted that if a company's stock control and shop floor control systems are inadequate or they operate inefficiently, then both productivity and profit potential within the company will inevitably be low. Such a company was investigated and the results presented in this report showed that the company's profile gives cause for concern. A study of the company's operating procedures showed that it was operated in a static, paper driven environment which resulted in both an inadequate stock control system and a chaotic shop floor control system.

This project report looks at the feasibility of introducing a menu driven data base to operate an order point inventory system within an independent demand environment, as well as monitoring shop floor activity. The introduction of the data base would result in a dynamic, realtime shop floor control system. By using the data base the stock levels could be reduced by as much as 77 percent from present levels and the store could be run on modern stock control methods without the store managers having any knowledge of stock control. As a result of introducing the stock control system it was anticipated that the time to train staff would also be reduced substantially, the company could now account for every expense incurred and the opportunities for pilferage would

be greatly reduced.

The computer package was written in such a manner that computer recommendations could be overwritten by system users, thus the human element was retained and stores personnel would not be given the feeling of being redundant. The introduction of this data base would allow the company to respond to challenges an problems in a dynamic and accurate way.

To NOUT and ARIEN

who made so many things possible,

of which this report is the least

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LIST OF SYMBOLS

Quantity/Description	Symbol
Bill of materials	BOM
Unit cost of an item	C
Average annual demand for an item	D
Data base management system	DBMS
Demand during lead time	DLT
Economic order quantity	EOQ
First in first out	FIFO
Inventory-carrying-cost rate	I
Kilo byte	Kb
Lead time	LT
Mean average deviation of demand during replenishment lead time	MAD
Mega byte	Mb
Master production schedule	MPS
Materials requirements planning	MRP
Order point planning	OPP
Personal computer	PC
Lot size	Q
Reorder point	ROP
Average cost of processing an order	S
Standard deviation of demand during replenishment lead time	Sd
Shop floor control system	SFCS
Statistical safety stock	SSS

Quantity/Description	Symbol
Incremental total cost	T_c
Work in process	WIP
Standard normal distribution probability	Z

1 Introduction

This project report deals with a company whose future seemed bleak and had been running at a loss for two years. This company is a very small subsidiary company of a large parent company, referred to in this report as Rail. Both the names of the parent and subsidiary company are fictitious, since the company did not want to be mentioned by its proper name, for reasons which will become clear when reading the report.

The company, Loco, is responsible for the maintenance of all Rail vehicles on the Witwatersrand. These vehicles range from trucks and four wheel drive vehicles to motorbikes. Loco is able to maintain any vehicle which is part of the Rail organisation, but cannot service any vehicle which is not owned by this organisation.

Loco is located on the outskirts of Johannesburg, on a property of approximately ten acres. The company buildings are two large hangers and an office block, the remainder of the property provides parking bays for vehicles. Loco employs approximately 200 people of which only 80 are classified as permanent staff.

The temporary staff turnover is in the region of 200% per annum, as a result the majority of the temporary staff are unskilled and are assigned to administrative work and staff the store. Seventy of the permanent staff members

are artisans and the remaining ten occupy managerial positions. With such a large staff and premises, it is possible for Loco to carry out major repairs on vehicles. The word vehicle in the rest of this project report shall be deemed to mean any mode of mechanised road transport, ranging from a 20 ton truck to a 500cc motorbike.

Major repairs involve rebuilding a vehicle from the chassis upwards, which incorporates mechanical, electrical, panelbeating and spraypainting work, because Loco has the facilities to cater for all repairs, it means that any vehicle which cannot be repaired on Loco premises by Loco staff, will be scrapped.

Loco operates in a maintenance environment, it is therefore necessary that the workshop stock sufficient spares for all the different types of vehicles it may have to maintain.
The words: spares, stock and inventory carry the same meaning wherever used in this project report.

2 Company background, policy and procedures

2.1 Company background and policy

Rail is a large organisation and through its subsidiary companies is involved in every facet of the economy. All vehicles belonging to Rail subsidiary companies must be maintained at Rail workshops; and in the case of the Witwatersrand, the company Loco runs the workshop.

2.1.1 Categories of repair

The aim of the workshop is to repair in as short a period as possible any out of commission vehicles. The two categories of repair which take place at the workshop are, pro-active repair and remedial repair. Pro-active repair tasks are preplanned and represent scheduled repair tasks based on hours worked or kilometers traveled. Remedial repairs are unscheduled repairs which are totally reactive and can not be preplanned.

The repair tasks can be split into one of the two above mentioned categories, but, the actual work done on a vehicle is further classified, depending on the make of vehicle. All work which is carried out on a four wheel drive vehicle, is classified as being a "B" job, and all work done on two wheel drive vehicles, is classified as being a "D" job.

2.1.2 Industrial repair

The repair of assemblies and sub-assemblies is carried out by specialised firms, which are not Rail subsidiary companies. Rail does not have a subsidiary company to do these repairs because these repairs do not occur frequently enough to warrant this. The definition according to Rail policy for an assembly and sub-assembly are given below.

a) Assembly: a combination of parts which usually is provided in assembled form, for example, the gear-box of a vehicle.

b) Sub-assembly: an assembly which forms a smaller part of a piece of equipment or a larger assembly, for example, the flywheel which forms part of the clutch.

2.2 Company procedures

2.2.1 Company stores procedures

2.2.1.1 Stores policy

The aim of the company's store procedures are the following:

a) To have spare parts and accessories available in the workshop when required.

b) To provide a simple accounting system which requires minimum manpower and time, in order to keep it up to date.

c) To bring about the speedy return of serviceable as

well as repairable stock.

2.2.1.2 Stores classification

All spares fall into one of two categories, which are:

a) "A" class items: these are referred to as accountable items or capital items, because they can be repaired or reused.

b) "E" class items: these are items which are considered to be expendable items or consumables.

2.2.1.3 Requirements for stock classification

a) As soon as the rate of consumption of an "A" or "E" class item indicates that it warrants having a stock thereof, then minimum and maximum stock notches must be determined and stock can be carried in the store.

b) A movement of six or more per year can be used as a measure to reclassify a non-stock item to a stock item.

2.2.1.4 Definition of stock notches

a) Stock notches are determined with due allowance of delivery time, and actual turnover of the specific part.

b) Notches must be based on the actual turnover of an item over a period of three months.

c) The minimum notch is half the maximum notch.

2.2.1.5 Accounting procedures

a) Stores are classified as accountable "A" class or expendable "E" class items.
b) Main ledger accounts are kept for items classified as accountable.
c) Bin cards are used to monitor stock quantities and reorder points for both "A" and "E" class inventory.
d) Bin cards are kept in the same bin as the spares.
e) A bin card contains the following information:
   -Item control number for spare part.
   -Description/official name of item.
   -Current bin number.
   -The quantity in stock.
   -The cost price of the spare.
   -Minimum stock notch.
   -Maximum stock notch.
   -End item for which the spare is intended.
   -Units of measurability.

2.2.1.8 Classification of stores

Items classified as being accountable are always reflected in the main ledger account. These items include workshop equipment and tools as well as main and sub-assemblies.

2.2.2 Repair procedures

The sequence of operations that are carried out in repairing a vehicle are illustrated in figure 2.1 and explained in the subsequent sections.

2.2.2.1 Call in

A written request for work to be carried out on a vehicle, in the case of pro-active repair, is sent to the Loco planning office from one of Rail's subsidiary companies. As soon as there is manpower and space available in the workshop, then the company who sent in the request is given two days notice to deliver their vehicle to the workshop. In the event of a vehicle breaking down on the road or of not being able to be driven to the workshop, then Loco sends out a recovery team to bring these vehicles back to the workshop. When the situation arises that a vehicle has broken down on the road then the procedures of having a written request etc., are not followed, and the vehicle is then repaired as soon as possible.

2.2.2.2 In-inspection

For every vehicle received at the workshop a full technical inspection is carried out. This inspection is carried out according to the standards and techniques, as laid down in the technical inspection report for B and D vehicles, DD 1828 (see appendix A). For every item in the

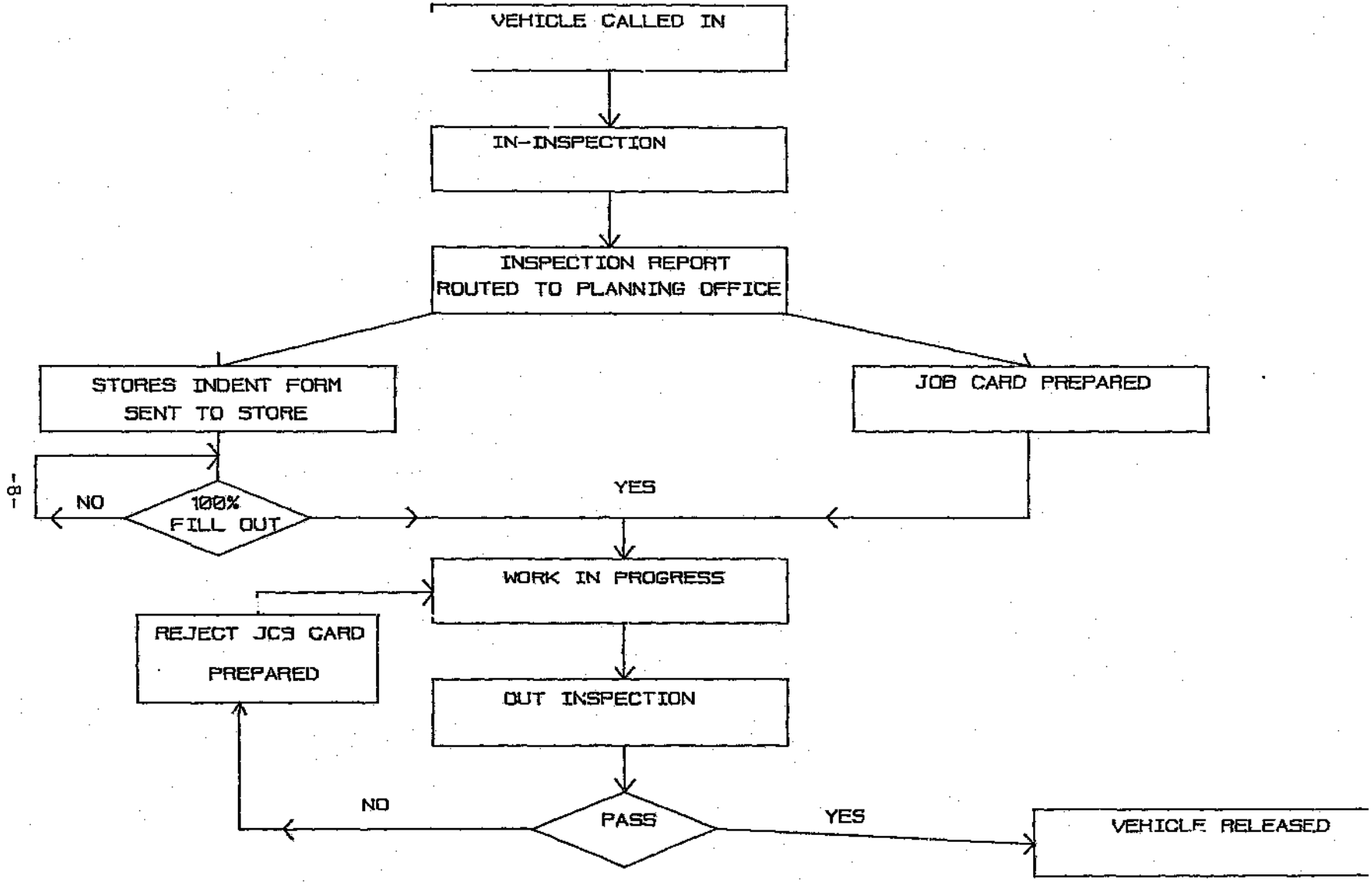


Figure 2.1 Steps involved with repairing a vehicle

technical inspection report, for which there is a defect, the artisan doing the inspection must decide whether the defect is serviceable or repairable, and the must specify how the service or repair should take place. The artisan then estimates the amount of time for the job, using a set of standard times, and lists any spares or consumables required to complete the work. This inspection can take anything up to eight hours to complete.

2.2.2.3 Planning office

The completed inspection report is then routed to the planning office, where a clerk has the job of completing a job card, DD 1813 (see appendix A), and filling out a store indent form, DD 1873. All the work which is required to be carried out is written on the left hand side of the job card as well as the times required for each task. The tasks are filled in on the job card, in four distinct categories. These categories describe the type of work which has to be done. The categories are mechanical, electrical, spraypainting and panelbeating work. Spares which are requested by the artisan who did the in-inspection, are ordered from the store by filling in a store indent form. The indent form must then be approved by the planning manager before being sent to the store for processing. The actual time taken for an indent form to get from the planning clerk to the store can take up to five days, from the time the procedure is initiated.

2.2.2.4 Stores

Work can not be started on a vehicle until all the required spares are available. As soon as the stores indent form is received, all the spares required for the job are retrieved, and placed in a holding bin specifically for that job. Once a week there is a meeting held between the stores and planning managers to review the progress on the ordering and receiving of spares for jobs which don't have a 100% fill out. Jobs can be held up for anything up to two months whilst waiting for a complete fill out on spares.

2.2.2.5 Work done

When work starts on a job, a complete record of the work done is filled in on the job card next to the original task as well as the actual time taken. If a specific task was overlooked during the initial inspection, for example, a faulty fuel pump, then this task is added by the foreman who also prepares a new stores indent form. When a section of work is finished, for example, the mechanical work, then the vehicle together with its job card are sent to the next section. The work is carried out in a specific order, beginning at the mechanical department, then panelbeating, followed by electrical and spraypainting work.

2.2.2.6 Out inspection

When the vehicle has passed through all the sections it then undergoes a further inspection before it is returned to its original owners. The purpose of this inspection is to ensure that all the tasks which were listed at the in-inspection have been completed. If some tasks have not been finished properly then the inspector draws up a "reject" job card also on a DD 1873. The rejected vehicle is then sent to the sections who had work which failed the final inspection. Once the vehicle has passed the out or final inspection it is released. Throughout the entire repair all important dates and times are recorded in a workshop journal, DD 1633 (see appendix A). The job card for the job which has been released is then archived.

3 Analysis of company operation

In the last two years the company (Loco) has made no profit, in spite of which it is still doing business. The reason for this is that Rail, have subsidised Loco over the bleak two year period. As a result of the past record of Loco, questions such as:

a) Is there enough repair work to justify continued operation by Loco ?

b) Can the current rate of subsidy be continued ?

c) Does the strategic necessity outweigh financial considerations ?

These questions, and others, are typical of the questions being posed by financial management. However, it was the prevailing view of the parent organisation that Loco provided an essential service that could not be disposed with. Therefore Loco was to be kept in operation. It was established that there was no need for the company to seek outside work as there was more than sufficient repair work for full operation of Loco. The reasons for the operating loss were perceived to be as a result of gross mismanagement at Loco.

Within every cell, organisation, company or community that is having difficulties, there is always one or two major problems which must be solved first, before the smaller problems can be clearly seen, analysed and solved. In the case of Loco, it was found to be an inventory problem,

which had then permeated into the different aspects of shop floor control, such as the monitoring of shop floor activity, quality problems and throughput.

3.1 Inventory management at Loco.

The number of different A and B class items in the store exceeds 40 000, and a total stock value which exceeds fifteen million rand. With such a large amount of spares, it is not possible to manage them on an outdated, complicated and paper driven system.

3.1.1 Stores staff

The store staff consists of one store manager and his assistant, both of whom are permanent staff members. These two permanent staff members are assisted by four temporary staff members. These six people are responsible for running the entire store, and carrying out the following tasks:

a) Initiating orders to purchase additional spares.
b) Accepting and processing invoices for payment.
c) Receiving, unpacking and checking goods against the order.
d) Receiving new stock into the store and updating the respective stock records.
e) Issuing stock to the shop floor; This involves the determination of part location and unit cost in one of the five stock catalogues.

Due to the large volume of spares, and having the high workload, it is humanly impossible, using a paper driven system to provide the following information at a rapid enough rate to plan and schedule the maintenance jobs on a dynamic basis:

* Current stock
* Demand for stock over a period of time
* Amounts of stock ordered
* Delivery date of stock ordered.

The above information can only be provided in an environment that is not hectic and has well trained personnel. At present the four temporary people are only used for issuing of stock to the shop floor, packing deliveries onto shelves, and updating the bin cards when either of these actions takes place. The other tasks mentioned earlier, when discussing stores staff's duties, as well as the information required to run a dynamic planning schedule, are carried out by the two permanent staff members.

The training for the temporary staff, is on the job training, which is provided for them by their fellow temporary staff members. The new temporary staff, firstly, have a serious motivation problem as they do not want to work for Loco in the first place, and this shows up in

many aspects of their work. It takes most the temporary members a few weeks to learn how the store works, where the bins are, how to use the catalogues and update stock cards etc. Inexperienced temporary staff have been known to take up to five hours, to find three stock items. The temporary staff members have been found to get very frustrated in this job and this has resulted in the following occurrences becoming common practice:

a) Artisans waiting up to an hour for a store man to retrieve a single stock item.

b) Artisans will be told the spare is not in stock, since the work involved; looking through a catalogue, locating the bin, filling in the price on the store indent and updating the bin card is too much work for the store man.

c) Jobs are costed incorrectly when it comes to the cost of spares, since the store man will often just give a fictitious price rather than finding the correct price.

d) The temporary staff will often not be bothered with going to the effort of filling in bin cards correctly or telling the store manager to reorder when bins are low, since they have no feeling of loyalty towards the company. The store manager will not know on his own to reorder an item if it is low, since he does not have the time to check every individual item, and he must therefore rely on the temporary staff to fulfill this duty. Stock outs, with no order yet having been placed

for new stock, are an every day occurrence.

e) Masses of paperwork hinder the permanent staff in being able to determine, dates of spares arrivals and being able to follow up spares queries. Consequently bins spend lengthy periods standing empty.

3.1.2 Stock control

No definite system of stock control is used by Looo, although an attempt is made to use a combination of the periodic review and the fixed order systems. Neither of these systems is used properly. The shortcomings in the application of the fixed order system, i.e. the bin cards, were discussed in the previous section. The periodic review system used is the Min-Max system.

The Min-Max system is not used properly, and this is due to the large amount of paperwork generated, the demotivated, untrained staff and the physical size of the store. This has resulted in company policy towards stock notches not being applied, and hence the maximum level is not updated every three months and nor is the minimum level determined with safety stock in mind. When stock notches are updated then it is done by the store manager or his assistant. The maximum notch is determined on the basis of an "irritation level", which means, that when the store man gets irritated with reordering the same item to often or he finds he has run out of stock on a particular item which is seldom used, he will then stop himself from

getting irritated, by setting an unrealistically high maximum. A result of the above action is that some items are grossly overstocked and order quantities are much to large.

It was found that the store manager and his assistant did not even understand the whole concept of stock control, how to work out maximum and minimum notches, and why it was even necessary to have stock notches. Through a study of store procedure it was found, that even if the personnel did understand how to determine stock notches they would still never be able to do it because they would not have the time due to the masses of paperwork they have to work through every day.

In the present stores administration system the excess of paperwork and general administrative tasks prevent such essential tasks as cycle counting being performed. The results of this are displayed when bin cards carry incorrect information and are found in the wrong bins. This results in premature stock outs, the wrong spares being ordered and excessive pilferage not being noticed until a stock out.

A spare can not be issued for a job unless a valid job card and store indent form exist. The reason is that without a valid job card and hence a valid job number it is impossible to account for what has happened to the

spares, i.e. the auditors will not be able to determine for which job the spares were used. What happens in practice, is that for small emergency repairs such as a tyre puncture, the artisan will often bypass the planning office, go straight to the store and get himself a spare tube without even filling in a store indent or having a job card. This means a lot of paperwork has been bypassed and Loco will have provided the client with a quick service, however, with no job card, Loco cannot account for that artisans hours and nor can they account for that spare. It has been found that in the case of a big job which has already been in progress for a period of time, some additional, and essential spares have not been ordered. The artisan will then often go to the store without a store indent and demand the spare; promising the store man he will bring the store indent form later.

The above has shown two honest cases of how spares can disappear without being noticed. This lack of control, however, leaves the store wide open to pilferage, and without regular cycle counting as well as proper completion of stock cards pilferage can become a serious problem. As an exercise, an attempt was made to determine on what jobs a particular spare was used for in a three month period. This involved having to recall all the stores indent forms for that period from the stores indent form archive, and then tracking down twelve digit part numbers on the store's indent form in an attempt to find

the particular spare. This job is almost an impossibility since one finds this archive does not have any form of filing system and it is also easy for store's indent forms to get lost. This exercise showed that pilferage could be rife within the store and it would be extremely difficult to prove.

When a stores indent form is received by the store for a new job, then the following procedure is followed. The spares which are needed for the job and are present in the store, are retrieved from their bins and placed into a holding bin assigned to that particular job number. Once there is a 100% fill out for the stores order then work can begin on the job. The shortcomings of this system are best illustrated by the following hypothetical example.

-Job No 1 requires spares A, B, C

-Job No 2 requires spares C, D, E

The present situation in the store is the following:

Spare	Quantity in stock
A	0
B	5
C	1
D	3
E	1

The stores indent form for job No 1, is received first by the store. After having retrieved the available spares for this job, from the store, and having placed them in the holding bin, it is seen that job No 1 has a 66% fill out.

The present situation in the store is now the following:

Spare	Quantity in stock
A	0
B	4
C	0
D	3
E	1

The stores indent form for job No 2, is received second by the store. After having retrieved the available spares for this job, from the store, and having placed them in the holding bin, it is seen that job No 2 has a 86% fill out, since there is no longer any C items in the store.
The present situation in the store is now the following:

Spare	Quantity in stock
A	0
B	4
C	0
D	2
E	0

If a static FIFO (first in first out) system did not exist then it would have been possible to fill the spares order for job No 2, and then there would only have been a 33% fill out for job No 1. This would have meant work could have started immediately on job No 2, but with the present FIFO, method work can not begin on either job.

3.2 Shop floor control system

The only method of monitoring shop floor activity is by the workshop journal. The journal only records start and finish dates for the jobs. It does not record how many hours have already been worked on a job that is in process nbr does it record what section is presently working on

the job. This static system allows the shop floor a lot of freedom to continue as they please since actual hours worked can not be accurately followed up every morning by management during production meetings, and therefore management has to rely on word of mouth as to the progress of the job. This results in jobs taking much longer than the estimated times which are indicated on the job card.

Shop floor control is also too lax with regard to the following aspects:

a) Quality problems: a lot of jobs have to be reworked but it is difficult to determine exactly how many, since the reject job cards always go "mysteriously" missing. Even when reject job cards are drawn up by the planning office and not by the out inspector, it is found that by the time the job cards get to the shop floor all the rejects have already been reworked. The artisan then denies having had any rejects and the root cause of the problem is never solved.

b) Job cards are archived according to job number and not vehicle registration. As in the case of attempting to find a stores indent form it is mostly impossible to retrieve a vehicles last job card. This therefore does not allow management to find out if they have a recurring problem due to inadequate records.

Loco is now in the position of being able to identify its problems and must now start to get the house in order. The

sympathetic audience which they have been given by Rail will not continue for very much longer and it is therefore of tantamount importance that management look at resolving their problems.

4 LITERATURE SURVEY

Workshop management is a very broad topic which covers a range of topics such as shop floor control, advanced computer systems, production planning etc. One of the most important topics in this area of study is that of stock control, since the most advanced operations systems within a workshop will be to no avail if inventory control is inadequate.

4.1 Introduction to Inventory

The question of investing in inventories is one of the most difficult questions to answer. According to Morgan <1963>, some of the most common views found within a company when it came to inventory were that the company was out of stock too often or had too much capital tied up in inventories. Other views were that storage costs were too high but business was being lost as a result of low inventories, excessive dead inventory exists and high premium freight costs existed due to a lack of inventory.

The above views and the frequency with which they have been repeated shows the many conflicts of interest which appear in most inventory systems. Conflicts such as those mentioned, have been resolved by considering certain uncertainties, such as:

a) Should a company have inventories.

b) What should the inventories be.

c) What is the correct inventory level for a product.

d) What measures should be used to control inventories.

e) The measurement of inventory performance.

Companies have found the easiest way to solve these issues has been to adopt a systematic approach which fell in line with the company's overall objectives.

Greene <1970>, considered that an investment in inventory was made for one of two reasons; firstly, inventory makes it possible to produce goods at some distance from consumers and/or suppliers; and secondly, the existence of inventory provides management with the flexibility to decouple successive production and distribution systems: movement and organisation inventories.

Magee <1958>, argued that inventories could be classified into two categories; either movement or organisation inventories. Movement inventories exist because of the time that is taken to manufacture products or to transport goods from one location to another. Inventory of this kind is referred to as work-in-process (WIP) within the manufacturing environment, and where used for transportation purposes they are referred to as in-transit or pipeline inventories. The purpose of organisation inventories has been to decouple successive stages in the production and distribution systems.

The different types of organisation inventories are:

a) Anticipation stock: Products that have been found to require these type of stocks are ones whose markets exhibit seasonal patterns of demand and whose production (or supply) is more uniform.

b) Cycle stock: Inventory that is purchased in larger amounts than was required to satisfy immediate requirements is referred to as cycle stock.

c) Safety stock: Stock of this type has been found to provide protection against irregularities or uncertainties in the demand or supply of an item. Safety stock has meant insurance that customer demand could be satisfied immediately and that customers would not have to wait while their orders were backlogged.

Greene (1970)however, considered inventory to be made up of three basic classes, raw materials, work in progress and finished goods. Raw materials were defined as materials that were purchased to be further processed. Components or assemblies which were purchased outside although classified separately were mostly considered as raw materials. Work in process is then seen as raw materials that have had labour and burden added to them and then await further processing into finished goods. Finished goods are products available for delivery. The above three classes of inventory can be seen as falling into both classes of inventory which were defined by Magee

(1956) as movement and organisation inventories. Movement and organisation inventories in turn form part of a dependent and independent demand inventory system. These relationships between the different inventories is summarised in figure 4.1.

Vollman (1984), saw a dependent demand existing more in a manufacturing environment where the demand for raw materials and component items was a derived demand which could be calculated exactly once the assembly and fabrication production schedules were determined.

Independent demand inventory management deals with the management of non manufacturing inventories, which includes finished goods at the factory or in field warehouses, spare part inventories, and non production items such as supplies and maintenance materials. The difference between an independent demand inventory and a dependent demand inventory lies in the source of demand for the items contained in either type of inventory. The demand for end-product type of items, such as spares, is influenced primarily by factors which are independent of the company decisions. These external factors induce a certain amount of variation in the demand for such items. As a result, forecasts of demand for these items are typically projections of historical demand patterns. These forecasts estimate the average usage rate and the pattern of random variation.

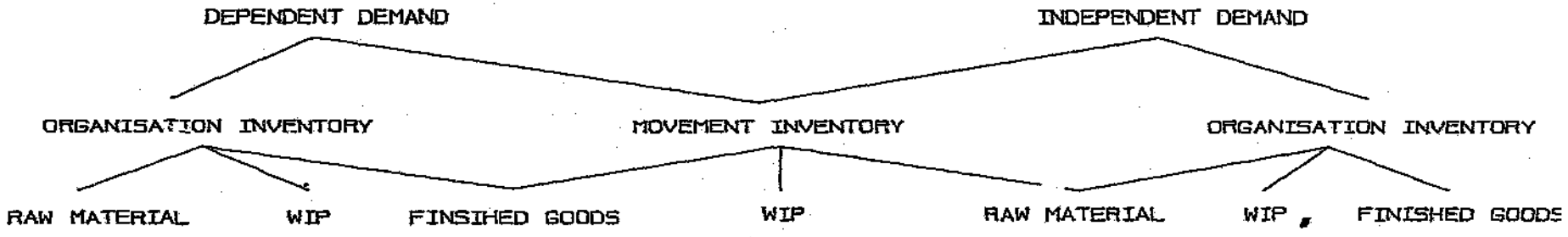


FIGURE 4.1 INVENTORY PYRAMID

The first part of this literature survey dealt with the different types of inventory present and from this it is felt that inventory should be classified according to the manner that best suits the company in question. A company will either either operate in a dependent or independent demand environment, but the way in which the stock will be classified within a particular environment is up to the company. So many different ways exist to classify inventory, but finally the name or method that best suits the environment should be used.

4.2 Inventory management costs

Vollman <1984>, stated that the benefits derived from inventory were evident, but the costs associated with inventory had to be clearly identified, since they were often not reflected directly in a firm's financial statement. In a financial statement, high inventory turnover suggests a large return on investment. Magee <1958>, considered accounting costs to have been developed under principles which had been evolved over many years and strongly influenced by tradition. Magee <1958>, hence concluded the basic objectives of accounting procedures to be that of providing a fair, consistent, and conservative valuation of assets and a picture of the flow of values in a business. The criteria which apply to accounting are; firstly, that the costs represent "out-of-pocket" expenditures, i.e. cash actually paid out

or opportunities foregone. The second criteria is that the costs represent only those out-of-pocket expenditures or foregone opportunities for profit whose magnitude is affected by the schedule or plan. Many overhead costs, such as supervision costs, are out-of-pocket, but neither the timing or the size is affected by the schedule.

Thomas <1980>, through his investigations found that an analysis of the costs actually affected by the inventory management decisions indicated that inventory turnover was not a comprehensive measure of inventory management performance. There are several pertinent costs which are not reflected in the turnover measure, these are:

a) Order costs. Each time an order is placed certain processes take place in the purchase department. Papers have to be typed and mailed, invoices accepted and paid, and goods received, unpacked, checked against an order, inspected, put into store, and entered on a stock record.

b) Stock out costs. When an item is out of stock and it is needed, then a more expensive substitute may have to be used, production may have to be switched to another product or even stopped, or a sale may be lost completely.

c) Carrying costs. Constable <1976>, regarded this cost as being one of the most important, since the cost of holding inventories must be weighed against their potential advantages. The cost of working capital which

is tied up can be expressed as an annual interest rate which is incurred due to inventory investment. This cost is not the only one, some of the others are the cost due to the extra storage space required and the increased rate of losses through obsolescence. Another cost to consider is that of administration costs. If any item is stocked, irrespective of the quantity or value of the stock, certain administration costs are incurred. A stock record has to be kept, the item must be counted and a record of its' store location must also exist.

The costs which were mentioned above apply equally to a manufacturing environment as they do to a maintenance environment, since both require inventory. The costs involved with inventory must be properly understood in order to work with inventory. Ritzman <1984>, quoting Taiichi Ohno, who, was responsible for initiating the Kanban system at Toyota; "There is nothing more wasteful than producing something you don't need and storing it in a warehouse. Both people and machines are wasted, and the warehouse puts your money to sleep." This statement applies equally well to the maintenance environment, where rather than producing too much inventory, inventory is purchased which is not required immediatley for maintenance purposes. This excess inventory which is not moving causes the same losses as excess production does.

4.3 Decisions within an inventory system

Thomas <1980>, found that certain preliminary steps had to be taken in order to control stock. Stock and stock items have to be identified and the units of stock, and how they are to be measured, must be decided. Rules are to be drawn up regarding which items are to be stocked and for each item which is to be stocked the consequences of a stock out must be assessed. The appropriate control levels can be set once a stock control system has been decided upon.

On completion of these preliminary steps it is possible to:

a) Measure the actual stock level for each item.
b) Compare the actual and control levels.
c) Decide what should be done.
d) Initiate this action.

The whole of inventory control is governed by the above steps.

One of the biggest problems that have always faced companies when introducing an inventory control system, is how to classify stock. One method is the ABC or Pareto analysis. Greene <1970>, wrote that Vilfredo Pareto, an Italian economist and sociologist (1842-1923), advocated some highly debatable concepts of economics and sociology. In summary, Pareto, pointed out that a very large portion of all the wealth in Italy was owned by a small proportion

of the people, this distribution concept became known as Pareto's law.

Ford Dickie, in America, adopted the Pareto approach to analysing stocks in the mid 60's, calling this technique the ABC analysis. The best description of how to apply the analysis is given by Thomas <1980>. Thomas, recommended the following steps be used:

a) The average usage value in monetary terms must be calculated for each item in any section of stock or stores.

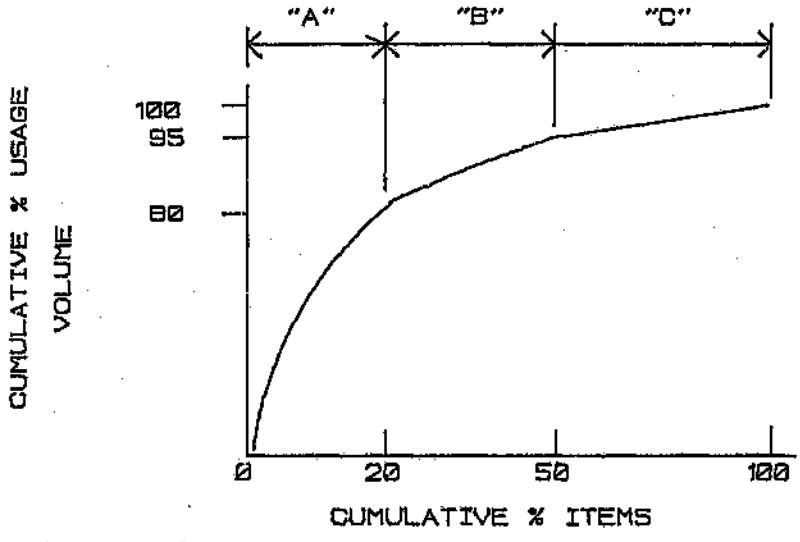
b) A list of these items must then be drawn up, with the item of highest usage value at the top and then descending according to the usage value.

c) The usage value of each item must be put opposite it on the list.

d) Cumulative totals of the number of items, and of the usage values can then be made.

e) Cumulative values must be changed to percentages of the total number of items and of the usage-values respectively.

Plossl <1985>, illustrates the results of an ABC analysis in figure 4.2.



"A" = HIGH-MONETARY-USAGE

"B" = MEDIUM-MONETARY-USAGE

"C" = LOW-MONETARY-USAGE

Figure 4.2 Curves used for ABC analysis [Plossl <22>]

The explanation of the figure, is that, A items are the top 20% of the items, and account for 80% of the usage value. B items are the next 30% of the items, and account for 15% of the usage value and C items are the remaini g 50% of the items, and account for only 5% of the usage value.

Benefits which can be obtained by treating A, B and C items in different ways are:

a) If A items are controlled very closely (only 20% of all items), 80% of the money is under close control.
b) At the other end of the scale, control of C items can be much less stringent, except in one very important respect-the danger of running out of stock.

Orlicky <1975>, explained the rationale behind ABC classification as being that it was impossible to give an equally high degree of attention to the record of every inventory item, due to limited information processing capabilities. Today, the principle of graduated control stringency may be somewhat difficult to comprehend, but in pre-computer days the degree of control was equated with the frequency of reviews of a given inventory item record. With computers available, this limitation has disappeared and the ABC concept tends to become irrelevant. Equal treatment of all inventory items is therefore feasible for planning purposes except in the case of extremely low cost items, that may have safety stocks and can be ordered in large quantities. These exceptions are made, however, not due to some inability of the computer system to plan and maintain the status of such items, but because of the impracticality of physical inventory control.
Orlicky <1975>, however concedes that physical inventory control remains a problem in inventory management, and the ABC concept, when applied to this area (inspection,

storage, frequency of cycle checks etc.) remains valid.

Groover (1984), looks at another method of classification namely that of part families. A part family is a collection of parts which are similar either because of geometric shape and size or because similar processing steps are required in their manufacture. Three methods are used for grouping parts into part families. The first method is visual inspection, which is the cheapest and least sophisticated method, and is carried out by looking at either the physical parts or their photographs and arranging them into similar groupings. The second method is that of using the design and production data to form families. Classification by this method takes place by examining the individual design and/or manufacturing attributes. The third method, production flow analysis makes use of information contained on route sheets rather than part drawings. Work parts with identical or similar routings are classified into part families. The classification of parts into families is used primarily for cell manufacturing, and no evidence could be found within the literature survey of where this method of classification has been used for inventory purposes.

Once a decision has been taken on how to classify the stock it is necessary to choose a method for ordering and controlling the stock. Plossl (1983), considers only two basic techniques for planning and controlling the ordering

of materials: stock replenishment and time-phased requirements planning; the common names are Order Point and material requirements planning. The former is designed to maintain at least some inventory of an item in expectation of a future need; the latter attempts to provide materials only where necessary to meet a pre-planned program of production. Both are needed; neither is adequate alone.

4.3.1 Order Point inventory system

Starr <1978>, found that order point planning (OPP) had been in use for many years. The fundamental economic order quantity (EOQ) model (also called the square root model) could be traced back to early industrial engineering endeavours, with very practical concerns. The economic order quantity model, according to Kanet <1984>, is used by companies such as Black and Decker which has a turnover in excess of $1 Billion. The Levis denim company and Bayer pharmaceutical company are just a few examples of the multi million dollar companies also making use of the EOQ model worldwide.

Schonberger <1982>, saw the EOQ as being the lot size for which the sum of setup, or purchase order cost, plus carrying cost was at a minimum. Vollman <1984>, said that by using the EOQ the ordering decision was stated in formal terms, he went on to say that the EOQ model is an

equation that described the relationship between the costs of placing orders, the costs of carrying inventory, and the order quantity.

According to Plossl (1985), several major problems existed with the conventional order point technique. It lacked the ability to develop revised order "need" dates, provided no information on future orders to be released after the current one and triggered ordering with no advance warning. The conventional order point technique cannot easily handle known future demand at specific times, and can also not easily handle seasonal or cyclical demand.

Schonberger (1985), described each of the costs individually as follows:

a) Order-processing cost. In a given period of time, for example one year, an item could be reordered once, twice or even a numerous amount of times. On placing the order the costs which were mentioned earlier on in the literature survey (see section 4.2) are incurred. Let S be the average cost of processing an order. Also, let Q (for quantity) be the lot size and, D be the average annual demand for an item.

   Annual cost of processing orders = S(D/Q) (1)

b) Carrying cost. Carrying cost is the cost to finance inventory and hold it in storage. Thus, carrying costs increases as number of units in storage increases.

Total carrying cost per period divided ' 'otal monetary value yields the inventory-carrying-cost rate, I.
To compute the annual carrying cost for a single item, the unit cost, C, is required.

Cost to carry one unit for one year = IC

For any given lot size, Q, annual carrying costs equal annual cost to carry one unit times average units in stock.
Average inventory is taken to be Q/2, because the average is halfway between planned maximum inventory, Q, and minimum inventory zero.

Annual carrying costs = IC(Q/2) (2)

The incremental total cost equation for the EOQ is shown as follows:

$$Tc = 1 + 2$$

which implies:

$$To = \frac{SD}{Q} + \frac{ICQ}{2} \qquad (3)$$

Vollman (1984), derived the EOQ by taking the differential of the incremental total cost with respect to lot size.

$$\frac{dTc}{dQ} = \frac{IC}{2} - \frac{SD}{Q^2} \qquad (4)$$

Setting the above equation to zero in order to obtain the minimum cost, yields the following:

$$\frac{SD}{Q^2} = \frac{IC}{2}$$

$$Q = \sqrt{\frac{2DS}{IC}}$$

which implies:

$$Q = EOQ = \sqrt{\frac{2DS}{IC}}$$

Thomas <1980>, describes the above equation by the curve shown in figure 4.3.

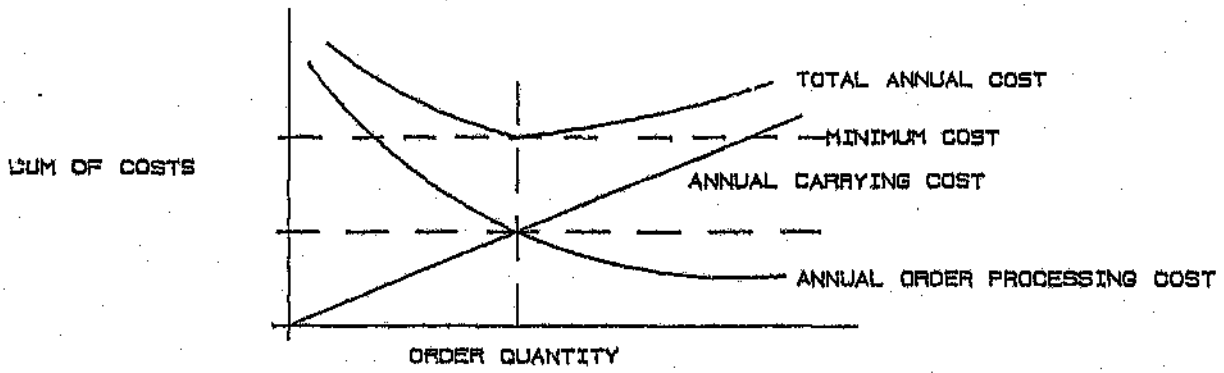


Figure 4.3 EOQ equation shown graphically [Thomas <1>]

The next important issue in an order point inventory system is the order timing decision i.e. when to place the order. Thomas <1980>, Vollman <1984> and Schonberger <1985>, will be used concurrently to discuss the order timing decision.

The classic reorder point is depicted by the perpetual inventory system. This means that every time an issue is made, the stock on hand is checked to see whether the

stock level equals that of the reorder point (ROP), if it does then an order is placed. The setting of the ROP is influenced by four factors. The first is the demand rate, since a higher rate of usage than was forecast could occur, the second factor is the lead time required to obtain replenishment inventory. The third factor is the amount of uncertainty in the demand rate and the replenishment lead time. It was Armstrong <1986>, who stressed that it was important to provide the inventory planner with the best available forecast information from all parts of the organisation so that he could concentrate on h's primary task of scheduling and following up to ensure that material was available when needed. The last factor to consider is management's policy regarding the acceptable level of inventory shortages.

The assumptions of a fixed demand rate and a constant replenishment lead time are rarely justified in actual operations. Either of these, in the absence of a safety margin of some kind, can lead to a stock out, with more or less serious consequences depending on the item concerned. The function of safety stock is best depicted by considering it as being a form of insurance premium against a stock out. Before the level of a safety stock can be decided, a criterion must be established for determining how much protection against inventory shortages is warranted.

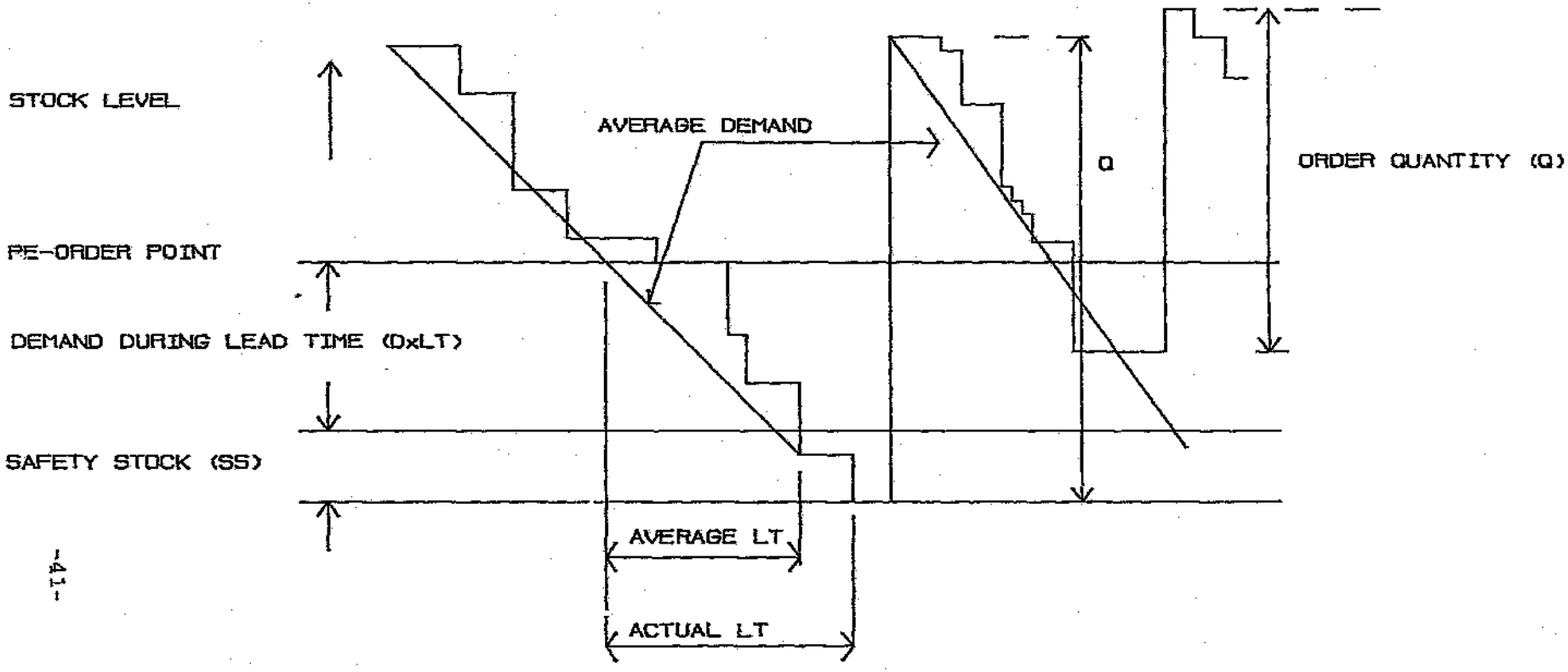


Figure 4.4 Re-order point replenishment cycle [Schonberger <20>]

The criterion for safety stock which would be considered important, since it is in line with company policy would be; "What is the cost penalty of a stock out in any given replenishment cycle ?".

This question is answered by specifying an acceptable risk of stock out during any replenishment cycle. The concept of a replenishment cycle is shown in figure 4.4.

As can be seen from figure 4.4. the risk of stock out can be reduced by making a larger investment in safety stock. The larger the investment in safety stock the more the company will fall victim to the law of "diminishing returns". This law is illustrated in figure 4.5.

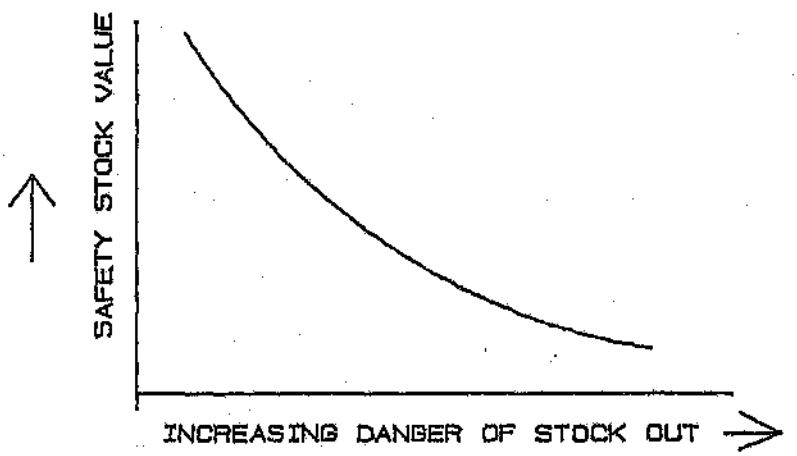


Figure 4.5 Law of diminishing returns [Greene <19>]

As can be seen from figure 4.5, a company will never reach the situation where the chance of a stock out does not exist. The company must therefore decide on an acceptable stock out probability and only purchase inventory that will be sufficient to protect them up to the acceptable stock out probability. By purchasing inventory beyond this point the returns that the company will gain from its inventory will be reduced, since factors such as reduced storage space, obsolescence, deterioration etc., will now become real expenses. If on the other hand the company decided not to carry much inventory at all then the company starts to face such problems as lost sales and having to stop production runs midway.

The generally accepted method used for determining the required level of safety stock is by specifying an acceptable relationship between the probability of stock out during a replenishment cycle and the investment of funds in inventory. A discrete distribution is used to describe the demand uncertainty during the replenishment lead time. In order to simplify safety stock and reorder point calculations it is convenient to approximate a discrete distribution with a continuous distribution such as the normal distribution. Using a normal distribution the required level of safety stock and the reorder point values are easily computed once the company has decided on what the probability of a stock out can be.

In order to determine the ROP, first, it is necessary to determine the mean and the standard distribution of demand during the replenishment lead time. The statistical safety stock (SSS) value can be calculated next, using a table of normal probability values.

$$SSS=Z(sd) = 1.25Z(MAD)$$

From the above equation the reorder point (ROP) is calculated as:

$$\underline{ROP=D(LT)+Z(sd) = D(LT)+1.25(MAD)}$$

Z = Standard normal distribution probability.

sd = Standard deviation of demand during replenishment lead time.

MAD = Mean average deviation of demand during replenishment lead time.

LT = Lead time

4.3.2 Material requirements planning

Orlicky <1975>, defined material requirements planning (MRP) as follows: "Material requirements planning calculates item demand and time-phases all inventory status data in time increments as fine as the user has specified. MRP represents the ultimate approach to manufacturing inventory management."

Plossl <1985>, considers an MRP system to be made up of

six components. The first one is a valid master plan, which states what is to be made, how many are to be made, when the parts are needed for each products, must be developed. This master plan is referred to as the master production schedule (MPS), see figure 4.6. The master production schedule is responsible for driving the MRP program.

Part Number 62145

PAST DUE	WEEK										
	1	2	3	4	5	6	7	8	9	10	11
50	-	60	-	-	-	80	-	-	40	-	-

Figure 4.6 Master schedule [Starr <25>]

The second component is an accurate bill of materials (BOM), detailing the components and items which make up the product, this forms the structure or framework of modern planning. The BOM shows the parent component item relationships of products as they will be made or procured, see figure 4.7.

Thirdly, it is essential that the information available on current inventories must be accurate, including a unique part number, quantity in stock and data necessary to describe the item completely for planning purposes. The

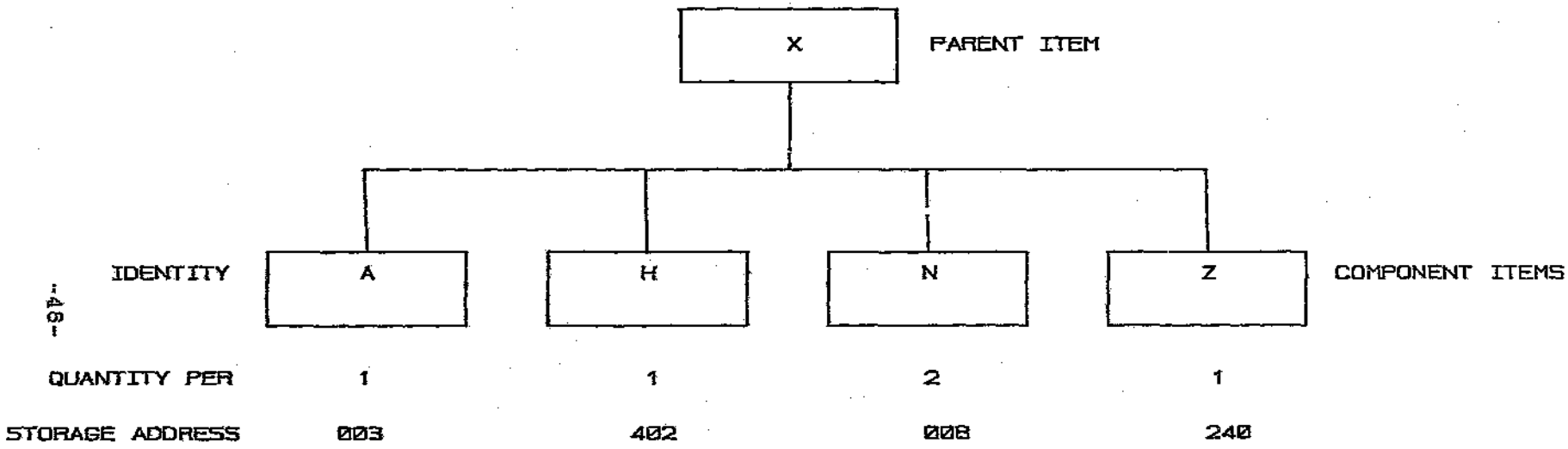


Figure 4.7 Bill of material [Orlicky <23>]

next essential component is that information on orders already released to obtain additional quantities of each item, whether purchased or manufactured, must include quantity ordered and date due. The fifth component making up an MRP system is that of lead times, reliable lead times to procure or manufacture batches or specific lots of materials are needed. The last point is that an MRP system will only succeed if an adequate flow of materials to satisfy all requirements through each facility involved in the total process,including suppliers, occurs.

By combining the six points which, Plossl <1985>, considered important it is possible to formulate a material requirements plan as shown in figure 4.8.

Groover <1984>, was of the opinion that the job of the material requirements planning processor, was to operate on the data contained in the marter schedule, the bill-of-materials file, and the inventory record file. The master schedule file gives a period-by-period list of final the products required is specified. The BOM defined what material and components are required for each product. The inventory record file contains the information on the current and future inventory status of each component. The MRP program uses these three files then to compute how many of each component and raw material are needed by means of "exploding" the end product requirements into successively lower levels in the

ON HAND =50 ORDER QUANTITY =350 S.S. =0 L.T. =2

PART 62145	LATE	PERIOD 1	2	3	4	5	6	7	8
PROJECTED REQUIREMENTS		100	150	120	150	100	90	110	120
SCHEDULED RECEIPTS		350							
PROJECTED ON HAND		300	150	30	-120	-220	-310	-420	-540
NET REQUIREMENTS					120	100	90	110	120
PLANNED ORDER RECEIPT					350			350	
PLANNED ORDER RELEASE			350			350			350

Figure 4.8 Material Requirements plan [Plossl <26>]

product structure.

Orlicky (1975), found MRP to be a highly effective tool of manufacturing inventory management because inventory investment can be held to a minimum, out is still change-sensitive and reactive. The system provides a look into the future, on an item-by-item basis and order quantities are related to requirements. Groover (1984), stated that MRP was the appropriate technique for determining quantities of dependent demand items.

Plossl (1985), expressed the fact that MRP techniques were able to do three valuable jobs. The first was, suggest (not dictate) the proper time to release orders. Secondly, indicate the proper date by which orders are needed and keep these dates valid during order processing times. The last job is that an MRP system can provide information to assist capacity requirements planning and machine and work centre loading.

In order to gain all the benefits listed above it is important to note the assumptions that are made in MRP. Plossl (1983), showed the following assumptions to hold true. The first assumption is that an MPS can be developed accurately enough to begin procurement and production of components. Secondly, bills of material are available showing accurate parent-component relationships on which to base sound planning, and replanning the data will trigger effective action to compensate for the inevitable

changes. The next assumption is that unplanned requirements outside those in the formal plan will not be significant or can be met in time and lastly, capacity and materials are available to handle the released orders.

As was described above there are numerous advantages to using an MRP system. There are however some drawbacks and limitations in MRP. Starr <1978>, recommended the following situations as being ones in which MRP should not be used. They are:

a) In the case of flow shops, maintenance supplies and finished goods, where the demand is independent of the production schedule.
b) In serial production, where process materials must be on hand at all times.
c) If the demand is fairly "lumpy and sporadic" rather than being fairly regular and continuous.

Plenert <1986>, states that among the downfalls of MRP are the fact that MRP production scheduling sequencing systems sequence, tasks as if the plant has infinite resources available. The second downfall according to Plenert <1986>, was that data accuracy is critical in MRP as inaccurate data disrupts the entire MRP system.

Having now considered both an MRP system and a classic order point system it is important to be able to decide which one to be used when. Starr <1978>, Plossl <1983> & <1985>, all recommend the use of the rule of thumb as

proposed by Orlicky in 1965. Orlicky recommended that independent demand must be forecast, and conventional or time-phased order-point techniques be used, whereas dependent demand can be calculated, in the latter case MRP is the correct technique. Figure 4.9 shows a comparison of the two ordering systems discussed.

4.4 Specific stock control systems

Magee <1956>, considers stock control systems to fall into one of two categories, fixed order or periodic reordering. The objective in a fixed order system is to place an order whenever the amount on hand is just sufficient to meet a "reasonable" maximum demand over the course of the lead time which must be allowed between placement of the replenishment order and receipt of the material. In the case of the periodic review system, the idea behind it, is to look at stocks at fixed time intervals, and to vary the order amount according to usage, since the last review.

Magee <1956>, judged one of the big advantages of the periodic review system as being that stricter control could be more easily exercised over A class items and B class items in a periodic review system than in a fixed order quantity system. This control can however be exercised in a fixed order quantity system by just using cycle counting, which is discussed in detail in chapter 4.5.

	CLASSIC ORDER POINT	MRP
DEALS WITH:	PARTS	PRODUCTS
LOOKS TO:	PAST (USAGE,SAFETY STOCK)	FUTURE
HANDLES:	ONLY AVERAGES	LUMPS OF DEMAND
INVENTORY IS:	MAINTAINED	USED UP
SHOWS:	ORDER START DATE	ORDER NEED DATE
USES LEAD TIME FOR:	ORDER DUE DATE	ORDER START DATE
CAN UPDATE:	NO	YES
FUTURE ORDERS:	NONE	ALL IN HORIZON

Figure 4.9 Comparison of ordering systems [Plossl <26>]

Thomas <1980>, examined two periodic review systems and two fixed order systems. The two periodic review systems examined are the topping up and the "Min-Max" system, the fixed order systems are the stock card and two bin system.

a) Topping up system. Whenever a review is held, orders are placed so as to bring the stock level up to a predetermined level, called the "maximum" for that item. The maximum is calculated by adding one review period to the lead time, multiplying the sum by the average rate of usage, and adding any safety stock.

b) "Min-max" or "S,s" system. In order to reduce the number of orders compared to the topping up system, a preset "minimum" or "s" level is used in much the same way as the reorder level of the fixed order system. If at a stock review the minimum or "s" value exceeds the current stock level a replenishment order is placed, which is sufficient to bring the stock level up to the preset maximum or "S".

c) Stock card system. Each transactio., that takes place is posted manually on a simple stock record card. After each transaction the stock balance is reduced and should be compared to the reorder level. If the reorder level exceeds the stock on hand then a replenishment order mut be placed.

d) "Two bin" or "Last bag" system. A quantity of stock equal to the reorder level is put in a sealed container and kept in a separate store room. The remaining stock

is placed in a normal bin in the store, but no individual records of withdrawals are kept. When this bin is empty the sealed one is opened and an order is placed to replenish the stock.

Nicol <1989>, saw the advantages of the two bin system being that it ensured constant supply at assembly, reduces material handling effort and associated cost of cycling bins through stores and therefore reducing paperwork. A few other advantages are that it provides inventory level feedback, maintains lot control and establishes a trigger mechanism to flag imminent stock outs on floor stock items.

4.5 Computerisation and shop floor control

For any type of computerised system to be accurate, be it for any type of application within the maintenance or manufacturing environment it is imperative to have proper shop floor control. Mabert <1986>, sees the shop floor control system (SFCS), as being the overall system that provides the shop with information on released orders to the floor. When a job order is released to the floor, a shop packet is created, usually containing a routing sheet, pick list and sometimes, blueprints. As a job moves through the shop, routinely updated reports note completed operations, provide useful data on shop performance, and compare actual to scheduled progress. In short, a good

SF'S performs the function of providing the necessary shop packet information so that the job may progress in a smooth manner, defines appropriate completion dates for the jobs different operations. The shop packet information will only be accurate if information is collected on a job's activity, in order to monitor its progress in relation to its schedule. A good SFCS must also provide s daily dispatch list showing the job status and priorities.

Goddard <1984>, went on to say that in order for a SFCS to perform the above mentioned functions, the following elements must be in place.

a) The right system. To cope with the constant stream of changes occurring on the factory floor, a computerised system is necessary.
b) Accurate data. To make good decisions, the system must produce reliable information.
c) Educated users. To use the information properly, managers and operators need to understand the information.

One of the most important pieces of data that has to be accurate for a good SFCS is the inventory. Meyer <1990>, considered the whole aspect of whether inventory accuracy was worth its cost. Meyer, found that the monetary value associated with inventory accuracy is based on worker and equipment productivity, however the cost associated with inaccuracy is difficult to assess. The benefits arising

from an increase in inventory accuracy certainly exist, and it has been found that inventory errors reduce worker productivity, morale and motivation. The biggest benefit of accurate inventory is that the worker and equipment productivity can be predicted since they will not be held up due to scheduled parts not being there.

The best method of obtaining accurate inventory is through cycle counting. The idea behind cycle counting is to maintain an acceptable level of accuracy in the inventory records. By using cycle counting there is no accumulation of errors in the records which are often only found during the annual physical inventory. Cycle counting of items can take place daily, weekly or monthly. Backes <1980>, showed that the conversion to a cycle counting program could be justified by the tangible cost savings it produced. Among the savings are that no annual physical inventory has to be held and with accurate inventory records it is not necessary to check materials physically before making decisions on promised deliveries. The other savings are that excess inventory will no longer appear unexpectedly, long after a design change or a product is discontinued, because inventory records will now be correct. Less time is lost because of unexpected material shortages, and labour productivity increases markedly with accurate records.

When trying to decide on a particular cycle counting program to be used the following points must be considered. Backes <1980>, considered these points to be, firstly, the greater the activity of an item, the higher the probability of record errors. Secondly, effort, time and money spent on inventory control must be divided among the items in proportion of their relative importance. The last point is that a small amount of elements in terms of numbers accounts for a large fraction in terms of effect.

All three of the above statements stress the need for an ABC analysis to be carried out. The results of this analysis would then determine how all the items are to be counted. It must be noted that regardless of classification, every inventoried item should be counted at least once in each fiscal year.

A good SFCS is imperative for running a manufacturing or maintenance environment efficiently, but also for running a data base management system properly. Joshi <1990>, saw the computer system as having the potential to increase productivity immensely. This could be achieved through management training users properly and exercising proper discipline. This would involve all appropriate data being entered and a file being updated as and when its status changes.

In order to fully understand a data base and how it works it is important to look at certain background information

related to computers. Thomas <1980>, provides a good background into computer files. Each set of data in a data base is called a "file" and a file is made up of many "records". Every different entry on a record is referred to as a "field", thus on a stock record "file", each stock item would have a record, the key to which would be the part number for example. The first field almost invariably, is the key, in this case the part number, and this could be followed by other fields for the description, stock on hand etc.. Dangerfield <1990>, described a data base as being a set of self describing files which are integrated in the sense that information can be produced by combining data contained in any number of records. Relational data base management systems (DBMS) software is based on the discipline of relational algebra. All files are treated as two dimensional flat files, referred to as relations, which can be combined according to the rules of relational algebra to yield the desired results. The general functions included in most relational systems are the following:

a) Search for data on a variety of conditions.
b) Sort output on various attributes.
c) Modify the structure of data and data types.
d) Add new data columns or tables.
e) Perform simple arithmetic operations and functions.
f) Perform simple string operations and substring functions on alphanumeric data.

Vollman <1984>, described a perpetual inventory system as being one that maintained a record of the current stock balance for each item, and receipt and disbursement transactions are routinely processed to update the inventory balance, as well as obtain historical usage data. Smolik <1987>, saw the computerised inventory system being able to do the following:

a) Maintenance of stock balances.
b) Recording of receipts and disbursements.
c) Record of stock locations.
d) Stock status reports.
e) Audit and cycle counts.
f) Production of stockroom picking list.
g) Storage of supply and demand data to be used for order calculations.

Thomas <1980>, saw a big drawback when it came to computers being the fact that a computer has to be programmed to the minutest detail, since it has no common sense, or any sense of judgment, and it could not recognise an exceptional case unless suitable criteria had been written into the program. Whybark <1988>, did however not see this as being a problem with computer as through his broad experience he had concluded that people themselves are good decision makers.

4.6 Conclusions

From the literature survey the following conclusions could be drawn:

a) An analysis of the costs actually affected by the inventory management decisions indicates that the inventory turnover as shown in financial statements, is not a comprehensive measure of inventory management performance.

b) Before decisions can be taken as to the inventory control technique to be applied it is necessary to agree on what can be classified as stock, what units it must be measured in, and what the consequences of a stock out would be.

c) Dependent demand exists more in a manufacturing environment where the demand for raw materials and components is a derived demand.

d) Independent demand exists more in a non manufacturing environment where the demand for spare parts and components is influenced primarily by factors which are independent of company decisions.

e) Material requirements planning calculates item demand and time phases all inventory status data in time increments as fine as the user has specified. MRP is the right technique to use in a dependent demand environment as the demand can be calculated.

f) The economic order quantity is an equation that describes the relationship between the costs of placing

orders, the costs of carrying inventory, and the order quantity. Time-phased order-point techniques are the right techniques to use in an independent demand environment since this demand must be forecast.

g) By using computerised data bases equal treatment of all inventory items is feasible except in the case of extremely low cost items, that may have safety stocks and can be ordered in large quantities.

h) Within a computerised stock control environment the ABC analysis is mainly used for stock control purposes.

I) A proper shop floor control system can only be started with accurate inventory data. This accuracy can be achieved by means of cycle counting.

J) By just considering costs and not data base accuracy a cycle counting program can be justified.

5 Requirements for a computerised workshop management program

The representative requirements for a data base management system (DBMS) are dictated by the environment in which the data base must operate. The environment as described in the first three chapters is a particularly harsh environment, due to the people working in it. The package must be written to cater for these people by requiring a minimum amount of input from them, tut at the same time not giving them a feeling of redundancy. For the package to succeed the people within Loco must regard the DBMS as being an aid to them since it will reduce their administrative tasks and paperwork, but at the same time not take away any responsibility. The responsibility factor is more pertinent in the case of permanent staff members than in the case of case of the temporary staff. If the permanent steff are made to feel redundant then it will result in them working against the DBMS. It therefore becomes of tantamount importance to remember the people factor when writing the package, because, the success or failure of the package is dependent on the people using it.

The DBMS, will be responsible for performing workshop functions ranging from basic stock and shop floor control, to providing query by report facilities. For this data base to be able to provide all these facilities properly,

it is important that data base maintenance be tightly controlled. To achieve this, it must be remembered that there is a critical difference between access to data which can be available to many users and authority to change a given data base. If the data base is truly to be managed, then specific individuals must have sole authority to make changes in specific data elements and similarly be held responsible for the accuracy of the data.

The system will be required to print job cards, print store indent forms, flag reorder points, monitor stock usage etc.. For the system to do this it will have to be a multi user system in the form of a network. The different aspects of the system will each be considered individually.

5.1 Stock control

The stock control method which will be used is the method which has been found worldwide to be one of the most popular and easy to apply techniques for the independent demand environment. Stock control will be carried out by means of the EOQ model. An ABC analysis will also have to be carried out on the stock, but, not for the purpose of determining the frequency of review of a given inventory item record. It will be done to determine extremely low cost items as well as for physical inventory purposes. With the computers available today, equal treatment of all

inventory items is feasible, except in the case of extremely low cost items, that may have safety stock and can be reordered in large quantities.

The ABC analysis will not be a feasible operation to carry out immediately, since it will then have to be done manually. The ABC analysis should be done approximately six months after the data base has been in operation. The analysis can be done by the computer and the results will be presented in the form of a report. The C items are to be placed in an open rack system, and stock control on these items will be done by means of the two bin method. Whenever a bin is found to be empty and is replenished then the entire amount used up in the last bin must be entered on the computer. This means that one entry is only made for the usage of an entire bin and not the usage of each individual item within the bin is entered. This is just done so as to see if the status of a C item changes. The replenishment bin is to be kept in a separate area in the store which is to remain locked. A bin card which specifies reorder details must be attached to the replenishment bin. When a temporary staff member goes to get the replenishment bin he must get the keys from the store manager, and on returning the keys, he must give the store manager the bin card so that an order can be placed. The store manager will then enter the usage details for this item onto the computer. Certain items are envisaged

to fall into the C class, and therefore should be categorised as this from the outset. The status of these preselected items can always be changed after the first six month or at any time that an ABC analysis is carried out. The items are such things as nuts, bolts, washers, grease nipples, etc..

At the time of entering the data for an individual item for the first time, it will be necessary to use estimates and fictitious figures to determine the EOQ and the reorder point. After a period of three months a more accurate EOQ and reorder point can be worked out for every item by the computer. The computer will then make use of information located in it's data base to predict more realistic values. Once the data base is in operation, the EOQ's and reorder points can be calculated at any time management requires it to be done. The time period between recalculations of the EOQ and the reorder point should preferably tend towards being an annual event. The previous statement is based on the assumption used in the EOQ and reorder point, which is, that the lead time and demand rate are constant. In practice this is rarely justified, and therefore by using a greater time span than the three months prescribed in the company policy, the effects of unrealistic highs and lows will be reduced.

A system that will be done away with once the DBMS is introduced, is that of having bin cards at the bins which

have to be filled out by store staff every time a transaction takes place. The bincards will now be on the computer and will be updated automatically for withdrawals, returns and new stock arrivals. This means that whenever the stock of a particular item is lower than the reorder point, the computer will automatically flag this situation, which will in turn inform the store manager. If the computer would have placed the order automatically, this would have lead to problems as the store manager might now have felt he was redundant. Instead the computer will recommend the quantity to reorder (EOQ), but the actual reorder amount is still the store managers decision.

The system of computerised bin cards which was discussed above can only work if the physical inventory level is equal to the computer inventory level. In order to achieve this situation it is necessary to introduce a strict cycle counting program. The frequency with which the different stock items must be physically checked will be indicated by means of the ABC analysis carried out by the computer.

When the computer flags a reorder situation, then this flag is to remain high until the actual stock has arrived. In order not to duplicate orders two high flags must exist, the one flag will indicate that an order has not yet been placed and the other will indicate that an order has been placed but goods have not yet been received.

One of the main objectives when introducing any inventory control system is to be able to save on certain costs. By combining the EOQ, reorder point and computerisation certain savings should be achieved. The ordering of items will be optimised by having a properly determined reorder point and quantity. The computer will also be able to identify the usage of items over a particular time period much better than it could be done manually. This would lead to having less dead stock and less deterioration in items because the computer will be able to scan for these items.

5.2 Shop floor control

A large amount of the shop floor control problems in Loco are due to the processing of paperwork taking too long, the store not being able to respond quickly enough to spares queries, and management's ignorance as to the status of work in process. A large delay period exists between the time that a vehicle is in-inspected and the time that work starts on the vehicle. In this period the planning clerk has to write out a job card and stores indent form, the store man must find the required spares in the catalogue and then retrieve them from the store, as well as updating the bin card. If spares do not exist then the store and planning manager have to get together to see which spares are not present and then the store manager has to order these spares.

The big time delay caused by the scenario mentioned above will be resolved by running the DBMS on a network. The in-inspector will open a job card and enter the details as well as entering a stores indent form for the spares required. The job card can then be printed out as and when it is required. This facility combined with the dynamic stock control system which is brought about as a result of computerisation, allows the planning manager to have a full report on the fill out of spares within minutes of the in-inspector having typed in the store indent form. Through having a dynamic stock control system it is not necessary to reserve spares as was the case in the static FIFO system. With the dynamic stock control system spares are only withdrawn from the computer stock and physical stock once there has been a 100% computer stock fill out. Only, after the order has been given to begin the job, are the spares withdrawn from the computer stock and therefore become reserved in the physical stock.

The network facility also allows for a continuous monitoring of work in process. This is achieved by having every foreman enter the work done on his jobs during the course of the day. The hours worked are transferred to a workshop journal file. This file remains abreast with all the work done in the workshop each day.

If during a job an artisan runs our of spares he does not have to go to the store, wait to be served, and then given inoorrect information, as has happened in the past, about whether an item is or is not in stock. The artisan can go directly to his foreman who can tell him immediately whether the spare is in stock or not because of the computerised bin cards, the network and the fact that computer stock is not reserved. The planning manager then types out a stores indent form and orders the spare. The planning manager will not be able to type in a stores indent form if a valid job number does not exist, or if the job number quoted is still awaiting initial spares ,or the job has been finished. The type of cross referencing mentioned above is only viably possible in a computerised environment. The data base will be used for accounting purposes as well, since the computer will be able to generate a report for any required time period, stating the amount of a particular item used and for what jobs it was used.

The data base not only replaces the bin cards but also replaces the spares catalogues. Every time spares are required from the store, a computer generated printout, in the form of a completely filled out store indent form is produced. On this form are the price of the spares, the bin locations of the spares, and the quantity to remove from the bin. This means that the training requirements for the temporary staff are now reduced to teaching them

where the different bins are as well as how to read a store indent form.

The out inspector will be able to type in reject job cards directly when they are required. By having these job cards in the data base they will not get lost, and this will aid management in determining where the quality problems lie. By being able to identify specific areas of consistent substandard work, management will be able to work on a policy of, building quality in rather than inspecting it in.

When a job is completed the job card and the stores indent form are archived in the data base. The job cards are stored in order of vehicle registration and the store indent forms according to job number. With the cross referencing facilities offered by computerisation, it means that every time a vehicle comes to be repaired all previous job cards for this vehicle can be recalled in the space of a few minutes. This facility allows management to decide whether it is a manufacturing, maintenance or driver fault that is causing a recurring problem. This information is extremely valuable, since if the problem is a manufacturing one, then management can look towards implementing a planned maintenance program for all vehicles of this type, so as to minimise the downtime of these vehicles due to a manufacturing error.

5.3 User friendliness and user input

In order to maintain tight control of the data base, all users must be given different data accessibility status within the data base. A person such as the store manager must be treated in the same capacity as a bank manager, and therefore he and his assistant are the only people allowed to alter or change computer stock levels. The planning manager can both order and withdraw spares by entering a stores indent form but he cannot return spares to the store or change a stock level. A person such as the workshop manager has no need to enter data relative to the day to day running of the workshop, as this is done by planning, stores and the foreman but has full access to all query by report facilities. The role of the workshop manager must be seen as that of a company director. The manager therefore only acts in an advisory or consulting role. Figure 5.1, shows the anticipated number of terminals on the network as well as the user at each terminal. The situation discussed above was that of limited accessibility to data for the purposes of changing it. People will also be limited to the extent that they can view data and generate reports. This must be done because it will discourage people from being to adventurous as well as generating unnecessary reports.

The majority of users are computer illiterate, and therefore will usually have a fear of computers. The

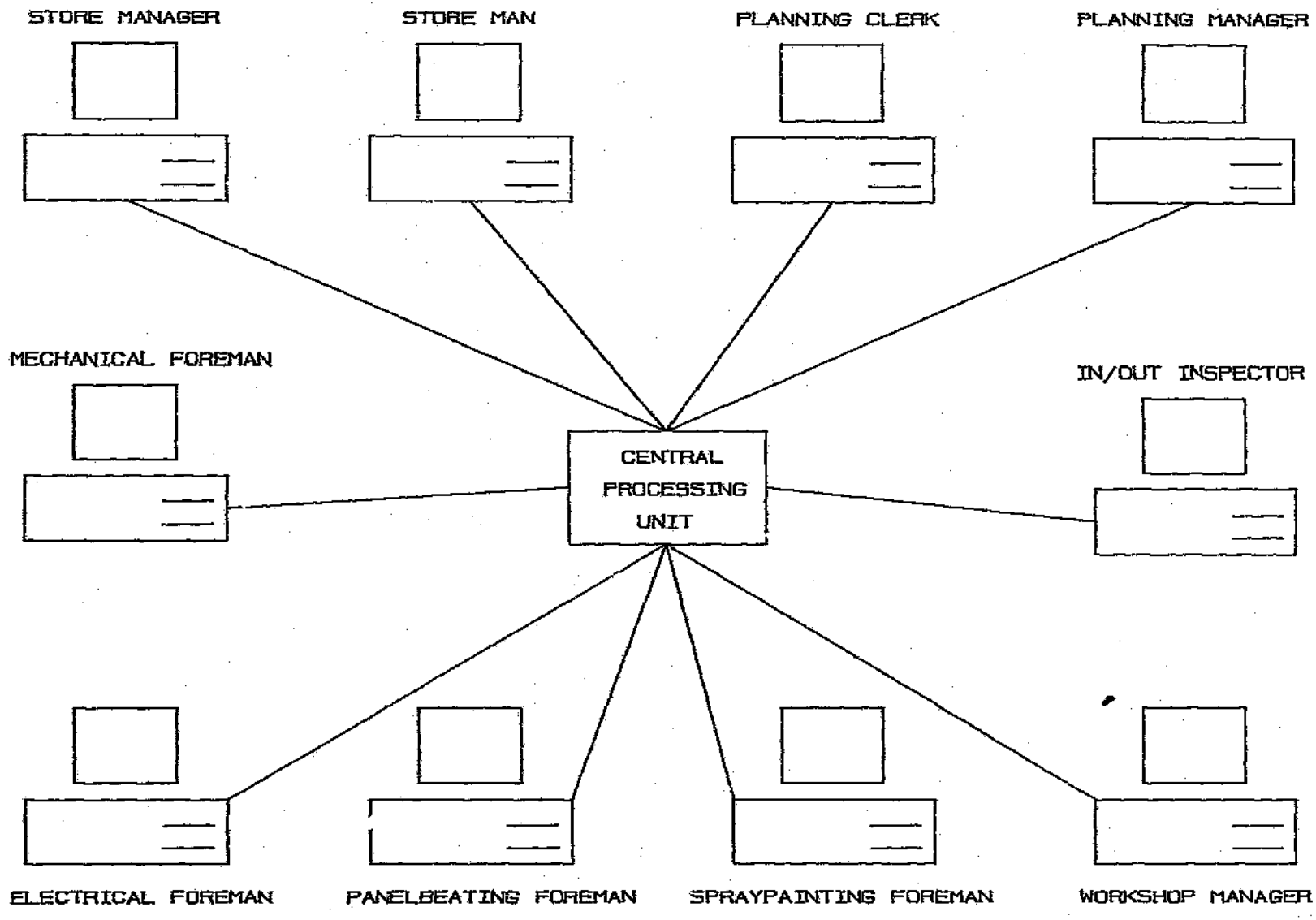


Figure 5.1 Proposed network terminals and users

package must therefore be very friendly and easy to use. It must also require a minimum of data input in order to function properly. In the case of the temporary staff it will be preferential to limit their use of the data base to a view facility only. This will not only reduce the chances of sabotage but will also reduce the training period for the temporary staff. The planning manager and foremen will be responsible for entering the majority of the data. They will have to enter job cards and store indent forms, the planning manger will also have to enter users as required on the workshop journal. The only data entered by the workshop manager is the quantity of physical inventory that does exist after a cycle count has taken place. The cycle count is both initiated and controlled by the workshop manager.The store manager is only responsible for updating a stock level after a delivery or return of spares. The above mentioned task is his main data base maintenance task and for the rest he will change the details of spares as required, eg. a change in unit cost for a spare or entering the details of a new spare. All other information to run the data base and workshop properly will be generated by the computer. Figure 5.2, shows the different data required to be entered by the different users.

USER	DATA ENTERED
PLANNING MANAGER	NEW/UPDATING JOB CARDS STORES INDENT FORMS JOURNAL DATES
MECHANICAL FOREMAN ELECTRICAL FOREMAN PANELBEATING FOREMAN SPRAYPAINTING FOREMAN	NEW/UPDATING JOB CARDS STORES INDENT FORMS
STORE MANAGER	NEW SPARE INFORMATION UPDATING/CHANGING EXISTING SPARE'S INFORMATION UPDATE OF STOCK LEVEL AFTER DELIVERY/RETURN/CYCLE COUNT
WORKSHOP MANAGER	NONE

Figure 5.2 Information to be entered by different users

To make the package as friendly as possible to the user it will be entirely menu driven and access to the different areas will be pass word controlled. If somebody attempts to gain access to a pass word protected area and access is denied, then the time and terminal at which the attempt is made is logged. This will give management a good indication of who is trying to break in.

6 Development of a workshop management program

This package has been written as both a development and demonstration package for a single user, in GW-Basic. It was never written for a multi-user environment as development is easier in a single user environment. Once the package meets with the approval of management, it will be rewritten in a fourth generation language by computer programmers. The language which the package will be rewritten in, will be far more efficient with respect to disk space used up for data storage, and have a quicker response time than that offered by Basic.

Basic was ideal for demonstration and development purposes, since the program and a limited amount of data, could be stored on a 1.2 Mega byte (Mb) disk. The program could then be run on any computer country wide without requiring the other computer to have the source language, since the source language, program and limited data were on one disk. If it was attempted to run the package in basic, in a multi-user environment such as the workshop one, it would be found to be non viable due to the disk space that would be occupied by the package. In the day to day running of the workshop the disk space that the package would occupy, if written in GW-Basic for a multi-user environment would be the following.

Item	Disk space
a) Program size	0.9 Mb
b) Workshop spares data bank	
i) 20 000 different "A" items	3.5 Mb
ii) 20 000 different "E" items	3.5 Mb
c) Stores 999 "B" and 999 "D" Job Cards	
Each job card has space for:	
61 Mechanical tasks	
25 Electrical tasks	
25 Panelbeating tasks	
25 Spraypainting tasks	35.4 Mb
d) Stores 999 "B" and 999 "D" store indent forms	
Each store indent form can handle 63 spares	6.0 Mb
e) Stores 999 "B" and 999 "D" reject job cards	
Each reject job card can have 34 tasks	9.2 Mb
f) Stores "B" and "D" job journals	
Each journal can handle up to 999 tasks	0.3 Mb
g) Stores information to monitor a turnover	
of 1 000 000 "A" and 1 000 000 "E" items	82.0 Mb
Total disk space required	140.8 Mb

With this type of disk space being occupied, and the resultant slow speed of the program, the only option available is to use the package for development and demonstration purposes, whilst written in GW-Basic. The package has been written to cater for both the "B" and "D" jobs as well as the "A" and "E" class items. While

discussing this package during the project report only "B" class jobs and "A' class items will be considered. The package is a duplicate so far as the "D' jobs and "E" class items are concerned. By limiting the discussion to the "A" and "B" classes, the project report will be easier to read and understand.

Each facet of the program will now be discussed individually. Figure 6.1, shows a menu flow chart for the package. This figure does not show the "exit" functions which exist on every menu, this was done so as not to make the page on which figure 6.1 is printed too cluttered.

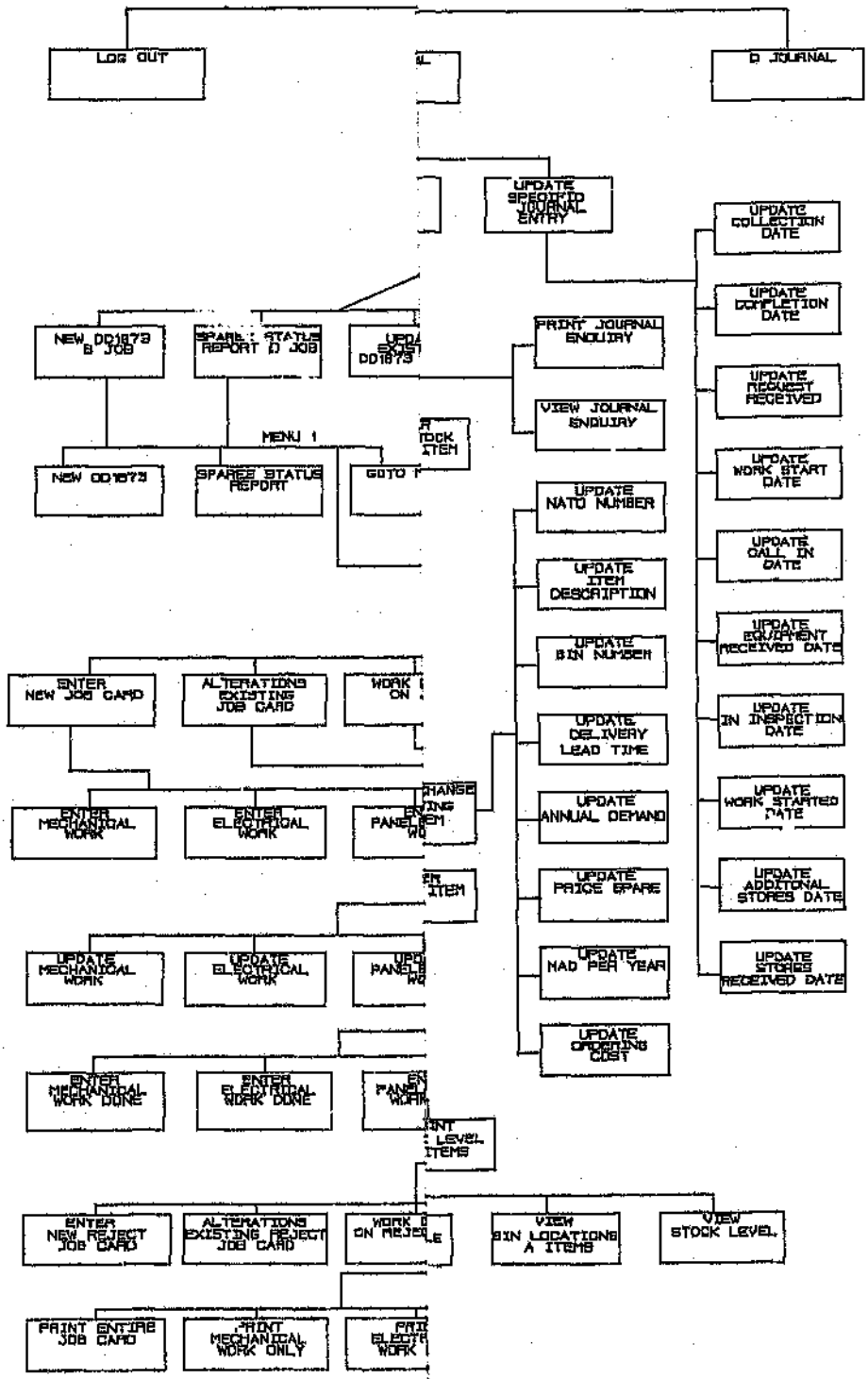

LOG OUT
D JOURNAL
UPDATE SPECIFIED JOURNAL ENTRY
UPDATE COLLECTION DATE
UPDATE COMPLETION DATE
UPDATE REQUEST RECEIVED
UPDATE WORK START DATE
UPDATE CALL IN DATE
UPDATE EQUIPMENT RECEIVED DATE
UPDATE IN INSPECTION DATE
UPDATE WORK STARTED DATE
UPDATE ADDITIONAL STORES DATE
UPDATE STORES RECEIVED DATE
NEW DD1673 B JOB
SPARE : STATUS REPORT D JOB
PRINT JOURNAL ENQUIRY
VIEW JOURNAL ENQUIRY
MENU 1
NEW DD1673
SPARES STATUS REPORT
UPDATE NATO NUMBER
UPDATE ITEM DESCRIPTION
UPDATE BIN NUMBER
UPDATE DELIVERY LEAD TIME
UPDATE ANNUAL DEMAND
UPDATE PRICE SPARE
UPDATE MAD PER YEAR
UPDATE ORDERING COST
ENTER NEW JOB CARD
ALTERATIONS EXISTING JOB CARD
ENTER MECHANICAL WORK
ENTER ELECTRICAL WORK
UPDATE MECHANICAL WORK
UPDATE ELECTRICAL WORK
ENTER MECHANICAL WORK DONE
ENTER ELECTRICAL WORK DONE
ENTER NEW REJECT JOB CARD
ALTERATIONS EXISTING REJECT JOB CARD
VIEW BIN LOCATIONS A ITEMS
VIEW STOCK LEVEL
PRINT ENTIRE JOB CARD
PRINT MECHANICAL WORK ONLY

Figure 6.

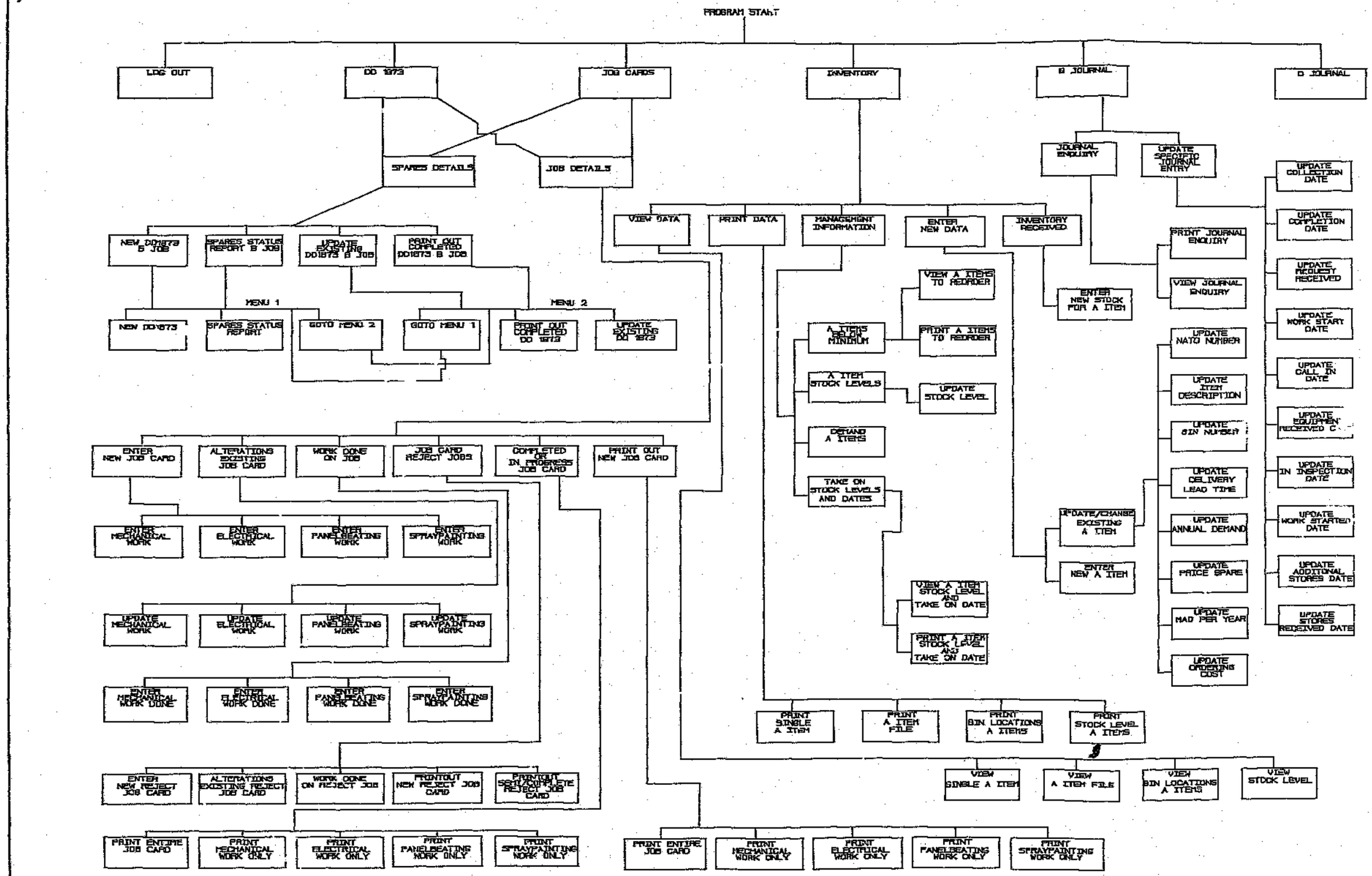


Figure 6.1 Menu flow chart for B jobs and A item spares

When the program is started, the first screen the user is taken to is the opening one shown in figure 6.2. The user can select options on this screen ranging from logging out to making entries in a "D" journal. In order to select an option from this menu, the user merely has to type in the number corresponding to the option they require. The program is totally menu driven but access to the different options is restricted by users having their own password.

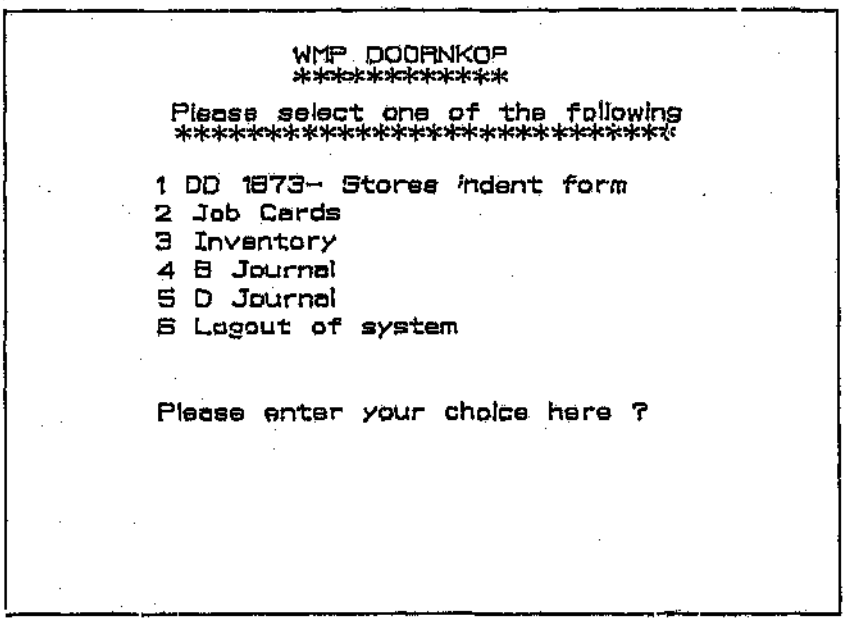


Figure 6.2 Opening screen of workshop management progam

6.1 Inventory option

By selecting the inventory option on the opening screen the user is taken to the main inventory menu. Access to this menu can be gained by anybody but the different

options on the menu are password protected. The main inventory menu is shown in figure 6.3. The only option to which everybody in the workshop has free access to, is the "view data" option. The data entry and the report generation options on the menu are password protected.

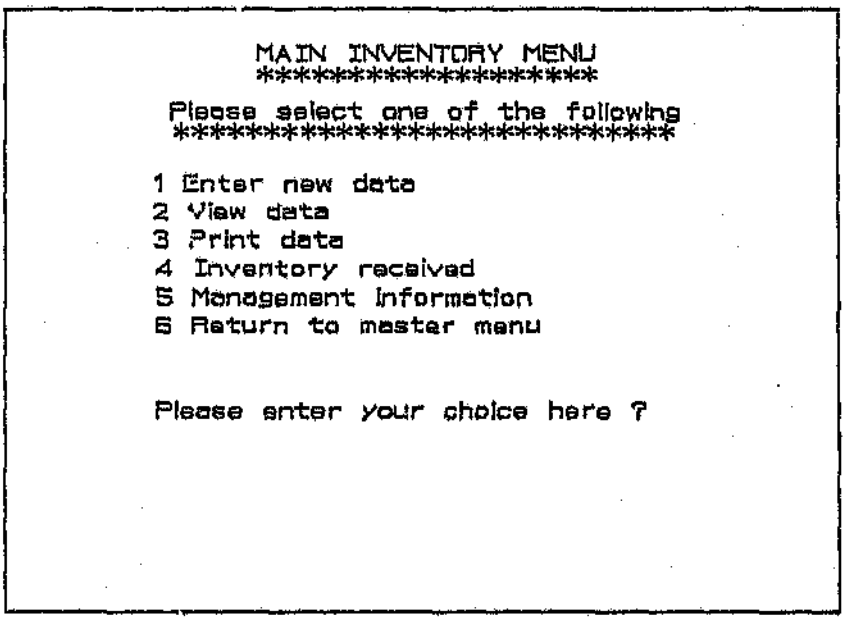


Figure 6.3 Main inventory menu

6.1.1 Data entry menu

By selecting option one, on the main inventory menu, the user is taken to the data entry menu shown in figure 6.4. The only people who can access this menu from the main menu are the store manager and his assistant. By selecting option number 1 or 2, the user can enter a new "A" or "E" class item to the computer stock. Once the information for

a new stock item has been entered onto the computer for the first time, then access to option number 1 or 2 for updating purposes is denied. The spare is now no longer new to the computer stock and therefore any changes which are to be made to the description, bin number, lead time etc., have to be done through the update option (option number 5), on this menu. Options number 3 and 4, are only present in the demonstration package. It is through either of these options that one of the data files, "A" or "E" class item file, can be initialised.

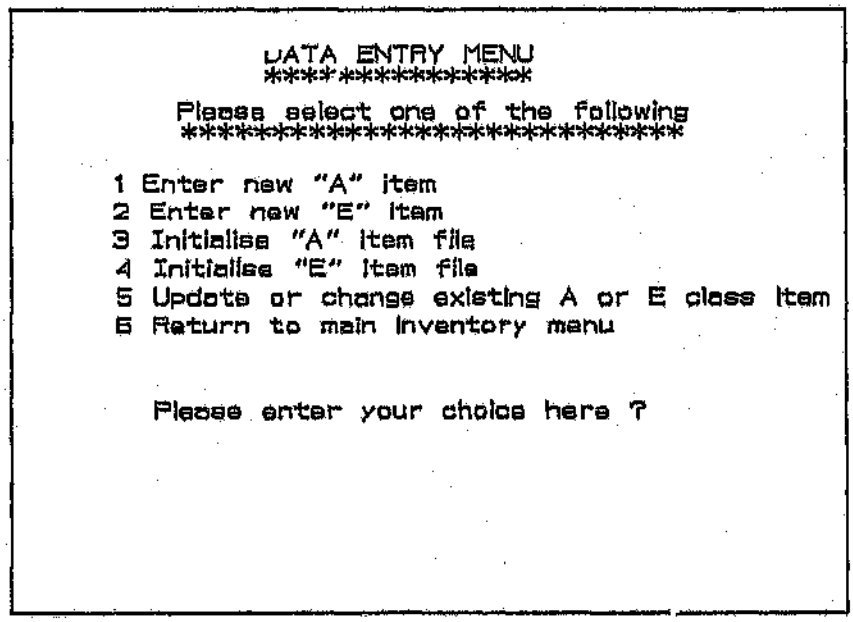


Figure 6.4 Data entry menu

The first option to be discussed is option number 1, "Enter new "A" item ". On selecting this option the user is first asked to enter the part number for the item to be added to the computer stock. The computer then searches through the "A item file" looking for a part number which matches the one which has just been entered. The item file for A items, contains all the information which is pertinent to an A item, and would, before computerisation, have been found on a bin card and in the catalogues described earlier. If a match for this part number is found, then the computer informs the user, that this part already exists in the computer stock and the user should therefore select the update option.

Every part number is made up of four distinct subsections. A typical number would be 1234-ZZ-567-8789. In order to speed up the retrieval time for a part number, the number is entered in four separate sections. The user is required to press enter after every section of the number has been entered. If the data base now searches for a part number, it only has to search for four short strings as opposed to having to search for one 13 bit alphanumeric string. This method of part number entry can be changed when the program is rewritten in a faster data base language. The way the data base searches for a number in the respective item file, is shown in figure 6.5, and described below.

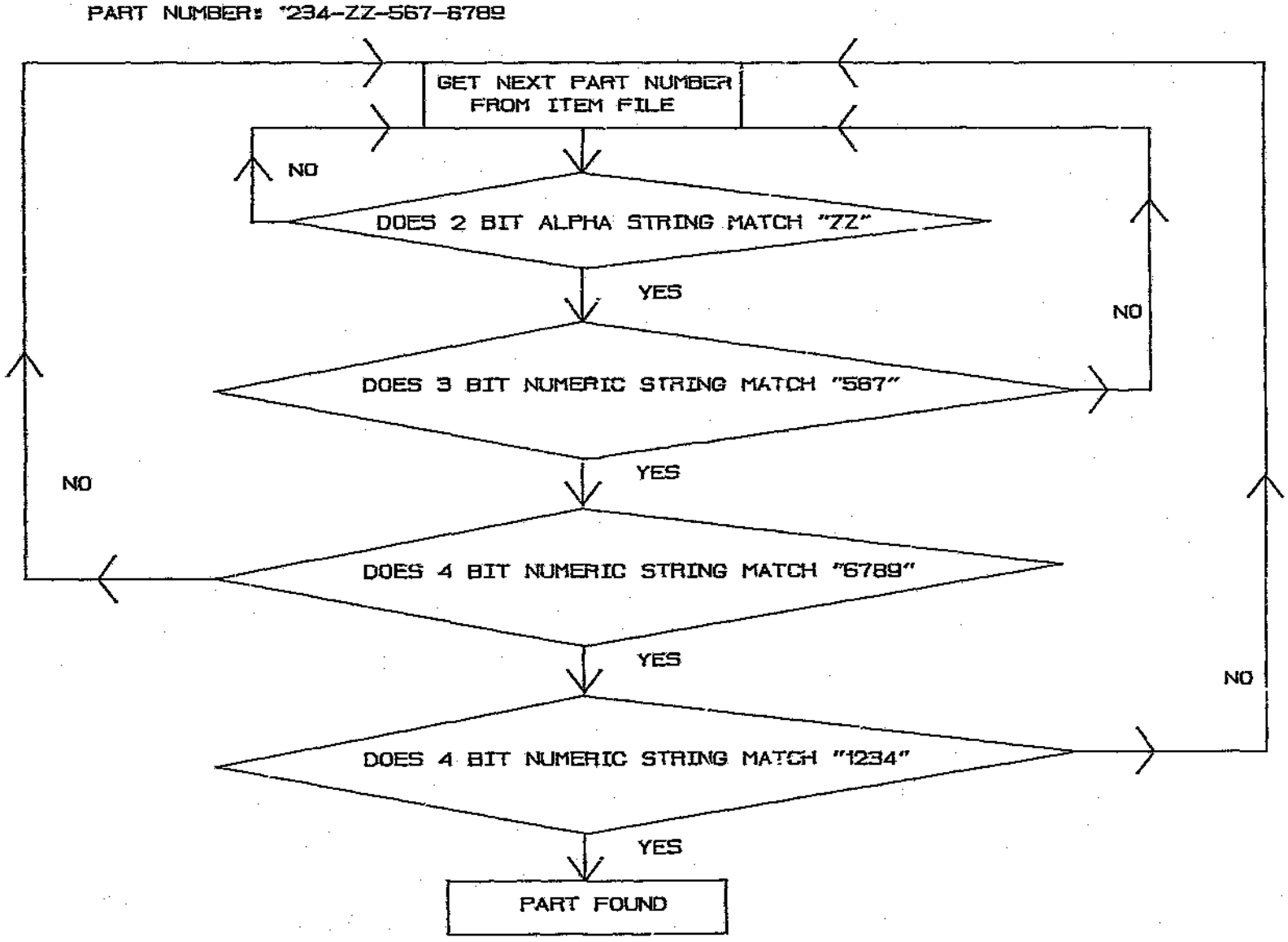


Figure 6.5 Flow diagram of data base tracing a part number

To search for the number, 1234-ZZ-567-6789, the computer would do the following.

a) The computer first considers the shortest string in the number, which is the two bit alpha string "ZZ". If a part number is found in the item file with the same alpha string, then the computer looks at the next string in this number. If the alpha string does not match, the computer aborts the search with respect to this number and considers the next part number in the data base.

b) Having successfully matched the alpha string, the computer now considers the next shortest string in the number. The next shortest string is the numeric string,"567". If the part number which is being considered also has the same numeric string then the computer will look at the next string in the number, else it will abort the search here, and consider the next part number.

c) The second last section of the number to be considered is the numeric string, "6789". If a match is found then the computer will look at the last string in the number else it will again abort the search here.

d) The computer now looks at the last numeric string, "1234". If the numbers match at this stage, then the computer has found the correct part number.

Having verified that the part number has not been entered on the computer stock the user is given access to the data

entry screen shown in figure 6.6 below. The user is required to enter the MAD (Mean average demand deviation during replenishment lead time) as well as the annual demand for the item. These two entries will never have to be updated by the user again, since the computer will gather usage data for the parts and then calculate the annual demand as well as the MAD itself. The information entered on this screen together with the EOQ and ROP which is calculated by the computer from the data entered, are stored in the "A" or "B" class item files, depending on part classification. If while entering the information for the spare, the user makes a mistake, then they can return to whichever field they made the error in.

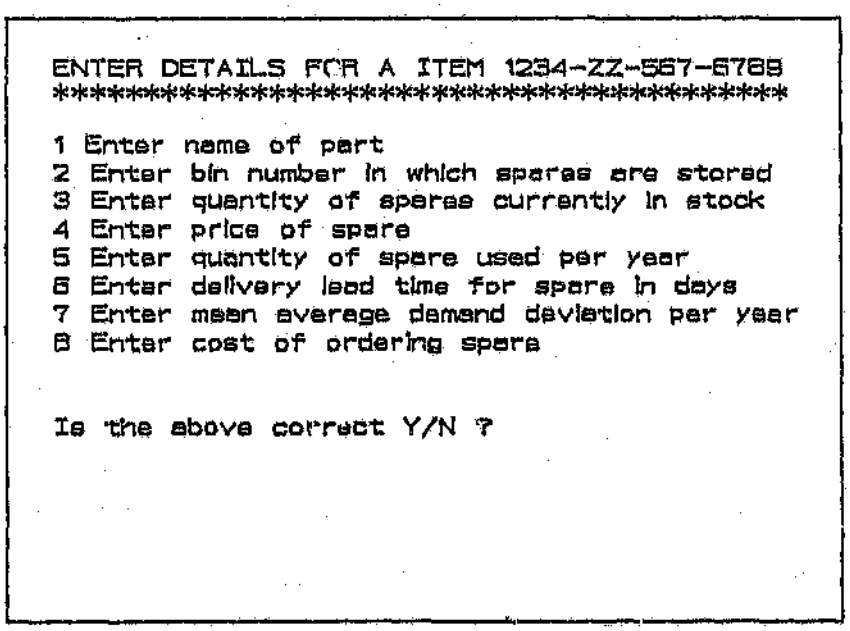


Figure 6.6 Details to be entered for a spare

The second option on the data entry menu is that of changing or updating an existing "A" or "E" class item. On selecting this option the user is again asked to first enter the part which they wish to update or alter. The computer carries out the same check as described above, and on verifying that the part number does exist the user is given access to the update menu, shown in figure 6.7 below.

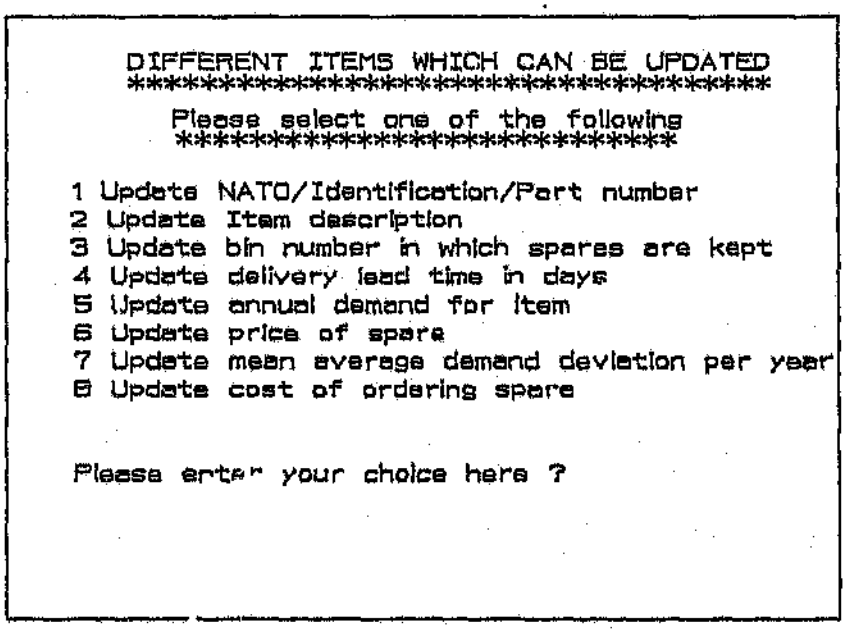


Figure 6.7 Menu for different update options

All the information which was originally entered for the part on the data entry screen shown in figure 6.6, can now be updated. The user is given the option on the update menu to change the MAD. This option will not exist in the proper multi-user package, since it will be calculated by

the computer. It is however useful to have this option available on the demonstration package, in order to illustrate the affect of the MAD to management. A field which can not be changed on the update menu is the stock level. The only time that a stock level has to be updated manually will be at the end of a cycle count, when it is found that the computer stock and the physical stock do not match. This can only be done by the work shop manager since it is he who has to answer for the discrepancy in the stock levels. The stock level can only be updated in the management information section of the program, which will be discussed later.

If as an example the user would like to update the bin number, option number 3, then the screen would appear as shown in figure 6.8. If the part number is changed then the original part number no longer exists in the computer stock and a new part could now be entered under the old part number.

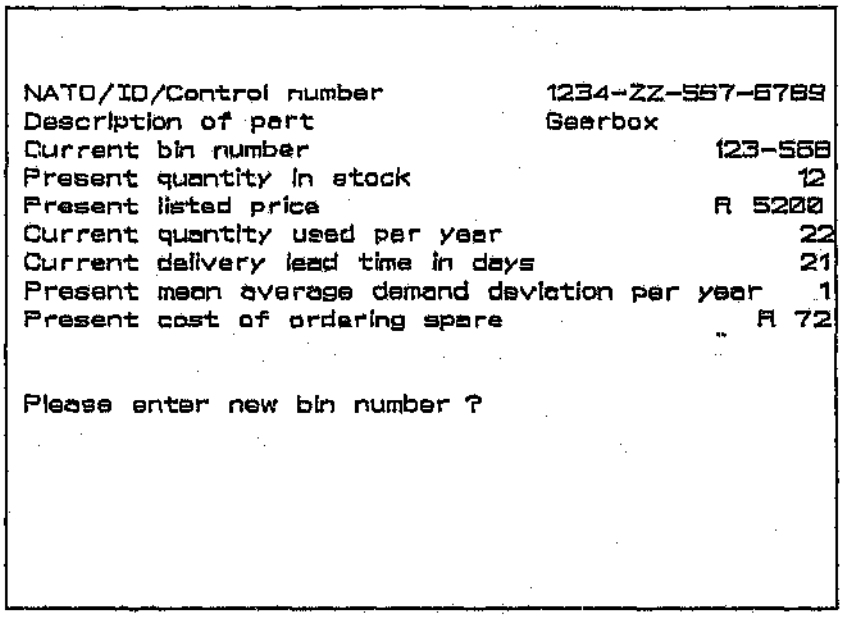


Figure 6.8 Screen when updating bin number

6.1.2 Data view menu

No password is required to gain access to this menu and therefore can be accessed by any of the network users. The data view menu is shown in figure 6.9. If the user selects one of the first two options then the soreen will be identical to that shown in figure 6.8, except that there will be no place to enter data.

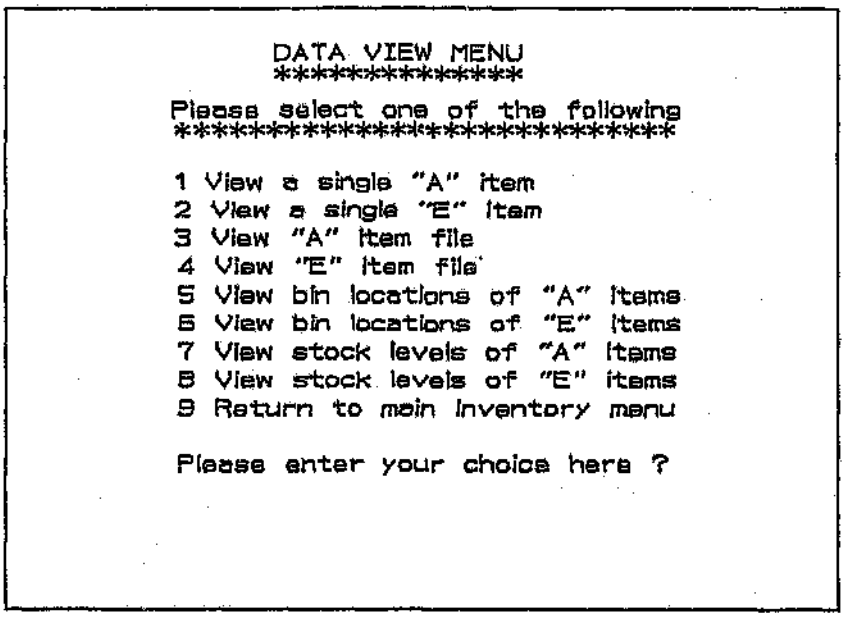


Figure 6.9 Menu for viewing data

When the computer files away the different spares in the data files it gives each spare a unique computer generated number. Therefore the first spare will be stored away in the data file as spare number 1, the second as spare number 2 etc. It does not file away the spares according to their part numbers. The rest of the options on the view menu allow the user to look through the entire "A" or "E" item files. If the user wants to look at the "A" item file then the computer will ask the user from what computer generated number the user would like to begin at. The option of viewing an entire file is useful, if the user wants to know what the part number for a particular spare is, but only knows the name of the spare.

The above query facility could not be written properly in basic because of the limitations of basic. As this query facility operates now, the user is forced to look through the entire file to find the part number corresponding to a particular part, unless the user knows what the computer generated number is for the part. In the proper multi-user data base, the data base will be able to search for parts by just being given details about a particular field pertinent to that part. As an example the user could get the database to search and retrieve all spares which have the word "gear" in their name. This is an improvement over having to sit and go through hundreds of computer generated numbers. The reason this facility can not be set up properly in basic is, because basic analyses an entire field and not just parts of it. A proper data base package will be able to analyse sub sections of a field and reads upper case and lower case letters as being the same, basic cannot do this.

Figure 6.10, shows what the user sees when viewing the "A" item file. If the user wants to view bin numbers or stock levels then the screen will be identical to that shown in figure 6.10, except that the part number will be replaced by bin level or stock level.

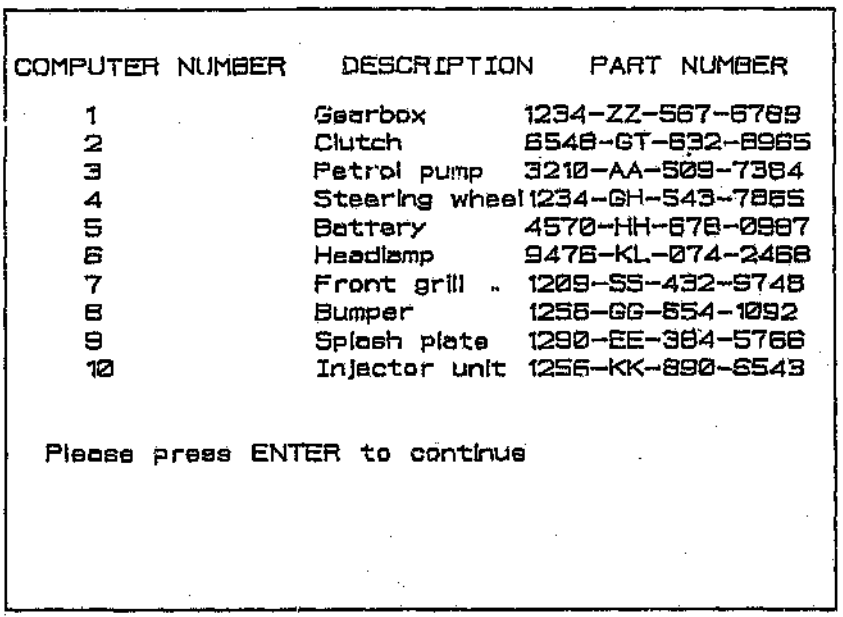


Figure 6.10 Screen as seen when viewing item file

6.1.3 Data print menu

This menu is password protected since it allows the user the facility of producing reports. This menu is shown in figure 6.11. The people who can access this menu are the workshop and planning manager as well as the stores manager. The reports which are generated on this data print menu are identical to those which could be seen in the data view option. By having both a data view and a data print option it prevents the generation of unnecessary reports, since the other users who have no real use for the reports can view the reports in the view option.

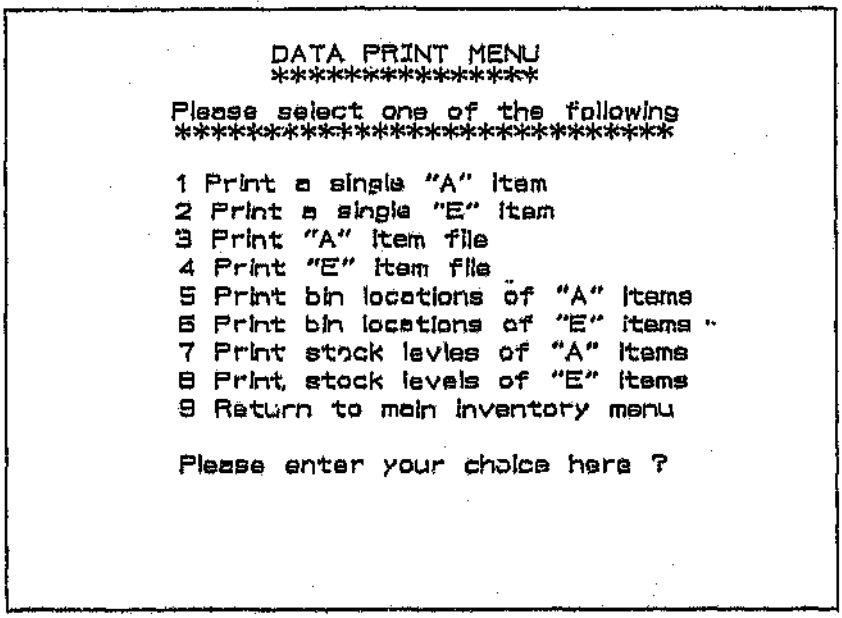


Figure 6.11 Menu for printing data

During the writing of the program it would have been easier to have both the view and print options on the same menu. This was not done and separate menus were drawn up in order to keep the program as user friendly as possible. People who are not computer literate often have a big fear of computers and therefore by having both the print and view options on the same menu,the general user will be able to access this menu and will then be denied entry to certain options within the menu. This can often be very frustrating for people. The next point is that had both the options been on the same menu, then the menu would have looked very cluttered and the program would again have lost its friendliness.

6.1.4 Stock receipts

The inventory received menu is password protected and the only people who can access it are the store manager and his assistant. Stock receipts are regarded as being any stock which is delivered by a supplier or returned to the store from the shop floor. The menu for adding stock receipts to the computer stock is shown in figure 6.12.

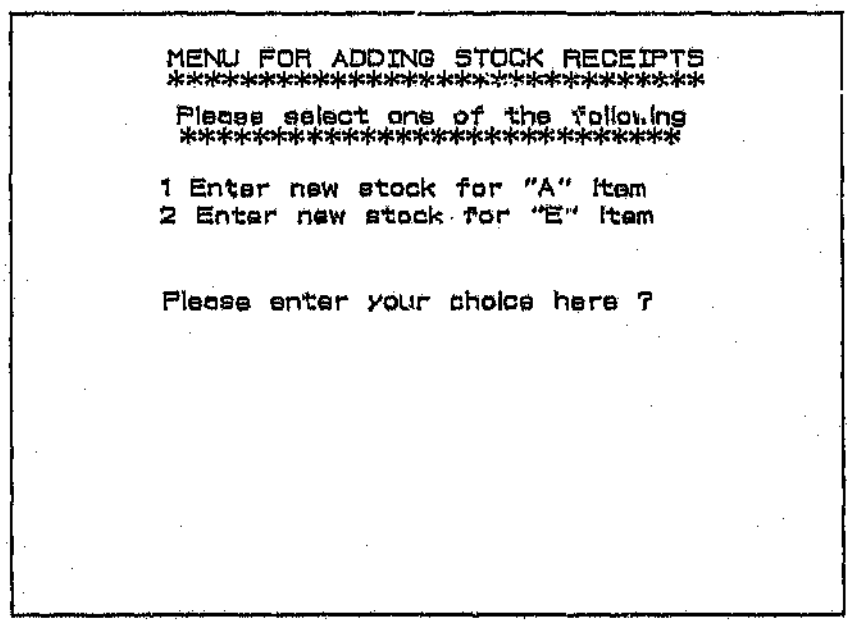


Figure 6.12 Menu for stock returns or deliveries

After the user has made a selection they are asked to enter the part number which is first verified by the computer. On entering a valid part number, the user is given access to the screen for entering new stock arrivals, which is shown in figure 6.13. The user has to

enter how much stock has arrived as well as the invoice number in the case of a delivery, or the job number in the case of a stock return. The user is not required to enter the supplying company since the spares suppliers are all on sole supplier. The stock which has arrived is added by the computer on to the existing stock total to give a new computer stock total.

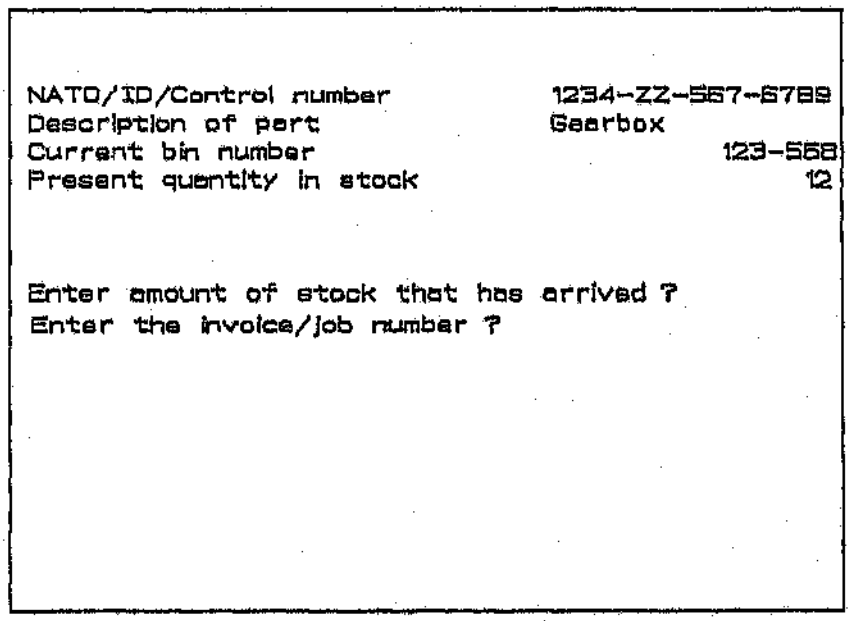


Figure 6.13 Screen for entering stock deliveries or returns

6.1.5 Management information menu

This menu is password protected and the only people who can access it are the workshop manager, stores manager and his assistant. The management information menu is shown in

figure 6.14. Once having gained access to this menu, accessibility of the different options is limited. This is mentioned above as being confusing, but it is felt that the three most educated users on the system will be the only ones accessing this menu and the menu will be restricted to five or six options only.

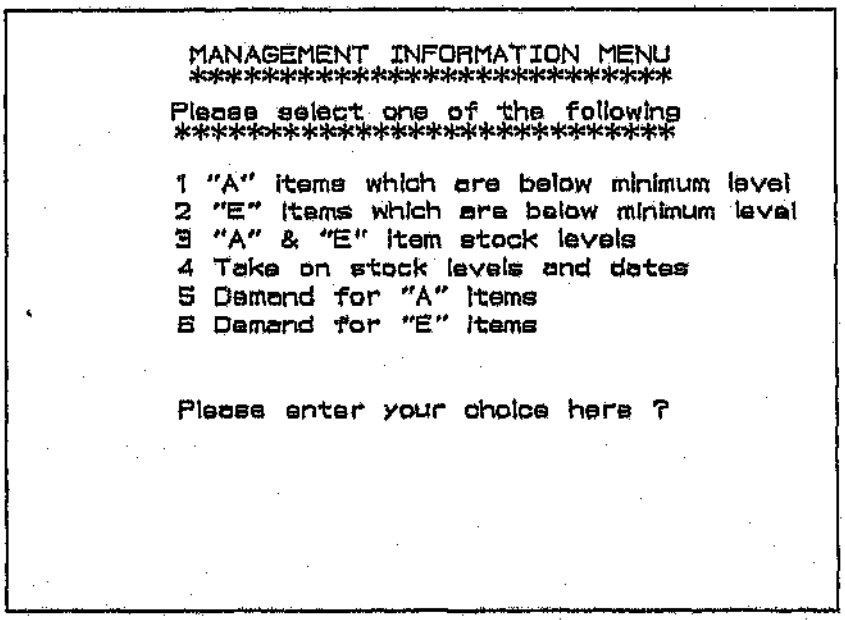


Figure 6.14 Menu for management information

The first option to be disoussed is one to which all three the users can gain access. The option is that of items which are below minimum level. On selecting this option the user can further decide whether they want to view the report or have a printout of it. The reorder point is calculated from the information found for each spare in

the item file, and is then stored in the item file. The EOQ is calculated using the same information source used to work out the reorder point and is also stored in the item file.

The reorder point represents the minimum point in a Min-Max stock control system. The reorder point is calculated using the equation which was derived in the literature survey:

$$ROP=D(LT)+ZSd=D(LT)+1.25Z(MAD)$$

The present quantity in stock according to the item file, is compared with the reorder point value, if this value is less than or equal to the reorder point, then a reorder situation will be flagged.

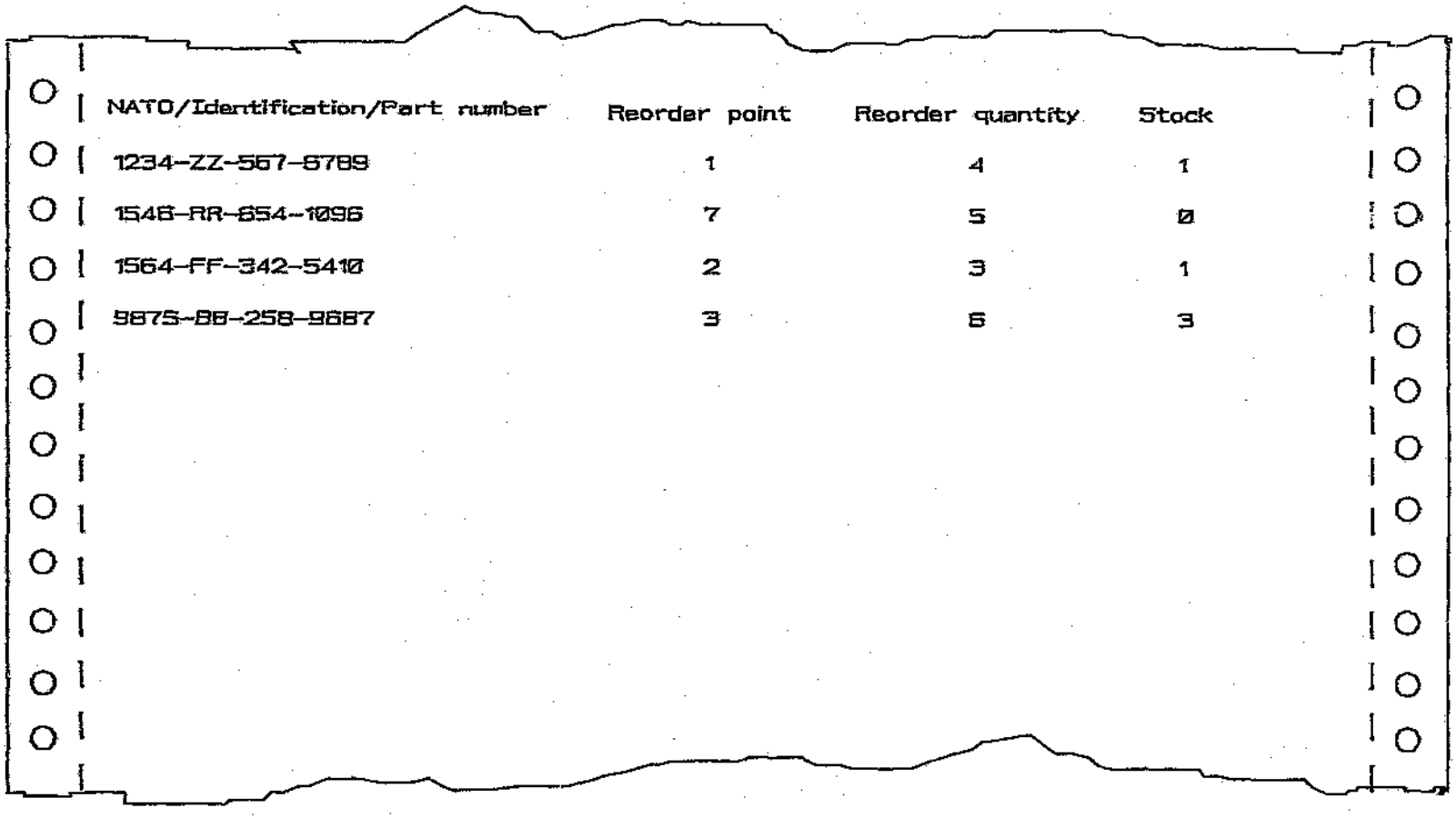
The EOQ is calculated by means of the equation derived in the literature survey.

$$EOQ=\sqrt{\frac{2DS}{IC}}$$

The report which is produced by the program for the "items below minimum level" option, is shown in figure 6.15. The report states what the reorder point is, as well as the reorder quantity and the present stock level. It must be noted that the EOQ is not always an amount equal to or greater than the reorder point. Therefore it is possible to place an order for an amount equal to the EOQ, but, this order will not be sufficient to make the stock level greater than the reorder point. The situation in which the above mentioned scenario can occur would be for an item

that is not used very often. If this item had a ROP of three and an EOQ of two, and there was to be a sudden rush for these items then the situation could arise where the on hand stock were zero, an order equivalent to the EOQ had been placed. On receiving the newly ordered stock there would still exist a reorder situation.

It would be very easy to write the program such that the order quantity would not be the EOQ, but rather twice the EOQ in the above situation. This has however not been done in the demonstration package and will also not be done in the final multi-user program. The reason being that the above case is an extremely exceptional case, and by leaving the decision to double the order as in the above example in the store man's hands, you leave him feeling as though he is still the total decision maker. He will now see the EOQ as being nothing more than the old maximum point which he would always have got from his manual bin cards. With the option displaying which items have to be reordered and recommending the order quantity as calculated by the EOQ, a proper stock control system has been introduced. The store manager and his assistant can now run this modern store without knowing anything about stock control and they have become independent of their store men for being told when to order. The reorder situation will continue to be flagged until the new stock has arrived and been entered on the computer.



NATO/Identification/Part number	Reorder point	Reorder quantity	Stock
1234-ZZ-567-6789	1	4	1
1548-RR-654-1096	7	5	0
1564-FF-342-5410	2	3	1
9875-BB-258-9687	3	6	3

Figure 6.15 Report for A class items below minimum

The third option on this menu can only be accessed by the workshop manager. This option is used for updating the stock levels of "A" and "E" class items. This option will only be used if, after a cycle count it is found that the computer stock and the physical stock are not in agreement. Figure 6.16, shows the screen for this option.

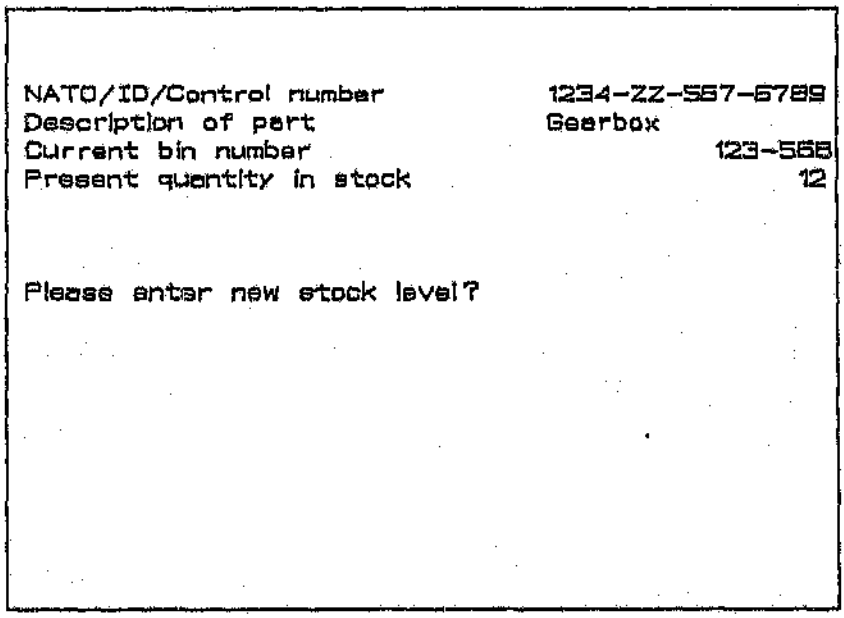


Figure 6.16 Screen for updating new stock level

The fourth option is that of take on stock levels, times and dates. The menu for this option is shown in figure 6.17. Here the user is given an option of viewing the report or receiving a printout of the report. The term "take on", refers to the last time the stock level was entered officially. The stock level can be entered in two

different places in the program and added to in one place in the program. The stock level is entered initially when the stock is entered onto the computer for the first time, this is the first place the stock level can be entered, and the second place is when the store manager alters the stock level as described above, after a cycle count. The stock level can be added to after a delivery has taken place or spares are returned to the store.

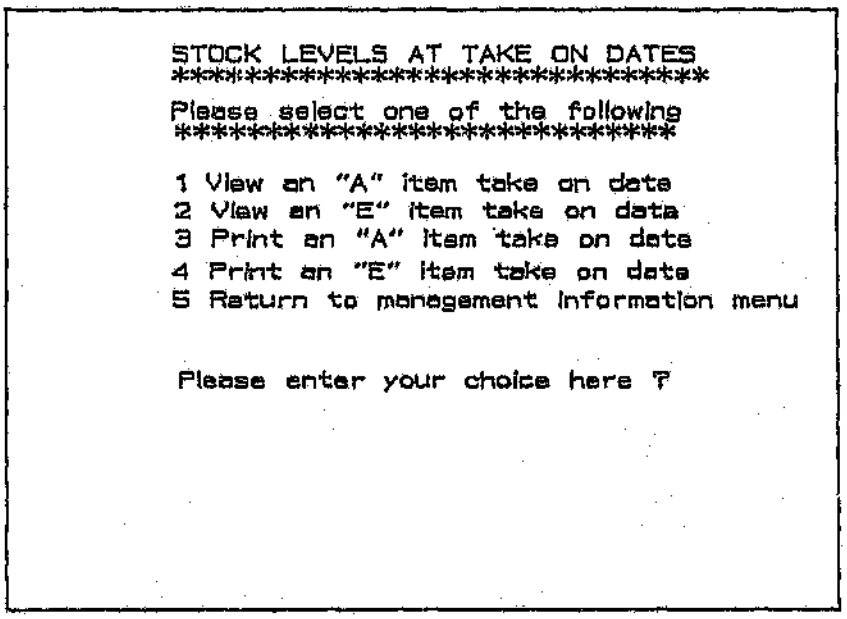


Figure 6.17 Menu for changing stock levels at take on dates

The take on stock level does not usually equal the present stock level, since the take on stock level, time and date are static figures which are used as a datum for accounting purposes. The following example will show how

the take on stock level and date are used. If on the first of the month a delivery arrives for item Z, and the total stock of Z, including the delivered amount is ten, then the take on stock is ten. The take on date, is the date on which the delivered items were entered onto the computer, and the take on time, is the time at which the transaction took place. Depending on when the stock level is changed, a corresponding stock code is assigned. If the stock level has never been altered since it was initially entered, then the stock code is 1. If it is altered due to a stock receipt then the code is 2, and if it is changed manually by the store manager then the code is 3. A report which displays this information is shown in figure 8.18.

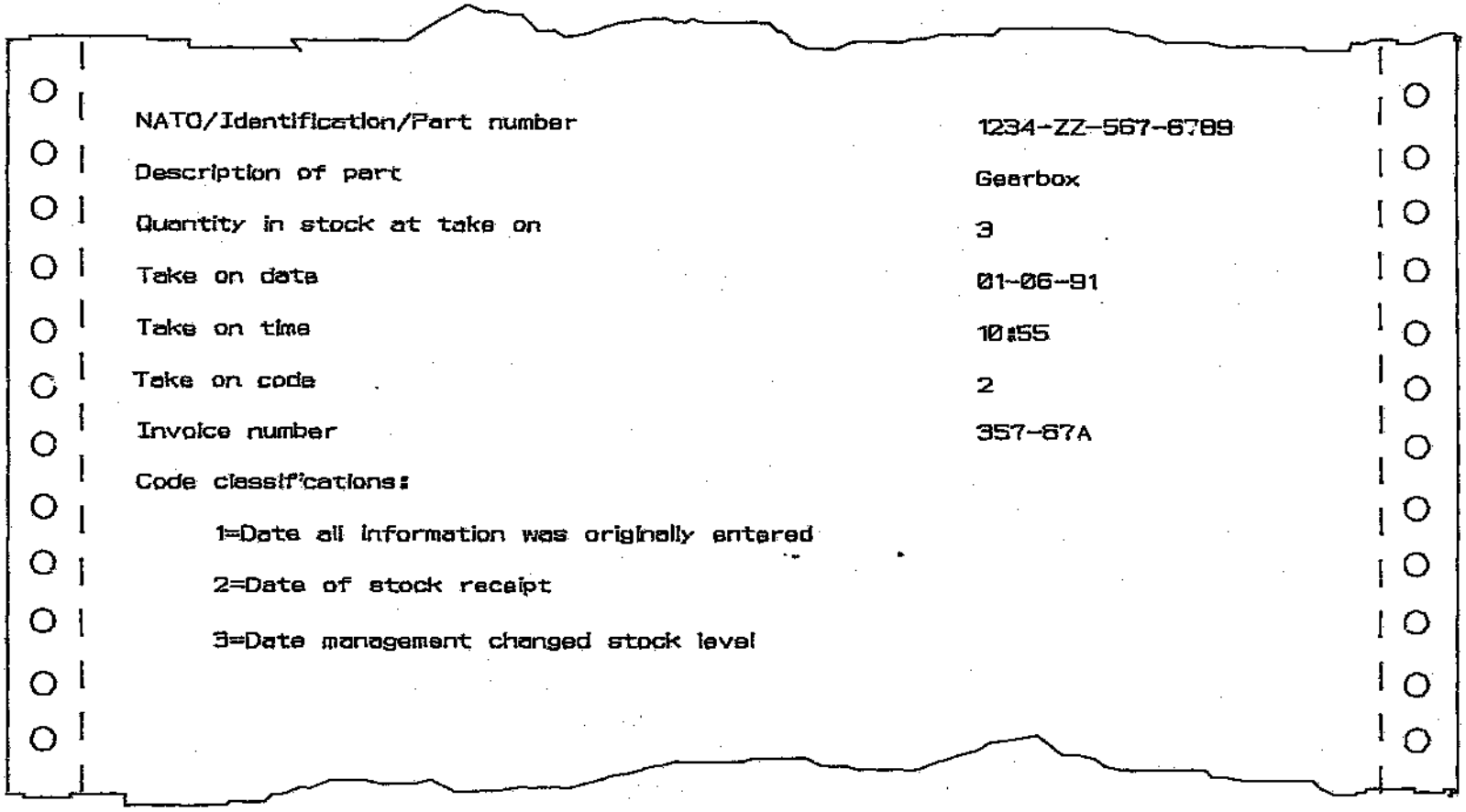
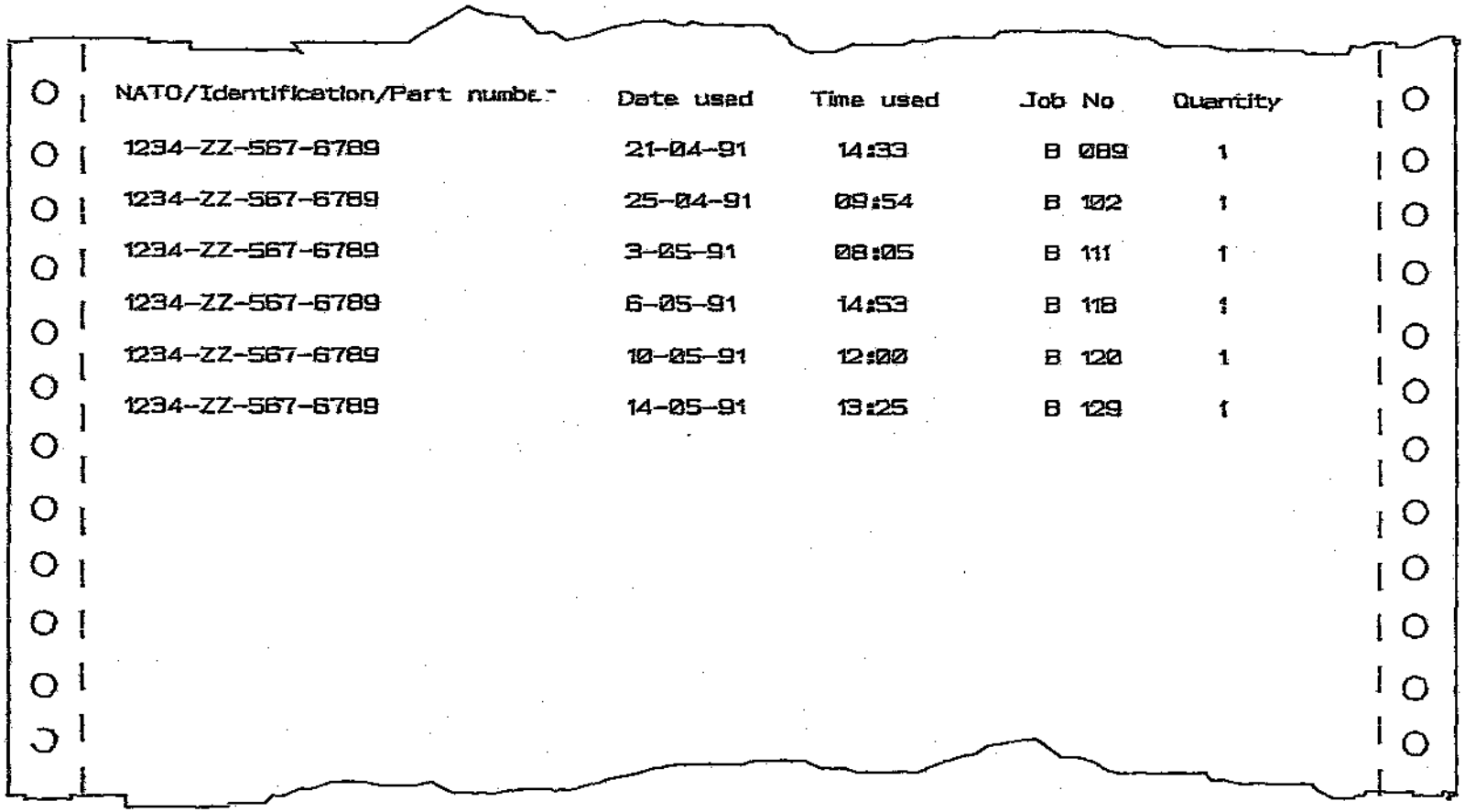


Figure 6.18 Report of stock levels at take on dates

The fifth option on this menu is the "Demand for an "A" or "E" class item". The report generated with this option is derived from the "item usage" file. Every time an item is drawn from computer stock to be used on a job, then the time, the date and the job for which the item is used is recorded in the "item usage" file. An item usage file exists for both "A" and "E" class items. The report which indicates these details is shown in figure 6.19. In the proper package it will be useful to not only list the part number but also a description of the part, this would make the reading of this report much easier. It is from this file that the computer can draw some of the information necessary to generate the new EOQs and ROPs for all the items each year. From the information stored in the "item usage" file the computer can calculate the average demand and the mean average demand deviation per year for each spare. It then combines this with the information found in the item file to work out the new EOQ and ROP This regeneration process has not been written into the trial package due to the small amount of data that can be stored in the trial package. The regeneration process will however be written into the multi-user package and can be accessed by the store manager only.



NATO/Identification/Part numbe	Date used	Time used	Job No	Quantity
1234-ZZ-567-6789	21-04-91	14:33	B 089	1
1234-ZZ-567-6789	25-04-91	09:54	B 102	1
1234-ZZ-567-6789	3-05-91	08:05	B 111	1
1234-ZZ-567-6789	6-05-91	14:53	B 118	1
1234-ZZ-567-6789	10-05-91	12:00	B 120	1
1234-ZZ-567-6789	14-05-91	13:25	B 129	1

Figure 6.19 Report of an item's demand

By obtaining the three following bits of information: demand for an item, take on stock levels and dates as well as the present stock level, it is possible to do the following investigation; supposing it is now the 15th of the month and the stock level for item Z, is now 5, according to the computer stock, then the following conclusions can be drawn.

a) The usage between the 1st and the 15th of the month is five items (take on stock level-present stock level).

b) By using the item demand report it can be confirmed that five items were drawn from computer stock during this time period.

c) If a physical inventory now takes place and it is found that there are actually four items in stock, then it means one item has disappeared and a reason for this must be found.

The store manager is now held directly responsible for this item. This ability to be able to monitor stock will lead to an immediate decrease in pilferage.

To use any of the options in the management information menu it is necessary to enter the part number every time. The computer will then first confirm this part number is correct, before allowing access to be gained to the selected option.

6.2 Job cards

The second option on the opening screen to be considered is that of job cards. This option is not password protected since it shares a common menu with the DD 1873 or stores indent form. Figure 6.20 shows the main job card and spares requisition menu. This screen would not exist in the final workshop management package, since a screen like this is bound to cause confusion and frustration with the inexperienced user. The user would become frustrated and confused by the fact that a decision which they took on the previous screen now has to be retaken, i.e. whether to work on a job card or a stores indent form. They will automatically start to assume they took an incorrect decision the first time and have now been denied access, and must therefore retake the decision.

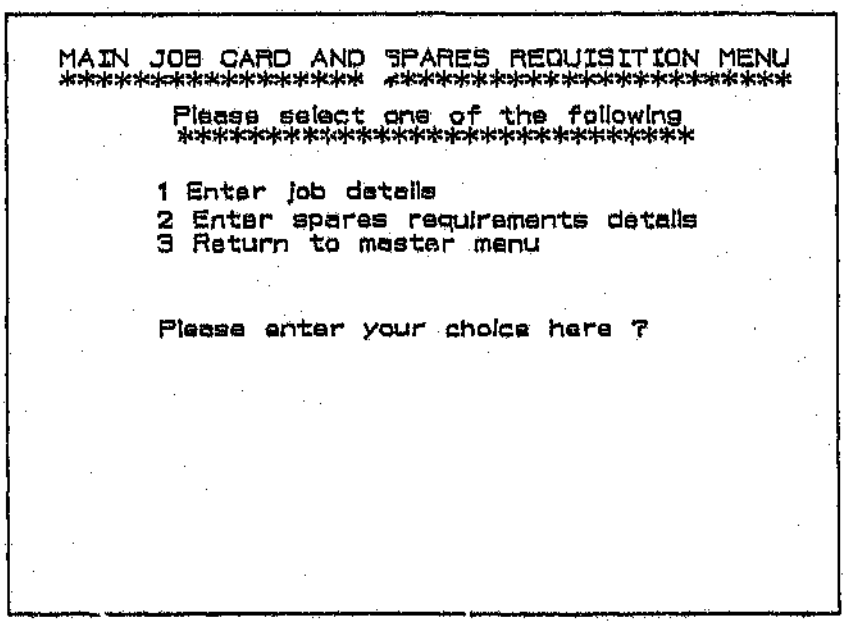


Figure 6.20 Main job card and spares requisition menu

This menu does however still exist on the trial package, because when the program was originally written it was expected that this module of the program would not be of such a large size, i.e. in excess of 55 Kb. It was therefore expected that both sections could be written in the same basic sub program.

By the user selecting the "job details" option, on the main job card and spares requisition menu, the user gets to the password protected job card menu shown in figure 6.21. The people who can access this menu are, the workshop and planning manager, the foremen and the in/out inspector. The first option on this menu is that of entering a new job card.

```
                    JOB CARD MENU
                    *************

          Please select one of the following
          **********************************

1 Enter a new job card
2 Make alterations to existing job card
3 Enter work done on a job
4 Job cards for reject jobs
5 Printout of completed or in progress job card
6 Printout of new job card
7 Return to main job card and spares requisition menu


Please enter your choice here ?
```

Figure 6.21 Main job card menu

6.2.1 New job card

On selecting this option the user is asked to choose between entering a new "B" or "D" job card. On selecting the "B" job card option the user arrives at the new "B" job menu, see figure 6.22.

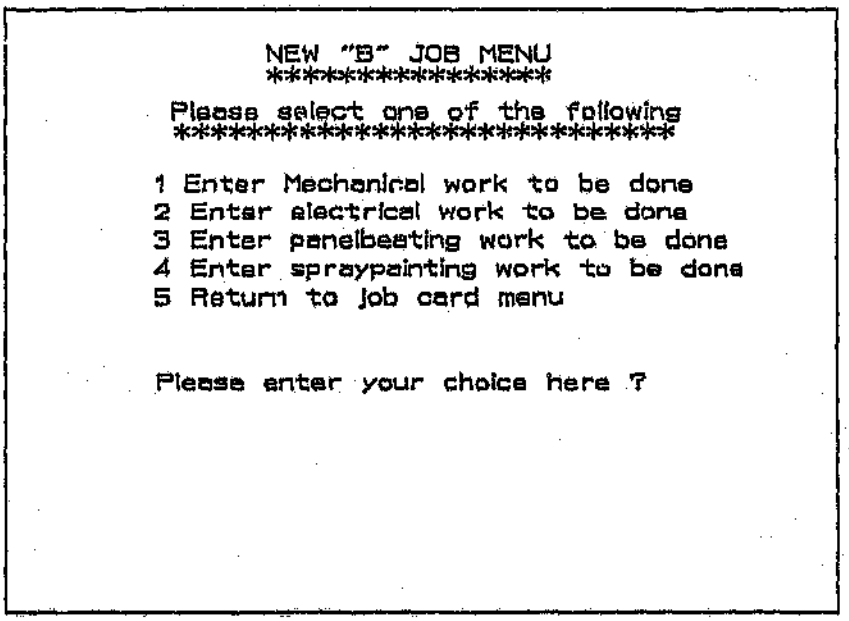


Figure 6.22 New job card menu for "B" jobs

The program does not assume that every vehicle arriving in the workshop requires major work to be done on it, and therefore the user can select only the options corresponding to the work which has to be done. The trial package has been setup to handle a total of 81 mechanical tasks, 25 electrical and panelbeating tasks, as well as 16 spraypainting tasks per job number.

To see how the menu works, the electrical work option shall be selected. Firstly, the user is asked to enter the job number. On entering the job number the computer goes to the "electrical "B" job" file, and searches this file to see whether this job card is already entered on the computer. If it has already been entered then the user is told to access the alterations option on the main job card menu. If the number did not exist then the user is taken to the data entry screen for new job cards which is shown in figure 6.23.

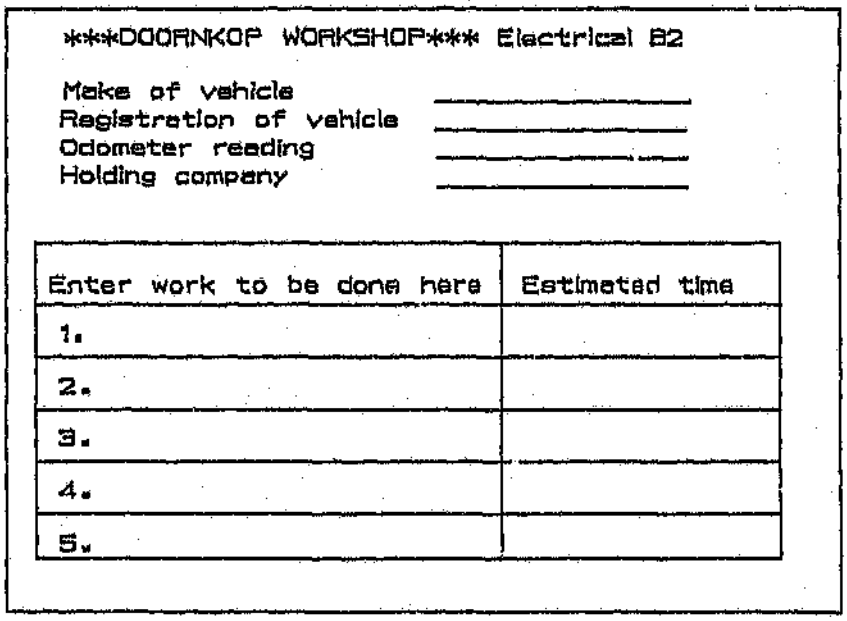


Figure 6.23 Data entry screen for new job card B2

The only people who can access the new job card menu are the planning manager and the in/out inspector. Once the details have been entered for a new job card then they are

stored in the electrical "B" job file. The total estimated time for the electrical job is written from the electrical "B" job file, to the ""B" journal" file.

The foreman are not allowed to access the new job card or the alterations to an existing job card option, because they have been known to alter the estimated time, as soon as this time becomes difficult to attain. The only two people who can access these options are the planning manager and the in/out inspector.

6.2.2 Alterations to existing job card

The second option on the job card menu, is the password protected option of making alterations to an existing job card. This option is used when artisans require extra time to complete a task or an additional task which was overlooked during the in-inspection has been found. An example of additional time being required occurs when an artisan is told on the in-inspection to change a faulty starter motor. On attempting to exchange it, the artisan finds that the holes for the hold down bolts on the engine block have been stripped, and must now all be retapped. The artisan now requires more time than the estimated time given on the job card to complete the task.

The only person who can make alterations to a job card is the planning manager. By not allowing the foreman to make alterations, serves a dual purpose. Firstly, the shop

floor control is tightened as the planning manager is up to date at all times with any changes that have occurred on a job. Secondly, it makes it impossible for the foreman to adjust estimated times, and they are therefore forced to meet their deadlines.

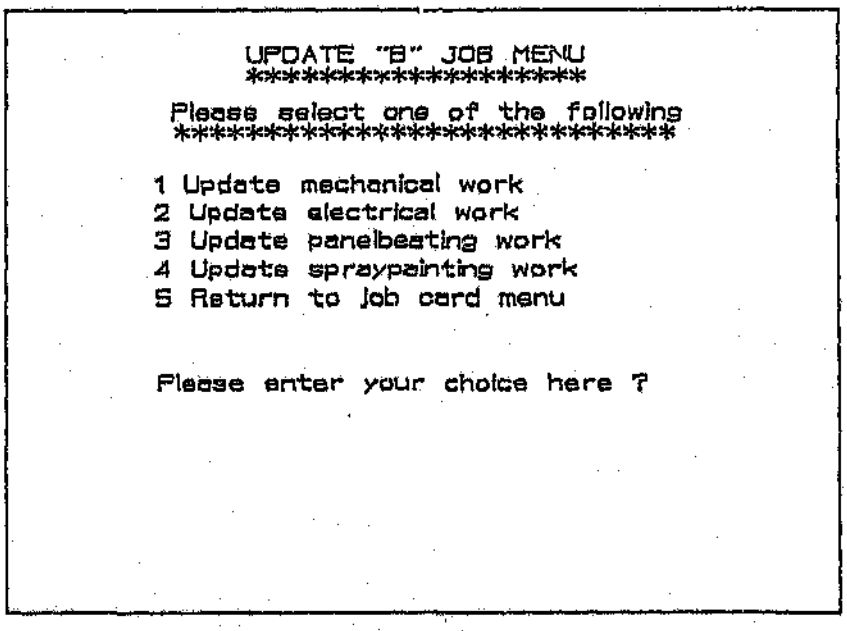


Figure 6.24 Update menu for "B" jobs

After having accessed the alterations menu shown in figure 6.24, the user must select the work they wish to update. If they wish to update the electrical work, in the case of a "B" job the computer will go to the electrical "B" job file and see if electrical work has been entered for this "B" job. If a job number does not exist then the user will

not be allowed to make alterations to the job card. Any alterations which are made to the job card are again stored in the respective "B" or "D" job file, and the estimated time is transferred to the respective journal file.

6.2.3 Work completed on a job

The third option on the menu, is the password protected option, of entering what work has been done on a job. The people who can access this section are the foremen and the planning manager. When selecting this option the user is first asked to decide between entering work done on a "B" job or a "D" job. On selecting the job type, for discussion purposes a "B" job, the following menu will appear, as shown in figure 6.25.

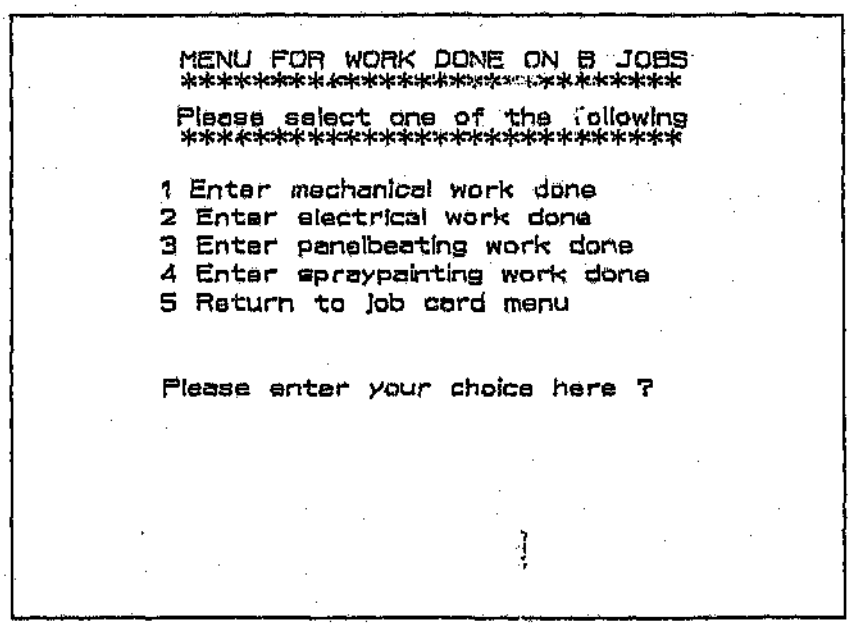


Figure 6.25 Menu for work done on "B" jobs

In the case of the electrical foreman, he would choose the option of entering work done on an electrical job. The user will now have to type in the job number for the electrical job he wishes to update. This job number will now be looked up by the computer in the electrical "B" job file. If the job card does exist, then the data entry screen shown in figure 6.26 will appear.

DOORNKOP WORKSHOP Electrical B2

Make of vehicle Toyota 4x4
Registration of vehicle NMP 319 T
Odometer reading 34532 Km
Holding company JKL Ltd

Enter work done here	Actual time
1.	
2.	
3.	
4.	
5.	

Figure 6.26 Data entry screen for work done on job B2

On this data entry screen the foreman enters the tasks completed, as well as the time they took him to complete. This information is stored in the "Elecdone "B" job" file, and the actual hours worked on the job are transferred to the "B" journal file. This information should be entered

every evening after the days work is finished. With this information being entered every evening it means that the workshop manager can call for a printout of the workshop journal every morning, and can immediately see how much work was done on the job the previous day. A comparison can also be made from this printout between actual hours worked and estimated hours, therefore the workshop manager will know exactly what the status of every job is.

6.2.4 Job cards for reject jobs

The fourth option on the job card menu, is the reject job card option. As can be seen in figure 6.27, the reject job card menu is a duplicate of the job card menu shown in figure 6.21.

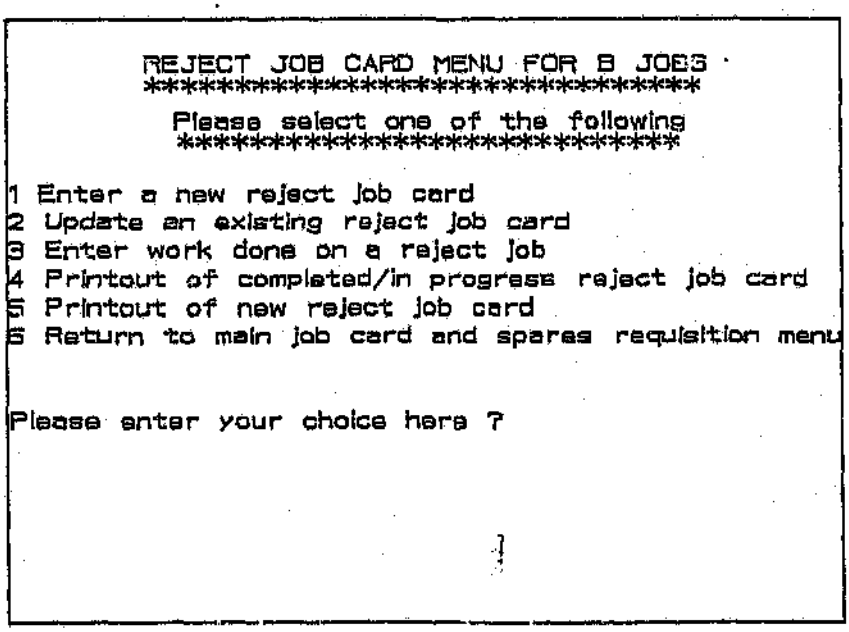


Figure 6.27 Reject job cards for "B" jobs

The separate options within the reject job card menu, which are the same options as those in the original job card menu, can only be accessed by the same people that could access them in the original job card menu.

When trying to access this menu the user is first asked whether the reject job is a "B" job or a "D" job. For discussion purposes it will be assumed to be a "B" job, and therefore the user is taken to the reject job card menu for "B" jobs. The first option on this menu, is that of entering a new reject job card. On selecting this option, the user will be asked to enter a job number. The computer then goes to the job card files and starts to search through these in order to find a matching job number to the one entered. The first file which the computer considers is the mechanical "B" job file. It looks through this file for the particular job number entered by the user, and on not finding it in this file it goes to the electrical "B" job file and looks here. If it still has not found the job number after this then it goes to the panelbeating file and finally the spraypainting file. Access to the new reject job card menu screen is granted as soon as the computer finds a corresponding job number in one of the files and thereafter confirms that a reject job card corresponding to this number has not yet been entered. In order to see whether a reject job card corresponding to this job number already exists the computer will search through the "reject "B" job" file. If

the job number is found in the reject "B" job file then access is denied to the new reject job card screen, and the user is instructed to select option number 2, update of work to be done on an existing reject job card. The reason the computer first checks through the different job files, is because there can be no rejects for a non existent job.

The new reject job card entry screen is identical to the new job card screen, except that details such as make of vehicle, registration number, odometer reading and holding company have already been filled in. These details are obtained from the job card file that has a job number corresponding to the reject job number. All the reject tasks are entered on the same job card and in one common section, irrespective of them being mechanical, electrical, panelbeating or spraypainting tasks. When a new job card has been entered or an existing one updated, then this information is stored in the "reject "B" job" file.

The only people who can access the third option on the reject job card menu; enter work done on a reject job, are the foremen and the planning manager. Any work which is entered as having been done on a reject job is stored in the "rejdone "B" job" file. The data entry screen for work done on a reject job is the same as that shown in figure 6.28, except that it is now for reject jobs. The procedure

for printing a new reject job card or a semi/complete reject job card, is identical to that used for proper job cards and will be discussed in sections 6.2.5 and 6.2.6.

6.2.5 Printout of new job card

The fifth option on the menu is that of a new job card printout. The only people who can access this option are the workshop manager and the planning manager. The printout menu which is linked to this option is shown in figure 6.28.

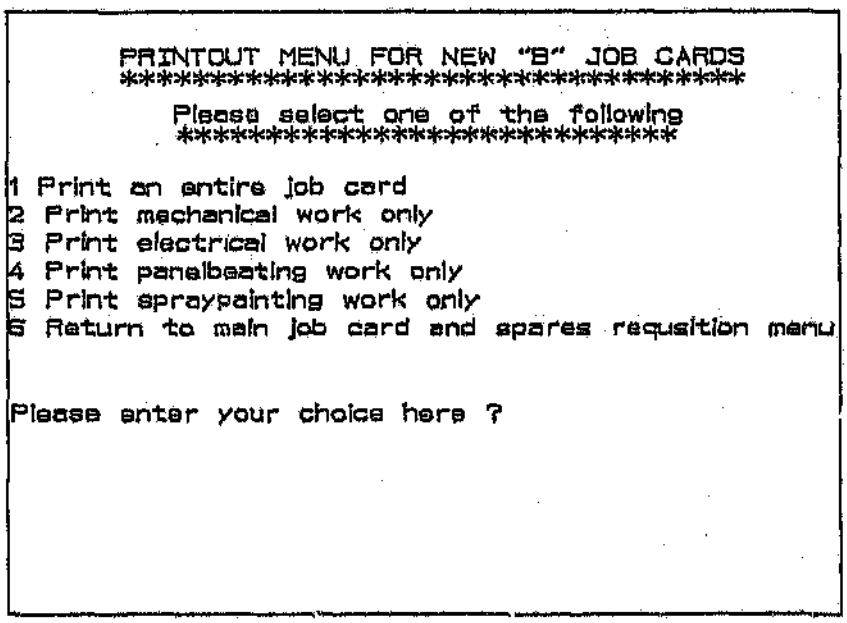


Figure 6.28 Printout menu for new "B" jobs

In order to printout a new job card the computer only has to access the mechanical "B" job file, the electrical "B" job file etc. It does not have to access both the mechanical "B" job and the mechdone "B" job file to produce a new job card printout, but this is not the case for a fully/semi completed job card.

The job card is printed onto a standard job card (DD 1813), as shown in Appendix A. The printout function of the computer was purposefully set up to do this, so that when management were given a demonstration of how the package works they would not discard it for the reason that they now had to order and make up new stationery. The computer prompts the user who requires a printout by asking the user to please ensure a new DD 1813 is in the printer and is properly lined up.

As shown in figure 6.28, there are a number of options available to the user. If the user chooses to printout a whole job card or a particular section only, then the computer will ask the user how many copies they require. The user can make up to a maximum of three copies, and the default value is set at one. When printing an entire job card the computer draws information from the mechanical "B" job file right through to the spraypainting "B" job file. Every subsection is printed on a separate DD 1813. Figure 6.29 shows a printout for a single section of a new job card. What has been discussed above applies equally

well to a printout for a new reject job card.

Figure 6.29 is shown on page 121. This figure has no title as it is an official document.

G.P.S 001-0299 DD 151

WERKSORDER—WORKS ORDER No.....

Werkplaas / Workshop: WIT COMMAND WORKSHOPS — Datum / Date: 07-06-1991

Toerusting No. / Equipment No.: FST 345 T — Fabrikaat / Make: NISSAN 4x4 — Tipe / Type:

Enjin of reeks No. / Engine or serial No.: — Odometer- of uurmeterlesing / Odometer or hour meter reading: 74521 Km

Eenheid of formasie / Unit or formation: CATERING — Werksaanvraag No. / Workshop requisition No.: B 1

BESKRYWING VAN WERK WAT UITGEVOER MOET WORD—DESCRIPTION OF WORK TO BE CARRIED OUT

MECHANICAL PAGE 1

	WORK TO BE DONE	ET AT	WORK DONE
1	REPLACE EXHAUST MANIFOLD	3.00	
2	SET TIMING	0.50	
3	REPLACE COIL	1.50	
4	REPLACE SPARKPLUGS	0.50	
5	SET HANDBRAKE	0.50	
6	REPLACE CLUTCH PLATE	5.00	
7	FLUSH OUT COOLING SYSTEM	1.00	
8	REPLACE FUEL FILTER	0.50	
9	REPLACE OIL FILTER	0.50	
10	CHANGE OIL	0.50	
11	TOP UP GEARBOX OIL	0.50	
12	REPLACE ENGINE/GEARBOX GASKET	5.00	
13	REPLACE GEARSTICK	0.50	
14	REPLACE SUMP PLUG	0.50	
15	TIGHTEN ENGINE MOUNTINGS	1.50	
16	REPLACE ALL SHOCK ABSORBERS	5.00	

TOTAL HOURS 25.5

Gemagtig deur / Authorised by: — Datum / Date: ..... 19.....

Ambagsman / Artisan:

Toetser / Tester:

Wkp. Offr. / Wksp. Offr.:

Opmerkings—Remarks

Aflos No. / Release No.: — Datum / Date: ..... 19.....

Gesertifiseer aangeteken in geskiedenisleer
Certified entered in History File
Geteken / Signed:

Blaai om—P.T.O.

6.2.8 Printout of a completed or in progress job card

This option can only be accessed by the planning and workshops manager. The menu for this option is identical to that shown in figure 6.28, except that now the user is not printing out new job cards but rather completed or in progress job cards. The computer again prompts the user about aligning the DD 1813 as described above. The difference between the computer printing out a new job card and a completed or in progress job card, is that the computer must access both the mechanical "B" job file and the mechdone "B" job file in order to do the printout. An example of this printout is shown in figure 6.30. This figure has no title as it is an official document.

WERKSORDER—WORKS ORDER No.....

Werkplaas / Workshop: W.I.T. COMMAND WORKSHOPS
Datum / Date: 07-06-1991

Toerusting No. / Equipment No.: FGT 345 T
Fabrikaat / Make: NISSAN Azs
Tipe / Type:

Enjin of reeks No. / Engine or serial No.:
Odometer- of uurmeterlesing / Odometer or hour meter reading: 34521 Km

Eenheid of formasie / Unit or formation: CATERING
Werksaanvraag No. / Workshop requisition No.: B 1

BESKRYWING VAN WERK WAT UITGEVOER MOET WORD—DESCRIPTION OF WORK TO BE CARRIED OUT

MECHANICAL PAGE 1

	WORK TO BE DONE	ET	AT	WORK DONE
1	REPLACE EXHAUST MANIFOLD	3	2,5	EXHAUST MANIFOLD REPLACED
2	SET TIMING	,5	,5	TIMING SET
3	REPLACE COIL	,5	1	COIL NOT REPLACED AS NOT FAULTY
4	REPLACE SPARKPLUGS	,5	,5	SPARKPLUGS REPLACED
5	SET HANDBRAKE	,5	,5	HANDBRAKE CABLE REPLACED
6	REPLACE CLUTCH PLATE	5	4,5	CLUTCH PLATE AND FLYWHEEL REPLACED
7	FLUSH OUT COOLING SYSTEM	1	,5	COOLING SYSTEM FLUSHED
8	REPLACE FUEL FILTER	,5	,5	FUEL FILTER REPLACED
9	REPLACE OIL FILTER	,5	,5	OIL FILTER REPLACED
10	CHANGE OIL	,5	,5	OIL CHANGE DONE
11	TOP UP GEARBOX OIL	,5	,5	GEARBOX OIL TOPPED UP
12	REPLACE ENGINE/GEARBOX GASKET	6	5	GASKET REPLACED
13	REPLACE GEARSTICK	,5	0	NOT NECESSARY AS GEARSTICK LOOSE
14	REPLACE SUMP PLUG	,5	,5	SUMP PLUG REPLACED
15	TIGHTEN ENGINE MOUNTINGS	,5	,5	ENGINE MOUNTINGS TIGHTENED
16	REPLACE ALL SHOCK ABSORBERS	5	1,5	ONLY REAR SHOCK ABSORBERS REPLACED
	TOTAL HOURS	25,5	20,5	

Gemagtig deur / Authorised by:
Datum / Date: 19

Ambagsman / Artisan:

Toetser / Tester:

Wkp. Offr. / Wksp. Offr.

Opmerkings—Remarks

Aflos No. / Release No.:
Datum / Date: 19
Gesertifiseer aangeteken in geskiedenisleer / Certified entered in History File
Geteken / Signed:

[Blaai om—P.T.O.

6.3 The DD 1873 or stores indent form

The third option on the opening screen to be considered is that of the DD 1873 or stores indent form. As mentioned in chapter 6.2, a common screen exists for the DD 1873 and the job cards; this screen is shown in figure 6.20. All users can gain access to this screen, since the stores indent menu option is shared with the job card menu option. By the user selecting the spares requirements option, access is gained to the spares requisition menu, shown in figure 6.31. The people who are allowed to access this menu are the workshop manager, planning manager and the in/out inspector. The first option on this menu is that of entering a new DD 1873.

```
                SPARES REQUISITION MENU
                ***********************

            Please select one of the following
            **********************************

1 Enter a new DD 1873 for a "B" job
2 Update an existing DD 1873 for a "B" job
3 Printout of a completed DD1873 for a "B" job
4 Obtain a spares status report for a "B" job
5 Enter a new DD 1873 for a "D" job
6 Update an existing DD 1873 for a "D" job
7 Printout of a completed DD 1873 for a "D" job
8 Obtain a spares status report for a "D" job
9 Return to main job card and spares requisition menu


Please enter your choice here ?
```

Figure 6.31 Menu for the requisition of spares

6.3.1 New stores indent form

This option is not password protected since it goes to a common menu, referred to as "menu 1 for "B" job DD 1873s". This menu is shown in figure 6.32. This menu would not appear in the proper workshop management program since it would cause to much confusion. This menu would be combined with menu 2, shown in figure 6.33, to form a single menu shown in figure 6.34. The two menus were not combined in the trial program, since the menus did not affect the output of the program. The reason for the two menus is that during the development stages of the program the actual sizes of the different subprograms were not known, and nor are the menu options. This results in these types of menu arrangements being present.

```
          MENU 1 FOR "B" JOB DD 1873's
          ****************************

        Please select one of the following
        **********************************

1 Enter a new DD 1873
2 Obtain a spares status report
3 Goto menu 2 for "B" job DD 1873's
4 Return to main job card and spares requisition menu


Please enter your choice here ?
```

Figure 6.32 Menu 1 for "B" job DD 1873

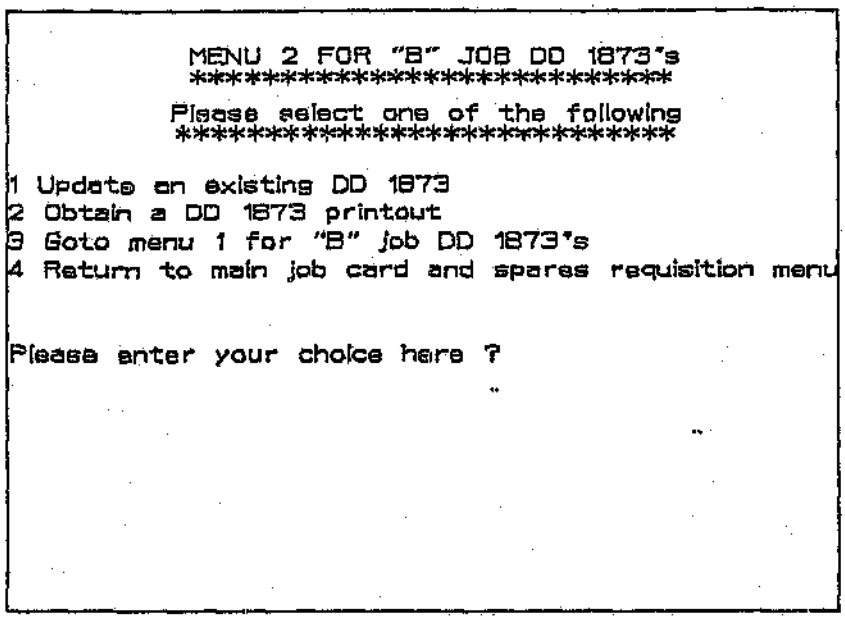


Figure 6.33 Menu 2 for "B" job DD 1873's

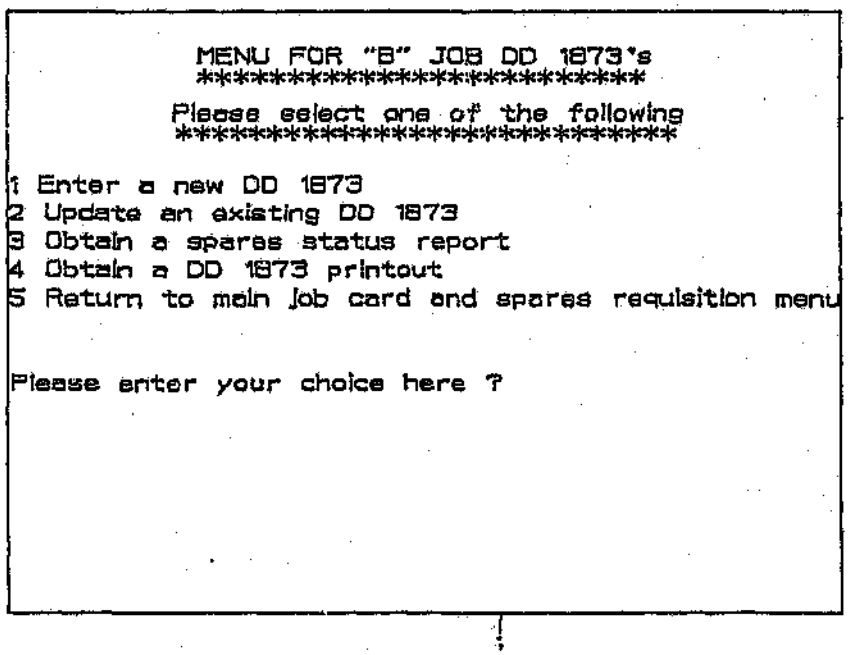


Figure 6.34 Proposed menu for "B" job DD 1873's

The first option on menu 1 for "B" job DD1873s, is that of entering a new DD 1873. This section is password protected and the only users who can access it are the planning manager and the in/out inspector. After the user has selected this option they are required to enter the job number of the job for which they wish to type in a DD 1873. The computer then goes to the job card files and starts at the mechanical "B" job file to look for the job number just entered. If it does not find the job number in the mechanical "B" job file, then it goes to the electrical "B" job file. If it does not find it in this file then it will continue to look through the panelbeating and finally the sparypainting file. If no job card can be found to match this job number, then the user is not allowed to enter a DD 1873. This policy is based on; "No job number equals no spare".

When the computer manages to find a job card that matches this job number, it will then search through the "spares "B" job file" or "spares "D" job file", depending on the job number entered, to see whether a DD 1873 corresponding to this job number already exists. If a DD 1873 does already exist then the user will be told to go to menu 2, and select the option for updating an existing DD 1873. If the computer can not find a DD 1873 for this job number, then the user is given access to the data entry screen for a new stores indent form. Figure 6.35 shows the data entry screen for a new DD 1873. The user can enter a total of 63

spares per job on the demonstration package. The user is first required to enter the part number and the description. The part number is again entered in four separate parts as explained earlier. Once these details have been entered the user is required to state whether the spares are "A" or "E" class items as well as the number of spares required. It would be ideal if the final package had enough speed to search for spares and then determine whether these are "A" or "E" class items and thereby not have to rely on the user to enter these details. Once all this information has been entered on the computer then it is stored in the spares "B" job file or the spares "D" job file depending on whether it is a "B" or "D" job.

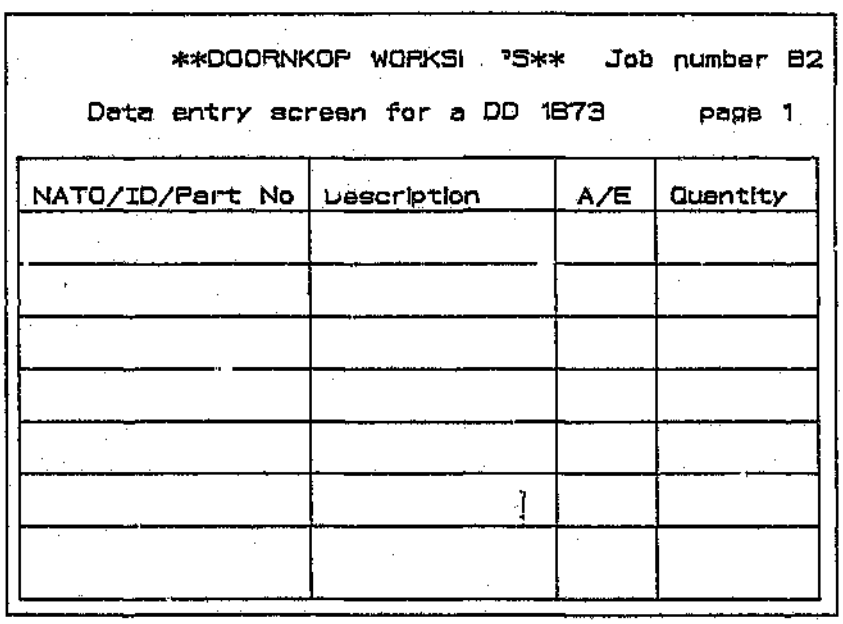


Figure 6.35 Data entry screen for a DD 1873

6.3.2 Updating an existing DD 1873

The second option on the spares requisition menu, is that of updating an existing DD 1873 for a "B" job. On selecting this option the user is taken to menu 2, which is shown in figure 6.33. This menu is once again not password protected since it is a common menu, as discussed earlier. The option which must be selected on this menu is that of updating an existing DD 1873.The only person who can access this option is the planning manager. If everybody were allowed to access this region then it would allow for large scale pilferage. The user is required to enter the job number of the DD 1873 to be updated. The computer now searches through the spares "B" job file to see whether a DD 1873 does correspond to this job number. When the computer has found the DD 1873 which corresponds to this job number, it asks the user from what page he would like to begin updating. The computer then goes to the page entered or else to the default page, page 1. The data entry screen is the same as that shown in figure 6.35, except that now the columns are filled in.

A feature that has not been included on the demonstration package but must be included in the final multi-user package, is that no information about a spare can be changed on a DD 1873, once the spares entered on the DD 1373 have been withdrawn from stock. This feature will prevent pilferage, by not allowing people to go and change

a quantity after the spare has been issued. The only time that a spare which has been issued can be altered on a DD 1873 is in the following example. If two widgets are required but there is only one in the store, and management decides to go ahead with the job, then after the issue has been made, the quantity required according to the DD 1873 will now be one. This value can now be altered since the spare has not been issued.

Another feature which has not been included in the demonstration package but must be included in the multi-user package, is, that the computer must check whether a spare has been ordered twice or not. This will be done by the computer checking all part numbers of spares that have been entered on the DD 1873 by the method described in chapter 6.1. If the computer finds a match then the user must be given the option of whether they want to order additional spares or disregard the part number they just entered.

6.3.3 Spares status report

The third option to be considered is that of the spares status report. After having selected this option the user is taken to menu number 1, where the spares status report option is selected. This password protected option can only be accessed by the workshop and the planning manager.

The spares status report is the most powerful job planning report that can be attained from the data base. It is the report that tells the planning manager, only seconds after a DD 1873 has been entered on the computer, what the fill out for spares is with respect to a DD 1873. This report can only be seen as a printout and has no view facility. A sample report is shown in figure 6.36. This report is drawn up from the spares "B" job file as well as the "A" and "E" item files. The quantity required according to the "B" job file, is compared with the quantity available in the "A" or "E" item file, depending on the class of spare. If the quantity available is equal to or greater than the quantity required, then there is a fill out for this spare. If there is not a fill out then the reason is specified and it can only be for one of two reasons. These reasons are, firstly, there is no such part in stock, secondly, the part is in stock, but there is not sufficient to meet the order requirement.

NATO/ID/Part number	Description	Quantity Required	Fillout	Stockout reason
1234-AA-567-6789	Brake cylinder	2	N	Low stock:present stock = 1
1234-BB-567-6789	Windscreen	1	Y	
1254-GH-456-5367	Gearbox	1	N	Spare not on line
1897-RR-896-0987	Alternator	1	Y	
1876-TT-789-5432	Clutch kit	1	Y	

Figure 6.36 Spares status report for a "B" job

The fill out for a particular job changes the whole time with the computerized system as there is no reservation of computer stock. As an example job No 1 could have had a 99% fill out yesterday, and was waiting for only one spare to arrive, which was due today. After this spare has arrived and a new status report is requested, it could be found that only a 90% fill out exists and not 100% as expected. This situation exists, because between the time that the two spares status reports were requested, the spares for job No 2 were issued as this job had a 100% fill out. In order to get the 100% fill out for job No 2 some of the same spares as required for job No 1 were required for job No 2.

The above, is a classic example of what can happen in a dynamic stock control system. This would never have happened in a static FIFO system where spares reservation takes place. It is better to have a dynamic system that is run on a first filled, first served basis, than have jobs not being started because the spares have been reserved. as described by the example in chapter 4.

6.3.4 Printout of a completed DD 1873

The fourth option on the spares requisition menu takes the user to menu 2. The only person who can access the, printout of a completed DD 1873 option, is the planning manager. When the user enters the job number for which a DD 1873 printout is required, the computer first checks

that this stores indent form does exist. After locating the DD 1873, the computer warns the user that if this printout is made, then the stock appearing on the printout will be withdrawn from computer stock in the different item files. The stores indent form is then printed onto the standard DD 1873, as shown in figure 6.37. This printout would then be the prompt for the store man to go and retrieve these spares from the respective bins. On the printout is found the quantity of spares to be removed, the bin number where the spares are found, as well as the unit price of a spare. This information is drawn from either the "A" item file or the "E" item file depending on what the spare is classified as.

As the printout is produced the computer changes the stock levels for the respective items in their item file. The spares which now appear on the DD 1873 have been removed from the computer stock and therefore have now been reserved in the physical stock. Every time a DD 1873 is printed, the following information is transferred to the "A" item usage file or the "E" item usage file depending on the type of spare. The following details are transferred to the usage files, the part number, the job the spare was used for, how many spares were withdrawn, as well as the time and date of withdrawal.

Doornkop Workshops DD 1873

Date 07-06-91 Job card No B2 Page No 1

NATO/ID/Part number	Description	Quantity Required	Signature head of section	Bin number	Quantity Issued	Price
1234-ST-576-7891	Spark plug	4		1036	4	5.5
3421-ZZ-789-0987	Carburettor	1		1067	1	225.
0864-FH-567-0192	Fuel filter	1		2543	1	10.0
6721-PO-768-3332	Head gasket	1		1765	1	90.00

Figure 6.37 DD 1873 printout

6.4 Journal files

The fourth option on the opening screen to be considered is the option of journal files. The user is asked to select either the "B" journal or the "D" journal option. Both options are password protected and the only people who can access them are the planning manager and the workshop manager. On selecting the "B" journal option the user is taken to the "B" journal menu shown in figure 6.38. The user can select one of two options from this menu, the first being the journal enquiry.

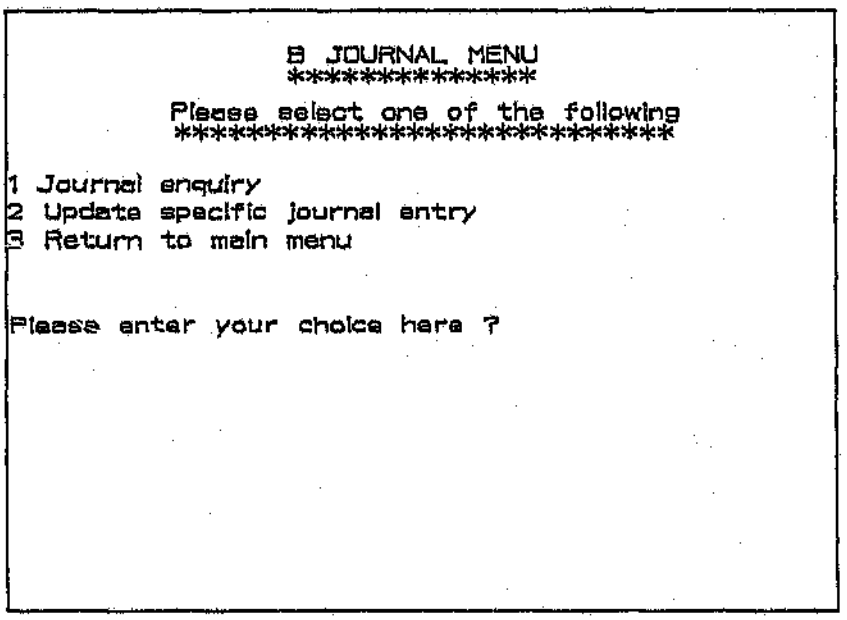


Figure 6.38 B Journal menu

6.4.1 Journal enquiry.

This option allows the user to either view the report or receive a printout of it. This report acts as the workshop managers eyes and ears, since he can now see which jobs are in progress as well as the work which has been done on the different jobs in the shop. The user is asked to enter the number of the job for which the enquiry is required and must then select whether they wish to view the enquiry or receive a printout of it. A sample printout is shown in figure 6.39.
Details such as the holding company, registration number, description, estimated and actual times, are all retrieved from the "job B" files and the "done job B" files. The actual hours worked, which are displayed on the printout, are up to date with the actual hours delivered at close of work on the previous day.

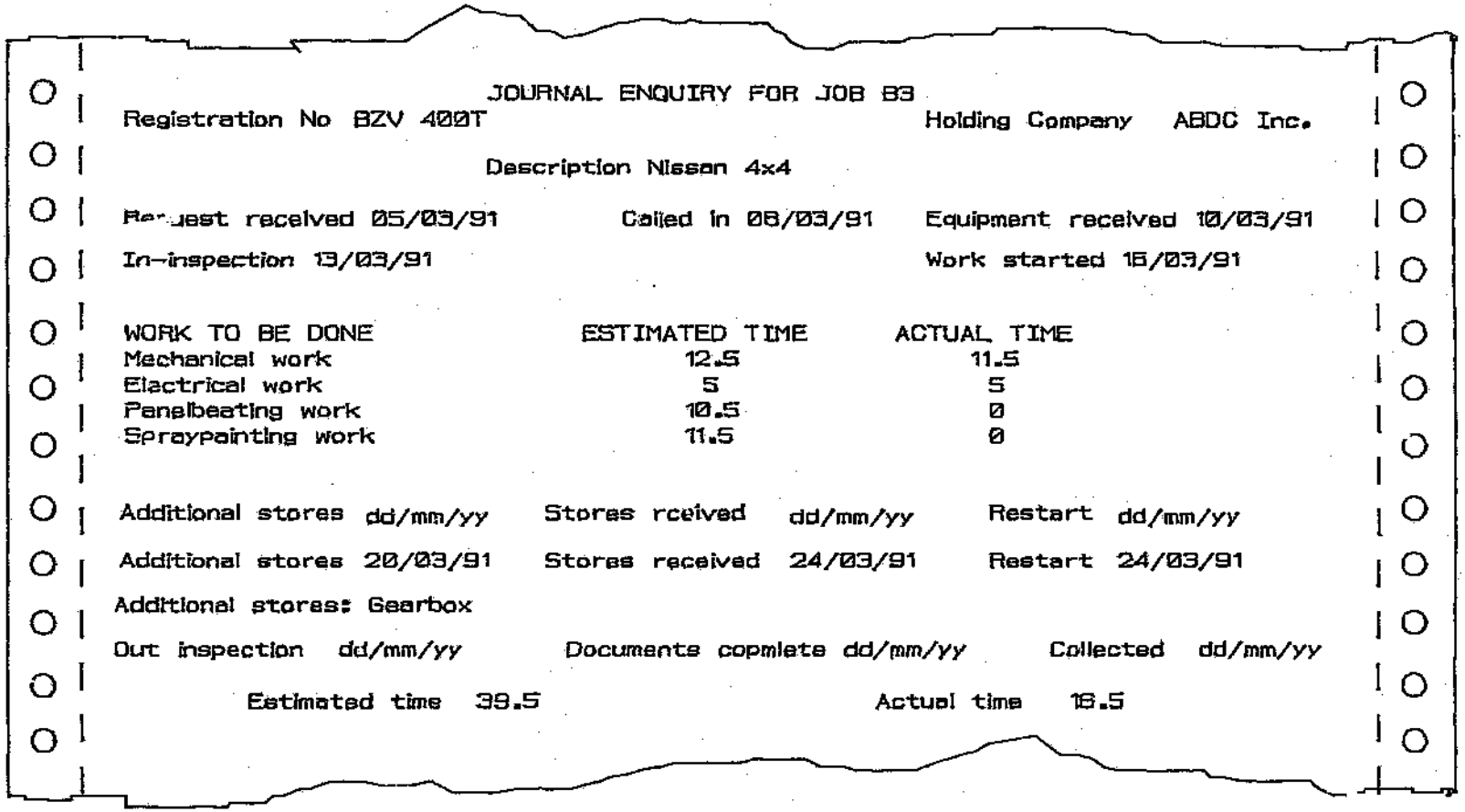
The journal report is not printed onto standard stationary, since this journal report is a modification to the existing journal. The following modifications have been made.

a) The existing journal does not show if work was halted because additional spares which were unavailable were required. The modified journal has space to show the two most recent work stoppages that were caused due to spares not being present. The spares which were not present for the most recent stoppage are shown on the

printout. This aids the workshop manager in knowing why a job has been halted as well as him being able to personally pursue on a daily basis the missing spare.

b) The second item which does not appear on the existing journal, is the estimated and actual times for all the jobs.

All the dates which are seen on the journal printout, are entered separately by the planning manager on the appropriate daces.



JOURNAL ENQUIRY FOR JOB 83

Registration No BZV 400T Holding Company ABDC Inc.

Description Nissan 4x4

Request received 05/03/91 Called in 08/03/91 Equipment received 10/03/91

In-inspection 13/03/91 Work started 15/03/91

WORK TO BE DONE	ESTIMATED TIME	ACTUAL TIME
Mechanical work	12.5	11.5
Electrical work	5	5
Panelbeating work	10.5	0
Spraypainting work	11.5	0

Additional stores dd/mm/yy Stores rceived dd/mm/yy Restart dd/mm/yy

Additional stores 20/03/91 Stores received 24/03/91 Restart 24/03/91

Additional stores: Gearbox

Out inspection dd/mm/yy Documents copmlete dd/mm/yy Collected dd/mm/yy

Estimated time 39.5 Actual time 16.5

Figure 6.39 Sample report for a journal enquiry

6.4.2 Updating a journal enquiry

The only person who can access this option is the planning manager. The user is once again asked to enter the job number of the job he wishes to enter details for. The computer then checks if this job exists in the journal file. If it does not exist in the journal file then no job card has yet been opened for this job and access is therefore denied. On finding that a journal entry does exist for the job number entered, the user is taken to the journal update menu, which is shown in figure 6.40. What can be noticed on the menu, is that for the first three entries on this menu, all of these events occur before a job card has been drawn up. The journal will however show absolutely no recognition of the fact that this vehicle does exist.

The way to overcome the above problem, is that when a request is received, a job number must be given to the job. This is not viable in practice though, because a large number of job requests are cancelled by the holding company because the workshop is overloaded with work and it will take the company a long time to get their vehicle returned to them, and therefore they send it to another workshop. The second reason that it is not viable is because the workshop will call in a job but the job will never arrive at the workshop. It therefore is not viable to reserve job numbers.

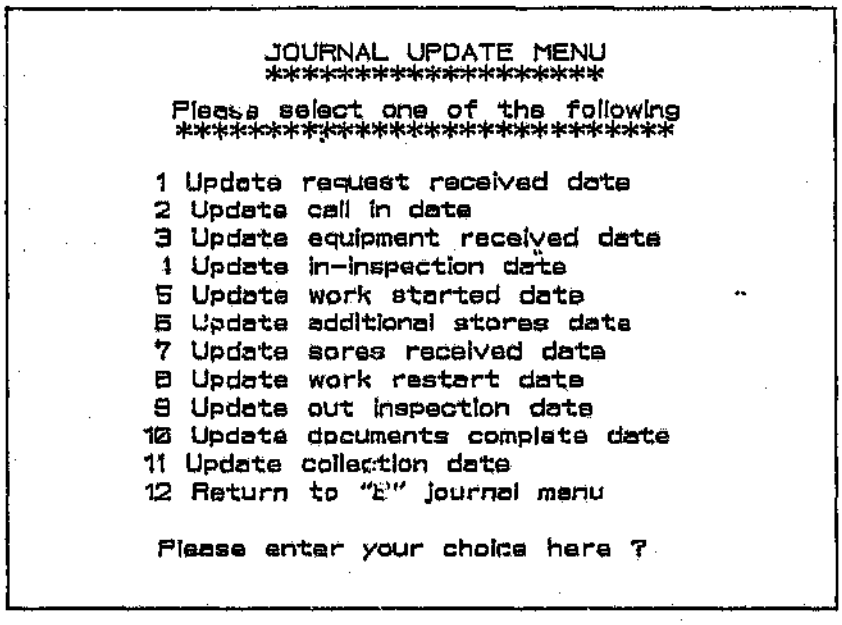


Figure 6.40 Menu for updating specific journal entries

6.5 Archives

The computer package in order to be viable must have a data base capable of storing 999 "B" and "D" job cards as well as their respective stores indent forms. Once the computer has got 999 of these entries then they must be stored in archives either on floppy disks or stiff disks. By doing this maintenance is continuously being carried out on the data base and it is not being overloaded. Whenever information is required from the archives then this can be done by means of a personal computer (PC). The archive program written for the PC will first look through

the job cards and trace the vehicles by means of registration numbers. Once the registration numbers have been found then it is just a matter of recalling the stores indent forms corresponding to the job number entered. This will give management the chance to access whether a problem has become repetitive or not.

7 Case study

A case study was carried out using twenty nine randomly selected items within the store. The aim of the study was to determine the difference in stock value when using the Min-Max approach as opposed to the EOQ and ROP approach. The difference in stock value would be determined by the difference in cost when loading the store to capacity for each of the individual items found on the bin cards. In the case of the Min-Max approach the store is classified as being loaded to capacity for a single item when the quantity in stock for that item is equal to the maximum value. To have the store loaded to capacity when using the EOQ and ROP approach, would mean to have an amount in stock equal to the EOQ value plus the ROP value. The twenty nine bin cards which were randomly selected from the stores all represented E class items, and the items came to a joint value of R 683.12.

The information which was found on the individual bin cards is shown in table 7.1. The first column in this table displays the part number of each individual item. The second column represents the cost price for each item.

Columns three and four show what the minimum and the maximum stock quantities for each individual item should be.

ITEM CONTROL NUMBER	PRICE (Rands)	MIN	MAX
4780-LE-000-5348	5.89	8.00	12.00
5930-12-165-8728	191.66	7.00	14.00
2540-18-420-1348	51.42	100.00	200.00
2520-AA-021-7628	35.65	10.00	20.00
2910-12-123-0966	8.21	10.00	20.00
0000-LE-000-3823	0.82	6.00	12.00
4720-LE-000-1991	15.10	8.00	16.00
5305-LE-000-5178	1.12	50.00	100.00
2530-12-123-2733	1.70	24.00	48.00
2530-12-155-0640	3.38	25.00	50.00
0300-AA-014-0853	24.62	25.00	50.00
2530-LE-000-4833	22.21	20.00	40.00
2590-LE-001-7185	52.31	5.00	10.00
0000-14-214-2729	7.00	4.00	8.00
2530-LE-000-5208	37.60	6.00	12.00
2530-AA-047-0806	112.53	20.00	40.00
2930-LE-000-5028	31.92	4.00	8.00
4730-AA-016-0193	1.33	3.00	6.00
2510-18-422-0244	16.72	5.00	10.00
5340-18-411-7192	2.33	10.00	20.00
0000-AA-006-1018	0.50	10.00	20.00
2920-AA-047-9301	24.50	2.00	4.00
0000-AA-013-3555	29.38	4.00	8.00
0000-AA-047-3239	9.81	4.00	8.00
2520-AA-021-7302	3.20	5.00	10.00
5330-12-186-5872	3.20	12.00	25.00
4730-18-401-1863	1.23	2.00	4.00
5310-AA-007-8254	0.13	50.00	100.00
0000-AA-021-4086	2.66	2.00	4.00

Table 7.1 Minimum and maximum values for the stock items

In table 7.2, the demand per year and the standard deviation in demand per year in the lead time were calculated from information found on the bin cards. The lead time was set at three weeks and was based on the past experience of the store manager. The order set up cost of R 8-48, was determined for the worst possible case. The cost is based on the following assumptions:

a) It takes the store manager 15 minutes to complete the administration work required to order a spare, and an additional 10 minutes to pack away the spare and do the necessary administration required on receipt of the spare. The store manager earns R 2000-00 per month and works a 22 day month, 8 hours per day.

b) If the spare is not delivered and the store truck must go to fetch the spare then two temporary staff members must drive a return trip of 200 Km which takes four hours. The temporary staff are paid R 7-42 per day and the cost of using the truck is R 0-45 per kilometer.

c) It is assumed that on a single trip twelve spares can be loaded on the truck.

Set up cost = (2000x25)/(22x8x60) + 7.42 + 200x0.45

= R 101-76

Since twelve different spares are taken per trip the set up cost for an individual spare is:

Set up cost = 101-76/12

= R 8-48

The EOQ and ROP are calculated using the above.

ITEM CONTROL NUMBER	DEMAND/YR	SD/YR	LEAD TIME	SET UP (Rands)	EOQ	ROP
4760-LE-000-5349	4.00	0.58	0.0577	8.48	8	1
5930-12-165-8728	8.00	1.34	0.0577	8.48	2	1
2540-18-420-1348	54.00	2.81	0.0577	8.48	10	4
2520-AA-021-7628	23.00	0.84	0.0577	8.48	8	2
2910-12-123-0966	19.00	2.38	0.0577	8.48	15	2
0000-LE-000-3823	7.00	0.98	0.0577	8.48	28	1
4720-LE-000-1891	18.00	0.87	0.0577	8.48	11	1
5305-LE-000-5178	32.00	3.02	0.0577	8.48	52	3
2530-12-123-2733	51.00	2.35	0.0577	8.48	53	4
2530-12-155-0849	51.00	1.47	0.0577	8.48	38	4
0000-AA-014-0853	66.00	1.36	0.0577	8.48	16	4
2530-LE-000-4833	7.00	0.55	0.0577	8.48	5	1
2590-LE-001-7165	14.00	1.10	0.0577	8.48	5	1
0000-14-214-2729	1.00	0.00	0.0577	8.48	4	1
2530-LE-000-5208	4.00	0.58	0.0577	8.48	3	1
2530-AA-047-9806	23.00	0.92	0.0577	8.48	4	2
2930-LE-000-5026	11.00	0.00	0.0577	8.48	6	1
4730-AA-013-0193	5.00	0.58	0.0577	8.48	18	1
2510-18-422-0244	5.00	0.00	0.0577	8.48	5	1
5340-18-411-7192	8.00	0.55	0.0577	8.48	18	1
0000-AA-006-1018	18.00	0.89	0.0577	8.48	55	1
2920-AA-047-9301	15.00	1.73	0.0577	8.48	8	2
0000-AA-019-3555	5.00	0.00	0.0577	8.48	4	1
0000-AA-047-3239	9.00	0.00	0.0577	8.48	9	1
2520-AA-021-7362	11.00	0.84	0.0577	8.48	16	1
5330-12-186-5872	24.00	2.37	0.0577	8.48	27	3
4730-18-401-1863	5.00	0.50	0.0577	8.48	20	1
5310-AA-007-9254	9.00	0.35	0.0577	8.48	81	1
0000-AA-021-4088	10.00	1.63	0.0577	8.48	19	1

Table 7.2 EOQ and ROP values for the stock items

ITEM CONTROL NUMBER	PRICE (Rands)	MAX	EOQ+ROP	MAX PRICE (RANDS)	EOQ+ROP PRICE (Rands)
4760-LE-000-5349	5.89	12.00	9.00	70.68	53.01
5930-12-165-8728	191.68	14.00	3.00	2,683.24	574.98
2540-18-420-1348	51.42	200.00	14.00	1.028E+4	719.88
2520-AA-021-7628	35.85	20.00	10.00	713.00	358.50
2910-12-123-0966	8.21	20.00	17.00	164.20	139.57
0000-LE-000-3823	0.82	12.00	29.00	9.84	23.78
4720-LE-000-1991	15.10	16.00	12.00	241.60	181.20
5305-LE-000-5178	1.12	100.00	55.00	112.00	61.60
2530-12-123-2733	1.70	48.00	57.00	81.60	96.90
2530-12-155-0849	3.38	50.00	42.00	169.00	141.96
0000-AA-014-0853	24.62	50.00	20.00	1,231.15	492.46
2530-LE-000-4833	22.21	40.00	6.00	888.40	133.26
2590-LE-001-7185	52.31	10.00	6.00	523.10	313.86
0000-14-214-2729	7.00	8.00	5.00	56.00	35.00
2530-LE-000-5208	37.60	12.00	4.00	451.20	150.40
2530-AA-047-9806	112.53	40.00	6.00	4,501.20	675.18
2930-LE-000-5026	31.92	8.00	7.00	255.36	223.44
4730-AA-013-0193	1.33	6.00	20.00	7.98	26.60
2510-18-422-0244	16.72	10.00	6.00	167.20	100.32
5340-18-411-7192	2.33	20.00	19.00	46.60	44.27
0000-AA-006-1018	0.50	20.00	56.00	10.00	28.00
2920-AA-047-9301	24.50	4.00	10.00	98.00	245.00
0000-AA-019-3555	29.38	8.00	5.00	235.04	147.03
0000-AA-047-3239	9.81	8.00	10.00	78.48	98.10
2520-AA-021-7362	3.20	10.00	19.00	32.00	60.80
5330-12-186-5872	3.20	25.00	30.00	80.00	96.00
4730-18-401-1863	1.23	4.00	21.00	4.92	25.83
5310-AA-007-9254	0.13	100.00	82.00	13.00	10.66
0000-AA-021-4088	2.66	4.00	20.00	10.64	53.20
TOTAL COSTS (Rands)	898.13			2.322E+4	5,308.79

Table 7.3 Cost implications of different ordering methods

Table 7.3 shows the maximum stock quantity for an individual item when using the two different methods of stock control. Column number two shows the value of the EOQ plus the ROP, which were calculated from the EOQ and ROP values found in table 7.2. The third column in table 7.3 shows the maximum number of items that can be present in the store when using the Min-Max approach. The values found in columns two and three are then multiplied by the individual value of the spare concerned. The individual value is found in table 7.1, column two. This yields the different cost values for the EOQ-ROP approach as well as the Min-Max approach, these values are shown in columns four and five respectively.

By using the Min-Max method the total maximum value of the stock would have been R 23 220-00, and by using the EOQ and ROP method it would have been R 5 308-00. This is an immediate capital saving of R 17 912-00 or 77%. The capital saving of 77% also gives an accurate indication of the amount of extra space that will be generated by the reduction in stock levels. By using the EOQ and ROP in a dynamic data base there will be a constant trend towards carrying optimum amounts of stock and reducing capital tied up in inventories.

8 Conclusions

a) The company is not dependent on staff to provide the necessary information and administrative service required to run a dynamic, realtime shop floor control and stock system. The updating of bin cards and the flagging of items to be reordered is carried out using the data base and is no longer dependent on the staff.

b) The excessive delay caused by the paperwork within the system is removed by the database reducing the amount of paperwork.

c) The training of temporary staff is greatly reduced since the tasks which were difficult to train these staff members in, example, searching for spares in catalogue, updating bin cards and noting that spares had to be reordered are now computerised.

d) All work that requires spares to complete the job can not be done without a job card. This reduces the opportunities for pilferage and ensures that all jobs done and hours worked are recorded.

e) The shop floor control system is dynamic and realtime This ensures that it can provide up to date answers on job and spares status within a matter of seconds. This is what helps to ensure that no jobs are started without a 100% fill out in spares.

f) The stores can be run by using the EOQ and ROP, without either the store manager or his assistant knowing anything about stock control. The manager and his

assistant, are however not made to feel redundant since the final decision on stock orders is still left to them, although they will be strongly advised to order according to the recommended EOQ.

g) The archives can be accessed easily and can therefore provide useful information about service records and spares used on a vehicle previously. This information can be used in planning the repair of the vehicle or helping to locate the cause of damage to the vehicle.

h) The case study shows that immediate financial and space benefits can be gained by changing over to the EOQ and ROP stock control methods.

i) The computer program has reduced the amount of paperwork for the permanent staff. This has now released these staff to carry out more important administrative and managerial tasks. This leads to an overall more effective running of the workshop.

j) The language used to write the package should preferably be a commercial data base language, which is quicker, uses less disk space and has better search facilities than basic.

Appendix A - Standard stationery

A.1 Workshop Journal

The workshop journal is an A3 sheet of paper referred to as a DD 1633. The monitoring of work in progress is done by using this journal. The problems encountered by using this journal for shop floor control purposes are discussed in chapter 3.2.

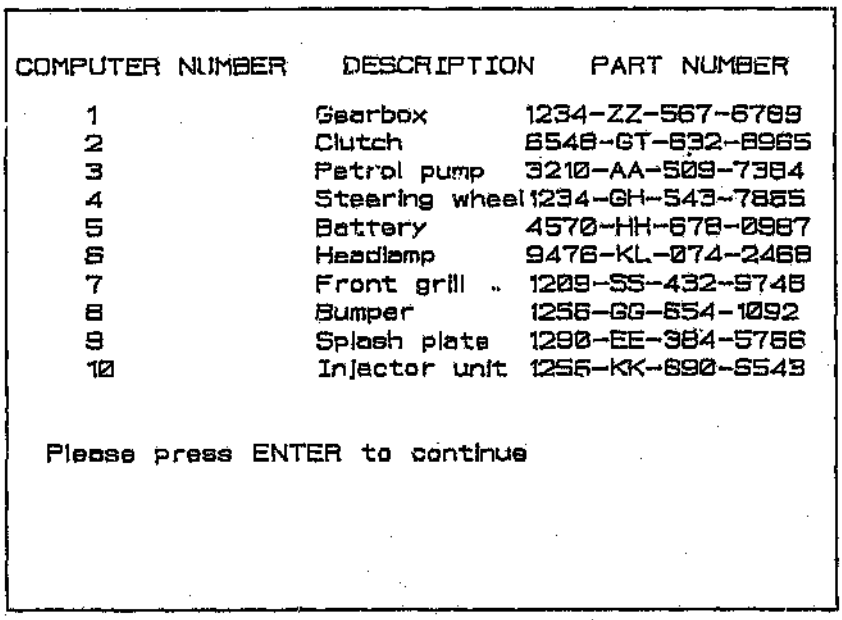


Figure 6.10 Screen as seen when viewing item file

6.1.3 Data print menu

This menu is password protected since it allows the user the facility of producing reports. This menu is shown in figure 6.11. The people who can access this menu are the workshop and planning manager as well as the stores manager. The reports which are generated on this data print menu are identical to those which could be seen in the data view option. By having both a data view and a data print option it prevents the generation of unnecessary reports, since the other users who have no real use for the reports can view the reports in the view option.

A.2 Workshop demand/Return-"E" class items

The workshop demand/return is referred to as a DD 1873, and is printed on an A4 sheet of paper. This form is not only used for "E" class items, as would be suggested by the name of the form, but also for "A" class items. The completion of this form is a laborious and drawn out task when it is done manually due to the large amount of cross referencing required between different catalogues.

G P-S-001-03117

7530-18-408-9403
DD 1873

WERKPLAASAANVRAAG/TERUGSENDING--"E"-KLAS ITEMS • WORKSHOP DEMAND/RETURN--"E" CLASS ITEMS

Werkswinkel Workshop	Afdeling Section	Datum Date	Werkkaartnr. Job card No.	Bladsynr. Page No.
Afdeling OO (Naam in drukskrif) Section NCO (Print surname)		Tel. bylyn Tel. ext.		
Volgende montasie Next assembly	Hoofmontasie Major assembly		Hoofuitrusting Major equipment	

NAVO-/Identifikasie-/Onderdeelnommer NATO/Identification/Part number	Benaming of beskrywing Nomenclature or description	Hoeveelheid benodig Quantity required	Handtekening hoof van afdeling Signature head of section	Vaknommer Bin number	Hoeveelheid uitgereik Quantity issued	Ontvang deur/VVO/Prys/Aksie Received by/IBR/Price/Action	Aanvraagnommer Demand number	TERUGBESORG/RETURNED	
								Hoeveelheid Quantity	Ontvang deur Received by

Gesertifiseer dat bovermelde items gebruik is op die taak hierbo beskryf.
Certified that the above listed items were used to complete the task described above.

Offr/AO/OO in bevel van afdeling
Offr/WO/NCO in charge of section

Uitreiker se handtekening en datum
Issuer's signature and date

A.3 Technical inspection report for B & D vehicles

This is a nine page report that is referred to as a DD 1828. This report is completed for all "B" and "D" type vehicles when they arrive at the workshop by the in-inspector. It is from this report that the job cards can be drawn up stating what work has to be done as well as the spares ordered to complete the different maintenance tasks.

TECHNICAL INSPECTION REPORT FOR B & D VEHICLES

Unit ..... Date examined .....

M Number ..... Type ..... Make .....

Odometer reading .....

INSTRUCTION

1. This document is used for all B and D vehicles inspection, maintenance, repair or BER/BLR purposes.
2. Technical order B vehicles A006 must be used to obtain repair times. (Column d.)
3. This document must be completed in full where applicable for record purposes.
4. Legend:
   a. S=Serviceable, R=Repairable, these symbols are used in column b.
   b. C=Check, R=Repair, E=Exchange, A=Adjust, S=Secure, these sympols are used in Column c.

Serial No.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
1.	ENGINE Mountings, bolts				
2.	Air cleaner and manifolds				
3.	Exhaust and silencer, leaks, rattles				
4.	Radiator, hoses, fan, cap, coolant mixture strength, pressure test				
5.	Water pump and seals				
6.	Carburettor, filter, throttle opening				
7.	Choke operation				
8.	Injection pump, calibrate (60 000 km), throttle opening, lift pump				
9.	Injectors, relief pressure and spray pattern (60 000 km)				
10.	Oil sump level, retaining bolts, drain plug				
11.	Oil pressure Idle..... Max.....				

Serial No.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
31.	Oil coolers, oil leaks				
32.	Transferbox, mountings, oil leaks, operation				
33.	Prop shafts, universals, sliding joints, bolts, centre bearing				Service universals without grease nipples every 60 000 km
34.	Axle wear, oil leaks, wheel bearing play, king pins, side shaft end play 2nd and rear axles				
35.	Tracta joints				
36.	Hydraulic drive				
37.	Winch, rope, rollers				
38.	Power take-off				
39.	ELECTRICAL SYSTEM Lights, switches, fuses, focus				
40.	Alternator generator drive, charging rate				
41.	Wiring screening and routing				
42.	Battery and terminals				
43.	Junction boxes, starter motor and switch				
44.	Battery carrier and hold down				
45.	Windscreen wiper operation, blades				
46.	Instruments operation				
47.	Reflectors				
48.	Hooter				
49	Windscreen washer				

Serial No.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
12.	Oil leaks				
13.	Ignition, coil, distributor, magneto, wiring, spark plugs				
14.	Oil cooler				
15.	Crank case ventilator valve operation				
16.	Starter mounting bolts				
17.	Valve clearance				
18.	Alternator mounting bolts				
19.	Compressor mounting bolts				
20.	Drive belts tension and condition				
21.	Idle speed				
22.	Abnormal noises				
23.	Exhaust brake adjustment and operation				
24.	Air cooled, cooling fins of cylinder heads and cylinders, cooling blower operation				
25.	Fuel pump				
26.	FUEL SYSTEM Tanks, taps, mountings, cap and vents				
27.	Filters, lines, guages				
28.	TRANSMISSION Clutch, wear, linkages, master and slave cylinders				
29.	Clutch pedal free play				
30.	Gearbox, mountings, controls, oil leaks, operation				

Serial no.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
31.	Oil coolers, oil leaks				
32.	Transferbox. mountings, oil leaks, operation				
33.	Prop shafts, universals, sliding joints, bolts, centre bearing				Service universals without grease nipples every 60 000 km
34.	Axle wear, oil leaks, wheel bearing play, king pins, side shaft end play 2nd and rear axles				
35.	Tracta joints				
36.	Hydraulic drive				
37.	Winch, rope, rollers				
38.	Power take-off				
39.	ELECTRICAL SYSTEM Lights, switches, fuses, focus				
40.	Alternator generator drive, charging rate				
41.	Wiring screening and routing				
42.	Battery and terminals				
43.	Junction boxes, starter motor and switch				
44.	Battery carrier and hold down				
45.	Windscreen wiper operation, blades				
46.	Instruments operation				
47.	Reflectors				
48.	Hooter				
49.	Windscreen washer				

Serial No.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
50.	STEERING Wheel, steering box				
51.	Oil level				
52.	Rods, joints, universals				
53.	Alignment, stops				
54.	Steering limiter adjustment				
55.	BRAKES Pedal adjustment				
56.	Servos, controls				
57.	Park brake operation				
58.	Flexible brake pipes				
59.	Master cylinder, fluid level				
60.	Air and electrical brake connectors				
61.	Trailer brake operation				
62.	Stop light switch				
63.	Brake linings				
64.	Air to hydraulic link rod adjustment				
65.	PNEUMATICS High—low range operation				
66.	Differential lock operation				
67.	Compressor drive				
68.	Wiring on electro pneumatic system				
69.	Compressor cut in and out out pressures				

Serial No.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
70.	Check system for air leaks				
71.	Air tanks, rust, mountings, drain valve operation				
72.	Tyre pump operation				
73.	FRONT SUSPENSION Springs, wear and damage				
74.	Shackles, wear				
75.	Shock absorbers, leaks, damage, mountings, rubbers and bolts				
76.	Shackle hanger retainer bolts/rivets				
77.	Bump stop rubbers				
78.	U bolts, centre bolts				
79.	Stabilizer system, mountings, links				
80.	REAR SUSPENSION Shock absorbers, leaks damage, mountings, rubbers and bolts				
81.	Springs, wear and damage				
82.	Spring slipper blocks				
83.	Torque rod bushes and mounting bolts				
84.	Trunnion bearing, free play, oil leaks				
85.	U bolts, centre bolts				
86.	Spring hanger bracket bolts				

Serial No.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
87.	Shackle hanger retainer bolts/rivets				
88.	Stabilizer system, mountings, links				
89.	Bump stop rubbers				
90.	WHEELS Tyres, pressure, thread, casings, spare wheel and carrier				
91.	Wheel nuts and studs				
92.	Rims				
93.	Balancing				
94.	CAB AND BODY Body, bows, tailboard, canvas, mountings, tool-boxes, can carriers				
95.	Cab, windscreen, fenders, bumpers, door locks, dovetails, hinges				
96.	Seat springs, adjusting mechanism				
97.	Bonnet adjustment, safety catches				
98.	Upholstery, cab and body trimmings				
99.	Boot lock				
100.	Glasses, winders and ventilators				
101.	Paint work				
102.	Floor mats				
103.	Cab mountings				
104.	Locking and safety catches on tilt cabs				

Serial No.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
105.	Safety belts				
106.	Mirrors				
107.	Inspect cab and body for rust				
108.	Heating and ventilation system				
109.	Rattles				
110.	Mud flaps				
111.	Number plates				
112.	CHASSIS Cross members and side rails				
113.	Cracks, damage, bolts, nuts, rivets, tow hook(s)				
114.	ADDITIONAL				
115.					
116.					
117.					
118.					
119.					
120.					
121.					
122.					
123.					
124.					

Serial No.	Item	Class	Work required	Man hours	Remarks/Spares required
	a	b	c	d	e
125.	ROAD TEST Engine performance, excessive exhaust smoke, unusual noises				
126.	Clutch, slippage, shudder				
127.	Gearbox, gear selection, noises				
128.	Splitter box, correct range changes				
129.	Transferbox correct range changes				
130.	Prop shafts, noises vibrations				
131.	Axles, noises, diff locks				
132.	Brakes, service brake operation				
133.	Parkbrake operation				
134.	Emergency brake operation, exhaust brake operation				
136.	Steering wandering, excessive free play, wheel wobble, noises				
		TOTAL MAN HOURS			

Roadtest results .....

.....

.....

.....

In—Inspected by: No..... Rank..... Name.....

Signature ..... Date.....

Workshop report on stores and condemnation certificate (DD 1632) *Issued/Not Issued .....

Sentence awarded .....

Certified vehicle serviceable

Out—Inspected by: No..... Rank..... Name .....

Signature ..... Date.....

Signature of OC, WKSP or LWT ..... Date.....

*Confirmed/Not confirmed

Signature of TSO ..... Date.....

* Delete which is not applicable.

SCHEDULE REPAIR

This vehicle is *serviceable/unserviceable/while awaiting call-in.

* Delete which is not applicable.

The following needs workshop/LWT attention:

.....

.....

.....

.....

.....

.....

.....

Signature vehicle fitter..... Date .....

Works requisition No. ..... submitted for work required.

Signature TPT NCO ..... Date .....

A.4 Works order

The works order is referred to as a DD 1813 and is printed on A4 paper. This form is used for both "B" and "D" class vehicles. It is filled in using the information found on the technical inspection report. A separate form is filled in for each department, i.e. spraypainting, electrical etc.

G.P.-S. 001-0239 DD 151

WERKSORDER—WORKS ORDER No.....

Werkplaas
Workshop..... Datum
Date.....

Toerusting No.
Equipment No..... Fabrikaat
Make..... Tipe
Type.....

Enjin of reeks No.
Engine or serial No..... Odometer- of uurmeterlesing
Odometer or hour meter reading.....

Eenheid of formasie
Unit or formation..... Werksaanvraag No.
Workshop requisition No.....

BESKRYWING VAN WERK WAT UITGEVOER MOET WORD—DESCRIPTION OF WORK TO BE CARRIED OUT

Gemagtig deur
Authorised by..... Datum
Date..... 19.....

Ambagsman
Artisan.....

Toetser
Tester.....

Wkp. Offr.
Wksp. Offr.....

Opmerkings—Remarks

Afios No.
Release No..... Datum
Date..... 19.....

Gesertifiseer aangeteken in geskiedenisiêer
Certified entered in History File
Geteken
Signed.....

[Blaai om—P.T.O.

Appendix B - Demonstration package

The minimum hardware requirements to run the demonstration package are a 640 KB, IBM compatible machine, using MS Dos ver 3.1 or better with either two, 1.2 Mb floppy drives, or with only one floppy drive which is a 1.2 Mb drive. The program will not work on a machine that has two dissimilar floppy drives or one floppy drive and one "stiffy" drive.

In order to access the package the program disk must be put in the A drive and the data disk in the B drive, where two 1.2 Mb floppy drives are available. If only one floppy drive is available then this is the A drive and the program disk must then be put into the A drive. The user will be prompted to load the data disk into the A drive as and when it is required.

The following commands are then to be entered in order for the package to work. The symbol,↵ shall refer to the enter button.

Step	Command to type in	Key to press
1	A:	↵
2	GWBASIC	↵
3		F3
4	HANS1	↵

Access has now been gained to the package.

The demonstration package has one spare and one job loaded onto it, any further information is for the user to enter

themselves. The job that is already loaded is mechanical work for job B1, and the spare entered is for an "A" class item with number 1234-AA-567-6789. When using the package the user should work using uppercase letters only and where passwords are encountered the password to fill in is "WILSON".

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