ENGINEERING INFORMATION SYSTEM IN OPERATION

TYRE 5 DEPARTMENT FOREMAN USING HIS V. D. U. TO REQUISITION A SPARE PART.

THE DEVELOPMENT AND IMPLEMENTATION OF A COMPUTER BASED MAINTENANCE INFORMATION SYSTEM

A thesis submitted by:-

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to the UNIVERSITY of ASTON in BIRMINGHAM
for the Degree of Doctor of Philosophy.

MARCH 1981

The Development and Implementation of a Computer Based Maintenance Information System.

Submitted for the Degree of Doctor of Philosophy, 1981

by
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SUMMARY

The installation of a Maintenance Information System in the Dunlop UK Tyre Division factory, Fort Dunlop is explained. This was achieved by developing two computer systems, one for on-line stock information and the other for job recording. Both systems use the IBM 370/158 computer at the Fort Dunlop factory. The stock information system is also available on remote terminals at the Tyre Division factories at Washington (Tyne and Wear) and Inchinnan (Scotland).

The thesis reviews Dunlop's situation in the late 70's, the manufacturing and maintenance functions at Fort Dunlop and explains the benefits of using data processing to provide a Maintenance Information System. This information has been made available at Fort Dunlop to Engineers, Managers and Buyers on VDU Screens in the maintenance workshop offices, stores and purchasing offices.

The following features are provided:-

- Catalogue of items stocked in 64 Dunlop factories
- Stock records for the 3 UK Tyre Division factories
- Parts can be requisitioned from stock by keying in an order at any terminal. This updates the stock record and prints a requisition at the factory stores.
- Stores receipts, returns and transfers are keyed into a stores terminal. This updates the stock record and produces all documentation.

The Job Recording system is based on a Work Order Card used to record details of all maintenance work and incorporates a Category Estimation Incentive Bonus scheme. The data from these cards are analysed weekly to provide plant history and management information. The information will be used by management to improve the efficiency of the plant and provides the foundation for a planned preventive maintenance scheme in the near future.

Further applications of data processing within the maintenance department are described and the thesis concludes that data processing is a useful, inexpensive maintenance management tool only now beginning to gain recognition. It is emphasised that all the system's potential users, from shop-floor to senior management, were involved in the systems developments, as this produces a better design and helps ensure a successful system implementation.

Keywords

Maintenance Information, Computer Systems.

ACKNOWLEDGEMENTS

I would like to acknowledge the help and facilities provided by:-

The Computer Centre Fort Dunlop

Whose staff helped to turn my ideas into reality; in particular

Mr D A Perry	Manager Information Systems
Mr G K Aubrook	Senior Systems Analyst
Mrs M M Powell	Project Programmer
Mr R Grant	Lead Systems Analyst

and the Programmers who wrote the Computer Systems Programs.

The 'Works Engineers' at Fort Dunlop

Whose staff provided much of the background information used in the thesis, co-operated in the computer systems development and are now operating the terminals. I am grateful for the guidance given by the 5 Chief Engineers who acted in their turn as my Industrial Supervisor. Special thanks must go to Mr Brian Marr the present Chief Engineer for the help and encouragement given to me over the last 3 years.

The University of Aston in Birmingham

I am grateful to Dr David Bennett and Dr David Scrimshire who supervised the project and to Dr Ivan Robertson my I.H.D. Supervisor.

Finally I must thank my mother for producing the illustrations and my wife for proof reading the text.

CONTENTS

Figures, Tables and Photographs | Page

PAGE

THE DEVELOPMENT AND IMPLEMENTATION OF A COMPUTER BASED MAINTENANCE INFORMATION SYSTEM - A RESEARCH PERSPECTIVE

The project described in this thesis has been undertaken under the auspices of the Inter-disciplinary Higher Degrees Total Technology scheme. The work is essentially of a practical nature defining analysing and solving real problems for Dunlop's U.K. Tyre Group. The philosophy of this approach to the higher education of engineers is worthy of discussion in order to compare and contrast the academic content of the Total Technology project with a more conventional research project.

Research and Academic Skills

The author's first degree was obtained in Mechanical Engineering on a 1.3.1 sandwich course basis. A further year had then been worked in industry before joining the Total Technology scheme. Against this general engineering background several new skills had to be obtained in order to complete the project:-

Computer Science	-	training in systems analysis and computer programming.
Factory Maintenance	-	Planned and Preventive Maintenance techniques, Maintenance Management organisation.
Stores Operations	-	Purchasing, Storage and Distribution.
Accountancy	-	Cost and Financial Accounting, with an emphasis on project appraisal and the sanctioning of company funds.
Man Management	-	Project team organisation and the management of change.

Psychology	-	Man-computer relationships, especially the removal of fear of computers.
Payment Schemes	-	Incentive bonus schemes and computerised payroll systems.
Communication Skills	-	Techniques of presentation and persuasion in the form of film, lectures and reports.

These skills were obtained by attending training courses at the University and Dunlop, by learning from colleagues and primarily by personal research.

The detailed investigation of the problem presented by Dunlop and its subsequent solution provided three valuable lessons which also apply to academic research:-

i) The symptoms of a problem are often obvious but it is the researcher's role to ascertain and eradicate the cause and not merely treat the symptoms.

ii) All information should be questioned as to its basis in fact.

iii) Results can often be interpreted in different ways.

<u>Originality</u>

The research and project work provided Dunlop with a crystallised view of their maintenance organisation and with two computer systems providing better management information and improved methods of working. This work was undertaken in an old established factory, and against a background of recession within the tyre industry which has resulted in redundancy and factory closures within the Dunlop Tyre Group.

The project's value outside Dunlop can be summarised as:-

i) It provides an account of successful implementation of modern systems within an established maintenance department.

ii) The participative methods of design and implementation played a major part in the systems acceptance and should be considered for all inter-active computer systems.

iii) It proves that effective computer systems can be implemented by 'non computer personnel'.

iv) The development cost of the systems implemented was small compared with the benefits generated.

v) Maintenance Engineering is an area that can greatly benefit from the intelligent use of computers.

The author presented papers, describing the systems, to the Birmingham branch of the British Standards Institution and the British Council of Maintenance Associations' Maintenance Management by Computer Conference (Ref 28). Interest was shown by several companies and, todate, Rowntree Macintosh and Unilever have expressed interest in purchasing some aspects of the systems.

Academic Work in Relation to the Projects Chronological Evaluation

In order to commence work on the project considerable background reading and research was required. Areas investigated included:-

- Maintenance Management theory
- Management theory
- Accountancy.

After on initial survey of the factory's maintenance management organisation and systems the need for computerised systems polarised the academic research towards computer science/management information systems:-

i.e. . Specific computer application - planned maintenance stock control, production control and payroll systems.

. General computing - theory of computers, hardware and software.

. Systems Analysis - man/machine interface ergonomics, health and safety.

. Software Packages - from the major hardware companies, software houses and bureaux.

. The Implementation of Change - Trades Union, Government professional and laymens reports and articles on computers and their social effects. The Management of change and techniques of persuasion and presentation.

. Formal Documentation of computer systems - to ensure the easy maintenance and inclusion of improvements/ additions to the systems.

Throughout the project regular course-work was undertaken to broaden the author's outlook and which was often of direct relevance to the industrial work e.g. accountancy and statistics.

In retrospect the academic areas that provided the major contribution to the project's success were the systems analysis and man-machine interface areas. The academic information helped to provide systems with which the users would enjoy working. The education of shop floor personnel in the purpose and actual operation of the systems was of vital importance. Use was made of lectures, informal presentations, demonstration tours of the computer room, 'hands on' training sessions and video training films. Presentation was therefore of great importance and texts on visual aids, presentation and lecturing were invaluable.

Research in Industry

The systems described and methods used are not presented as a panacea for successful systems implementation in other companies. But it is hoped that the work will kindle ideas and provide an outline in both systems design and implementation that would be of value to other workers.

The role of the Total Technology research student is difficult in that he is neither a "full time employee" of the company nor a "student" of the University but has to take up an itinerant role dividing his days between the two. The author spent the vast majority of his time working at the factory as this was seen to be essential if the assembled project team was to be effectively managed and the systems designed and implemented within the constraints of time and money agreed with the company. The academic content of the project should not be under estimated as the three years provided an excellent opportunity to learn skills normally outside the work area of a young engineer in industry. The programme provides a unique opportunity to stand back from the day to day running of the factory, examine new techniques and methods and concentrate on identifying and solving a particular problem.

Conclusion

Total Technology projects form a symbiotic link between Industry and Universities. The University gains access to real problems requiring a solution and continuous contact with industry ensures that the curricula of future degree courses are based on real requirements. Successes within industrial management and technology can also be more easily fed back to the academic world. Industry benefits from fresh ideas for solving problems and the forging of contacts within the University which can often provide a source for future research and consultancy. Industry also stands to gain graduates who are trained to understand the problems and technology to be encountered in industry.

The University of Aston Total Technology graduate has spent three to four years working on a specific project within industry, under the guidance of three supervisors, two based at the University and one in industry. The student therefore has three mentors providing academic and industrial counselling at a period early in his career, when he would normally be left on his own in industry. The student manages his own project which quickly teaches him to optimise the main industrial resources:-

- People
- Equipment
- Materials
- Money

The course therefore provides a method of advancing academically and as an industrial technologist or manager.

CHAPTER 1 BACKGROUND TO THE PROJECT

1. Background To The Project

1.1 Project Organisation

The research described in this thesis was undertaken as a collaborative project between Dunlop Limited, Tyre Division and the University of Aston in Birmingham via the Interdisciplinary Higher Degree (IHD), Total Technology scheme. Funding was provided jointly by a Science Research Council industrial studentship, tenable for three years, and a salary paid directly by Dunlop.

The research work was undertaken at the Tyre Division's Fort Dunlop Factory in Birmingham. The Author was employed as a Research Assistant, working directly for the Tyre Division's Chief Engineer. This position gave ready access to all areas of the business and to all levels of engineering management at Fort Dunlop. In April 1979, the Author was appointed Engineering Systems Manager at Fort Dunlop, with responsibility for the operation and further development of the systems conceived and implemented during this project.

The research commenced in January 1977 under the industrial supervision of Mr J A Bladon, Chief Engineer for Dunlop Tyre Division. Supervision at the University was provided jointly by Dr. D Bennett, Management Centre (main supervisor) and Dr. S Smith, Department of Production Engineering (associate supervisor). Dr. Smith left the University in September 1977 and Dr. D Scrimshire, also from the Department of Production Engineering took over the role of associate supervisor. During this period the following changes in the position of Chief Engineer took place:

Chief Engineer:-	Mr. J Bladon	Jan 1977 - Jan 1978
	Mr. T J Brockas	Jan 1978 - April 1978
	Dr. R M E Sullivan	May 1978 - March 1979
	Mr. C A Borlace	March 1979 - Dec 1979
	Mr. B W Marr	Jan 1980 Onwards

All acted in their turn, as Industrial Supervisor. The I.H.D. Total Technology tutorship was given by Mr. G A Montgomarie and, later, by Dr. I T Robertson.

The I.H.D. Total Technology scheme aims to give an Applied Science or Engineering graduate a suitable technological training to enable him to pursue a career in general management or technology management in a science based enterprise. The course is built around a project based in industry or a public body, with up to 300 hours of related course work providing general background, not specifically related to the project. If specific skills are required, instruction can be obtained from the relevant University department. The course also provides a valuable opportunity to meet people facing similar problems in other companies and to exchange information and ideas.

1.2 Terms of Reference

The original terms of reference for the project are given below. They were written by the Central Personnel Department at Dunlop House London.

"Engineering Planned Maintenance"

"A system of planned maintenance within the Works Engineers' Department at Fort Dunlop is required. Because of the size and complexity of the factory the formulation of a system will call for an in depth study and plan of operation including computerisation.

What systems at present successfully operated in industry could be adapted to those requirements and what detailed plans of action are recommended?"

After discussion with the Chief Engineer and Works Engineer at Fort Dunlop in Birmingham it was decided that the theoretical exercise originally defined should be replaced with a more 'practical' project. The terms of reference were therefore re-written as:-

"To develop and assist management to implement a system of planned maintenance at Fort Dunlop.

The study should include an investigation of systems at present used in industry and the use of computers in this area. The problems to be encountered in introducing a new method of work to an established workshop should also be considered."

The thesis title was originally registered with the University as:

Development and Implementation of a System of Planned Maintenance.

The title was changed in March 1979 to:-

The Development and Implementation of a Computer Based Maintenance Information System.

A system of planned maintenance is still required at Fort Dunlop but a maintenance information system was considered a pre requisite to the successful operation of a planned maintenance system. The project's industrial supervisor agreed that a comprehensive management information system should be introduced. The information would be used to decide what maintenance method or combination of methods should be used on each machine, operate the planned maintenance system and monitor the effectiveness of that system.

1.3 Project Scope

The three years of work described in this thesis have resulted in the development of a computer based maintenance information system for the Fort Dunlop factory of the UK Tyre Division of Dunlop Limited. Two computer systems have been designed to collect maintenance data providing a plant history and management reports, they are:-

The Engineering Spares System

This system provides an on-line stores stock information and facilities to record stock movements as they occur.

At Fort Dunlop, visual display units and keyboards have been installed in the major maintenance workshops and Machine Tool Department. The terminals access a data base held on the Fort Dunlop mainframe computer (IBM 370 158) providing a full commodity catalogue of items used within the UK Tyre Division and their stock records. The commodity catalogue for 64 other Dunlop factories is also available. The terminal can also be used to requisition any item stocked at the main factory store at Fort Dunlop. To requisition an item, the order is keyed in on the workshop terminal, the computer updates the data base and prints a requisition in the stores. The order is then either delivered by stores van, or, if indicated on the requisition, collected by runner from the workshops. The system alone was justified by the man hours saved in delivering commodities by van. Each item issued is recorded on an issues history file and, in the case of machine parts, the issue is recorded against the actual machine requiring the item (previously it was recorded against a general factory/cost centre). This history file provides part of a comprehensive plant history, planned as part of this project. Reports listing stores issues are produced weekly for each maintenance manager.

The factory stores has a VDU and keyboard to record on-line receipts, returns and stock transfers to and from other Dunlop stores. The data base is updated and all paperwork required to clear the invoice, produced automatically by the computer.

The information held by the system is of use to other business areas, and terminals are used by the Buying Department, Overseas Purchasing Office and Commodity Coding Clerks to assist them in their jobs. The Buying Departments at the Inchinnan and Washington Tyre Division factories also use the systems information and stock recording facilities and will shortly (early 1980) implement the requisitioning facilities for their maintenance departments.

The stock position on any item at any UK Tyre Division factory is therefore available on any terminal 24 hours a day during the working week (Monday - Friday). The systems implementation has resulted in three major benefits:-

i. improved information on commodities (on-line)

ii. the ability to requisition via a terminal and record the items issued against a machine (or cost centre)

iii. the acceptance of factory floor computer terminals. (The Spares System VDU's are the first terminals to be used on the factory floor).

<u>The Engineering Request Card</u> (To be implemented early in 1980)

The request card will provide the second element of the plant history. The card is issued by Production Foremen to request engineering work and by Engineering Foremen as an instruction to their men. Codes are used to record the priority of the work undertaken, the equipment or machine worked on, the cause, and the action taken. The Tradesmen also record start and finish items and dates, and their individual working times. The card will be introduced as part of a categorised work value incentive payment scheme for Fort Dunlop's engineering workers being implemented by P A Management Consultants. The job described on the card is categorised by the engineering foreman using this technique. The data from the completed cards are then submitted to a suite of computer programs which provide reports on machine downtime, labour utilisation and standard hours of work to be used in calculating the incentive payment. The engineering data is stored to provide a record of every job undertaken on each machine and time spent on general activities such as shop lighting, repair or hoists etc.

Plant History

The history files from the Spares System and Request Card will be available for analysis using the standard analysis utility program available at Fort Dunlop's computer centre, reports being available 24 hours after a request is submitted.

These systems provide a means of collecting the fundamental engineering data required to manage a maintenance function whilst giving indirect benefits in providing facilities to access on-line stock information, requisition stores items via a terminal and operate an incentive bonus scheme.

Further work is planned to expand the engineering systems and utilise the information made available:-

1. On-line Job Recording

   This would be the direct input of the Request Card data via the Spares System terminals. The data would be held on disc and be available for analysis with reports being displayed on the workshop terminals.

2. Planned Preventive Maintenance

   The data collected by the job recording and spares systems would be used to develop and monitor a planned preventive maintenance schedule for the machinery requiring this form of maintenance.

3. The Scheduling of Maintenance Work

Estimates of time and labour required to carry out the work would be given to each job as part of the incentive bonus scheme. A system can be devised to schedule these jobs against the labour available and known priorities.

The Thesis

The computer systems have been designed and the spares system implemented against a background of recession in the tyre industry and redundancies, factory closures and heavy restrictions on expenditure in Dunlop's Tyre Division. However, the need for improved maintenance efficiency has been recognised and senior management have backed these developments, contributing considerably to their successful implementation. The first two chapters detail this background, Chapter 1 contains a brief history of the company and an analysis of Dunlop Holdings financial results 1976 - 1978 showing the problems faced by the company as a result of poor performance in the Tyre Division. The Chapter also provides a literature review. Chapter 2 describes the Fort Dunlop Factory, the maintenance function and the maintenance information available - the final section of the chapter identifies the major information problems to be solved. Having given the organisation and financial background Chapter 3 describes the use of data processing in maintenance and the advantages of operating planned maintenance backed by a sound maintenance information system. The outline of such a system is given and the difficulties of persuading the Computer Centre Management at Fort Dunlop to attempt the project described.

The Computer Centre management's eventual agreement led to the development of the two systems which are described in Chapters 4 and 5. Chapter 6 lists the possible future developments directly resulting from the development of the spares and request card systems and the longer term work planned to provide a full maintenance information system. Chapter 7 provides a discussion on the work undertaken and concludes that computer systems are a valuable, inexpensive maintenance engineering tool only now gaining recognition and emphasises the importance of involving the maintenance departments workforce and management in the computer systems design and development.

1.4 Dunlop Limited - A Brief History

In 1888, John Boyd Dunlop invented the pneumatic tyre and a year later "the Pneumatic Tyre and Booth Cycle Agency" was formed. In 1900, the Company commenced manufacturing car tyres and the name changed to "The Dunlop Rubber Company Limited". It retained this title until 1967 when it became "The Dunlop Company Limited".

In the early 1900's the company consolidated its position by obtaining control of its supply of rubber and textiles (the major raw materials). It began investing in Malayan estates in 1909 and opened its first cotton mill in Rochdale in 1916. Dunlop Textiles Limited, now produces nylon, rayon and polyester tyre cords at Rochdale. In 1925, Dunlop started to broaden its base of activity by purchasing the "Charles Macintosh" group of companies, manufacturers of tyres, footwear, cables, clothing and general rubber products, including belting and hose. These new areas were formed into the Industrial and Consumer Groups in 1932. A sports racket factory was also purchased in 1925. In 1929, the invention of "Dunlopillo" latex foam provided the company with an additional product.

Overseas expansion during the 1930's saw new factories in Ireland, India, South Africa, France and Germany. At this time, Dunlop Aviation Division diversified into hydraulic and pneumatic operating systems and the manufacture of aeroplane wheels and brakes.

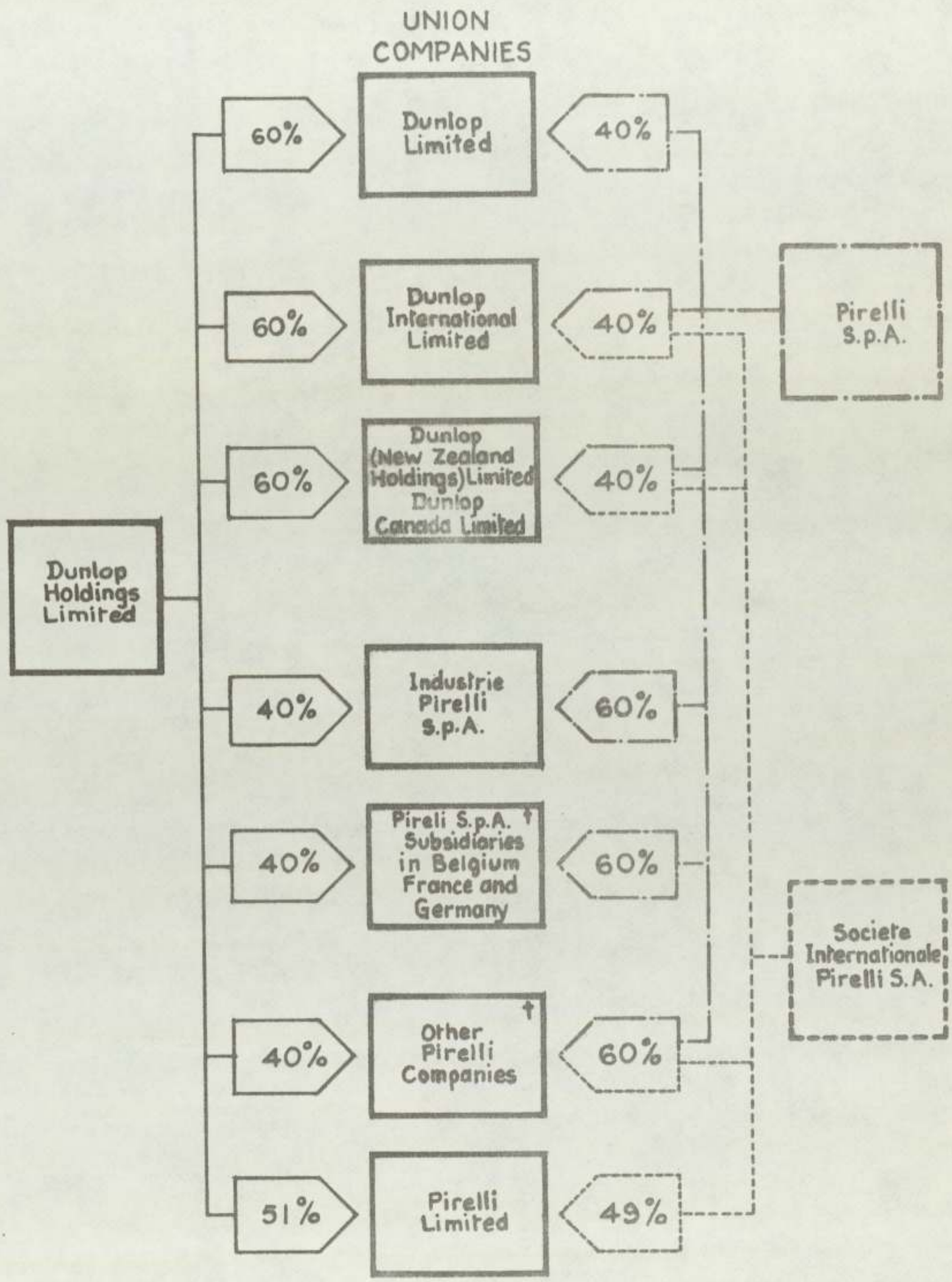
During the 1939-1945 war a whole new range of products was developed: e.g., barrage balloons, underwater swimming suits, anti-G suits and many others. In the post war period, Dunlop rebuilt its war damaged European factories and also set up new plants 'overseas'. Diversification also continued into sports goods with the acquisition of John Letters (Golf Clubs), Slazenger and Carlton Plastics.

In 1968, Dunlop acquired George Angus and Company Limited, who manufactured fire hose, fire armour, fluid seals, industrial hose and belting, brake linings and protective clothing.

In 1971, the Dunlop-Pirelli Union was formed. Dunlop obtained a 49% interest in Pirelli's operations in Italy and other E.E.C. Countries and 40% elsewhere, in exchange for a transfer to Pirelli of equivalent interests in Dunlop's operations. Dunlop was re-structured at this time, with a holding company, Dunlop Holdings Limited, being formed. (See Figure 1.4.1. "Dunlop-Pirelli structure").

1.5 Dunlop's Financial Results 1976-78

In 1978, Dunlop in the UK employed 42,450 people, with a turnover of £530 million plus £945 million from overseas companies. UK Tyre



† The percentage holdings of the parent companies shown are percentages of the existing Pirelli holdings in those companies.

FIGURE 1.4.1

DIAGRAM OF THE UNION STRUCTURE.

Source:- Dunlop internal document

Division made a loss of £16 million, whereas the other UK Divisions (Engineering, Industrial, Consumer, Fire Armour and Sports) made a profit of £22 million. Tyre Division's worldwide profits reduced the overall loss on tyres to £12 million (current costs).

The company's results have become progressively worse over the last three years. A statement of Value Added and a summary of results (Figure 1.5.1.) shows the company's position. The losses made by the group are, among other things, due to the trading position of the European tyre business. The main problems are:

(i) Over-capacity in the European market due to the widespread building of new factories in the 1960's.

(ii) The development of the steel braced radial, giving twice the life of a cross-ply tyre.

(iii) The halt in growth of motorists' mileage due to the continuing shortage of oil.

(iv) A decline in the original equipment market, in line with the contraction of the British Motor Industry, with imported cars taking a larger share of the market.

(v) Low-cost, East European, imported tyres taking a larger share of the replacement market in Europe (6% in 1978).

(vi) Low productivity in the Tyre Division factories.

VALUE ADDED (HISTORIC COST)

		1976 £m		1977 £m		1978 £m	
	Sales	1,275		1,361		1,475	
Less	Materials and Services	770		836		929	
	Value Added	505		525		546	
Add	Associated Company's Profits and Investment Income	17		12		14	
		522		537		560	
	Applied to Meet						
			%		%		%
	Employees Remuneration	385	74	412	77	441	79
	Cost of Loans	26	5	30	6	35	6
	Tax	30	6	25	5	24	4
	Extraordinary Item (See Page 16)					34	6
	Dividends	13	2	15	2	14	2
	Depreciation	37	7	38	7	41	7
	Profit Retained for						
	Dunlop Shareholders	20	4	12	2	(15)	(2)
	Minority Shareholders	12	2	5	1	(14)	(2)
		522	100	537	100	560	100

	1976	1977	1978
Operating Profit (excluding associated companies)	83	75	64
Profit as a % of Sales	6.5%	5.5%	4.3%
Profit Before Tax (subtracting profit attributable to minority interests)	74	57	43
Net Assets Employed	664	718	763
Return on Ave. Net Assets Employed	15%	11%	9%
Capital Expenditure	43	55	56

Figure 1.5.1. Dunlop Holdings Value Added 1976 - 78 With Summary of Overall Results.

Source: Annual reports 1976, 1977, 1978.

The Tyre Division

A more detailed analysis of the results reveals some salient points about the Tyre side of Dunlop's business.

i. Tyre Sales

	1976 £m	1977 £m	1978 £m
Tyres	776	815	862
Total Sales	1275	1361	1475
Tyres as a % of total sales	61	60	58

It may be seen therefore that tyres, though still the company's largest sales group, are decreasing in importance.

ii. Operating Profit

By product	1976 £m		1977 £m		1978 £m	
	Historic	Current	Historic	Current	Historic	Current
Tyres	42	3	25	(8)	16	(12)
Industrial	19	13	20	13	20	14
Engineering	7	2	8	4	6	2
Consumer	5	1	8	4	10	7
Sports	6	3	6	3	4	2
Plantation	4	1	8	7	8	7

Profits from consumer goods and plantations have improved but Tyre Division has produced rapidly declining results. On current costs, losses have occurred in 1977 and 1978. (Current Cost accounting adjusts the accounts for the effects of inflation).

iii. Capital Expenditure

	1976		1977		1978	
	£m	% of total	£m	%	£m	%
Tyre Division	31	72	36	65	34	61
Industrial	5	12	9	16	11	20
Engineering	2	5	2	4	3	5
Consumer	2	5	3	6	5	9
Sports	2	5	4	7	2	4
Plantation	1	2	1	2	1	2
Total	43		55		56	

Capital expenditure is low because of poor results and extremely high financing charges on the current borrowings. There is a shift in investment from tyre manufacture to the industrial and consumer areas, which are seen as potentially more profitable.

iv. Extraordinary Item 1978

The extraordinary item in the 1978 figures of £34 million (see Figure 1.2), is a fund set up to be used in the rationalisation of the business. The majority of the money will be spent within Tyre Division. This process started in April 1979 with the closure of the Tyre Division factory at Speke, Liverpool, with the loss of 2,500 jobs.

1.6 Literature Review

The development of a Maintenance Information System encompasses several disciplines including:-

Maintenance Technology

Planned Maintenance, Condition Monitoring, Operations Research

Terotechnology

Computer Science

Systems Analysis

Accountancy

Industrial Relations etc.

The published information in each of these areas is considerable but little has been found by the author on the direct application of computer systems to industrial maintenance. This chapter draws together the publications that were used to shape the information system developed for Fort Dunlop. The sources used were:-

- The Libraries of Aston, Loughborough, Nottingham and Birmingham Universities
- The National Computer Centre, Oxford Road, Manchester
- The National Terotechnology Centre, Cleve Road, Leatherhead, Surrey
- The Production Engineering Research Association Library and Information Service at Melton Mowbray.

1.6.1 Computers and Maintenance

For commercial reasons Companies using computers to assist their maintenance function tend not to publish the results of their work. An information search at the National Computer Centre provided a list of relevant, published articles and commercial software packages. Amongst the commercial packages I.B.M. produce an excellent series of application guides for their COPICS (Ref 1), MEMIS (Ref 2) and Plant Maintenance (Ref 3) systems. I.C.L. have developed a planned maintenance system for BICC Ltd. based on their 1900 PERT package (Ref 4) which has recently been refined whilst working with the Severn Trent Water Board (Ref 5).

Maintenance Engineering text books are now beginning to have extensive sections on computers and their maintenance applications. This is most noticeable in American texts. MANN (Ref 6) describes an I.B.M. system, based on an article written by Wilkinson and Lowe for the March 1971 edition of Plant Engineering (Ref 7). The Maintenance Engineering Handbook (Ref 8) provides an excellent introduction to the subject and has useful articles on:-

Work Authorisation and Control

Computerised Labour Reporting

Computerised Planned Maintenance

The Management Handbook for Plant Engineers (Ref 9) includes sections on:-

Safety (Computer Records and Analysis)

Systems and Management reports

The Computers Impact on Plant Engineering

British textbooks tend to refer to computers as useful tools without making specific reference to applications, CLIFTON (Ref 10) "Principles of Planned Maintenance" (published 1974) only describes 'manual' systems as does WHITE (Ref 11) in his book "Maintenance Planning, Control and Documentation". CORDER (Ref 12) in his 1976 text book, "Maintenance Management Techniques", recommends the use of a computer if the company already uses data processing. HUSBAND (Ref 13) in his 1976 text book "Maintenance, Management and Terrotechnology" recommends the use of a computer for storing and scheduling the routine maintenance work and for the stock control of spares. This recommendation is qualified by stating that the size of the maintenance task must justify the expense and that new control systems (such as planned maintenance) should be proved manually before being computerised.

Magazines and journal articles provide a useful source of system descriptions, again American articles predominate. In the early 1970's, articles on preventive maintenance suggested that computers should be considered for scheduling maintenance. (e.g. 'Organising for Preventive Maintenance' (Ref 14) and "Controlling Preventive Maintenance" (Ref 15) both published in 1972). A computer based scheduling system used for lubrication is described by WU (Ref 16) in a 1971 article. By 1975, descriptions of computer based maintenance information and control systems were being published. HUSS (Ref 17) describes a system which receives as inputs, completed planned maintenance cards, time cards, work orders (new work and completed), a dispatchers' log for reactive maintenance and details of inventory withdrawals and returns. The data were input into a batch system, producing daily reports on work backlog and spares issued. Weekly reports gave a backlog summary, planned maintenance schedules and incomplete planned maintenance. Monthly history and accountancy reports were provided. Equipment history reports were also available on demand.

U.K. papers relating the importance of planned maintenance, scheduling work, and information systems tend to describe manual systems and only refer to computer applications for 'large plant'. KELLY (Ref 18) in his two papers "The Control of Industrial Maintenance" written in 1974 refers to computer simulation for optimising the sizes and distribution of the maintenance trade force, and refers to JARDINE's Book "Operations Research in Maintenance" (Ref 19) and suggests computers should be considered for preventive maintenance scheduling when the activities exceed 80,000 a year. The importance of the role computers could play in maintenance was seen by a few writers in the early 1970's. Professor HUSBAND (Ref 20) writing in 1974 on the trends in maintenance organisations states that many companies had production control and standard costing systems but had not expanded their data processing activities to help collect maintenance data and feedback information to the maintenance management. The lack of computer systems for maintenance spares and consumables was also noted. The same article states that the use of operations research techniques in maintenance will only be made possible when historical data is kept for all maintenance activities.

In the U.K. the cost and, therefore, the importance of maintenance was only gaining recognition in the late 70's. The Ministry of Technology commissioned P.A. Management Consultants to conduct a study of maintenance in the U.K. This report was published in 1969 (Ref 21). The 'major' findings were:-

- Direct cost of maintenance in the U.K. was approximately £1100 in (1969) per annum
- Between £200 and £300m per annum could be saved by basic improvements in maintenance practices.

- That maintenance workers productivity could be improved by 60% and this would provide further savings of between £250 and £300m per annum.

This report also notes the lack of basic accountancy and management techniques in most maintenance departments. This report, according to JOST (Ref 22), led the Ministry of Technology, to set up the "Committee on Terotechnology" who were to establish training and education facilities and to provide an advisory and consultancy service to industry via a national centre. The committee defined Terotechnology as follows:-

"Terotechnology is a combination of management, financial, engineering and other practices applied to physical assets in pursuit of economic lift cycle costs; it is concerned with the specification and design for reliability and maintainability of plant, machinery, equipment, buildings and structures, with their installation, commissioning, modification and replacement, and with feed-back of information on design, performance and costs". (From CORDER Ref 12).

As these concepts related directly to the author's project the National Terotechnology Centre was visited and several of the centres publications obtained (Ref 23). The centre's Director advised that a meeting with Mr Raymond Reynolds of B.P. would be useful. Mr Reynolds was an Accountant working for the Maintenance Department at a B.P. Refinery, he is currently involved in the design of a Maintenance Control and Information System for B.P. (Ref 24). Mr Reynolds recommended an article "Engineering and Supply in the RAF" by Air Marshall Sir Charles Pringle (Ref 25). This aricle provides a fine description of Terotechnology at work and amongst the systems described, reference is made to a computerised stock control system which uses V.D.U's in R.A.F. bases, linked to a central mainframe computer. In this system a keyboard request will show whether equipment is available in the station's own store, from the local depot, from another station or directly from the manufacturer. By pressing an accept key the operator produces a transaction voucher at the location where the equipment is held, enabling the parts to be issued and recorded in the accountancy system. The computer controlling this system is located at the Supply Control Centre (SCC) at Hendon, London. A visit to the SCC by Dunlop personnel at the author's instigation took place in 1977 and proved extremely informative, convincing the Senior Engineering Management of the viability of a V.D.U. based stock ordering and information system.

The use made of data processing by the Armed Forces is only occasionally mentioned by writers on maintenance. The 1970 Nato Conference "The Organisation of Logistic Support Systems" (Ref 26) provides a description of systems for stock control, planned maintenance and cost control. Papers on information systems, mathametical models and systems analysis are also included. Most of the systems described at this Nato Conference were in operation in the mid sixties. The armed forces need for rapid response, the value of assets being maintained and the need to optimise expenditure has led to a level of use of data processing in the services as yet unseen in industrial maintenance. The R.A.F. were prepared to discuss the hardware and software aspects of their spares system with Dunlop personnel and indicated that they would assist wherever they could in helping a company implement a similar system.

The major part of the literature review was undertaken early in 1977 in preparation for the project. In late 1977 the British Council of Maintenance Associations organised a conference on the use of computers in maintenance. Their 'Maintenance Management by Computer' conferences now provide the main platform within U.K. for companies willing to describe their maintenance computer systems developments. The 1977 conference (Ref 27) produced speakers from the R.A.F., C.E.G.B., B.I.C.C., J.C.B., Eastern Electricity, I.C.I., Pedigree Petfoods, and Sir William Reardon-Smith and Sons, showing the wide range of companies using computer systems. The 1980 conference (Ref 28) provided speakers from Kodak, B.P., The Department of Health and Social Security, British Steel, The Greater London Council, I.T.T., British Nuclear Fuels and Dunlop Tyre Division (a presentation of the two systems developed for this project). These conferences provide rare opportunities to see other systems and discuss their development problems and justifications.

Having looked at the literature describing the application of computers to maintenance the financial advantages of such actions are now considered.

An attempt to determine the true cost of maintenance in the U.K. is discussed in the Ministry of Technology report already referenced (Ref 21). This report provides a bleak picture of maintenance, and is precised in an article by HUSBAND and BASKER (Ref 29) published in the Production Engineer in February 1976. In this article the point is made that "It is simply going to be too expensive to ignore the level of maintenance costs". An article by HANNA (Ref 30) "Reducing the Cost of Maintenance" states that the effectiveness of maintenance management depends on how well it can:-

- Organise resources - money, manpower, materials etc.

- Measure its performance - budgets, performance standards
- Control - determine the degree of success in achieving objectives and formulate corrective measures as needed.

A paper by JOHNSON (Ref 31) to the A.S.M.E. in 1975 describes a maintenance control system of ten elements designed to provide the above features.

The elements are:-

Inventory and History files

Maintenance Standards (acceptable conditions of plant, buildings etc)

Continuous Inspection (scheduled inspections)

Work Classification (priority and scheduling of work)

Work Input Control (recording of all requests for maintenance work including inspection reports)

Planning

Material Co-ordination (stock control and issue)

Scheduling

Work Performance and Evaluation (the feedback)

Reports (Management analysis providing the means of evaluating the use of resources)

He concludes that with this type of maintenance information and control system in operation management can effectively control the maintenance resource.

1.6.2 Computer Software Packages

Software are computer programs, and are defined by IBM (REF 1) as "sets of instructions or statements, in a form acceptable to a computer, prepared in order to achieve a certain result". The computer has little or no intelligence without these instructions, and according to HORNER (REF 28) software costs constitute the greater part of a computer systems cost. The current trend (1980) is that hardware costs are decreasing whilst software costs are on the increase. Horner states that estimates put software development 10 years behind its counterpart hardware. He advises a newcomer to computers to "find the right software package, and then worry about the hardware". He goes on to argue that there are eight main areas in maintenance where computers are used:

- Job planning
- Preventative maintenance scheduling
- Stock/spares control
- Project control
- Cost control
- Error/fault logging
- Inventory control
- Resource allocation.

Many of these functions , it is argued fall into identifiable commercial areas for which standard software packages are available. Using one of these packages and adding suitable back/front end programs could, HORNER suggests save the user having to 're-invent the wheel'. In addition he recommends that a standard data base management system software should be used, and a data base query system software utilised. If a customised system is to be designed and written, a standard data base management and query system should still be considered.

Horner therefore advocates the use of commercial software packages, whereas EASON (REF 27) provides a less positive view of packages and describes a common problem with package software as follows:-

"The next surprise is that the purchase order, accounting and stock control of software packages which were the main reasons for selecting the particular computer are what the computer company thinks these packages ought to be and not quite what the purchasing company wanted. A decision then has to be made to either change company procedures to align them to the capability of the software, hire the computer company's programmers to amend or re-write the software to meet the user's requirements, hire an independent software company to do the same thing, or employ your own programmers and systems analysts to specify your requirements in computer terms and write the required software. The other option, that of retracing one's steps and attempting to get out of the contract will not be countenanced as the decision to obtain a computer was probably a board decision and no one, either invidually or collectively will be prepared to admit that a mistake has been made."

Commercial software falls into 4 main categories:

1. Those program products which are offered by computer equipment manufacturers exclusively to their own hardware users.

2. Products tied to bureaux usage.

3. Products requiring the user to purchase some form of hardware from the supplier as a condition of usage.

4. General software products which can be used on one or more manufacturers hardware.

To obtain details of software available for use in the maintenance/ stock control function, the following sources were used:

Manufacturers - approaching any of the major computer manufacturers will provide an abundance of literature. Dunlop Tyre Group traditionally uses IBM equipment, and an extensive range of literature was supplied by the IBM Account Executive. IBM's "maintenance" literature and systems are extensively described later in this section.

Bureaux - tied software and general software are recorded by the National Computer Centre (NCC) (REF 32) at Manchester, and they will provide a literature/systems search for member companies. This search was carried out for Dunlop in 1977 and provided several of the references used in the literature review, but no useful software product references.

The most comprehensive source (1980) of software information is the International Directory of Software (REF 33) listing 3223 general software products available from independent sources throughout the world. Comparing the software listed in this source with the areas stated by HORNER (Page 25), there is a considerable choice of software for

Job planning
Stock/spares control
Project control
Cost control
Inventory control
Resource allocation (within production and process control).

For "preventive maintenance scheduling" only the Boeing Computerised Preventive Maintenance System sold by the Boeing Company is listed.

Error and fault logging software is available from ICI - PLANT CONTROL

PACKAGE (Imperial Chemical Industries) and DATA AQUISITION SYSTEM supplied by P.M.A. Consultants Ltd.

Only two companies are listed as selling 'full' maintenance systems namely,

A - Mar - Z - Planned Maintenance System; a system for controlling Ships spare parts and maintenance, which is supplied by A. and P Appledore Ltd.

AMM - Automated Maintenance Management supplied by H.B. Maynard and Co. Inc., USA. This system provides component inventory, work order process, completed work order modules and optional maintenance budgeting and accounting modules.

The ability of a maintenance department to buy an "off the shelf" system providing all the functions listed by Horner (REF 28) would currently therefore appear to be impractical.

Production Control Systems and Maintenance Systems

The independant software houses provide some 90 production control systems, and the major bureaux and computer manufacturers provide several dozen more. These systems normally provide combinations of the following facilities:

Order Processing Parts file Bill of materials Requirements planning Shop loading Stock recording Costing Inventory control	)	Appledores' Production Control System (REF 33)

or

Inventory Control Requirements planning Analysis of load versus capacity Shop orders scheduling Cost control Control of open orders	)	P.A. Management Consultants PACS - Planning and Control System (REF 33)

To help illustrate the differences and common aspects of a production control system and a maintenance system, reference should be made to IBM's Plant Maintenance, Application Guide (REF 3). IBM do not market a maintenance software package, but have published several guides and brochures on the subject (REF 1,2,3,12,34,35 & 36). The Plant Maintenance guide is designed to help the IBM user to produce a detailed appraisal of the potential benefits of such a system to his organisation.

IBM illustrate a data base system which provides the following features:

- Work Order Management Providing:

  Job request.
  Verification.
  Preliminary cost estimate.
  Approval.
  Work order generation.
  Planning.
  Scheduling.
  Execution.
  Reporting.

- Spare Parts and Materials Management Controlling:

  Stock levels.
  Allocation.
  Re-ordering.
  Receiving.
  Disbursement.

- Equipment Management

  Generation of maintenance and job plans.
  Evaluation of preventive maintenance requirements.
  Analysis of deterioration rates.
  History analysis.
  Reports on equipment availability and performance.
  Generation of spare parts lists and plant maintenance inventories.

- Purchasing

  Provides access to existing purchasing systems (part of a production control system

- Workshops

  Provides an interface to the production scheduling system, providing access to information that influences maintenance planning and scheduling.

- Cost Control and Accounting

  Provides management reports and passes data to a factory accounting system.

. Data Communications Modules

Provides the interface between the application modules and the data bases.

Provides the following:

Data base generation
Recording and updating of data
Handling of enquiries
Retrieval of information
Production of reports

Certain aspects of the plant maintenance system may already exist e.g. Stores sytems and accounting system. In other areas the maintenance system will have to be designed to interface with existing systems, such as a production control system. Production Control and Plant Maintenance systems are therefore different but may share data (in the form of data bases), and have some common aspects.

1.6.3 ERGONOMICS

The use of ergonomics in computing can be broadly divided into aspects related to hardware design, the working environment and software design. The hardware and environment issues were tackled first (in the 1960's), and it was only in the mid seventies that interest switched to software and the cognitive aspects of the design of man/machine dialogues.

The change of emphasis has occurred because of the decrease in cost of computing and the wide spread use of Visual Display Units (VDU's). MARTIN (Ref 37) illustrates this point by showing how many program instructions could be executed for one dollar.

Year	Instructions
1955	100,000
1960	1,000,000
1970	100,000,000
1980	1,000,000,000

This increase is even more marked when inflation is also taken into account!

In contrast, the cost of employing people to interface with the computer has been escalating in the same period. Computer manufacturers and users must now optimise the use of people, rather than the use of the computers C.P.U. & storage. The system design must encourage the user to make full use of the computer's power. The computer now has to become the servant of the operator, where as previously the reverse has usually been true.

Hardware Design

To most 'users' the terminal is their only contact with the computer, the hardware (and software) design of the terminal is therefore vitally important. The man - machine relationship aspect is well documented in general ergonomic texts, e.g. SHACKEL (REF 38), MURREL (REF 39), VAN COTT and KINCADE (REF 40). The current guide for designers and purchasers of computer terminals, and VDU's is CAKIR, HART and STEWART'S (REF 41) VIDEO DISPLAY TERMINAL MANUAL.

Working Environment

The introduction of mini computer and mainframe terminals in 'user' areas have aroused concern about possible health hazards directly related to the equipment, and changed working patterns and environment.

VDU's have taken the brunt of this concern with several trades union publications, claiming that operators of such equipment have suffered adversly from radiation, and have had their vision affected. Most trades unions (office based) have now issued codes of practice for their members when operating VDU's. An article in Data Processing (REF 42), discusses these T.U. recommendations, and those made by professional medical associations. The Association of Optical Practitioners published their own report (REF 43), which states that there is no evidence of any harmful effects on vision from VDU's, and gives guidelines for VDU operation, and operation vision requirements.

This report was in agreement with ROSENTHAL and GRUNDEY whose report (REF 44) in Data Systems shows that there is also no evidence of any harmful effects from the radiation emitted from VDU's. The Business Equipment Trade Association published their views on VDU operation in 1979 (REF 45), setting down the industries views on the debate, and recommending guidelines for safe operation. The Video Display Terminal Manual, (CAKIR, HART and STWART (REF 41) provides a comprehensive report on the issue of VDU's and health.

Software Ergonomics

The need to investigate the way man communicates with man, is a pre-requisite to being able to design computer systems which attempt to mimic man. The terms 'user friendly' and 'English computer language', are now freely used in advertising to sell computer soft-wear and systems.

Research into the way man perceives, thinks, makes decisions and remembers, and the relationship between these actions and the way man operates machinery, should enable designers to provide computer systems that are better matched to their potential users. This area is called cognitive ergonomics by FITTER (REF 46), the early computers, for purposes of efficiency, forced man to adapt to the 'computers' way of performing a task. The reduced cost of computing now makes it possible to make the 'computer' bend to its users cognitive behaviour, and thus encourage the full use of the computer's power. The type of user and the task he has to perform is the most important consideration in designing a system. STEWART (REF 47), states that different users have a need for a different interface, even when using the same system. Stewart quotes a survey (EASON et AL (REF 48), which showed the information requirements of Managers, specialists (Engineers, Accountants etc.) and Clerks. Managers required a highly flexible system, supplying complex information which had to be relevant to their changing needs. They were not prepared to spend time learning how to use the system or specify their questions in terms the system would accept.

The specialists required complex software which they could tailor to their needs. They were prepared to learn how to program, but only spent a small proportion of their time using the system.

Clerks tended to be used by the computer, rather than actually being users of computers. They spend a considerable amount of time actually using the computer system. The hardware and software should therefore be designed with this in mind. Programs should allow for learning, and hardware should not cause discomfort after continuous use. SHACKEL (49) states in a 1979 paper that the field of 'Psychology software engineering' is an open field for good research. He goes on to say about computer software ergonomics, that "while the extent of readily applicable knowledge may still be relatively small, the methodology of ergonomics experimentation is a basic tool for research and applied studies in any field". However, several interesting papers have been published on computer languages, and the man/machine dialogues within them. The languages used can be divided into Non Navigational (natural languages and constrained languages), and Navigational languages (linear languages, such as COBOL, FORTRAN etc. and diagramatic languages). FITTER (REF 46) describes these languages as follows:

Navigational

The language requires the user to describe the actions/data required, and then instruct the system how to find the answer to his instructions. The general purpose languages fall into this class e.g. A.P.L., The diagramatic programming techniques are navigational. In both cases the user has to understand the programming technique, which often requires him to memorise strings of instructions.

Non Navigational

In these languages the user is protected from the language. The simplest forms are the menu or multiple menu, form filling or prompting, referred to as constrained language systems. The user is restricted in the information he can obtain by the number of choices offered to him. The other form of non navigational language is Natural language, it is this area which appears to have gained most 'ergonomics' interest in recent years. Natural language systems attempt to let the user interface with the computer in 'everyday' language. Examples of natural computer languages are ELIZA and FASE. ELIZA (REF 50), an experimental language which uses key words in the input which the program can identify, and then formats an English reply. The program therefore is selective in the words it actually operates with. This can result in long transaction times as the computer searches for words or strings of words, it has been programmed to recognise. FASE (fundamentally analysable) was simplified English developed at BELL TELEPHONE LABORATORIES (REF 51), and requires the user to write in a strict form with clear syntax, which takes several months to learn. Recently (1977) KELLEY and CHAPANIS

(REF 52) found that pairs of subjects undertaking problem solving tasks, faired no worse using a vocabulary of 300 words, than working with a full vocabulary. This approach removes the complexity of English language, but is bringing natural language computer dialogue back towards the linear programming languages e.g. BASIC.

In conclusion, James MARTIN (REF 37) suggests that ... "The proper place for natural language dialogue is still in the research laboratories, where material for PhD's is needed. In commercial applications we will seek greater precision and simplicity".

Man Machine Dialogues

The design of VDU screens is now extremely important if the 'user' is to be encouraged to use and gain full benefit from the computer system. The VDU dialogue design used in the computer system developed during this project was influenced by the textbook, "Design of Man Computer Dialogues", by James Martin of the IBM Systems Research Institute (REF 37), which can be strongly recommended for its practical approach to the subject.

The text covers:

- Alpha numeric Dialogues.
- Dialogues with sound and graphics.
- Psychological Consideration
- Operators without training.
- Implementation considerations.
- Form Design.

Man Computer Communication

The speed of commercial development of computing and its applications, has overtaken scientific research for a solution to computing problems, as SHACKEL states (REF 38).

"The speed of growth of computing and the market-place demand has put a premium upon speed and upon intuitive, rather than scientific, solutions. But the result is that we have too little proven knowledge. Since MCC (Man Computer Communication) is at the interface between computing and human sciences, it is hardly surprising that the gap in proven knowledge is even larger there. At least the gap has now been recognised, which is the first step towards bridging it."

The Ergonomics of Form Design

Most computer systems now rely on on-line input of data, and therefore do not require "form filling". Even so the ergonomics of good form design can be applied to VDU screen design. Good document or VDU screen design reduces the number of errors in the data, and makes the system more attractive to the user. The layout of information screens and computer printed reports is equally important, enabling the user to quickly find the information he requires.

The Dunlop Computer Centre has its own set of standards (REF 53), which have been compiled from the experience of Dunlop analysts, and the NCC standards (REF 54). These standards encompass most aspects of form design:

Colours.

Field Size.

Layout (for both punching and completion).

Standard information (program number, title, data type).

The literature available on document design provides some interesting reading. The knowledge available from research would not appear to have been passed on to Systems Analysts. As an example POULTON (REF 55), showed that lower case teleprinter output is more easily read than uppercase, yet computer input forms, VDU displays and mainframe line printers normally use uppercase.

Advice on the design of forms and the methods of asking for information is available from WRIGHT and BARNARD (REF 56), GRAY (REF 57) and SINCLAIR (REF 58), all writing in Applied Ergonomics.

1.6.4. The Social Aspects of Computers

There is currently a considerable press relating to computers, their applications and implications. In this section the major topics of the current debate are described, to provide a general background to the systems described in the thesis.

The advances made in micro electronics have made fast, powerful manframe mini and micro computers available at very low cost. Micro computers and processors are now being incorporated into 'automated' machines to be used in both the service and manufacturing areas. Whether these computers create or destroy jobs or simply displace labour to other tasks, depends on which report or writer is to be believed. PETCH in the New Scientist (1978) (REF 59), argues that in an expanding economy, automation will not cause an increase in unemployment as the labour will be displaced into other jobs, but automation within a static economy will precipitate a rapid increase in unemployment. ROBINSON (REF 60) in the same edition of New Scientist argues that automation is not the cause of the current high levels of enemployment, but that it is the "Recession that really bites". British newspapers have carried several articles on the subject, as an example FRYER (REF 61) in June 8th "Sunday Times" has an article which states that micro electronics will cause considerable unemployment in the service industries.

The British Governments view is that the unemployment will not be as extensive as first feared and, in fact, adaption of computerised systems will improve manufacturing output (by increasing capacity, and improving efficiency) and this will create more jobs. Two major reports relating to micro electronics and employment have been published by the D of I and D of E. The Department of Industry's in its (REF 62) "Impact of micro processors on British Industry (1979)" obtained the views of various Government 'experts', the electronics industry, manufacturers and retailers. The report covers education and training requirements, unemployment, the skills required, job satisfaction, pay differentials and the role of women and managers within the new technology.

The Department of Employment report produced by SLEIGH et al (REF 63) (1979) is a major contribution to the 'computer' debate. The report is based on interviews and case studies in the U.K. manufacturing and service sections. The report describes the impact of computers in cash registers, cars and car components, domestic electrical appliances, textile machinery, machine tools, the railways, postal services, colour televisions, telecommunications, office equipment and retailing. There is extensive coverage of computer aided manufacture and design. The use of industrial robots and word processors. The use of automation to rectify skill shortages is discussed, as are unemployment, industrial relations, and the need to train and retrain the workforce and "technicians" to work with the computer. (The employment debate is set against the current ecomonic background).

The Trades Unions have not adopted a "Luddite" approach to computers. Their view is that whilst the introduction of computers in all their forms should not be resited as a matter of course, the introduction should be negotiated, and several unions have published guidelines (see later). In summary, the unions accept the inevitability of computer usage, but the unemployment (assumed in most union reports) should be minimised by reducing overtime, reducing the working week, improving holidays and work sharing.

Two of the principal commentators have been Jenkins and Sherman of ASTMS (Association of Scientific, Technical and Managerial Staff), who have published several articles and spoken at conferences on the subject. These views are probably best summarised in two books: 'Computers and the Unions' (REF 64) (1978), and 'The Collapse of Work' (REF 65) (1979). In the first book the effect of computers, the content of jobs, the workers' job satisfaction, job security and promotion prospects are discussed along with the types of new jobs that will be created as a result of computer technology. In the "collapse of work" the arguments put forward in "computers and work" are extended, and a picture of a society moving away from "the work ethic" towards "the leisure society" is presented. Micro electronics are discussed, and the long, medium and short term effects on employment in the manufacturing and service sectors are given.

The T.U.C. General Congress Council report (1979) on "Employment and Technology" (REF 66) sets out the trades unions considered response to micro electronics against the U.K.'s economic background. A detailed plan of action is given to provide education and training, and a checklist for negotiating new technology agreements is included.

The Amalgemated Union of Engineering Workers (AUEW) & the unions' Technical and Saleried Staff (TASS) union published a book "Computer Technology and Employment" (1979) (REF 67), which records the proceeding and background papers to a conference held by the union to discuss the unions policy to computers. Delegates came from all sectors of industry (including one from Dunlop), and provided first hand experiences of the effects of computerisation, and in several cases the effects of not adopting computer technology (e.g. National Cash Registers where several hundred jobs were lost). The health and safety aspects of working with VDU's are also discussed at some length, and the view is expressed that eye damage can result from VDU operation.

APEX the Professional and Executive Union have provided a report "Office Technology : The Trades Union Response" (1979) (REF 68). Details of office automation are given (word processors etc), and the health hazards and employment consequences described. The report sets out guide lines for negotiating the introduction of new technology.

The 'negative' effects of computer technology, already described, can be balanced by some positive points. LAMOND (REF 69) writing in Computer Weekly (1978), claims that micro processors will create jobs in the home and cottage industries, killed off by the first industrial revolution. He argues that increased automation will remove jobs in industry and commerce, but people will resurrect the old skills, producing an industrial revolution in reverse with large factories being disbanded.

The jobs created by computers have helped several handicapped groups. The training of blind people as computer programmers is now common place, and has been described by STERLING et al (REF 70) and STERLING (REF 71). SMITH (REF 72) describes the advances being made in the U.S.A (where computer technology is becoming a "cottage industry") and housebound people are being used as programmers. IBM are also deeply involved in training the severely handicapped for jobs within the data processing industry. The work is described by KNORR and HAMMOND (REF 73).

The rapid adaption of computer control within the process industries has led to a severe shortage of technical back up personnel. The Manpower Services Commission reported the acute nature of this problem in a 1978 report (REF 74).

The problems of educating people to meet the present and future requirements of industry and commerce, have been muted by EDWARDS (REF 75). In an article for New Scientist he suggests that a radical rethink should take place about how children not destined for higher education should be educated, and how the current workforce should be retrained to cope with the different style of life, now made possible by computer technology.

Several commentators are arguing that computer technology is not being adopted rapidly enough in industry and commerce. SHAFER in a paper to the American Society of Mechanical Engineers (REF 76) states that in his opinion automation is not taking place rapidly enough in the U.S.A. The unemployment feared by so many is not occurring and in fact he states that "Indeed given the growing international competition in marketing manufactured products, it may be necessary for the U.S. to speed up the rate of automation to maintain our standard of living".

The position within the U.K. is similar according to BRAUN (REF 77) (1978), who states that we must increase the rate of automation (i.e computerisation) within manufacturing, to enable us to increase productivity and therefore our international competitiveness. He states that unemployment will result but can be combatted by increasing public and private sector growth, and by promoting product inovation. In another paper BRAUN (REF 78) endorses the views given above, and states that "what options we have arise out of how we use micro electronics, not out of whether we use it".

These opinions are endorsed by the Government 'think tank', and KELLOCK (REF 79) in an article for Machinery and Production Engineering discusses their view that more jobs will be lost if micro processors are not adapted by British industry and commerce, than if industry ignores the 'new technology'.

The justification used by companies for the adaption of computers has been reported in a study of French, German and Dutch firms by NEIDLEMAN (REF 80) (1978). Neidleman studied 267 small and medium sized firms and found that the majority did not fully understand the capability of the computer, and had not calculated correctly the costs and benefits of using the machine. This view is endorsed by BISHOP et al (REF 81) who when writing about micro computers argues that these machines are being oversold and that the true cost of operation is often considerably more than first envisaged, when the costs of implementation, programming and technical back up are considered.

To successfully implement a computer system, requires a considerable amount of planning and the co-operation of those people who will use the system. MUMFORD (REF 82), discusses the participative approach to computer system implementation in an article aptly entitled "Social Aspects of Systems Analysis", he also provides 3 case studies to emphasize the importance of getting the user involved. There are three excellent texts available on this topic:

FARROW (REF 83) "Computerisation Guidelines".

GUEST and KNIGHT (REF 84) "Putting Participation into Practice".

MUMFORD and HENSHALL (REF 85) "A Participative Approach to Computer Systems Design".

Getting the implementation wrong can be both embarrassing and expensive.

"Word Processing Takes Bradford into the Jet Age", FRAKLAND and JONES (REF 86) is an article in the Municiple and Public Service Journal on the 18th of August 1978, describing the experimental use of word processors in local government offices in Bradford.

To be followed on the 15th of February 1979 by an article "Chips Go Down" by FORESTER (REF 87), who comments on a strike in local Government offices in Bradford over the introduction of word processors (Christmas 1978). This article appeared in "New Society", no reference was made in the Municiple and Public service journal!

As general background reading on computers, micro computers and the related technology the following books and articles can be recommended.

'The Micro electronics Revolution' edited by FORESTER (REF 88), this book contains chapters written by experts in their relevant fields such as B. Sherman (ASTMS) on Unemployment and Technology Trade Union View. N. Swords - Isherwood and P. Senker on Management resistance to the new technology.

'The Computerised Society' by J. MARTIN and A. NORMAN (REF 89), a

1977 text written as a laymans guide to the implications of computers in all their manifestations.

'The Micro Revolution' by T. ARMSTRONG and P. HUGHES (REF 90) written for Management today, and providing a guide for managers to micro processors, the organisational changes caused by computers, distributed processing and the impact of word processors.

'The Social Impact of Computers' by G. SILVER (REF 91) provides an introduction to how computers are used, and their effect on each member of society. Several legal, ecomonic, psychological and ethical questions surrounding the use of computers are also raised.

'Computing and People' edited by PERKINS (REF 92). This booklet provides 16 papers given to a 1977 conference at Leicester University. The topics covered range from the recruitment and training of programmers, to the implementation of computer systems.

"Behavioural and Organisational Aspects of Computers and Allied Technology" by FOOTE, MASON and McLEAN, (REF 93) this 1975 publication provides a comprehensive bibliography with 526 references, and provides a starting point for further research.

The debate that surrounds the use of computers, in all the manifestations within society owes much to television. Both the BBC and Independant Television have produced programmes related to the topic. The BBC Horizon programme 'Now the Chips are Down', was first broadcast in 1978 (REF 94). This programme is reputed to have drawn the Governments attention to the new technology, and triggered off Government support for microprocessor technology. The BBC followed this programme with "The Robots are coming" (1979) (REF 95), which discussed the limitations and applications of robots. The use made by the FIAT motor company was shown and concurrently FIAT used an advertisement showing the construction of their STRADA motor car by robot welders. This advertisement had a major impact on the British public, showing dramatically the implications of using computers and robots within industry. The BBC also produced a series of 3 programmes "The Right to Work" (REF 96), updating the material used in "Now the Chips are Down" (REF 94)including studio discussions, and debated the employment implications related to "new technology" and providing a case study at a glass plant which had been automated to remain competative, but causing several hundred redundancies.

Thames Television produced a series of 5 programmes, 'The Mighty Micro' (Ref 97)introduced by Christopher Evans who explored the implications of micro processors and computers. The series was accompanied by a book "The Mighty Micro" written by EVANS (REF 98).

In 1980 the BBC screened a series of 3 programmes "The Silicon Factor" (REF 99) containing similar material to its earlier programmes.

1.6.5 Inventory Management

The amount of stock held by U.K. industry is a millstone around the country's neck according to RAY (REF 100). In 1977 the U.K. stock figure was £48,685 million, equivalent to 39% of the Gross Domestic Product (G.D.P.) for the year. Ray compares the stocks held by some of our competitors (as a percentage of national income) over an eight year period:

U.S.A	24 %
Sweden	25 %
France	28.5%
Germany	28.5%
United Kingdom	45 %

The majority of the U.K. stock being held by the industrial, commercial and financial companies who have held, on average, some 74.5% of the total over the last 10 years.

The rate at which stock in turned over (i.e. converted into cash), is a reasonable measure of inventory management performance. Ray uses the United Nations General Industrial statistics yearbook for 1975, and compares turnover figures for manufacturing industry in the following countries:

Japan	3.1 times
W. Germany	3.0 times
U.S.A.	3.0 times
Australia	2.3 times
Denmark	2.3 times
United Kingdom	1.8 times

(median figures for years 1969-75).

The net result of our poor inventory performance is a lack of competitiveness. Ray gives the cost of financing these stocks as a cost of sales in July 1979 as:

	Pence per £ of sales	UK % Disadvantage	Cost of finance
Japan	7.8 p	10.5	7½ %
W. Germany	8.0 p	10.3	7
U.S.A	9.7 p	8.6	12
Denmark	12.2 p	6.1	11
United Kingdom	18.3 p		16

U.K. manufacturers are therefore faced with giving Japanese and W. German companies a 10 percent advantage in price.

Ray states that "If we are to become really competitive in this period of world recession, not only must we hope to get inflation firmly under control, not only must we hope for much lower interest rates, we must get stocks moving and moving fast!".

The size of our inventory problems is put into perspective by showing that if the U.K. stock holding level was reduced to 25% of G.D.P. (i.e. U.S.A/Swedens levels), this would provide:

1. A one off cash generation, which based on 1977 national stock figures, would release £21 billion, or thereabouts in current prices (1980).

2. An eventual national saving of around £ 6 billion per annum.

Consider in the early 1980's the total revenue taken from the North Sea, that is, North Sea Oil royalties, Petroleum Revenue Tax and North Sea based Corporation Tax, will in totality generate about the same, £6 billion per annum.

The science of inventory management has a considerable general literature. The control of raw materials, components, fuel, work in progress and finished goods is extensively covered in text books. Examples are BAILY (REF 101) "Successful Stock Control" by Manual Systems, THOMAS (REF 102) "Stock Control in Manufacturing Industry" and Wright (Ref 103) "Production and Inventory Management in the Computer Age".

The American Production and Inventory Control Society Inc., publish 4 booklets of papers each year which are re-printed by the British Production and Inventory Control Society (REF 104). These papers cover aspects of inventory control, and provide a medium for the description inventory control techniques.

Inventory Management and Maintenance Stock

The control of Engineering maintenance spares, is a topic only briefly touched on in maintenance textbooks. KELLY and HARRIS (REF 105) devote a chapter to the subject, mentioning the financial advantages of closely monitoring stock levels, and setting economic order quantities (E.O.Q.). The E.O.Q. calculation is shown for high usage items, but a warning is given that the technique should only be applied with care and that more sophisticated techniques are available covering the whole range of stock usage. CORDER (REF 12) devotes less than half a page to stock control, and analytical methods of inventory management receive no mention. HUSBAND (REF 13) devotes a chapter to the use of analytical techniques, and quotes TURBAN's

(REF 106) 1966 survey of 309 plants in 30 major industries, which found that only 9% used mathematical modeling for spare parts inventories. Husband shows the E.O.Q. calculation, and provides the same warnings as Kelly and Harris as to population sizes and their importance when using statistical techniques.

A more recent survey published (1979), has been carried out by TAYLOR (REF 107), into the 'state of the Production and Inventory Management art' within the American Process Industries. Reporting on analytical methods in use by leading firms he states that the techniques most used are:

'Exponential smoothing or moving averages for short range forecasting'.
'Correlation, regression and econometric models for medium and long range forecasting'.
'Analytical techniques to develop aggregate production control strategy'.
'Multi time period, multi location linear programming models'.
'Economic batch quantity models'.
'Run out lists and simulation models for scheduling'.
'Statistical analysis of safety stocks/recorder point inventory systems'.
'Material requirements planning'.

Taylor studied the inventories held for Maintenance, Repair and Operating (M.R.O.).M.R.O. inventories averaged 15% of the investment in process inventories.

The survey showed that computer systems for M.R.O. had lagged behind systems for process inventories. The survey also showed that M.R.O. inventories normally held more items than the process inventories.

The 'leading firms' (those making best use of analytical techniques) taking part in this survey, had 3 major characteristics which complemented the body of work within this thesis:

- A well developed computer information system was in place for handling inventory transaction data.
- Three or more persons were working on the development of integrated planning systems.
- A pre-requisite for developing inventory planning and control systems is an information system with accurate and timely information on stock levels!.

Operations Research

Operations Research (O.R.) has been used with some success in inventory management. Large U.K. companies such as Rolls Royce, Unilever, the National Coal Board (N.C.B.) have large O.R. Departments. There is an extensive range of O.R. literature available from such sources This section will describe some general references, and the specific literature relating to engineering spares control.

JARDINE's text book "Operations Research in Maintenance" contains a chapter by ALSFORD (REF 108) on the N.C.B's O.R. study of the centralisation/distribution of maintenance stores. The N.C.B. found that centralising stock would provide large savings (reduced stock outs and holding costs), but agreed with the findings of LAWRENCE et al (REF 109) that certain small items should be readily available locally. The choices open to the N.C.B. were to either physically move the stock, or set up a computer based information system encompassing all stores. The N.C.B. decided to physically divide their stock into slow and fast movers; the slow movers are held centrally in a single store, the fast movers are held locally. OR is being used to decide which parts fall into each category based on use and the cost of transport. The distribution of parts is also being studied in an attempt ot minimise distribution costs. A comprehensive computerised stock control system was not implemented due to "the size of imformation system" required.

(The article contains N.C.B. references on stock control, setting recorder levels, and recorder quantities).

The control of slow moving spares within the N.C.B. is described by MITCHELL (REF 110). This method allows the user to decide whether to hold 0, 1, 2 or 3 spares based on a simple chart. The decision being based on the ratio of stock out cost to purchase cost, the incidence of failure and the lead time in obtaining the new part.

Mitchells article is used by LEWIS (REF 111) as the basis of a chapter within his textbook Scientific Inventory Control. One of the few texts that details slow moving engineering spares as a specific subject.

Other texts reviewing the analytical models available for inventory control are:

HADLEY and WHITIN (REF 112) - Analysis of Inventory Systems

NADDOR (REF 113) - Inventory Systems.

The Operations Research Quarterly and the Journal of the British Production and Inventory Control Society provide a regular platform for the publication of articles in this subject area. The most regularly referenced articles are included at the end of this section of the literature review.

Inventory Control In the Armed Forces

The armed forces regard inventory management as a major topic. The organisation of legistic support systems was discussed at a NATO Conference in 1970, and the papers published as a book in 1972 (REF 26). Several of the papers' topics are worthy of consideration in an industrial application, two of these are described below:

GERAERDS (Royal Netherlands Airforce) (REF 26). Philosiphising on inventory control and the development of analytical models states. "The underlying philosophy is the recognition of having stocks, involves the cost of stock holding and that having too small or too large stocks in the end leads to higher costs than choosing the right amount. The models concentrate on finding minimum stock levels for a set minimum service rate. The service rate represents quantitatively the acceptability of having to wait".

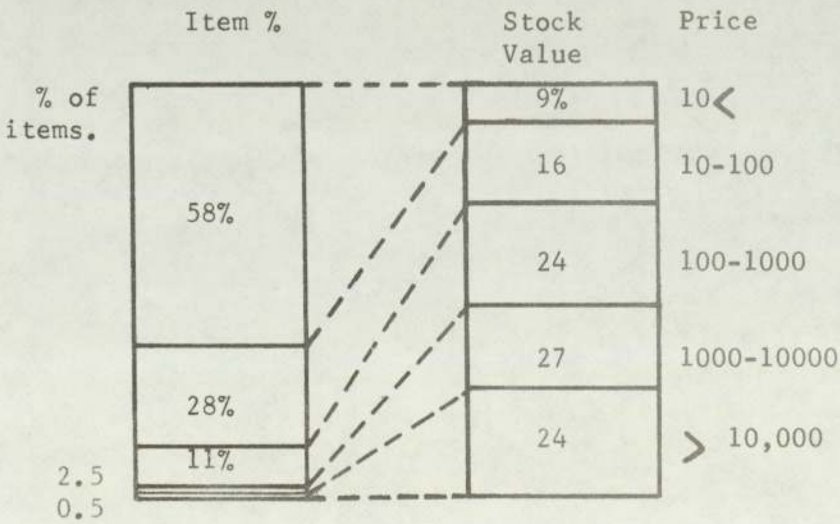
Geraerds views on maintenance inventories are worthy of repeating, and can be summarised as:

1. In a maintenance inventory it is difficult to quantify the delay penalty in case of stock cut. The diversity of materials/ spares than can cause machine unavailability requires a rather sophisticated inventory control system.

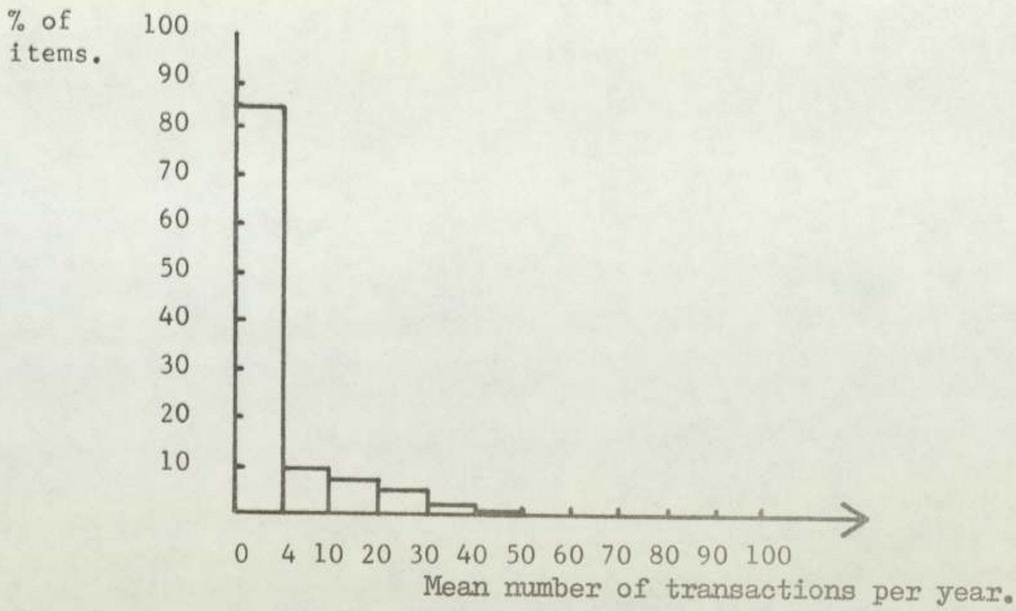
2. The maintenance items to be stocked are determined by the mere fact of possessing a piece of equipment, and having to maintain it. It is therefore not possible to exclude items from the inventory, because they are unattractive from the inventory control view point (as can be done for a 'production' item).

Geraerds illustrates this point by describing a typical maintenance inventory of some 240,000 items.

The diversity and frequency of transactions of the inventory are given as:



Value distribution of stocks



Item transaction frequency.

The majority of items have a low frequency of demand, and as a large mumber of these items are complicated, involving long and unreliable procurement times and high prices, they normally account for the greater part of the investment in stocks for maintenance. The problems of applying statistical techniques are therefore made worse by the limited effectiveness of statistics when applied to such small populations.

3. The initial spares stock levels set for a machine can not be made from historical data. The only sources of information are the manufacturers recommendations, and the experience of the users personnel. If historical data of equipment supposed to be similar is available, this may be of some use. Manufacturers in future will be expected to provide better advice on initial stock levels as a by-product of the reliability and maintainability

aspects of design, which are currently receiving greater attention. Geraerds doubts if man will be replaced by quantitative models for this type of forecasting.

The conclusions in this article are worth noting, as they aptly sum up the state of the art of inventory control and maintenance:

"Scientific fields that appear to have been or are being researched sufficiently in the present state of development of a maintenance theory are:

- Production control theory.
- OR theory in particular concerning failure rate, behaviour, reliability and availability.
- Inventory theory as far as fundamental aspects are concerned.
- Modern organisation theory.
- Economics.

Problem areas requiring fundamental research aimed at the maintenance process appear to be:

- Maintenance policies including object behaviour.
- Design of maintenance conceptions.
- Cybernetic mechanisms concerning the balance of the maintenance and production process.
- Inventory control of spare parts.

Geraerds paper was given in 1970, his conclusions are still valid as the lack of fundamental maintenance research is still apparent. Geraerds states that "The systematic analysis of, and approach to, maintenance in real cases will primarily be a task of the using organisations. As the maintenance task is relatively small compared with other functions in an organisation, activities of a reasonable size can be expected only from large organisations and from the military organisations in particular".

BARNARD and SEGER described their company's, (The Lockhead Corporation) (Ref 26) development of a spares provisioning model for aircraft. The model uses a series of mathematical routines to determine the optimum quantity of spare parts for initial support of aircraft fleets. The criteria used are limits on funds available, weight and volume. The spares are then calculated to provide the maximum aircraft availability. The system is described in detail in the paper, and was subject to considerable questioning by the conference audience. The model only covers spares for initial provisioning, and other methods would have to be used for setting subsequent stock levels as historical usage data becomes available.

The United States Air Force has made considerable use of OR, as early as 1952, an Economic Order Quantity system was in use for the purchase of expendible weapons systems. The U.S.A.F. commenced a project in 1974 to modernise its E.O.Q. system, and allow for "a price discount solicitation capability". The project is described by AUSTIN (REF 114), and several points are worthy of note as this paper describes the difficulties encountered in implementing "well known theoretical inventory models in a large real world system".

- The common E.O.Q. model assumes price per unit is constant regardless of order size i.e. the suppliers economic production cost is ignored.

- The demand forecasting technique used by the U.S.A.F. was an eight-quarter moving average, this was tested against 4 more sophisticated techniques - (single, double end triple exponential smoothing, three different weights for each, and simple linear regression, from Whitin and Hadley's text (REF 112). Single exponential smoothing with a smoothing constant of 0.1, was approximately 3 times more accurate than the next most accurate tested.

  The rate of usage should determine the forecasting method chosen:

  Low Demand (issues in 3 of the last 8 quarters)

  - Management sets forecast levels at their discretion.

  Erratic Demand (issues in 3 of the last 8 quarters but with demand standard deviation 7 average demand).

  - Use single exponential smoothing.

  Normal Demand

  - Use single exponential smoothing with a smoothing constant of 0.1.

- The analysis of safety stock gave some interesting results. The research team were unable to develop a satisfactory method of determining the stockout cost for expendible weapons systems spares. A secondary objective was to minimise the total investment in safety stock for a given overall fill rate, the results were inconclusive. To obtain this optimisation, high safety stock levels should be held for low cost items, and correspondingly low or zero stocks should be held for high cost items. This "totally ignores mission essentiality". Further research work is recommended in these areas.

Computer Packages

Most commercially available production control computer systems provide an inventory management module. In addition, several stand alone packages are available. For example I.B.M. provide IMPACT (Inventory Management Program and Control Techniques) (REF 115), ICL's SCAN (REF 116) and Siemens HOREST (REF 117) (For an interesting critique of IMPACT see KLEIJNEN and RENS (REF 118).

The optimisation of engineering spares holdings is an area almost devoid of commercial packages.

Referring to the International Directory of Software (REF 53) only two packages are listed.

LASS - Logistics Analysis Simulation System supplied by Decision Sciences Corporation. This package provides a High Value Inventory Model which establishes stock levels for high value, low demand repairable items. The stock selection criterion may be either inventory value or acceptable service level. The company also provides a module for low value inventory which is used to establish the minimum cost stock level for this type of item.

Space Shuttle Spares Optimisation Module supplied by Rockwell International USA. The program was written to provide the engineers on the American Space Shuttle Project with an analytical means of quantifying spares holdings and setting spares budget forecasts. The program also calculates the risk associated with the recommended spares holding. The software is now being sold for use in industry for computing spares holdings, and the assoicated risks.

Summary

In conclusion there is a considerable literature on inventory control. Several articles and books on the subject make reference to the same articles, which would appear to be standard references:

Mitchel G.H.	- Problems of controling slow moving spares (REF 110)
Croston J.D.	- Stock levels for slow moving items (REF 130)
	- Forecasting and stock control for intermittent demands (REF 131)
Burgin T.A.	- The Gamma distribution and inventory control (Ref 132)
Burgin T.A. & Wild A.R.	- Stock control - Experience and usable theory.(Ref 133)

Burgin and Wild worked for Dunlop at Fort Dunlop, extensive investigation by the author could find no current evidence of the actual use of any of the methodologies described in the articles. The O.R. department has been disbanded, as has the Organisation and Methods department, and no work is being carried out in inventory management theory by any other department. The current Fort Dunlop stock systems are described in chapter 2 of the thesis, and it should be noted that no O.R. inventory techniques are currently used.

The reader requiring a full bibliography in Inventory Planning should refer to Production and Inventory Management Vol 19 No. 1 1978. Pages 1 to 16.

1.6.6 Project Appraisal

"The profitability of a firm is primarily a function of its ability to generate projects or investments that provide returns greater than the cost of funds. Often management must choose between different projects, perhaps because they are mutually exclusive, or because there is a temporary shortage of funds and managerial skills".
- FRANCE and SCHOLEFIELD (Ref 119).

There are a number of different accountancy techniques available to assist in enabling a decision to be made on the viability of a project. The methods and their suitability can be summarized as follows:-

If the projects have no effect on fixed costs, then the break even or marginal cost technique is indicated. Break even is limited in use to single project situations, and marginal cost to the selection between alternatives. If fixed costs are affected the differential cost or a cash flow technique should be used. (Adapted from HARPER REF 120).

In 1976 CARSBERG and HOPE (REF 121) published the results of a survey carried out to ascertain what methods of investment appraisal have been adopted by large British firms, and to compare their findings with the methods advocated in the literature. They sent a questionnaire to a sample 325 companies, chosen randomly from The Times list of 1,000 leading U.K. companies for 1971 - 1972, and received 103 replies. One of their tables of results is reproduced below:

Choice of method of investment appraisal

Method	Number of times ranked: 1	2	3	4	5	6	7	Not mentd	Points Score
(a) Payback period-without discounting	19	7	10	9	5	4	7	42	533
(b) Payback period-with discounting	8	2	10	8	7	3	3	62	644
(c) Accounting rate of return-first year profit as ratio of book value of initial investment	12	6	8	1	3	2	6	65	641
(d) Accounting rate of return-average profit/average book value	11	4	6	13	4	-	7	58	622
(e) Net present value	10	10	7	11	4	4	7	50	588
(f) Internal rate of return (D.C.F. Yield)	28	15	10	11	3	5	9	22	436
(g) Net terminal value	-	-	-	1	-	-	4	98	816
(h) Qualitative judgement of-e.g., strategic value	34	6	15	20	6	5	2	15	365
(j) Other methods-various	4	1	2	1	1	-	-	94	

The participants ranked the methods of investment approval in the order of importance, '1' representing the highest level of importance. The overall importance of each method was then calculated by multiplying the "number of times ranked" figure by the "rank number" and summing the results, which are given as 'Points Scores' in the table. Therefore the lowest points score indicates the most popular method.

Hope and Carsbergs results therefore indicate that a "qualitative judgement" is very important in practice. This judgement may be taken after explicit financial measures have been made, or it may be that a project is 'strategically' necessary and its benefits can not be judged solely in direct cash terms. As examples, the publicity associated with the development of advanced technology or the introduction of a product that will complete a range of similar products, and thus attracts customers. The view is expressed that British management would be well advised to make more of the numerical methods available "to improve the chances of optimal decisions". The survey results do show that 76 (of 102) firms regard calculations to be fundamentaly important when making decisions, and 26 only used calculations to provide secondary confirmation of decisions already taken in principle.

When performing calculations 85% of the respondents used one of the main discounted cash flow methods, net present value or internal rate of return. In fact, internal rate of return was more popular than pay back or accounting rate of return, (see table previous page).

In the literature net present value (NPV) is sited as the 'best' method available, (see CARSBERG REF 121),for project appraisal. Internal rate of return (IRR) is probably used by British management because :-

1. NPV requires a cost of capital to be specified at the start of the analysis. IRR allows the choice of target return to be postponed right up to the final decision time.
2. IRR is expressed as a percentage, and this may be more acceptable to managers than the money values used in NPV.

from MERRETT and SYKES (REF 122).

The use of the traditional appraisal methods of payback (calculating the minimum time when the present value of receipts equals the outlay) is common,as is accounting rate of return, on both the first year basis, and as average over the projects life.

Carsberg and Hope conclude that the investment appraisal methods used by larger British firms tend to lead to investment below the optimal level.

"A large number of firms use a money target rate of return, in association with cash flow estimated at current prices (with the added disadvantage of failure to predict the effects of differential inflation, as it effects their resources). Several firms use the internal rate of return as a method of appraisal, and others use a first year accounting rate of return. Both methods in comparison with the net present value method, are likely to lead to under investment. Several firms use the payback method, which appears to reflect an unduly cautious approach to investment decisions. To affect these factors we have identified only the use of the average rate of accountancy return method, which may involve a relatively slight bias to over-investment."

The investment appraisal methods mentioned in this section have not been explained in detail, but can be found in most text books relating to the subject. Two of which are:

W.M. HARPER	MANAGEMENT ACCOUNTING (REF 120) Part 3 Decision Making.
J.R. FRANKS and H.H. SCHOLEFIELD	CORPORATE FINANCIAL MANAGEMENT (REF 119)Chap's 3,4,5,6,7 & 8.

KEEF and POINTON have written an article for the Production Engineer (REF 123), vividly explaining Discounted Cash Flow (net present value) investment appraisal, in a case study including NC machine operation, which also shows how taxation and grants can affect the viability of a project.

CHAPTER 2 ENGINEERING AT THE FORT DUNLOP FACTORY

Engineering at the Fort Dunlop Factory.

Introduction

This chapter describes the management, organisation and control systems of the Works Engineering Department at Fort Dunlop. Several management changes have occurred during the three years of this project (1977-80) and with these changes in leadership, have come changes in methods and organisation. The original (1977) organisation is described, as are the methods of work, changes that occurred are then described. Systems effected by this project have only been described in their original form to provide a starting point for the developments described in Chapter 5 and Chapter 6.

2.1 Factory Layout and Production Operation

Fort Dunlop was established in 1916 as a tyre manufacturing factory. Since then it has expanded to cover 330 acres, housing the Divisions' Machine Tool Department, Commercial Headquarters and Research Centre. Direct labour employed in the tyre factory in 1977 was 2500 with a further 846 maintenance personnel working a three shift system from Monday morning until Friday night.

Fort Dunlop today manufactures a wide range of tyres for both aeroplanes and motor vehicles, including the Denovo run flat car tyre. The "Fort" is the major factory in the U.K. Tyre Division the other factories are located at Washington, Tyne and Wear and Inchinnan, Renfrewshire.

Fort Dunlop consists of a number of separate manufacturing departments connected by a corridor, which is used as a materials highway. A site plan Figure 2.1.1 shows this relationship.

Each Tyre Manufacturing Department is supplied with rubber from the Compound Preparation Department (CPD) and with rubber fabric products from the Fabric Preparation Department (FPD). The Tyre Departments then use these products to completely build and cure a specific type of tyre. An exception to this usual pattern is Tyre 1, the Lightweight Car Radial Tyre Department, where tyres are built and then transferred to Tyre 5 for curing and finishing.

Production Management Changes

When this project was started in 1977, the production organisation consisted of foremen responsible to Departmental Managers. The Departmental Managers were responsible to one of three Production Managers (Truck, Car or Preparation). These managers in turn were responsible to the Works Director. The following changes occurred in the next two years. The plant was divided into two, each with a General Works Manager, the Departmental Managers responsibility remained the same, the Production Managers job being absorbed. When one General Works Manager resigned in June 1979 the two General Works Manager's jobs were combined. All Departmental Managers now report to a single Works Manager.

2.2 Engineering Organisation in 1977

The policy of having separate production shops within a large factory

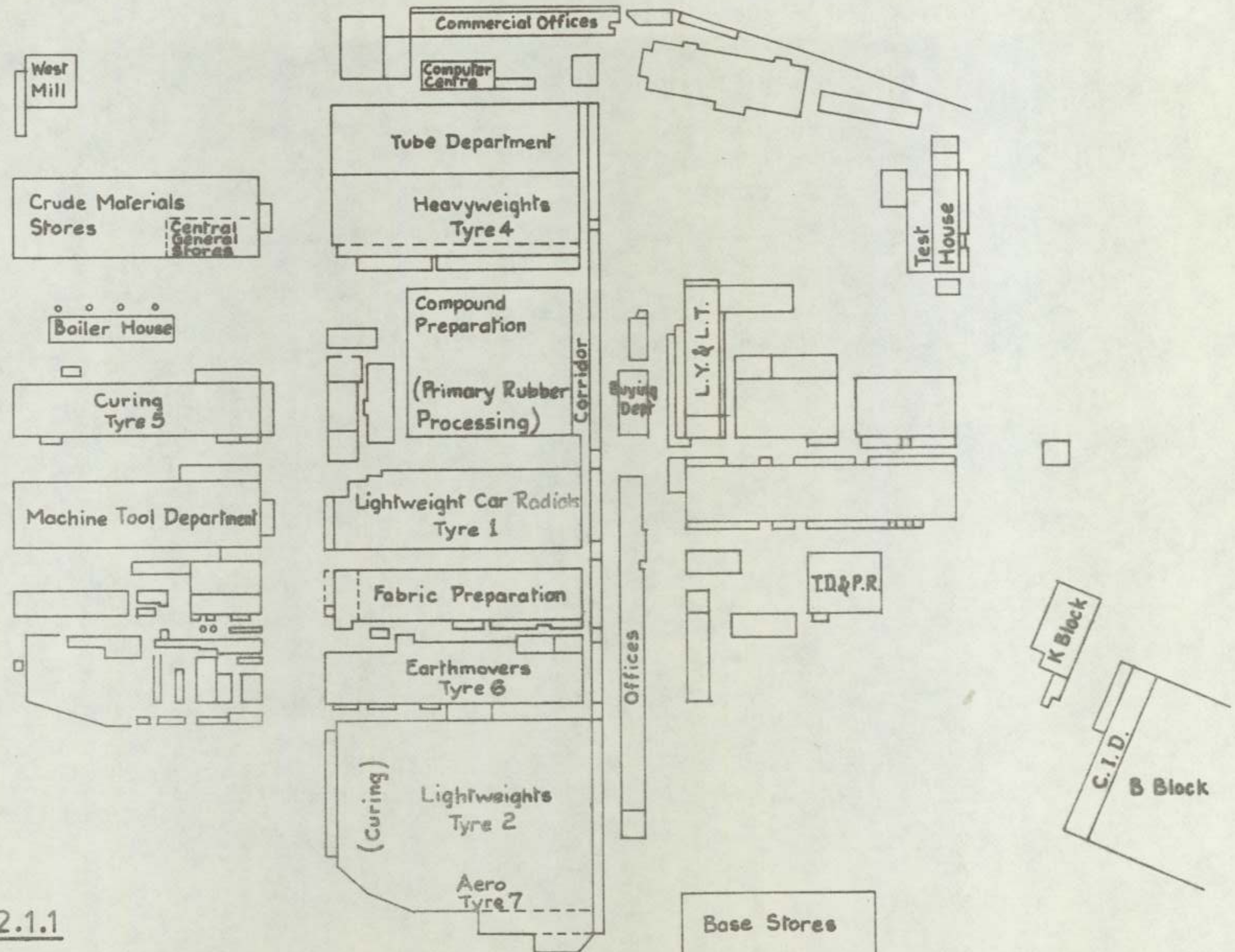


FIGURE 2.1.1
PLAN OF FORT DUNLOP

was reflected in the maintenance organisation. Each Tyre or Preparation Department had its own autonomous maintenance organisation, with separate workshops for Electricians, Millwrights and Plant Fitters. Instrument Fitters, Electronics and Scale Fitters worked from central workshops, providing a service, as required, to the factory.

The Works Engineering staff grew with the factory; by 1977 they comprised 846 tradesmen and mates, supervised by 57 foremen, working from 130 locations. These "locations" varied from a few, well equipped workshops with foremen's offices, Welding Bays, Mess Rooms showers etc., to many one and two-man unsupervised cribs. The ratio of tradesmen and mates to foremen was 14.8 to 1 but, with the size of site and 130 locations, supervision of some tradesmen was minimal.

The Works Engineering organisation chart for the above (Figure 2.2.1) shows the division of the Engineering function into:-

Zone A Zone B Zone C	Production Maintenance
Zone E&I:	Electrical, Electronics and Instruments
Service Zone	
Administration	

This organisation gave rise to a number of problems.

i. The Works Engineer had nine Engineering Managers responsible to him and had to spend a considerable amount of time on the

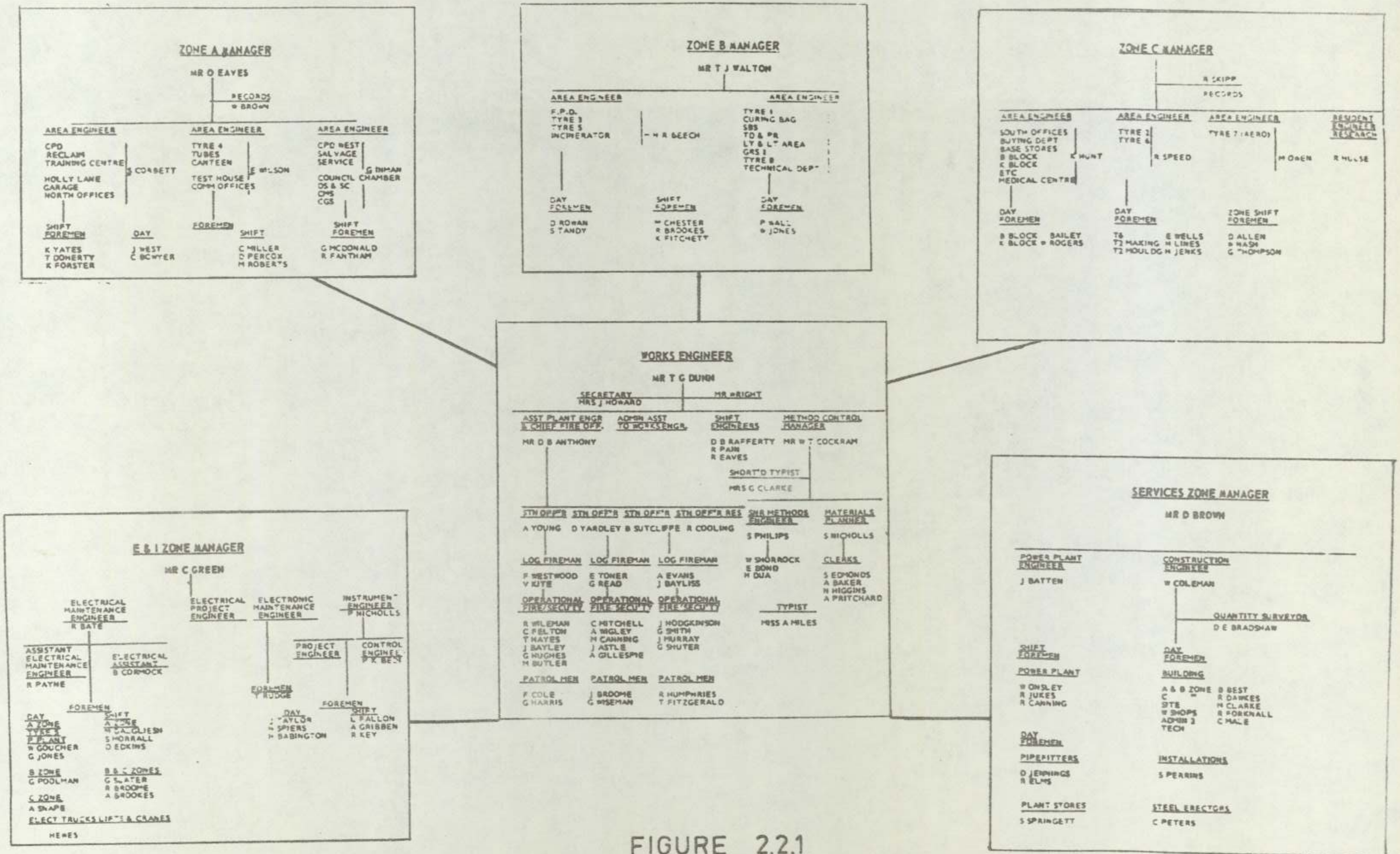


FIGURE 2.2.1

WORKS ENGINEERS ORGANISATION 1977

day-to-day factory maintenance. Little time was left for considering the longer term management of the maintenance function.

ii. The A, B and C Zone Engineering Managers provided a mechanical maintenance service to their Production Department but had no control over the electronics, electrical and instrument men working within their zone.

iii. In zone A, B and C there were 3,4 and 5 Production Managers respectively. The Zone Engineering Manager, therefore, had complex communication problems and spent a considerable amount of time in meetings.

iv. The 'Area Engineer' who was directly responsible to the Zone Engineering Manager had no authority for discipline over the men in his area as he was a non-line manager. The Zone Manager, therefore, was heavily overloaded and the whole system was very ineffective.

These problems were recognised by senior management and some reorganisation was, therefore, proposed. This was blocked by the foremen and lower levels of management who wanted payment for any organisational change. (See Engineering Organisation Changes 2.3).

2.3 Engineering Organisation Changes

The Fort Dunlop Engineering function underwent some fundamental organisation and manning changes during the period 1977 to 1979, (refer to Organisation Chart figure 2.3.1).

1. The factory was divided into two plants, (Plant 1, Plant 2)

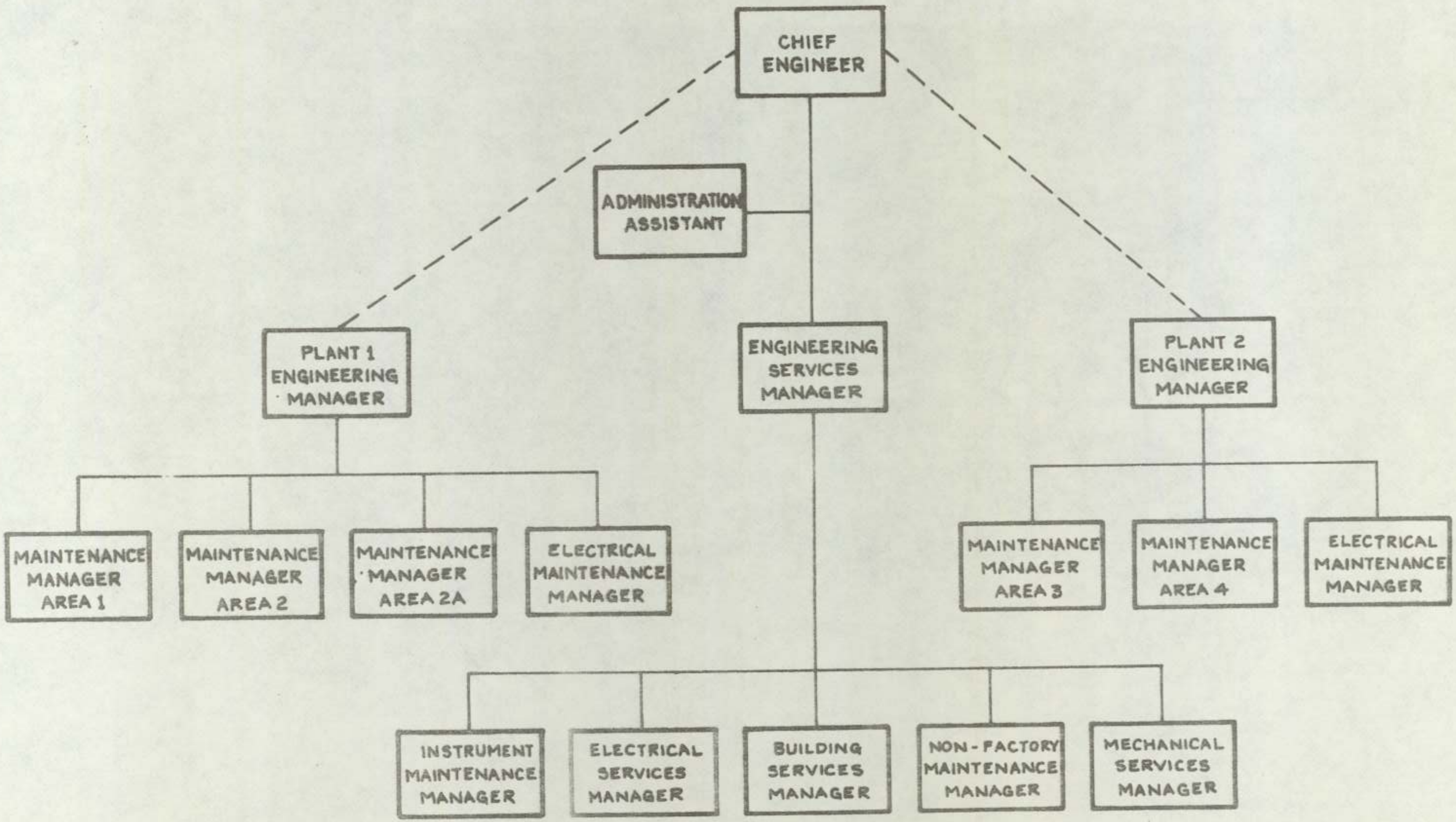


FIGURE 2.3.1

ENGINEERING ORGANISATION 1979

each with an Engineering Manager responsible to the plants' General Works Manager. The Electrical and Instruments Zone and Services Zone were combined underan Engineering Services Manager. The position of Works Engineer disappeared and the Chief Engineer took over direct responsibility for the Engineering function.

2. The maintenance 'zones' A, B and C were replaced with five maintenance areas (area 1, 2, 2A, 3 and 4) reducing the number of Production Managers serviced by each Engineering Manager. At the same time, the role of Area Engineer disappeared.

3. A redundancy exercise early in 1979 reduced the maintenance force by 240 to 606, with 49 foremen. This was mainly achieved by voluntary redundancy.

4. A scheme to reduce the number of engineering workshops to 17 (from 130) was agreed by engineering management. The first of the workshops has been built for Tyre 5 and a second has been sanctioned for Tyre 4 and Tubes.

2.4 Machinery

Fort Dunlop is an old factory with approximately 1600 production machines. Many critical items of production and service plant are 20 to 30 years old and subject to frequent and expensive breakdowns. The plant is also extremely diverse. Within a given type of machine there are variations of mark and numerous modifications have been added by the suppliers and Dunlop themselves. The machines in general were obtained from the following three main sources:

i. Dunlop Plant and Engineering Division, Coventry

Machinery is designed and built to Dunlop Tyre Division specification.

ii. Pirelli

Pirelli Machinery is now common place in Dunlop factories, after the 1971 Union of the two companies. These machines have often been "Anglicized" by the installation of British electrical, hydraulic and pneumatic control equipment. There is no consistency in this policy and equipment from several manufacturers is used for these modifications.

iii. Proprietary Machines

Standard machines are used throughout the Rubber Industry - examples are Banbury Mixers, Bag-O-Matic Tyre Presses and Bridges Mill Lines. In Dunlop all such machines have been modified by the company.

With a factory as old as Fort Dunlop, a diversity of plant can be expected. However, Dunlop appears to have adopted a policy of "buying one to try it" and this has, for example, led to mini computer controlled press lines running in the same department as rubber fabric cutting machinery installed in the 1920's.

The factory had excess manufacturing capacity in tyre building and curing. If a machine failed it was often possible to transfer the operative to another machine already set up to make the same size tyre, whilst his original machine was repaired. This was not the case, however, with most of the rubber processing machinery, mills, extruders, calenders etc., which were operated to provide the minimum of process stock. Breakdown of machines in this, 'the process' side of the factory, could cause considerable disruptions to production.

2.5 The Engineering Function

The Works Engineers have no written brief but it is expected that they should provide a universal service to production. This service would appear to cover the following:-

i. Repair, overhaul and modification of equipment
ii. Fault diagnosis
iii. Installation of equipment
iv. Equipment commissioning
v. Adjustment and set up of equipment
(even to suit the individual operator's taste)
vi. Routine cleaning and oiling
vii. Providing all factory services
viii. Providing all site and building maintenance

This policy relieves production personnel of almost all responsibility for plant and its operation in an economical manner.

Machine repair is operated on a day to day basis. The order of repairs being dependent on "who shouts loudest" rather than by planning. However, lubrication is to a planned schedule (supplied by Shell) and inspections are carried out on machines currently causing high production losses. These checks often revealed the need for an immediate repair or a job for the weekend. The weekends are also used for repairs to machines "kept going" during the previous week.

The vast majority of engineering work comes as direct requests from Production Foremen on a Work Authorisation Note (figure 2.5.1). The W.A.N. gives brief details of the job, the machine or plant identity, a cost centre, the reported time and an authorised signature. The note was a duplicate document, one copy was retained by the Production Foreman for his records, the other was taken to the Engineering Workshops and clipped onto a notice board. This board has three tiers:-

Jobs Pending

Jobs in Progress

Jobs Complete.

Tradesmen requiring work came to the board, selected a job, moved the note to "Job in progress", completed the job and on returning to the shop clipped the note on to the bottom row - "Jobs complete".

75.35.2954 BC32191/87

S 081950

DUNLOP LIMITED

Work Authorisation Note

Date 19-7-79.

From T/1 Sect. S.B.S.

To ENGS'

BREAKDOWN OR MAINTENANCE

Charge to:— Code Sanction 50/431

Req: M2

Particulars of Work

FIT CENTRE BAG.

Check No. and Name

Time On 4.00 Time Off T.A.

Equipment available to Engineers

Delivery to

Authorised Signature

FIGURE 2.5.1

FORT DUNLOP WORK AUTHORISATION NOTE.

This system was designed by the American Consultancy Company Emerson. In 1969 Dunlop had employed Emerson to restructure the Works Engineers and introduce a system of job planning and planned preventive maintenance.

Emerson's system had required the W.A.N. to be passed by the Production Foreman, to an Engineer's Planner, who gave an allowed time for the job and then scheduled the job into the day's work for the maintenance shop. The tradesman on completing the task would fill in his name, clock number and time on and time off. The notes would then be collected and the data input to an Engineering Information Computer System. This planning system ran for a short period, and failed because management never encouraged the tradesmen to fill in the information required on the W.A.N.

The planners were removed from the workshops but the note continued in use as a form on which Production Foremen could write out the particulars of a request for maintenance work. The tradesmen now either file the notes or throw them away on completing the job. Emerson's Engineering Information Computer System was never used as no data was available.

It can be seen, therefore, that the Engineering Foreman is not involved in the allocation of work. He could set priorities for his men and occasionally instructs them to do the more unpleasant jobs which are not voluntarily selected from the board. Not all jobs come with a Works Authorisation Note; a telephone call or a verbal request to a tradesman is common.

This 'system' was not designed, it is the remnant of a consultancy exercise that failed. With separate trade workshops within each department and electronics and instrument skills only available from the Central Engineering Service Workshops, a breakdown requiring several trade skills becomes a logistics nightmare. Each tradesman only responds to the foreman for his own trade from his own maintenance area. Thus a Millwright Foreman cannot directly ask an electrician to do a job. A telephone call has to be made to the Trade Foreman, or the Production Foreman has to issue another Work Authorisation Note to the electrician. The Production Foreman, therefore, has to push the job from one trade workshop to another in order to get his machine repaired. As the Works Engineering Foreman takes overall responsibility for a breakdown, down-time can be considerable. Maintenance Managers are not in control of electrical, electronic or instruments tradesmen working in their areas, as these skills come under the Electrical and Services Manager.

In 1977, as previously stated, the Works Engineering Maintenance work force was 846 tradesmen and mates which represented 25% of the direct labour force. The Ministry of Technology study of maintenance engineering in manufacturing industry (Ref 21) gave the "rubber and rubber goods manufacture" section of their sample an average figure of 9% maintenance to direct labour. Figures of 25% were only exceeded by the "chemical and allied industries" where the average was 38% which could be expected as they are generally more capital intensive. Fort Dunlop, therefore, had one engineer or mate to three production operatives or one engineer to two production machines.

The efficiency of the Engineering Department in labour utilisation or lost production time had never been accurately measured. Estimates rated the engineers working hours at between 30 and 40% of clocked hours and down-time around 15% of production hours. (See Management Section 2.6). The level of machine availability should have been excellent with a maintenance force of this size available, yet it was not. The reasons for its ineffectiveness were:-

i. Labour Utilisation

During their 1969 study, Emerson consultants concluded that a 23 man Zone crew became, in effect, a 12 man crew when allowance was made for:-

"a. Physical/mental limitations
b. Skill levels and resident machine specialists
c. Shop custom and practice, mates, oilers, sweepers
d. Union duties and other indirect time
e. Illness and absenteeism".

Their findings were equally as true in 1977 with 11% of the workforce physically handicapped, absenteeism running at 8% per annum and the other non-productive activities still continuing.

ii. Supervision

With many maintenance workers totally unsupervised, working from cribs and only seeing a foreman occasionally, a 'relaxed atmosphere' existed and this had spread into the supervised areas.

iii. Redundancy and Redruitment

Past redundancy exercises had left the Engineers' Department with less skilled men whilst young,time served men had taken redundancy pay and moved on. As a means of reducing costs, apprentice training was curtailed and engineers' wages kept low. The company was, therefore, not recruiting skilled men or training them in-house. Many semi-skilled men had been made up to skilled during and just after the second World War, but these men were not recognised as skilled outside Dunlop and, therefore, never volunteered for redunduncy. Thus, Dunlop had a group of workers who could not properly fulfil the role for which they were employed. Hence, the workforce was dominated by men aged between 50 and 60, with low skill levels.

iv. Machinery

Fort Dunlop had in the past produced the profits to set up other Dunlop factories, however, lack of investment in "the Fort" was now showing in ageing machinery and production processes. These machines were the subject of frequent breakdowns and required a high maintenance input.

The factory was carrying a considerable maintenance overhead.

Amounting to:-

£3.9 million	1976	
£4.4 million	1977	
£8.0 million	1978	
£6.4 million	1979	(lower production, 240 maintenance personnel made redundant).

In each year, wages accounted for 60% of these costs.

2.6 Management Information

2.6.1 Cost Centres

Fort Dunlop revolves around accountancy systems and the 'Cost Centres' used within these systems. To fully understand the Works Engineers information systems and their short-comings the cost centre system should first be understood.

As an example the SBS Tyre Making Machines and SBS Belt Making Machines in Tyre 1 Department are used. (The belt consists of a tread and steel 'breakers' which are assembled on the belt machine and then transferred to the tyre making machine).

i. Each factory department is given a two digit code.
Tyre 1 is 50 - department code.

ii. Each production grouping of machines is given a "supervisory cost centre code". This normally corresponds to the group of machines supervised by one Production Foreman.

SBS is 400 (within Tyre 1)

∴ 50 <u>4</u>00

iii. A group of like machines is given a cost centre. There are 17 Tyre Making Machines and 17 Belt Making Machines, all are booked to the same code.

SBS Making Machines (17) - 431 full code 50 4<u>31</u>

SBS Belt Machines (17) - 432 full code 50 4<u>32</u>

Thus all Stores Requisitions and engineers time bookings show the cost centre, 50 431 for parts and time respectively used on any SBS Making Machine in Tyre 1.

Production materials are only booked into and out of the department and so only use the two digit departmental code (50 for Tyre 1).

To record the issue of spare parts a requisition is required (section 2.7) showing the receiving department's code, cost centre and a requisitioning department code. The Works Engineers requisitioning departmental codes are three digits and in the case of Tyre 1 Engineers would be 111 (A spare part requisition for an SBS Making Machine would show receiving departmental code/cost centre 50 4<u>31</u> and requisitioning department 111 - the Works Engineers in Tyre 1). For maintenance work not directly related to a cost centre, a three digit general maintenance code is used with the departmental code.

Example lighting within Tyre 1 50 092

cranes " " " 50 095

In this way engineering labour and parts can be 'booked' to codes and the charge recovered against production cost centres.

This system is appropriate for accountancy purposes but has two major drawbacks for engineering information collection.

1. A cost centre normally contains many items of production plant e.g., a line of 14 Tyre Presses, 3 Banbury Mixers or, as in the case described, 17 Tyre Making Machines.

2. All Engineering Labour hours must be booked to production cost centres, as there is no engineering waiting time code. This results in the total clocked hours each week for the engineering labour in the department being divided proportionately between the cost centres by the Engineering Clerks. The labour utilisation figure is, therefore, 100% with men always booked as working on production machines. For cost recovery purposes this is adequate but gives false information regarding machine maintenance.

2.6.2 Management Reports

Maintenance Engineering Management at Fort Dunlop operated in an information vacuum. The reports supplied to management were a by-product of the accountancy and buying computer systems and were of little use for engineering management purposes. Six major reports were issued as listed overleaf:-

i. Cost Control Report - Disposal of Cost Appendix 2A

Produced weekly, this gave the actual maintenance cost of labour, spares and outside purchases for each Production Department compared with the absorbed costs. It was sent to the Senior Engineering Managers as it presented an overall view of the engineering expenditure.

ii. Cost Control Report - Appendix 2B

Produced weekly, this gave an overall breakdown of engineering expenditure on rechargeable materials, labour, engineers own materials, machine tool and services against the Engineering Departments' budget. This was sent to Senior Engineering Managers.

iii. Central General Stores (CGS) Issues to All Engineers - Appendix 2C

Lists, by production area, of the previous week's stores items requisitioned by any engineers working within that area. The items were shown against the cost centre they were charged on. Distributed to local Engineering Managers and read by their foreman, this report informs the manager of what items other engineering trades (electrical and services) have used within his department.

iv. CGS Issues to Engineers - Appendix 2D

This report listed all general stores items issued to the Engineering Managers Tradesmen, irrespective of the department which used the item and was issued weekly to local Engineering Managers.

v. Down-Time - Appendix 2E (Produced Manually)

The shift engineers produced down-time reports for the afternoon and night shifts. Reports on major problems were passed to the Works Engineer each morning, by the Zone Managers after consultation with the Area Managers. Down-time analysis sheets were produced weekly by the three production zones. All engineering down-time figures could be traced back to the production logs, as Engineering Foremen kept no records of their own. When there was excess machinery available, no production down-time was recorded and, on most machinery, no down-time of under one hour was recorded. The figures produced by Production and Engineering always agreed, but did not present a true picture of the situation. Only major plant was listed and machinery was grouped together within a 'cost centre' which was the area of responsibility for a Production Foreman. No information on down-time was presented (or recorded) on a machine - by - machine basis. The Electrical and Instrument Department kept a shift log recording major electrical breakdowns, normally only recording down-time in excess of one hour.

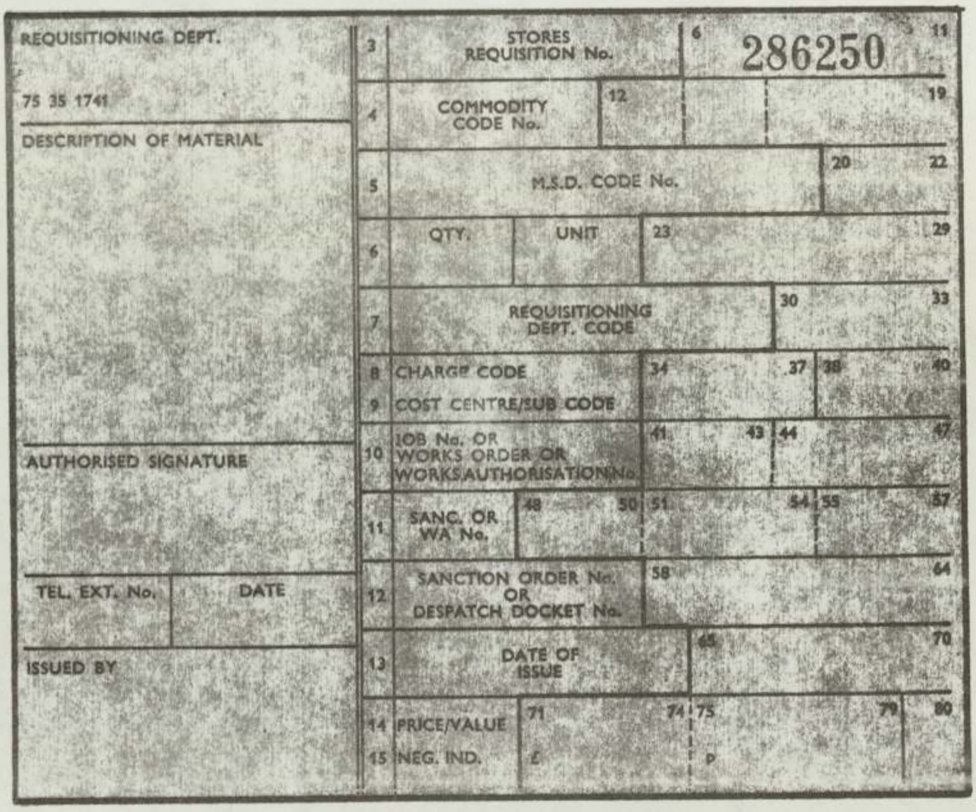
vi. Engineers Payroll - Appendix 2F

Details of hours and pay by department and worker were reported weekly as an output report from the payroll system. Many Engineering Managers did not understand the accounting reports, or how budget and absorption systems work. The Central General Stores Spares Issue Reports were looked at, but normally only to check that machine 'spares' charged to 'their' departments were requisitioned by their foremen. None of the information was detailed enough to be used for machine performance analysis.

2.7 Engineering Stores

Fort Dunlop held 12,000 different machine spare parts, valued at £904,000 at the end of 1978 with an expenditure for that year of £906,000 for parts replacement. The spares are held in a Central General Stores (C.G.S. on plan figure 2.1.1) and are issued on presentation of a requisition signed by a foreman or manager. During 1977 the stores processed 87,760 requisitions from the 57 Engineering Foremen, and 27,545 from the Machine Tool Department Foremen and job planners. To complete a requisition (figure 2.7.1) the foremen supplied:-

- a description of the item
- a commodity code obtained from the stores catalogue
- quantity
- unit e.g. Kg, yard etc.
- requisitioning department code, the engineering department code number



REQUISITIONING DEPT.
75 35 1741
DESCRIPTION OF MATERIAL
AUTHORISED SIGNATURE
TEL. EXT. No.
DATE
ISSUED BY
3 STORES REQUISITION No. 6 286250 11
4 COMMODITY CODE No. 12 19
5 M.S.D. CODE No. 20 22
6 QTY. UNIT 23 29
7 REQUISITIONING DEPT. CODE 30 33
8 CHARGE CODE 34 37 38 40
9 COST CENTRE/SUB CODE
10 JOB No. OR WORKS ORDER OR WORKS AUTHORISATION No. 41 43 44 47
11 SANC. OR WA No. 48 50 51 54 55 57
12 SANCTION ORDER No. OR DESPATCH DOCKET No. 58 64
13 DATE OF ISSUE 65 70
14 PRICE/VALUE 71 £ 74 75 P 79 80
15 NEG. IND.

FIGURE 2.7.1

STORES REQUISITION.

- charge code, the production department cost centre (see 2.6.1)

or . the sanction number or works allocation number for capital work

or . the job number (Machine Tool Dept only)

- his signature
- telephone number
- the date

In order to obtain a nut, bolt and washer, 3 requisitions had to be written out. The requisition was then either taken to the stores by a mate or tradesman or left for collection by the stores van driver who made 2 hourly rounds of the workshops (0800-1600 hrs). The goods from less than 1 in 10 requisitions were delivered by van (see chapter 4). The requisition facility was regarded as time consuming by the foreman, but they accepted the single item requisition and tolerated their men walking to and from the stores collecting mainly consumable items, the heavier machine spares being delivered by the van.

The engineers had little confidence in the stores ability to supply a spare part and so had set up 27 small, unofficial stores of their own, around the factory. Parts were booked out to production cost centres and then secreted away in these stores for future use.

Independent estimates valued the stock held in this matter at between £100,000 and £250,000. This stock was not audited, recorded or insured. If a part was unobtainable in the main stores, it was often to be found in one of these engineering stores. However, with no stock records, an engineer from another area would not know the part was on site and raise an emergency order or have the part manufactured at considerable cost to the company.

A computer system controlled the stock records, with automatic order printing at pre-determined re-order levels. These levels were set and adjusted manually by the buyers. The usual conflict of interests occurred between engineering, who wanted to keep high stock levels of spares, and the buyers, who were instructed to keep the stock to a minimum.

To have an item inserted into the Stock Control System the Engineers completed a list of items they wanted stocked (Appendix 2G) and indicated the stock levels they required. The items were then given Dunlop commodity codes by the Coding and Standards Section, and set up as a computer record. Buyers would then set up a supplier and re-order level for each part, depending on foreseen usage and lead times. This system had a number of faults. When a second machine requiring the same spares as an existing machine was installed, the stock levels were rarely altered. Also, the foremen's original spares list may have contained surplus items or the suggested stock levels may have been too high or too low.

The Coding and Standards Section catalogued parts for 64 Dunlop Group factories and had approximately 120,000 items coded as spare parts. All these items were listed in code books issued to all Dunlop factories. At Fort Dunlop, only 12,000 of the listed items were stocked and hence page after page of the code books contained no articles of interest to a Fort Dunlop Engineering Foreman (Sample attached as Appendix 2H).

With many machines so old that spares were no longer available, items had to be specially manufactured or modifications made to more readily available alternatives.

The diversity of machinery resulting from no company policy for standardisation, had led to considerable duplication of items. For example, 24 different makes of electrovalves were held where two or three would have sufficed had a company standard been issued.

CHAPTER 3 MAINTENANCE AND DATA PROCESSING

PAGE

CHAPTER 3

Introduction

To attempt to introduce a system of planned maintenance against the background described in Chapter 2 would not have been in the company's interests. The Chief Engineer at that time agreed that a means of recording basic engineering data and improving some of the methods of work was first required. Recording data for 1600 production machines being maintained by 846 men was beyond the scope of a manual system; data processing appeared to offer the answer. This chapter therefore looks at maintenance, the advantages of planned maintenance, shows that Fort Dunlop is not exceptional in not having a maintenance information system, describes the chequered history of 'shop floor' computer systems at Fort Dunlop and finally describes the Maintenance Information system required by Fort Dunlop.

Maintenance and Data Processing

3.1 Maintenance

Machines are subject to deterioration and breakdowns. This happens because materials used in manufacturing the machines deteriorate with age and use. A maintenance department's responsibility is to keep the machinery available for use and, whenever possible, try to reduce the periods of unavailability by maintaining the original condition of the machine. The constraint being the cost of providing this service.

Advances in technology have led to the use of integrated, automated machines, designed to a price and for a 'fixed' life. These machines do not have the built in 'safety factors' of older more robust and simple machinery and the reduction in original cost is later offset by the maintenance department absorbing extra costs in maintaining the machines. The machinery at Fort Dunlop reflects this national trend. The original tyre building machinery was little more than a wooden forming drum, spun by an electric motor. Tyre curing was by hand loaded autoclaves. Current technology has made it possible to install automatic tyre building machines making four tyres a minute and requiring no manual production work within the building cycle. Also available is fully automatic tyre curing with robot press loading and unloading on mini-computer controlled presses. Although such equipment is not yet in use at Fort Dunlop any preventive maintenance system must be capable of catering for such advanced technology.

In these integrated systems, with the output of one machine feeding the next, the availability of each machine is important. In a system of five machines an average availability of 90% for each machine gives a system availability of 59%. The normal practise is to hold work in progress between the machines to give a buffer against the breakdown of one unit. This ties up capital, requires floor space and increases production lead time. A 5% increase in average availability (90 to 95) gives a system availability of 77.4%. To obtain 95% availability for the five machine system, the average machine availability must be 99%.

To compensate for low availability, extra production capacity may have been acquired. Where five machine systems are required to meet the production plan at 100% availability, it takes seven machine systems at 75% availability to make the same goods.

When a production machine breaks down, the cost to the company is considerable. The order is delayed, production workers are idle and time is lost transferring to another machine.

3.2 Maintenance Policy

Before going on to discuss the various types of maintenance activities, it is worthwhile defining the terms used. The British Standard BS3811 (Ref 32)defines maintenance terms and a chart based on this standard is reproduced as Figure 3.2.1.

Maintenance activities can be generally divided between.

- Unplanned maintenance (corrective or emergency)
- Planned maintenance (corrective or preventive)

3.2.1 Unplanned Maintenance

This is a traditional breakdown or 'fire-fighting' approach. When a machine fails, a man is despatched as quickly as possible to get the machine back in service. No advanced planning is undertaken. The workload is random and the maintenance department can be caught without enough labour to handle all the breakdowns occurring.

Penalties of this type of maintenance are:-

1. Idle production personnel.

2. Accidents to machine operators

3. High rates of scrap.

4. High rates of machine wear and cost of damage.

5. High levels of work in progress between production process.

6. Low overall factory efficiency.

7. Large maintenance force.

3.2.2 Planned Maintenance

The emphasis is on the planning of the job. If the task was foreseen and the tools, parts etc., are ready, the job can be tackled more rapidly. This is defined as planned, corrective maintenance on figure 3.2.1. Planned Preventive maintenance is 'Maintenance carried out at predetermined intervals, or to other prescribed criteria, and intended to reduce the likelihood of an item not meeting an acceptable condition' (from BS3811, Ref 124) and includes inspection, lubrication, adjustments, cleaning and overhauls done at fixed intervals with manning, equipment and duration all known.

The method of introducing a planned maintenance system is seen as:-

i. Deciding on which machines the technique should be used. Lubrication and cleaning will probably be carried out on every machine but it may well be decided not to use planned preventive maintenance on machines where spare production capacity is available.

ii. Identify the items on the machine to be lubricated, adjusted, replaced or overhauled.

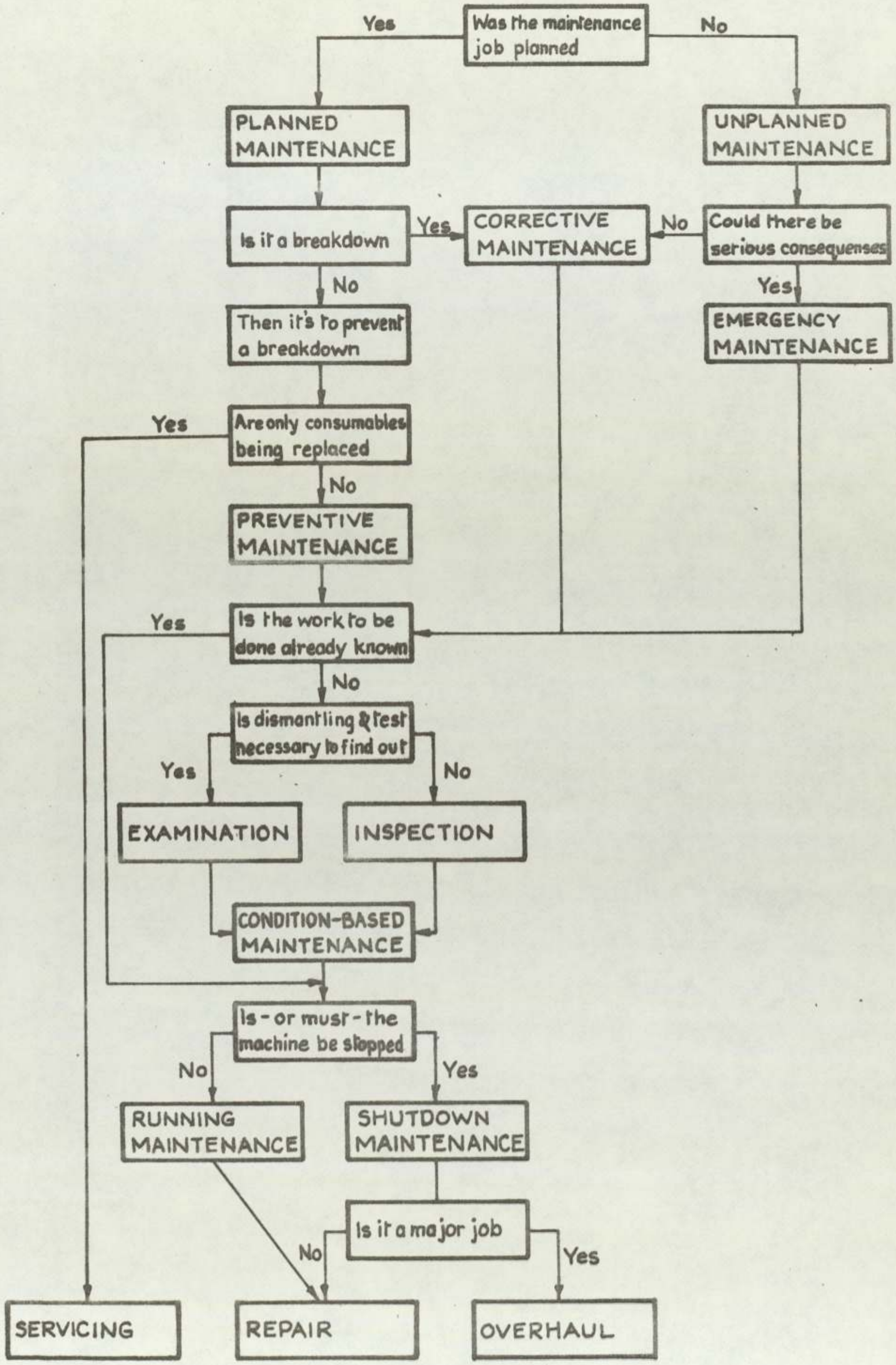


FIGURE 3.2.1

TERMS USED IN MAINTENANCE.

Using terminology from B.S. 3811
Source:– HUSBAND (Reference 13)

iii. Set up a procedure to detect the impending failure of parts. This should include machine inspections, analysis of machine repair records and the direct monitoring of the parts subject to failure. Direct monitoring is the most sophisticated and modern technique. Instruments are attached to the machine and connected to a computer. The computer compares the condition of the item with pre-set standards and indicates when maintenance is required. Examples are the temperature of a bearing, the torque of a motor, the air or oil flow through a filter, the noise level etc.,

iv. Selecting the interval between planned maintenance routines so that the machine receives attention either before it fails or deteriorates below a set level.

3.3 Control of Maintenance

The management techniques used within the production area are not in general use in the maintenance area. This is because:- 1. There are difficulties in accurately measuring the work content in maintenance jobs, (time standards etc). 2. The widely dispersed labour force is difficult to supervise. (One of the attractions of working within a maintenance department is this "right" to move freely around the factory). 3. If breakdown maintenance work predominates the work load, it makes job estimation and advanced planning difficult.

3.4 Maintenance Systems

If a maintenance department is to optimise its operation, it must control its labour, monitor its performance, keep records, pre plan work and stringently control costs. There are therefore several criteria here that a management system must fulfil.

This type of information has not, traditionally been recorded by maintenance departments. The Ministry of Technology report 1969 (Ref 21) summarised its findings as follows:-

> <u>Planning</u>
>
> Of the firms visited as many as 50% used no planning for corrective maintenance and 33% practised no preventive maintenance at all. Of those companies practising preventive maintenance, only 50% selected the machinery and frequency of maintenance on a basis of past records. Furthermore, 63% of the companies made no use of any form of work measurement or pre-determined time standards and only 4% used them effectively.
>
> Only half of the firms kept records of downtime due to inadequate maintenance and amongst these some examples of unexpected benefits were noted. In one large firm, the introduction of preventive maintenance led to the measurement of machine utilisation for the first time. This resulted in the sale of 30 machine tools which were found to be unnecessary.
>
> <u>Accounting</u>
>
> Of the sample firms visited 74% used budgets, but in only 38% were they of any real use. The main concern was too often only the equitable sharing of the maintenance expenditure between production departments.
>
> In 38% of the cases, budgets were based on history and opinion only and not prepared in the light of real quantified needs.
>
> Only 37% of firms had a prompt cost reporting system which would enable effective control to be exercised.
>
> Although 42% had a full knowledge of their direct maintenance costs only one firm (a large one) had quantified indirect costs due to downtime etc., in meaningful terms. This we consider to be among the most serious failings discovered, since without such information there is no direct measurement of the effectiveness of the maintenance force.

In the same report it was concluded that:-

> "Most Maintenance Managers are practical men, finding their promotion throughout the workshops, and few have any professional qualifications in the higher grades. In addition, their knowledge of the simple management techniques of planning, measurement and control is poor. This, together with

the detachment of most senior managements from the problems of maintenance, has led to low productivity and extensive over manning."

The types of data a maintenance department needs to record, have in the past, required considerable amounts of paperwork, costly manual analysis and difficulties in retrieving information. The results from this type of system were not available within a time scale that could effect the day to day running of the maintenance department. The answer now lies with data processing. The computer has been used for recording data in certain aspects of maintenance, normally as part of the companies accountancy system. A survey on the use of computers in maintenance administration was carried out by the British Council of Maintenance Associations (1975) (Ref 27). Two of their tables of results are reproduced see Table 3.4.1 and 3.4.2. Table 3.4.1 shows the use of computers for maintenance control, from this table it can be concluded that small companies do not use computers and neither did the two large (5000+ plus employees) companies approached. As most small companies are only starting to use computers in their accountancy departments, it is not surprising to see little use made of them in engineering. The large companies represent such a small sample that no real conclusions can be drawn.

The second table Figure 3.4.2 shows the applications. The major area of use is cost allocation, followed by plant inventory and spares stock control. These areas are all standard parts of a factory accountancy system and are most probably operated for the accountants use and not directly at the engineers' request.

Use of Computer

Of the 51 returns, 16 organisations use a computer to provide Maintenance Control Information.

Company Employees		YES	NO
0 - 500	-	1	21
501 - 1000	-	4	4
1001 - 2000	-	6	4
2001 - 5000	-	4	3
Over 5000	-	Nil	2
Unknown	-	1	1
		16	35

Table 3.4.1.

Use made of Computers to provide Maintenance Control Information.

Source BCMA (Ref 27)

Application/Function		
Job Planning/Programming	-	5
Resource Allocation	-	5
Preventive Maintenance Information	-	3
Corrective Maintenance Information	-	3
Lubrication Scheduling	-	3
Breakdown Recording/Analysis	-	3
Costs Allocation	-	15
Plant Inventory	-	7
Spares Stock Control	-	7
Project Control	-	1
Statistical Analyses	-	5
Other	-	1

Table 3.4.2

Application of Computers in Maintenance.

Source BCM[illegible] (Ref [illegible])

The BCMA concluded that in 1975 computers were not being widely used for maintenance information.

3.5 Dunlop

The description of Fort Dunlop's Engineering Operation (Chapter 2), fits almost exactly into the "typical" maintenance organisation described in section 3.4 of this chapter. The data available was a 'spin off' from the accountancy and stock control systems and of little use to an engineer. An engineering information system was required and with a factory of Fort Dunlop's size the only practicable system would be computer based.

3.5.1 Fort Dunlop Computer Systems

Dunlops Tyre Division has used computers since 1961, when a LEO III was installed. A second LEO was installed in 1965. In 1969 the LEO's were replaced with an IBM 360/50. In 1971 the first 'Real Time' and 'Tele-processing' systems were introduced. A remote job entry facility, linking an IBM mini computer to the 360's central processer was also installed. In 1972 the 360/50 was replaced by a 370/155. This machine was replaced in 1977 with the IBM 2 megabyte IBM 370/158 currently in use at Fort Dunlop.

The 370/158 computer uses Virtual Storage (VS) soft ware - the operating system IMS/VS (Information Management System) for data base management and CICS/VS (Customer Information Control Systems) to provide the interface between the VS operating system, access methods (IMS) and application programmes thus enabling terminals to interact with the data bases. There are currently some 150 terminals in use, this reflects the policy that computers should provide 'up to date' information and collect data at source, whilst reducing the number of reports circulating in the company. The Software products and central hardware are listed in Appendix 3.A.

3.5.2. The Use of the Computer Resource

The division of processing time on the computer (1977) is shown in Figure 3.5.1. The division of processing time was heavily in favour of accountancy and National Tyre Service (Dunlop's tyre retailing company). The production functions received only 4% of processing time. The systems network (1977) Figure 3.5.2 shows all the areas using computer resources and how they are interlinked. The lack of any manufacturing control systems is evident, and was acknowledged by the computer centre management as an area where systems should be introduced.

The need to use computers on the factory floor had already been seen. Two systems had been attempted in the recent past. As has already been described, in 1969, Dunlop had employed Emerson Consultants to develop a Planned Maintenance system. The Works Authorisation note and engineering time booking systems were remnants of this system. The shop floor and management had been soured to both planned maintenance and computer systems because of the paper work Emersons' had wanted to introduce. In brief, it utilised planners in each department who handled both planned and breakdown maintenance, feeding the data to the computer for analysis and report purposes. The system ran for under a week failing because of the tradesmens refusal to complete the job cards.

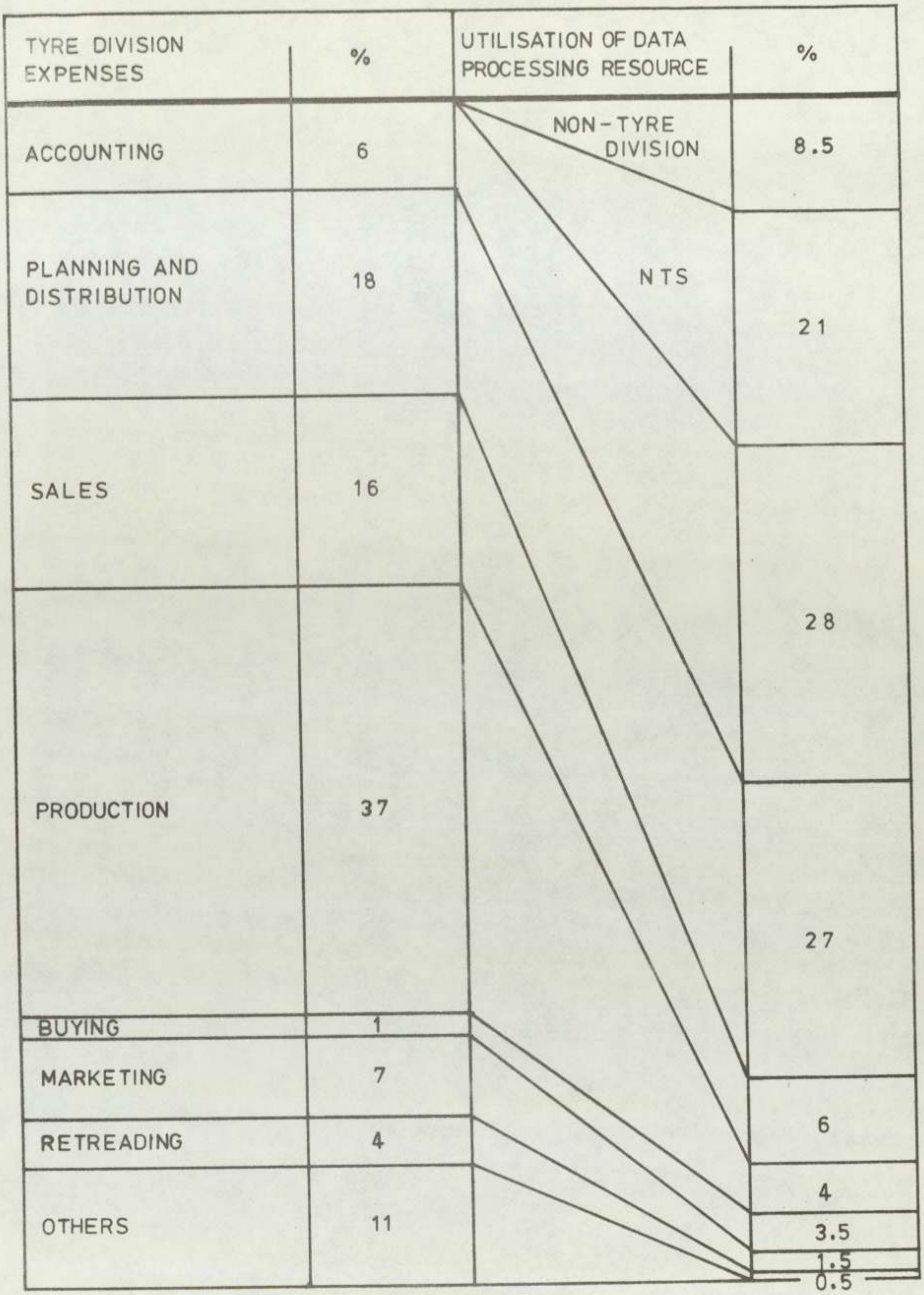


FIGURE 3.5.1

UTILISATION OF TOTAL DATA PROCESSING RESOURCES 1977

Compared with Tyre Division Expenses by Functional Area (1977 Plan)

Source:- Dunlop Computer Centre

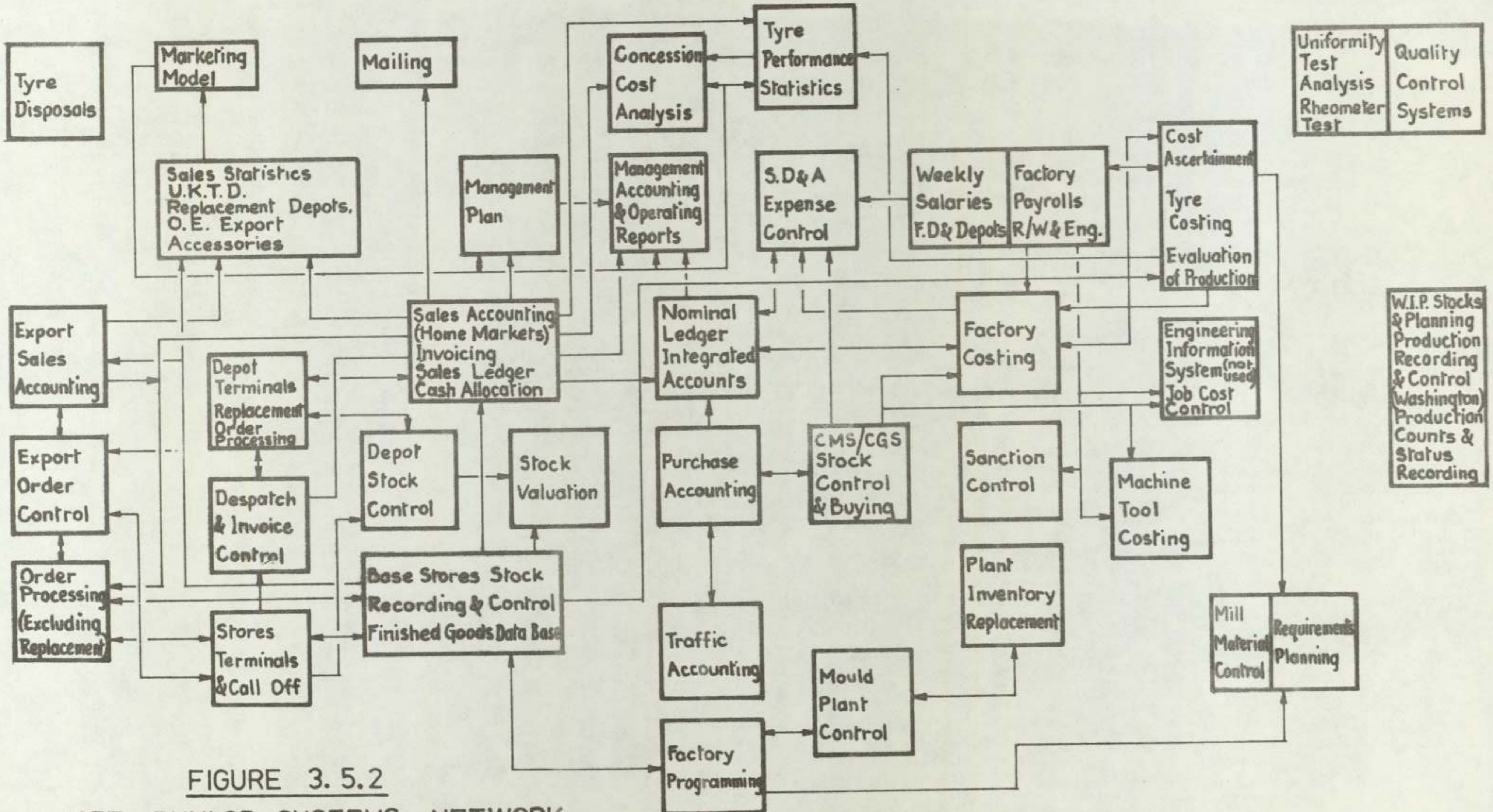


FIGURE 3. 5. 2

FORT DUNLOP SYSTEMS NETWORK

FOR UK. TYRE GROUP

Source - Dunlop Computer Centre

A later attempt at introducing a monitoring system had also failed. A manufacturing guidance system (MAGS) used successfully at the Washington factory and by Dunlop France was installed in Tyre 4, Fort Dunlop. MAGS is a production control system, with status units attached to each machine. These units are connected to a mini computer (General Automation SP45) which logs the output of each machine. The status unit has a switch which could be set by the machine operator to inform the computer of problems such as lack of rubber product, mechanical breakdown, production foreman required etc. The computer records these requests and then signals the appropriate action. Engineering down time is recorded and the status and production details of each machine is available on line printers in production and engineering offices.

During the first week of operation at Fort Dunlop, the production operatives refused to use the status units unless the company made a considerable payment. Protracted negotiations followed but came to deadlock and the system fell into disuse. The computer and terminals stood idle from this time.

The author decided that the establishment of a maintenance information system, recording the cost, frequency and nature of all engineering work, was essential before the planned maintenance system specified in the original terms of reference could be developed.

Coming after these systems a 'new' computer based system would have to meet the following objectives if it was to be adopted successfully.

- produce simply understood - one page reports
- provide easy access to all data recorded (VDU's being the best means)

- Capture data at source
- Restrict the collection of shop floor data. (Collecting too much data becomes self defeating as analysis becomes difficult and the maintenance worker makes mistakes in recording the data).
- The system must be designed with the co-operation of shop floor personnel, as they provide the input. Reports should be designed to feed back results to these workers.
- Senior engineering management must become involved in the design, implementation and operation of the system.

3.6 A Maintenance Information System for Fort Dunlop

The financial position and maintenance organisation of Fort Dunlop, have been described in Chapters 1 and 2 respectively. Within this background of management re-organisation, labour reduction exercises and expenditure restrictions the necessity of providing a much improved maintenance service became imperative. The need to plan work, utilise labour and monitor the costs and machine performance was seen as essential by the senior engineering management. A comprehensive maintenance information system was required with the objectives of:-

1. Minimising maintenance costs whilst maximising profits.
2. Accumulating data to be used in analysing the performance of process machinery and maintenance departments.
3. Providing information for management to enable decisions to be

based on the most up to date data available.

With these objectives in mind an outline system design was produced. A full maintenance information system could not be implemented 'overnight' but would have to be built up in stages which were seen as:-

i. Job Recording

The details of all work undertaken by the engineering tradesmen should be recorded using a work order and this data submitted to the computer to form part of the machine history and provide information on labour utilisation.

ii. Materials Control

All items stocked by the UK Tyre Division were recorded using a stock control system on the IBM mainframe at Fort Dunlop. Stock information was made available to Tyre Divisions Buying Department personnel. A system was required that would make stock information available to the maintenance engineers and register stock movements as they occurred. The issue of a commodity should be recorded against the production machine (or plant) requiring the item (rather than the cost centre) which would provide a further section of the plant history.

iii. Purchases

Purchases of items for use on production machinery or plant should be recorded on a computer file to complete the plant history.

iv. Analysis of Equipment and Maintenance Costs

Analysis of the computer plant history file generated from the systems detailed in i, ii and iii would then provide information on costs, frequency of breakdowns, use of spares, relative performance of machines, performance of the maintenance function etc.

v. Planned Maintenance

Using the data from the plant history file, the maintenance requirement for each item of plant and production machine can be ascertained and schedules produced. If found to be justified, the computer could be used to store these schedules and print daily/weekly lists of routines to be carried out and record the satisfactory completion of the work. The effectiveness of the planned preventive maintenance work undertaken could be monitored using the plant history file and schedules amended as required.

vi. The Scheduling of Maintenance Work

If estimates of time and labour required are given to each job arising, a system of work scheduling by computer can be introduced.

The job recording and materials control systems (including purchases) were seen as pre requisites to the full plant maintenance system. This was discussed with the then Chief Engineer and the author was asked to write a report on a means of developing a limited information system for use in one department at Fort Dunlop. The report, "Computer

Aided Machinery Performance Analysis" June 1977 (Reference 129) outlined an information system for Tyre 4 Department. It was suggested that the General Automation SP45 mini computer installed for the Manufacturing Guidance System (See Section 3.5.2) which was standing idle should be used as a dedicated engineering information computer recording data on tyre making machinery.

A fully on line Job recording system was proposed whereby production foremen enter the initial requests for maintenance on a terminal. The computer would record the request and display the nature and priority of the work on engineering V.D.U. Engineering foremen would then record the trades used and nature of the work. Times and dates being either recorded automatically or input to the system (Figure 3.6.1). A materials control system was also planned whereby the SP45 computer would carry a complete spare parts listing for the Tyre 4 machines. Engineering foremen could then interrogate these lists via their VDU, select a part and order it via a link to the factory central stores. The order information would include the machine number so recording the part to a machine. The SP45 does not have the capability of being interfaced with the IBM 370/158, therefore a tape would have to be produced daily to update the accountancy systems on the main frame with details of spare parts issued to machines.

This system was seen as a means of developing the software for a whole factory system, whilst giving an important production unit in the factory an engineering information system.

The report was presented to the Fort Dunlop Computer Centre management where it received a negative response. The main comments being that all other factory systems had failed, they had extremely limited

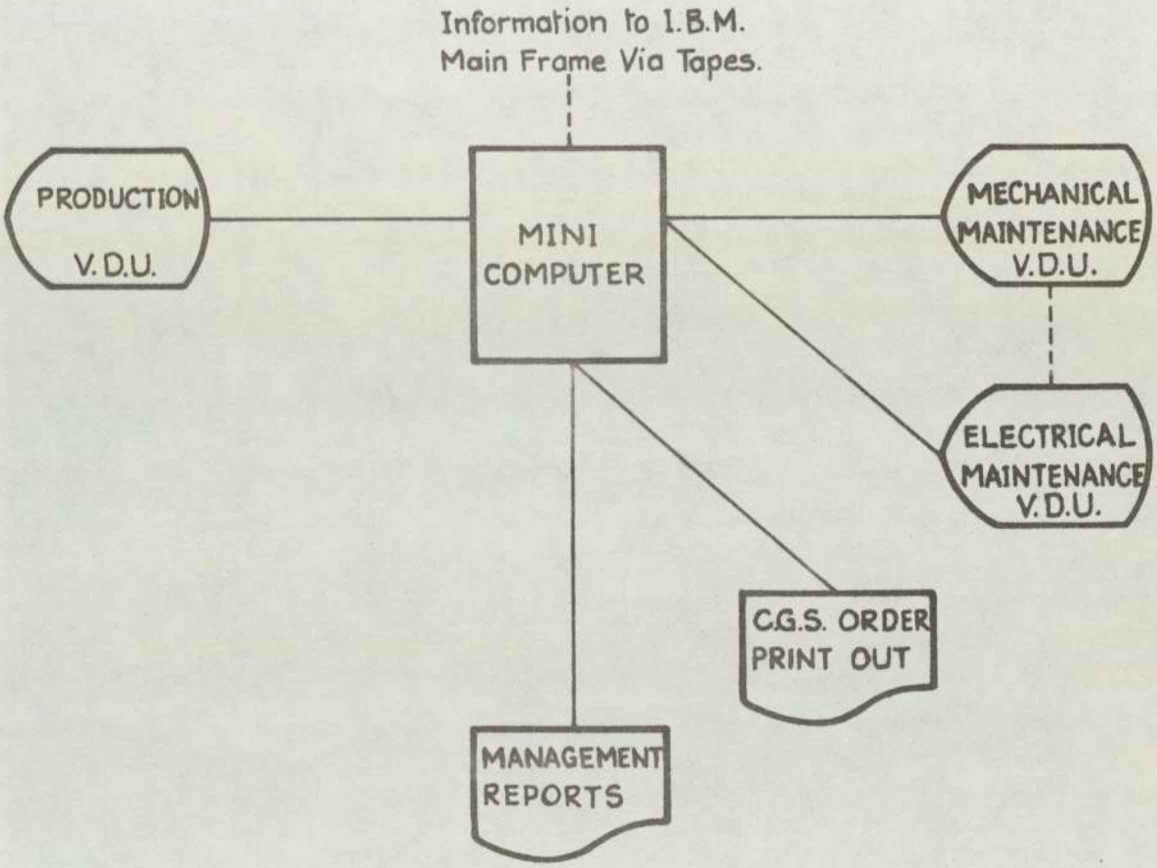


FIGURE 3.6.1
ENVISAGED TYRE 4 MINI COMPUTER SYSTEM.

programming resources and that the SP45 was a machine of questionable reliability. After repeated approaches to the Computer Centre management, the engineering management decided to look into the possibilities of purchasing a new mini or micro computer to undertake the materials control section of this system. A review of micro-computers was undertaken with the help of the Department of Production Engineering at Aston University. This resulted in a decision to apply for the purchase a ZILOG Z80 micro computer system. The Works Engineer at the Tyre Division, Washington, factory expressed an interest in using a similar system for spares control. It was envisaged that the micro-computer would hold a spare parts catalogue, and using a terminal it would be possible to check the availability of a part and order that item from the factory store. The computer would record the issue of the part to the appropriate machine. Washington would use the system for the whole factory and at Fort Dunlop the system would be used in Tyre 1, as an initial application.

The circulation of an application to purchase these machines caused considerable interest amongst the Computer Centre management and a meeting was arranged to discuss the implications of the Engineers developing their own computerised system.

Following a change of systems development management staff at the Computer Centre, the principles of a maintenance information system were favourably received. However, after much consideration it was agreed that the materials control system should be developed using the IBM 370/158 mainframe which already ran the stock control system. The job recording system was seen as potentially more difficult to implement as the system would require the completion of some form of job report by the tradesmen. At that time the management was negotiating the principles of a self financing productivity deal and it was thought that the acceptance of a job report form could be obtained as part of the 'package'. The Chief Engineer left the company at this stage (December 1977), and the Divisional Engineer temporarily took over the Chief Engineers role until a replacement was appointed in May 1978. Development work progressed on the materials control system and initial investigation and design work was undertaken on the job recording system. The new Chief Engineer hired P A Management Consultants to provide an incentive payment scheme based on work measurement rather than use his predecessor's scheme based on departmental savings (e.g., energy, use of contractors) which was being discussed when he arrived. Work on the job recording system was suspended at this time and recommenced at the end of September 1978. During this period (April - September 1978) P. A. and the Engineering Management developed an Engineering Strategy designed to reduce the engineering workforce by 240 workers and negotiated a Plant Agreement between the management and engineering unions. An incentive payment scheme will be implemented early in 1980 and the job recording system designed as part of this project will operate the scheme, and monitor its effectiveness.

The development of the materials control system is described in Chapter 4. The system was entitled "The Engineering Spares System" because of its engineering origins. The job recording system (entitled the Engineering Request Card) is described in Chapter 5.

CHAPTER 4 ENGINEERING SPARES SYSTEM

4. ENGINEERING SPARES SYSTEM

4.1. Overview

The Engineering Spares System was first operated in October 1979. It is a computer system providing stock information for Dunlops U.K. Tyre Division and a computerised stores catalogue for 64 of Dunlop's factories. The system also provides facilities for the Works Engineers at Fort Dunlop to requisition stores items and for stores personnel to record the receipt of goods.

At Fort Dunlop, the five main Engineering Workshops and Machine Tool Department each have a Visual Display Unit (V.D.U) and keyboard linked to the IBM 370 158 mainframe computer. The engineering foreman can access a stores catalogue and a Material Control data base providing up to date information on any stock item. A stores order can be keyed in, and a requisition is printed at the factory Central General Stores.

The item is then either delivered to the workshop by a stores delivery van or placed in a rack for collection by a 'runner' from the Engineering Workshop.

The stock record within the Materials Control data base is updated with the issue and the requisition details, (date, charge code, foremans identity etc) are recorded on an issues history file for analysis purposes.

Goods arriving at the stores are booked into the system on a stores V.D.U. and keyboard. The stock records in the Materials Control data base are updated and a record of the receipt is printed as an authorisation for the Financial Accounts Department to clear the invoice for payment.

Internal transfers of stock between Dunlop factory stores are also recorded on the terminal. Goods returned to suppliers are booked out of the system on the stores terminal, the data base again being updated.

The spares system is available 24 hours a day for enquiry purposes. The requisition and goods inwards facilities are available from 0700 to 17oo hours, there being little call for them outside these hours. The stock information and stores catalogue facility are used by the Buying Departments at Fort Dunlop, Washington and the Inchinnan Tyre Division factories. They provide the Buyers with a comprehensive information system available on a V.D.U., or as hard copy from a line printer.

Fort Dunlop houses the 'Group Purchasing' department with responsibility for purchasing stores items for Dunlops overseas factories and producing and maintaining the stores catalogue. Group Purchasing's buyers use a terminal to access the stores catalogue and the Tyre Division Buying Departments information, obtaining current prices and suppliers. The stores catalogue information is the keystone to the Engineering Spares System and ,to ensure its currency, a terminal is used by the Group Purchasing Coding clerks. Updating the catalogue is performed by a batch program, but the terminal reduces the time spent coding new items compared with manual coding.

4.2. Development

Tyre Division operated a conventional stock control system, taking paper requisitions, goods receipts, stock checks etc., and passing them through a series of batch programs twice weekly. Each stock item had a designated re order level, order quantity and supplier. When the stock reached or fell below this level an order was raised by the computer, endorsed by a buyer and sent to the supplier. All issues receipts and orders were recorded on history files and a series of reports produced weekly and monthly.

The stores catalogue information for 64 of Dunlops factories including Tyre Divisions was also held on the computer; approximate file sizes were:-

<u>Overseas factories</u>

25,000 commodities
(41,500 catalogue entries)

<u>U K Factories</u>

69,000 commodities
(113,000 catalogue entries)

included in the UK factories are:-

<u>U K Tyre Division</u>

20,000 commodities
(51,000 catalogue entries)

<u>Fort Dunlop</u>

12,000 commodities

When combined the total catalogue now has 120,000 entries.

Catalogue entries exceed commodities because an item can be recorded as being used on more than one machine. In this case it is given a master code number (the code it is actually stocked under in the stores) and each catalogue entry is given a code within the sequence for the machine being coded. The master code is also shown on the machine listing in the catalogue and is used when requisitioning the item from the stores.

The computer was therefore holding a spares catalogue and operating a stock control system for the U K Tyre Division. To provide an on line, information system the stock control system would have to be converted to a data base to allow the issue and receipt of commodities to be recorded. To completely re program the stock control system could not be justified, so a compromise was made. The batch stock control system would be kept and run twice weekly but a data base would be created after each of these runs, providing data for display in the Engineering Spares System. This data base would then be updated with stock issues and receipts between the batch runs. V.D.U's linked to the system would display the information and keyboards be used to enter transactions. The batch Stock Control run would then receive data from a log file recording all terminal transactions and paper input of stock checks, stock and supplier information etc., as in the past.

4.2.1. Terms of Reference

To provide some guide lines for the systems development the author wrote terms of reference which were agreed by the Chief Engineer and the Computer Centre Management.

TERMS OF REFERENCE FOR AN ENGINEERING SPARES SYSTEM

Objectives

1. To improve the effectiveness of Engineering staff by:-
   - Reducing the volume of paperwork, thereby enabling the Foremen to spend more time on the shop floor.
   - Improving the availability of Tradesmen by:-
     - Eliminating wasted journeys to the stores.
     - Increasing the percentage of spares delivered by CGS van.
     - Increasing the use of mates in collecting urgent spares.

2. To improve machine availability by:-
   - Reducing stockouts through the more up-to-date stock records made available.
   - Faster response, by Engineering Foreman, to stockout situations.
   - Enabling spares to be 'reserved' for specified purposes (eg shutdown work).
   - Providing data that can be used to assist Engineering Management in decision making.

3. To increase stock security by:-
   - Eliminating paper requisitions.
   - Quickly indicating abnormal withdrawals.

4. To provide a basis for future developments by:-
   - Providing an essential part of the Engineering data base.
   - Providing data for use in the standardisation of parts.
   - Establishing the use of on line computing in shop floor Engineering.

Scope

1. The system will be designed to be capable of extension to all parts of the Fort Dunlop and Washington factories.

2. Account will be taken of the requirements of Speke* and Inchinnan factories so that the system can provide the basis for similar developments at these sites.

3. The system will be capable of handling all types of machine spares.

4. The system will be required to operate on a 24 hours/day 5½ day week basis.

5. The development will be in phases. The first phase will be a pilot scheme in one Tyre Shop at Fort Dunlop (probably Tyre 1).

4.2.2. Business Areas Effected

The Engineering Spares System originated from the Works Engineers Department's requirements for information and improvements in the logistics of obtaining spare parts. The Stock Control System was used by several departments in the business who either supplied data or worked from the systems output. It was, therefore, decided to discuss with the managers of these departments the system being planned for the engineers and to design a comprehensive system catering for all users.

The areas with direct involvement in the Stock Control System were:-

* Note: The Speke factory was closed in 1979.

Central General Stores	-	Issue and receipt of stores items. Stockchecking.
Buying Department	-	Stock control, placing orders, setting up contracts etc.
Financial Accounts	-	Payment of invoices.
Coding and Standards	-	Maintenance and initial set up of commodity code numbers.
Computer Centre	-	Maintaining and operating the stock and commodity coding system.
Maintenance Engineers	-	Using spares, providing lists of items to be set up as spares, setting stock levels (in collaboration with Buying Department).
Internal Audit	-	Auditing Stores System.
Site Security	-	Security of stock.
Machine Tool	-	Requisition of spare parts and materials.

All were visited and wherever possible their requirements were included in the Engineering Spares System.

The IBM mainframe computer operated the Stock Control System for the Tyre Division factories at Inchinnan and Speke. These factories transmitted their input data to Fort Dunlop to be submitted to the Stock Control system. The Engineering Spares System could therefore be used at these factories and meetings took place to ascertain their requirements. The third Tyre Division factory at Washington did not have a data transmission link, as the cost of putting in a line had not been justified. It was thought that the Spares System would provide sufficient return on capital to justify the line and a visit was made by the author to discuss the computerisation of their stock records and the adoption of the Engineering Spares System.

4.2.3. Time Scale

Figure 4.2.1., shows the various stages in the systems development during 1978 and 1979. Each stage is now briefly explained.

1. Screen design and Index System

The V.D.U. screens' contents, their layout and the method of calling up a screen was designed. After demonstration to potential users the screens were modified.

2. Demonstration System

A series of screens, showing a user how the system operated, was programmed and shown to representative groups of personnel from all departments to be effected by the system's introduction. Care was taken to include the Engineering Trades Union stewards and all Engineering foremen and managers. The demonstration was shown at Speke and Inchinnan on terminals already installed. All Central General Stores staff were shown the demonstration. Comments were noted and the screen design and system's operation were amended to encompass several of the suggestions made during these sessions.

3. Justification Report Produced

This report is available as Reference 35. All sanction applications for computer hardware must be accompanied by a justification report written to a prescribed Dunlop standard. The report had to include the system design and therefore could only be written after the screen design and the majority of the computer suite design had been completed. Section 4.10 summarises the main points in the justification.

4. Suite, Design, Program Design and Specification Writing

An overall system design was produced and all program specifications written. At this stage a Project Programmer became a full time member of the project team to work on the data base design.

5. Programming

The Project Programmer and a programmer had been involved in the suite design and wrote several of the programs. The majority of the programming took place in November 1978 when 9 Computer Centre Programmers were seconded to the project, for one month.

6. Systems Trials of Buying, Supplier and Commodity Screens

The Buying Information was tested out and this single screen implemented at the Buying Departments at Fort Dunlop, Speke and Inchinnan (Point 7).

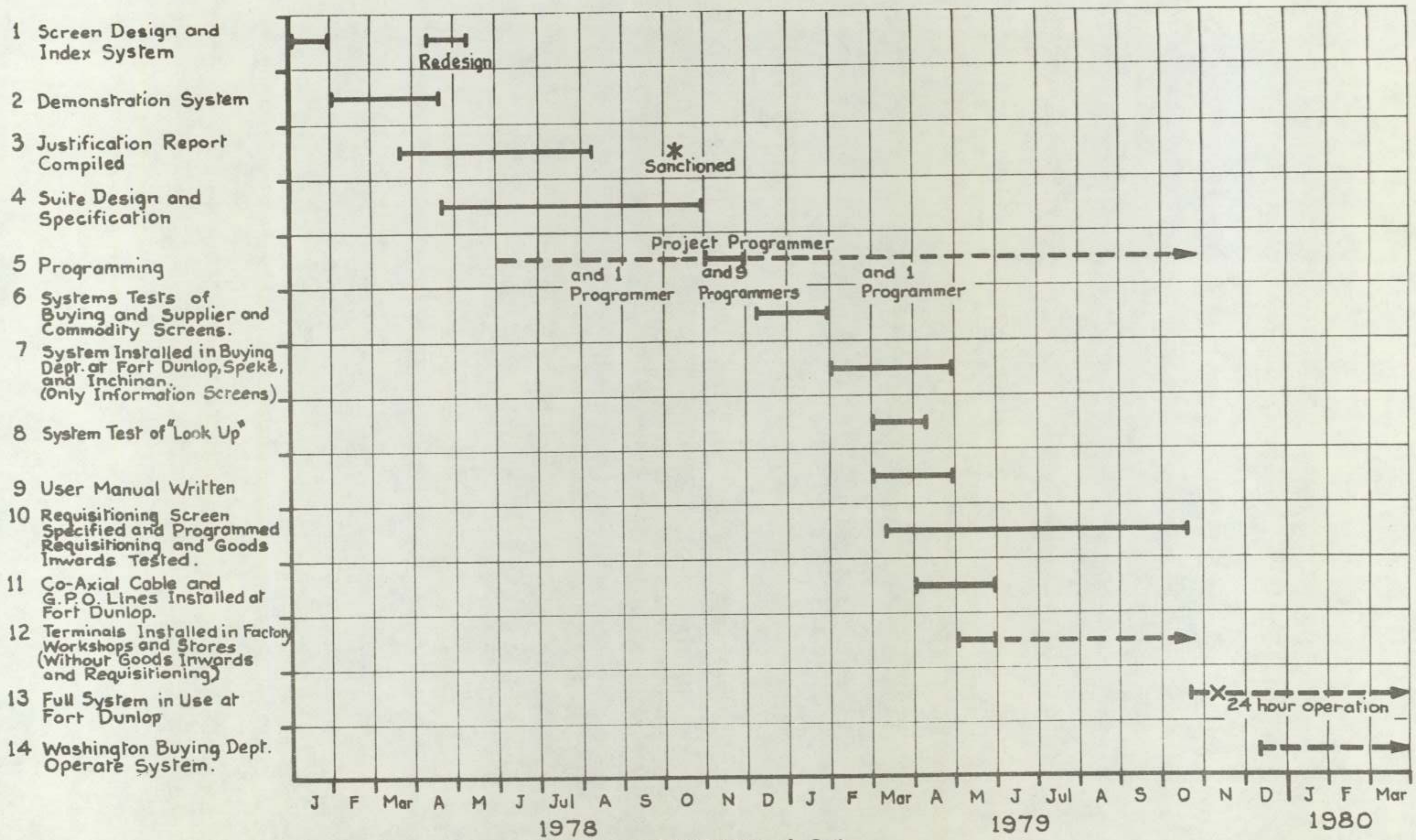


FIGURE 4.2.1
THE ENGINEERING SPARES SYSTEM DEVELOPMENT TIME SCALE.

8. System Trial of the Look Up System (the item enclosed)

The Look Up System is the series of V.D.U. Screens which allow the commodity code number of any item to be found. The screens were tested and errors corrected.

9. Writing of User Manual

This manual was written using a Word Processor function on the Fort Dunlop mainframe.

10. Requisitioning and Goods Inwards System Trials and Programming

The Goods Inwards Screen was programmed and tested along with the Requisitioning Screen. The programmer assigned to the project left the company at this time thereby delaying the project.

11. Co-Axial Cable installed at Fort Dunlop

A contractor was used to lay co-axial cable to connect the factory terminals to the mainframe. The G.P.O. line to the Machine Tool Dept. 'remote' terminal was also installed. (See Equipment 4.2.4.).

12. Terminals installed at Fort Dunlop

For list of equipment see 4.2.4. The system was implemented without the Requisitioning and Goods Inwards Screen.

13. Full system in Operation

The full system was operated on 'days' (0800-1700 hours) until it was seen to be working properly. It was then switched on to 24 hour operation. This involved several major changes in the computers operation as no other on line system operated 24 hours a day.

14. <u>Washington Buying Department</u>

Terminals and a G.P.O. link were installed at the Washington factory and the systems information screens are now in use. The full system is to be introduced early in 1980.

4.2.4. <u>Equipment Installed</u>

<u>Fort Dunlop</u>

The equipment currently installed for the 'Spares System' is shown on the site plan figure 4.2.2. All terminals are linked to the Mainframe IBM 370 158 housed in the Commercial Office Block.

<u>Local</u> (Co-Axial Cable Connection)

Tyre 4 Maintenance Workshop Compound Preparation Workshop Tyre 1 Maintenance Workshop Tyre 2,6,7 Maintenance Workshop Central General Stores Buying Department	IBM 3278 Visual Display Units and Keyboards.
Central General Stores Buying Department	IBM 3287 Model 2 line printer (120 characters per second)

<u>Remote</u> (G.P.O. Line Connection)

Machine Tool	IBM 3276 Control Unit, Visual Display Unit and Keyboard.
Tyre 5 Maintenance Workshop	IBM 3278 VDU and Keyboard.
Coding and Standards B Block Group Purchasing B Block	ITT Visual Display Unit and Keyboard.

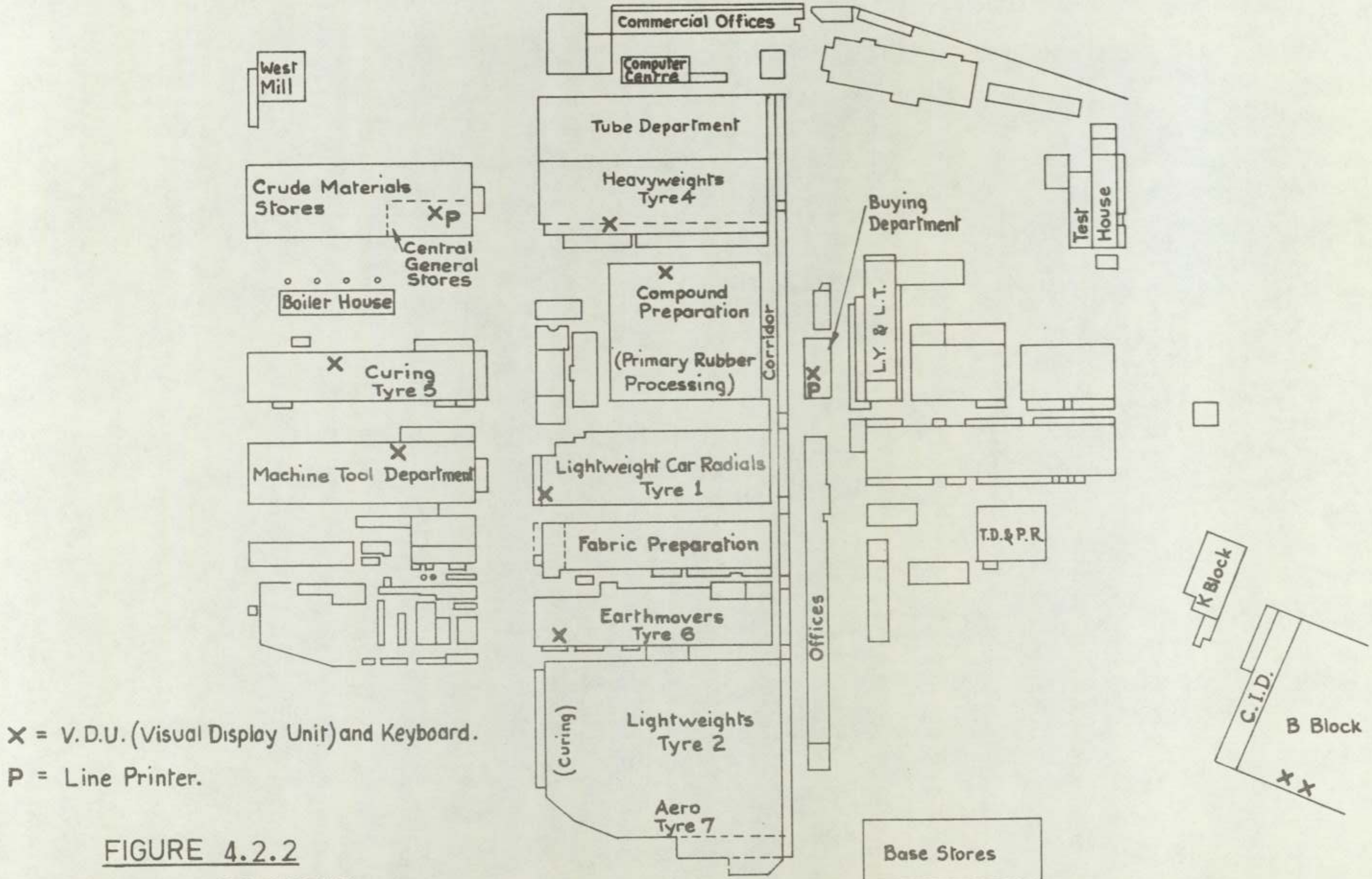


FIGURE 4.2.2

TERMINAL LOCATIONS

These terminals are dedicated to the Spares system but several other terminals are casual users of the system and any of the 100 V.D.U's in use at Fort Dunlop can access the system.

The Engineering Workshop terminals cover 80% of all requisitions issued, the remaining workshops were not given terminals as the volume of requisitioning was too low to justify installation. (See justification report section 4.10.).

Management plans to reduce the number of workshops to 17 major Work Centres and when this occurs further terminals will be installed.

Washington

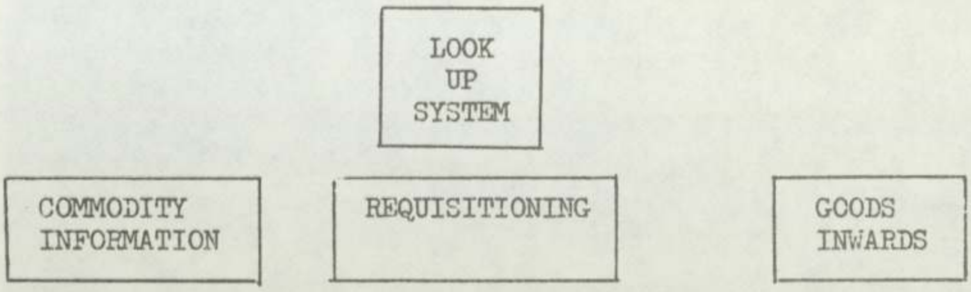
The system is available in the Buying Department at the Washington Factory. An IBM 3276 Control unit VDU and Keyboard have been installed with a 3278 model 2 line printer. A terminal for the stores has been sanctioned and should be installed early in 1980.

Inchinnan

The system is available on a terminal already installed in the Buying Department, a line printer is available to make hard copy of screens.

4.3. Method of Operation

The Spares System can be divided into 4 sections:-



Look Up System

A screen where the user's personnel code is entered and a series of screens provide the user with an index that allows the commodity of any item on file to be quickly found. This is fully described in Section 4.4.

Requisitioning

A screen is available where the user can order any stocked item and record the issue to a specific machine or charge code. The item is then delivered to the workshop on a stores van or collected by hand. This is described in Section 4.5.

Commodity Information

Three screens of information are available, Buying Information, Commodity Details abd Supplier Address. The Supplier and Buying Screens are only available for UK Tyre Division stock items. A commodity screen is available for each of the 120,000 items in the stores catalogue. This is described in Section 4.6.

Goods Inwards

A screen allows goods receipts, returns and inter store transfers to be recorded. This is described in Section 4.7.

The detailed operation is now described and the programs performing these tasks are described in section 4.8.

4.4. The Look Up System

Background

The stores catalogue on the computer contains 120,000 entries. The UK Tyre Division has 51,000 catalogue entries for 20,000 stocked commodities. Each of these Tyre Division items has a corresponding stock record in the computer stock system. (The Central General/ Crude Materials - CG/CM system). With so many items on file,a rapid means of finding any item was required.

All commodities used by Dunlop are given an 8 digit commodity code[1] and the CG/CM stock control system uses this code as the 'Key' to the information held for the item. All items were coded strictly to this structured code, which was developed by N.A.T.O., as a military system and adapted by Dunlop for industrial use (Ref 125). Two methods of using this code to provide an index were considered. An alphabetic index providing a starting point to the approximate point where the item could be found or, a series of display screens prompting the user to build up a full commodity code. After discussion it was decided to use the Code build up technique as:-

Note 1: A 3 character suffix is available and is occasionally used when coding raw materials.

- All the potential users of the system were used to the code structure.

- A workable alphabetic index would require a considerable amount of commodity description changes and re coding and coding clerks were not available to undertake the work.

The Look Up system was therefore designed around the commodity code structure which is now described.

The Commodity Code as an index

The Dunlop commodity code for a set of seals for the stub axle on the side arms of a 63.5 inch Bag-o-matic tyre press is.

13 39 1056

13 the Group Moulding Presses and Associated Equipment

39 the Class 63.5" Bag-o-matic Press.

1056 The Item Set of seals for Stub Axle.

The code ranges therefore allow :-

90 Groups (10-99) - 80 are used

90 Classes (10-99) within each Group

9000 Items 1000-9999 within each Class

IBM 3278 VDU's had been specified for the system giving a screen size of 80 characters by 24 lines. The Group descriptions were 40 characters and with the 2 digits for the code 4 screens would be required to display all the Groups. It was decided to combine the Groups into 12 sections e.g.,

01 Production Machine Spares

The first screen displayed could then show all 12 section headings. The appropriate section can then be selected to obtain a display of the Groups it contains. Selecting a Group then gives the Class listing. When coding an item the coding clerk uses an 'unofficial' list, developed by the clerks, that divides the particular class into ranges of codes corresponding to machine assemblies or in the case of general items (such as bearings), ranges by the size or manufacture. After discussion with the Coding and Standards Section management it was agreed that these Class sub divisions should be added to the table of Group and Class headings already held on the Computer. This table now has over 10,000 entries and the Class subdivision is referred to a SUBSET. A sample page figure 4.4.1., shows the 63.5" Bag-o-matic press and its assemblies (1339). The table format has been structured to show sub-assemblies within the main assemblies, by indenting by 3 characters. This format is transferred directly on to a display screen. Figure 4.4.2., shows the Coding structure, each box corresponding to a display screen in the Look Up System.

The Look up System therefore, has a SUBSET screen for each class, dividing the possible 9000 items into logical assemblies or ranges. The assembly code is selected and gives a starting point in the item listing, commonly there are only 20 items within an assembly and 7 items displayed on each item screen.

Using the Look Up System

To increase the systems flexibility any screen in the system can be obtained from any other screen. Each screen has a selection criteria of Commodity Code number (or part of the code) and an Option. The option is used to distinguish between different displays for the same

TABLE NUMBER 115   02 COMMODITY CODE BOOK TITLES/SUB
SIZE 10000   (CONTINUED)

TABLE ENTRY KEY		
1335	S	BAG -O- MATIC PRESSES 42 INCH.
13351000	X	SIDE ARMS, SHORT LINK ARMS, WHIFFLE TREE
13352000	X	EJECTION CYL, LIFTING ARMS, LOAD/UNLOAD
13353000	X	RAM PISTON CENTRE & TOP WEIGHT CYLINDER
13355000	X	VALVES, PIPEWORK, HOSES.
13356000	X	MAIN DRIVE GEAR, BRAKES, COUPLINGS.
13357000	X	LUBRICATION SYSTEM
13358000	X	ELECTRICAL ITEMS
1336	S	BAG-O-MATIC PRESSES 45 INCH
13361000	X	SIDEARMS, SHORT LINK ARMS WHIFFLE TREE
13362000	X	EJECTION CYL, LIFTING ARMS, LOAD/UNLOAD
13363000	X	RAM PISTON CENTRE & TOP WEIGHT CYLINDER
13365000	X	VALVES, PIPEWORK, HOSE.
13365001	X	SWIVEL JOINTS, GAUGES
13365090	X	HUNT & MITTON/SINCLAIR VALVES.
13365249	X	MARTONAIR & FISHER VALVES
13365309	X	SCHRADER & VALVAIR VALVES
13365500	X	HOSE, FITTINGS
13366000	X	MAIN DRIVE GEAR, BRAKES, COUPLINGS.
13367000	X	LUBRICATION SYSTEM
13368000	X	ELECTRICAL ITEMS
1338	S	BAG -O- MATIC PRESSES 55 INCH.
13381000	X	SIDE ARMS, SHORT LINK ARMS, WHIFFLE TREE
13382000	X	EJECTION CYL, LIFTING ARMS, LOAD/UNLOAD
13383000	X	RAM PISTON CENTRE & TOP WEIGHT CYLINDER
13385000	X	VALVES, PIPEWORK, HOSES
13386000	X	MAINDRIVE GEAR, BRAKES, COUPLINGS
13387000	X	LUBRICATION SYSTEM
13388000	X	ELECTRICAL ITEMS
1339	S	BAG-O-MATIC PRESSES 63.5 INCH.
13391000	X	SIDE ARMS, SHORTLINK ARMS, WHIFFLE TREE
13392000	X	EJECTION CYL, LIFTING ARMS, LOAD/UNLOAD
13393000	X	RAM PISTON CENTRE & TOP WEIGHT CYLINDER
13393100	X	STEAM BOX ASSEMBLY
13393210	X	BAG CONTROL MECHANISM ASSEMBLY
13393369	X	PISTON & PISTON ROD ASSEMBLY
13395000	X	VALVES, PIPEWORK, HOSES
13395029	X	FITTINGS
13395070	X	VALVES & SPARES
13396000	X	MAIN DRIVE GEAR, BRAKES, COUPLINGS
13397000	X	LUBRICATION SYSTEM
13398000	X	ELECTRICAL ITEMS
1340	S	BAG -O- MATIC PRESSES 75 INCH.
13401000	X	SIDE ARMS, SHORT LINK ARMS, WHIFFLE TREE
13402000	X	EJECTION CYL LIFTING ARMS, LOAD/UNLOAD
13403000	X	RAM PISTON CENTRE & TOP WEIGHT CYLINDER
13405000	X	VALVES, PIPEWORK, HOSES
13406000	X	MAIN DRIVE GEAR BRAKES, COUPLINGS
13407000	X	LUBRICATION SYSTEM
13408000	X	ELECTRICAL ITEMS
1341	S	BAG -O- MATIC PRESSES 85 INCH.
13411000	X	SIDE ARMS, SHORT LINK ARMS, WHIFFLE TREE
13412000	X	EJECTION CYL, LIFTING ARMS, LOAD/UNLOAD
13413000	X	RAM PISTON CENTRE & TOP WEIGHT CYLINDER
13416000	X	MAIN DRIVE GEAR, BRAKES, COUPLINGS

FIGURE 4.4.1

As an example:- CODE 13 39 1056

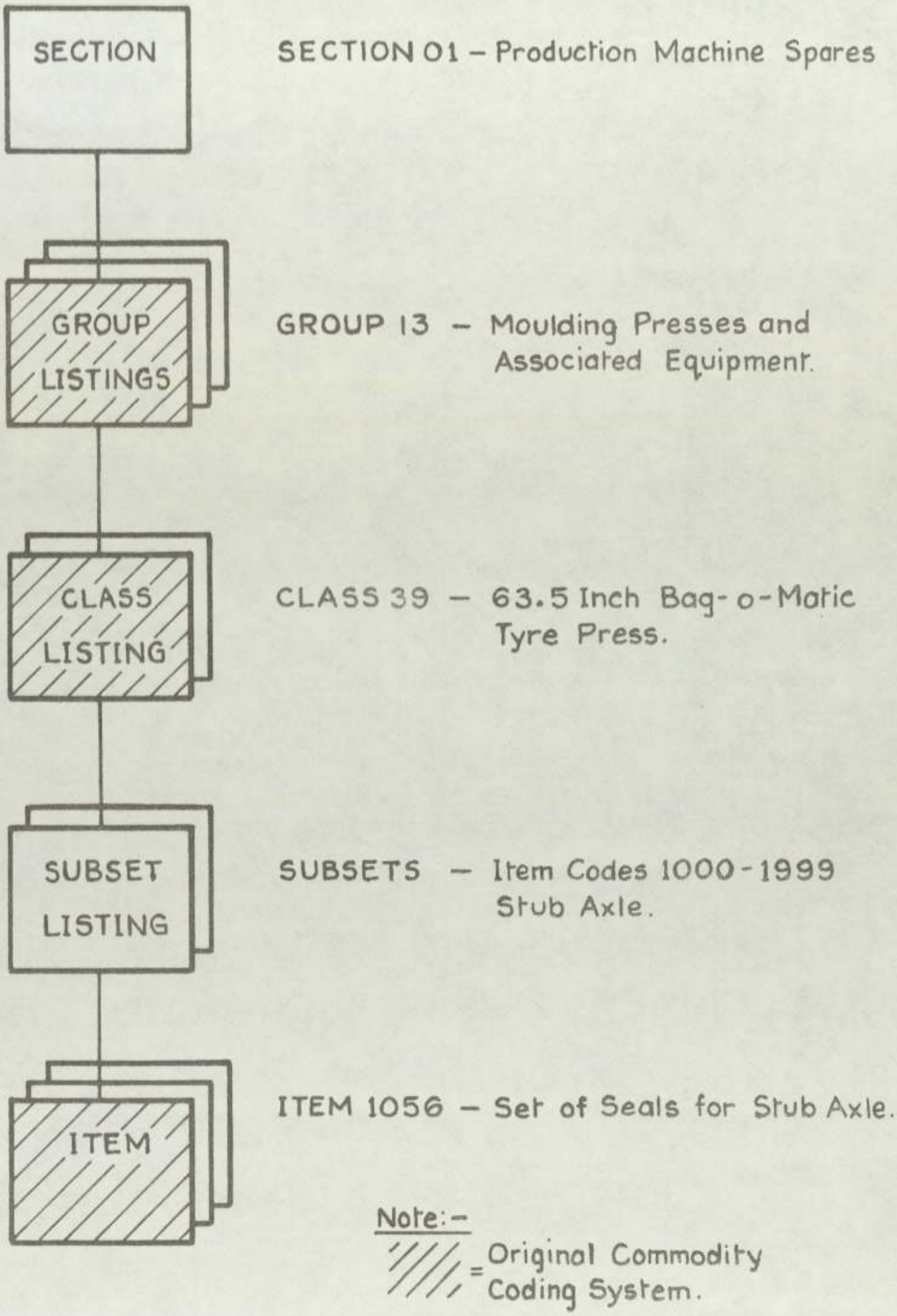


FIGURE 4.4.2
DUNLOP COMMODITY CODING STRUCTURE.

commodity code e.g., R = Requisitioning Screen B = Buying Information.

The bottom right hand corner of each screen is used for inputting data to select the required screen:-

CODE __ __ ____ ___

OPT _ STORE __

CODE the commodity code or part code, the Section number or the Supplier number

OPT the option, signifying the type of screen required

STORE the number identifies which factory store the information displayed refers to. (e.g., 01 is Fort Dunlop's main Central General Stores). This number is obtained from the users identity code. (See below).

Figure 4.4.3., shows the CODE and OPT combinations needed to obtain each of the Look Up System screens. OPT is preset on each of the screens for the subsequent screen normally required. This speeds up the operation of the system as normally only the CODE has to be entered. Note that these screens correspond directly to the structure of the commodity code (figure 4.4.2.).

Sign On Procedure

The VDU is switched on and signed on to the C.I.C.S. system. The Spares System is then selected by entering CG/CM (the system identifier). The MENU screen is then displayed (figure 4.4.4). The user then enters his identity code, which is not displayed. This code is checked against a table of users and, if found, the users name, LEVEL and

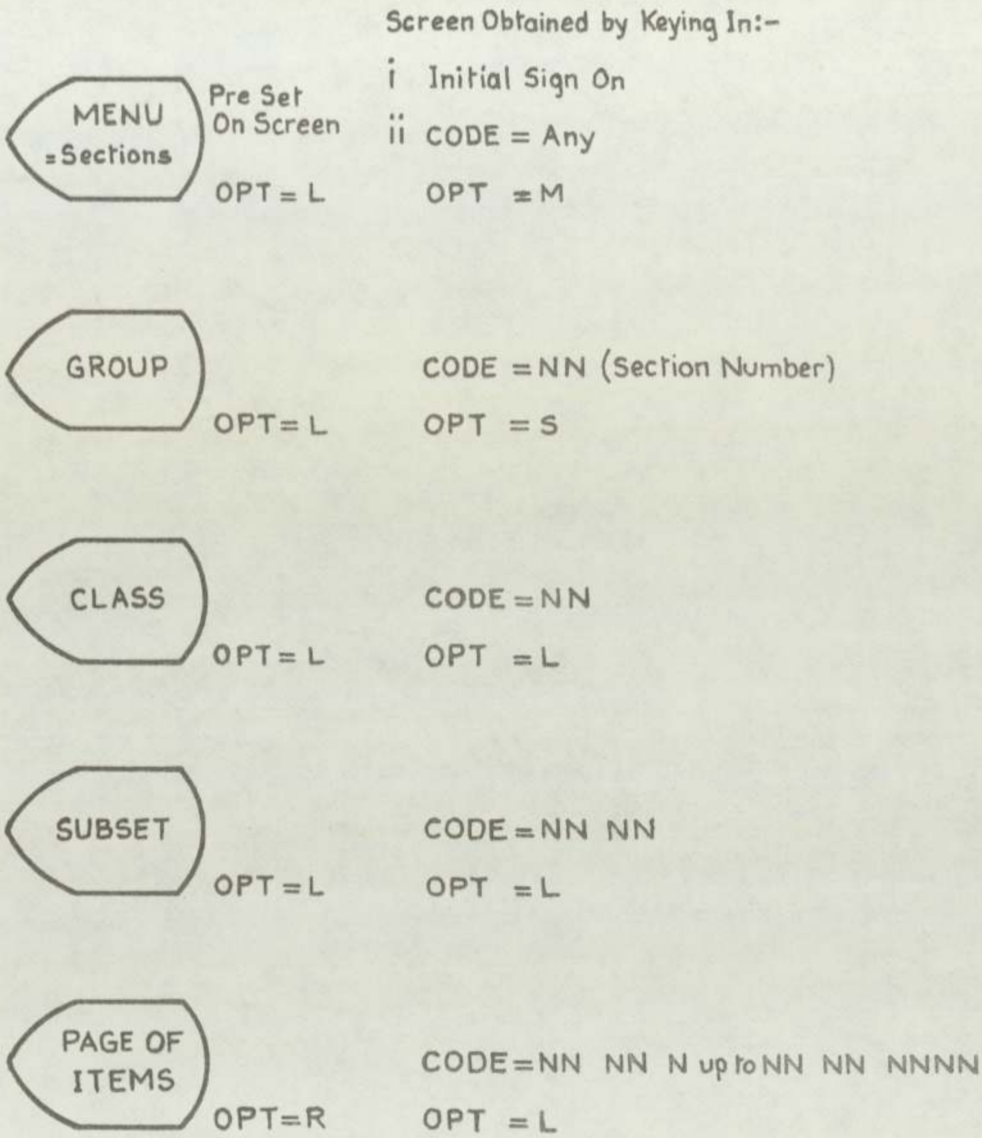


FIGURE 4.4.3

THE LOOK UP SYSTEM-CODE AND OPTION COMBINATIONS.

normal store for stock information are displayed. This table also passes instruction to the program on whether or not the user is permitted to requisition, book goods into the system and book goods returned to the stores back into the system. The table also carries all the details required for printing requisitions - users name, telephone number, department, requisition code etc.

The LEVEL displayed is used by the program to reduce the amount of information it displays, with the level set at:-

A = All 120,000 commodities used World Wide

T = Only Tyre Division commodities

F = Only Fort Dunlop commodities

W = Only Washington commodities

I = Only Inchinnan commodities

S = Only Speke commodities (still used even though the factory is closed as there is still stock on the site).

The Level can be changed by keying in the new character, which the system remembers until the user makes a further change or signs off.

Looking Up A Commodity Code

Having 'signed on', the Look Up System can now be used to find the commodity code of any item. This is best described by using an example:-

Find the commodity code of the T.B.A. Automotive V Belt used in the gear box on a Banner Bias Cutter Machine.

The system will be displaying the Menu Screen with the curser waiting at CODE, data can then be entered (figure 4.4.4.). The Banner Bias Cutter is a production machine used in the manufacture of tyre bias belting. Its spares will be found in the Section:-

01 Production Machine Spares

01 is entered in Code, the Option (OPT) set to S and the enter key pressed. (Option is preset at L on this screen as most users know the Group and Class Codes of the items and jump to the subset screen).

The list of Groups within the selected Section is then displayed (figure 4.4.5.). The Bias Cutter is coded under:-

11 Textile Fabric Manufacturing Equipment

The screen curser is waiting at CODE, 11 is entered and the enter key pressed. (The option is preset at L).

The first page of Classes within Group 11 are displayed (figure 4.4.6.). The Bias Cutter is not listed but CONT (*3 on figure 4.4.6.) indicates that a further page is available. Pressing the PA1 Key on the keyboard gives the next page (figure 4.4.7.). The Bias Cutter is Class 80, the Group, 11, is preset in Code, 80 is entered and the enter key pressed.

The Bias Cutter's subset is then displayed (figure 4.4.8.). The indentations show the sub assemblies within the machines main assemblies. The gear box is listed as 11 80 5000 with 4 sub assemblies, the belts being coded between 11 80 5076 and 5099. (The Code 11 80 5000 provides a heading, the assembly stocked items commencing at 11 80 5001) Code has 11 80 preset, 5076 is entered and the enter key pressed.

MENU SCREEN
===========

```
MATERIALS CCNTROL INFORMATION SYSTEM

01 PPODUCTION MACHINE SPAPES
02 CTHEF MACHINE SPARES
03 MECHANICAL SPARES
04 SEPVICES SPARES
05 ELECTRICAL SPARES
06 HARDWARE AND BUILCING MATERIALS  *4
07 VEHICLES ENGINES TYRES TUBES
08 PAW MATEFIALS ANC CHEMICALS
09 EQUIPMENT AND FURNITURE
10 SAFETY FQUIPMENT AND CLOTHING
11 GENERAL
12 GRCUPS NCT ALLCCATED

                                   USER      BUYING DEPT FD *1
                                   LEVEL     T              *2
                                   IDENTITY                 *3

                                        CODE
                                        OPT   L     STORE 01
```

THIS SCREEN IS OBTAINED BY ENTERING USER IDENTITY CODE CN SIGN CN OR BY KEYING AND ENTERING OPTION 'M' FROM ANY SCREEN IN THE SYSTEM.

DETAIL
------

*1	USER NAME	CISPLAYED AFTEP SIGN ON (OBTAINED FROM USEP SIGN ON IDENTITY CODE).
*2	LEVEL	DISPLAYED AFTEP SIGN ON (OBTAINED FROM USER SIGN ON IDENTITY CODE). AMENDABLE AS FOLLOWS:- . A = ALL . T = TYRE DIVISION . F = FORT DUNLOP . I = INCHINNAN . S = SPEKE . W = WASHINGTON
*3	IDENTITY	KEYED IN USER IDENTITY CODE (IN DARKNESS FOR SECURITY).
*4	SECTIONS	FOR LOOK UP PROCEDURES.

FIGURE 4.4.4

LOOK UP SYSTEM - GROUPS SCREEN
===============================

```
                    PRODUCTION MACHINE SPARES   *1

  10 MIXING COMPOUND SHEETING EQUIPMENT
  11 TEXTILE FABRIC MANUFACTURE EQUIPMENT
  12 FABRICATION EQUIPMENT
  13 MOULDING PRESSES AND ASSOC EQUIPMENT
  14 PRODUCT FINISHING/INSPECTION EQUIPMENT     *2
  15 SPECIALITY EQUIPMENT
  16 LATEX PLASTIC SOLUTION EQUIPMENT
  17 CONTROL TESTING WEIGHING EQUIPMENT
  24 MATERIALS HANDLING EQUIPMENT




                                                      CODE
                                                      OPT  L   STORE 01
```

THIS SCREEN IS OBTAINED BY KEYING IN SECTION NUMBER AND OPTION "S".

DETAIL
------

*1 SECTION TITLE.

*2 GROUPS WITHIN SECTION.

FIGURE 4.4.5

LOCK UP SYSTEM - CLASS SCREEN

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X              11 TEXTILE FABRIC MANUFACTURE EQUIPMENT   *1                   X
X                                                                             X
X  11 WINDING MACHINE, CONE                                                   X
X  12 LEESONA WINDING MACHINE                                                 X
X  13 BOBBIN WINDING MACHINES                                                 X
X  17 RING DOUBLERS 3 1/4 INCH                                                X
X  20 RING DOUBLERS 5 1/2 INCH                                                X
X  23 WEAVING MACHINES                                                        X
X  27 WARPING MACHINES                                                        X
X  35 KNITTING MACHINES                                                       X
X  37 SEWING MACHINES - SINGER     *2                                         X
X  38 SEWING MACHINES - OTHERS                                                X
X  46 HEAT STRETCHING MACHINES                                                X
X  49 METAL FABRIC CREEL                                                      X
X  50 THREAD CREEL                                                            X
X  52 RAYON FABRIC DOPING M/C MATHER AND PLATT                                X
X  53 RAYON FABRIC DOPING AND STRETCHING M/C                                  X
X  54 FABRIC IMPREGNATING M/C (TOWER)                                         X
X  55 SPREADING MACHINES                                                      X
X  61 CORD DRYING M/C                                                         X
X  62 RAYON DRYER                                                             X
X  64 CYLINDER DRYING MACHINES                                                X
X  67 CUTTING AND TRIMMING MACHINES                       CODE 11             X
X  70 SLITTING M/C - CAMERON                   CONT  *3   OPT  L  STORE 01    X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

THIS SCREEN IS OBTAINED BY ENTERING GROUP CODE WITH OPTION "L".

DETAIL

*1 GROUP TITLE.

*2 CLASSES WITHIN GROUP.

*3 CONT = FURTHER CLASSES AVAILABLE (PRESS PA1 KEY).

FIGURE 4.4.6

LOOK UP SYSTEM - CLASS SCREEN (CONTINUATION)

```
11 TEXTILE FABRIC MANUFACTURE EQUIPMENT

71 SLITTING MACHINE - HARNDEN
72 CUTTING MACHINE - BELLOWS
74 SLITTING M/C - DIXON
76 SLITTING M/C - OTHERS
77 SLITTING MACHINE - MERKLE
79 CHAFER SLITTING M/C
80 BIAS CUTTER BANNER
82 BIAS CUTTERS - GAZUIT
83 BIAS CUTTER SPADONE
84 BIAS CUTTERS - OTHERS
85 DOUBLE DISC CUTTER
86 BIAS CUTTERS - PIRELLI
87 PIRELLI SP BREAKER CUTTER
88 HOGGS BREAKER CUTTER
89 DOUBLE DISC CUTTER 90 DEGREE
90 BRAIDING MACHINES
94 WEB GUIDE UNIT
95 LINING WINDING M/CS
96 SOAP IMPREGNATING M/C FOR LININGS
97 ANCILLERY EQUIPMENT GROUP 11
99 BOX ROLLERS                                    CODE 11
                                                 OPT  L  STORE 01
```

FIGURE 4.4.7

LOOK UP SYSTEM - SUBSET SCREEN

```
            11-PO BIAS CUTTER BANNER   *1

 1000 FRAME, TABLE
 2000 CROSS CUTTING CARRIAGE                           *2
 2001    BELTS, RACKS, KNIVES                          *3
 2101    GEARS, SPROCKETS, SHAFTS, CHAIN, BUSH
 2200    VALVES, CYLINDERS, CON RODS, CLAMPS
 2300    ROLLERS,WHEELS , DIAPHRAGMS, PLATES
 3000 BEARINGS, BUSHES
 4000 BRAKES, CLUTCH
 5000 GEARS, GEARBOX
 5001    GEARBOX & MOTOR UNITS, COUPLINGS
 5022    GEARS, PINIONS, SPROCKETS
 5076    BELTS, CIRCLIPS, KNIFEMOTOR
 5100    GEARED MOTOR UNIT
 6000 DUPLEX STRIPPER
 6001    GEARS, BELTS, BEARINGS, BRAKES
 7000 AIR & HYDRAULIC ITEMS
 7001    VALVES, CYLINDERS
 7039    REGULATORS, LUBRICATORS, GAUGES
 8000 ELECTRICAL ITEMS
 8001    SWITCHES, RELAYS, RECTIFIERS
 8046    BRAKES, CONTACTS, COILS                  *4  CODE 11 80
 8099    PHOTOCELLS, OVERLOADS, FUSES, MOTORS  CONT OPT  L   STORE 01
```

THIS SCREEN IS OBTAINED BY ENTERING THE CLASS CODE AND OPTION "L".

DETAIL

*1 CLASS TITLE.

*2 SUBSETS WITHIN CLASS.

*3 SUBDIVISION OF A SUBSET (COMMENCING AT CODE STATED).

*4 FURTHER SUBSETS AVAILABLE (PRESS PA1 KEY).

FIGURE 4.4.8

The first page of Items for the sub assembly is displayed (figure 4.4.9.). Seven items are listed on each screen and the next page is obtained by pressing the PA1 key. Paging is only allowed up to the end of the selected subset at which point the subset screen should be obtained and another assembly selected. The TB.A V Belt is listed as 11 80 5076. Knowing the commodity code, the requisitioning, information on goods inwards screens can be obtained by entering the CODE and the appropriate option.

The Item Screen (figure 4.4.9.)

The information displayed on the Item screen is dictated by the LEVEL and STORE either entered on the MENU screen or obtained from the User Identity Table by the program.

Level	Items Displayed	Stock Balance Figure	Notes
A	All commodities	Blank on 'T. Div' for items stocked by Tyre Division.	
T	Tyre Division items	A stock balance figure for the selected store or 'T. Div' for items held elsewhere in Tyre Division.	'T. Div' can mean the item is held at another store at the same factory.
F,W,I or S	Items stocked at the selected factory.	A stock balance figure for the selected store. 'T. Div' for items held at another store on the same site.	The total stock on the site and in Tyre Division, is available on the Buying Screen.

LOOK UP SYSTEM - PAGE OF ITEMS SCREEN

```
       11-80 BIAS CUTTER BANNER   *1
   *2                                                *4
 5076  TB.A. AUTOMOTIVE 'V' BELTS NO. 3253.          33  EACH *5
        TOP WIDTH 0.50" THICKNESS 0.313"   *3
        ANGLE 40 DEGREE INSIDE CIRCUMFERENCE                          *6
 5077  DUNLOP VEE BELTS. NO. A60.                    17  EACH 30-30-2060
        METRIC A1550.

 5078  DUNLOP VEE BELTS. NO. A61.                     6  EACH 30-30-2061
        METRIC A1580.

 5079  ENDLESS VEE BELTS. SIZE A31.                   4  EACH 30-30-2031
        METRIC REF A820.

 5080  DUNLOP VEE BELTS. NO. A30.                     2  EACH 30-30-2030
        METRIC A790.

 5081  DUNLOP VEE BELTS. NO. A56.                    15  EACH 30-30-2056
        METRIC A1460.

 5085  ROTOR SHAFT ASSEMBLY 0040/A66005100/00 TDIV   EACH XREF
 FOR BIAS CUTTERS-BANNER.

                                                     CODE 11 80
                                                     OPT  R   STORE 01
```

THIS SCREEN IS OBTAINED BY ENTERING THE SUBSET CODE AND OPTION "L".

DETAIL

*1 CLASS TITLE.
*2 ITEM NUMBER.
*3 UP TO 3 LINES OF COMMODITY DESCRIPTION. (UP TO 10 LINES AVAILABLE ON COMMODITY SCREEN).
*4 STOCK BALANCE:-
- NUMBER = STOCK AT STORE (AS SET).
- BLANK = ITEM NOT HELD FOR TYRE DIVISION.
- TDIV = NOT STOCKED AT THIS STORE (AS SET) BUT HELD ELSEWHERE IN TYRE DIVISION.

*5 STOCK UNIT (UNIT OF ISSUE E.G. EACH).
*6 COMMODITY CODE - THE ITEM IS CROSS REFERENCED AND IS HELD IN STOCK ON THIS CODE.
X REF - OTHER MACHINES CROSS REFERENCE TO THIS CODE (THE STOCKING CODE).

FIGURE 4.4.9

Machine parts that are common to several machines are given a commodity code on which they are stocked in the stores and a pseudo code number within the machine listing. The computer file design allows up to 12 machines to 'Cross Reference' to the 'Stocking' commodity code. As an example the V Belt 11 80 5077 on figure 4.4.9 is the pseudo code for the machine, the actual stock being held on 30 30 2060. The reverse case is illustrated by 11 80 5085 in the same diagram, the stock is held on this code and other machines cross reference to this code, therefore XREF is displayed. The full list of machines cross referencing is available on the Commodity Details screen for the item.

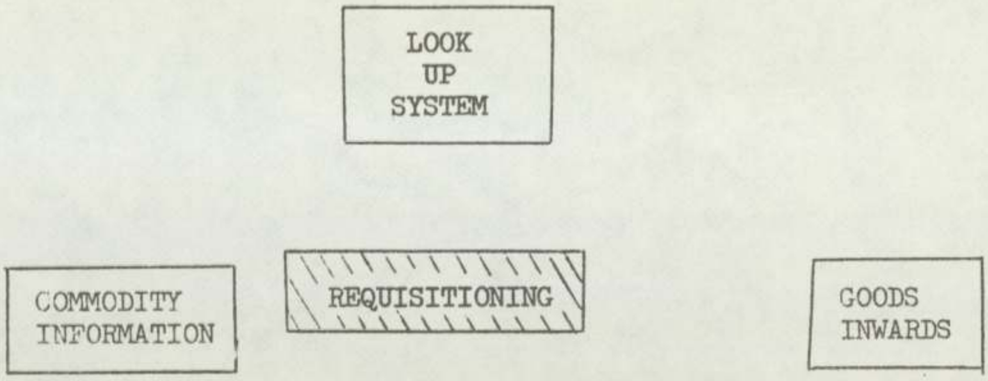
The Look Up System can therefore be used to find any item on the file. The task is simplified by selecting the appropriate level and entering part of the Commodity code, if known. A two digit section and Group or Class must be entered but item numbers can be partially entered:-

CODE 11 80 2___ ___

OPT L STORE 01

the program will display an Item screen commencing at 11 80 2000 or the first item after this that satisfies the Level set.

4.5. <u>Requisitioning</u>



The Requisitioning screen is obtained by entering a full commodity code and the option R. The screens purpose is to allow stores items to be ordered.

The requisitioning facility is currently only available at Fort Dunlop and only for items held in the Central General Stores (CGS), (the CGS holds the vast majority of engineers spare parts and general items used on the site).

All engineering foremen and management have been issued with a personal identity code authorising him to requisition. The requisitioning procedure is then to:-

1. Sign into the terminal with the user number.

2. Obtain the requisitioning screen (figure 4.5.1.) for the item required by using the Look Up System or entering the full code if known.

3. i. Check that there is sufficient stock
   ii. Enter the quantity (QTY)
   iii. Enter the CHARGE DETAIL JOB/REF in one of five ways.

REQUISITION SCREEN

```
RADIAL BALL SINGLE ROW  *1                                10-41-4064   *2

SINGLE ROW RADIAL BALL BEARINGS                           31-10-1003   *4
EXTRA LIGHT - BRE SERIES                                        7BC5   *5
3/8" BORE X 7/8" OD X 7/32" WIDE  *3                            EACH   *6
     SKEFKO REF: EE3                                          £0.85   *7
        BS REF: BRE3/8
       RHP REF: KLNJ 3/8                          STOCK           55   *8
                                                                  36   *9



                                  *10




             QTY       CHARGE DETAIL JOB/REF C DEPT
                                                  0105


                                                          CODE
                                                          OPT R   STORE 01
```

THIS SCREEN IS OBTAINED BY ENTERING A FULL COMMODITY CODE AND OPTION "R"

DETAIL

*1 CLASS DESCRIPTION.

*2 INPUT COMMODITY CODE.

*3 COMMODITY DESCRIPTION (UP TO 10 LINES ALLOWED).

*4 COMMODITY CODE ITEM IS STOCKED UNDER.

*5 LOCATION IN STORES.

*6 UNIT ITEM IS STOCKED IN.

*7 AVERAGE PRICE PER STOCK UNIT.

*8 STOCK IN STORE.

*9 STOCK AT OTHER STORES IN TYRE DIVISION.

*10 EXTRA TWO LINES OF COMMODITY DESCRIPTION.

FIGURE 4.5.1

a. Chargeable Department and Cost Centre - this records the issue to a cost centre within a production department.

b. Sanction or a Works Authorisation number - this charges the item to a specific capital expenditure sanction or engineering expenditure account.

c. Machine Code - the issue is recorded to a specific machine (this code was developed as part of this project - see section 5.4'Completing the engineering request card'). This method of booking items to a specific machine, will enable a history file to be built up to recordthe frequency of use of machine parts on each machine.

d. Job Number - only used by the Machine Tool Department who work to a job number system.

e. Left blank - the item is charged to the code in DEPARTMENT on the screen. This is 'entered' when the item is to be used by the engineering department and is not to be recharged to a production department.

4. If the item is to be collected by hand a C is entered beneath C on the screen, otherwise the item is delivered by the stores van.

5. The users requisitioning department is pre set in DEPT, the program obtaining it from the User Information table. The department number can be changed by simply keying in the required number.

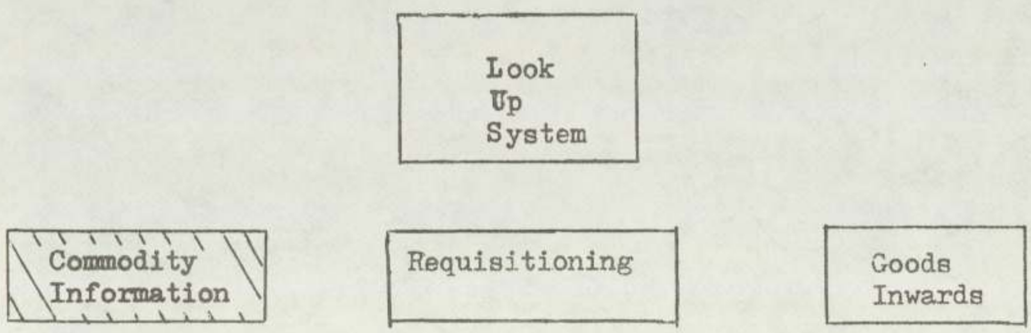
6. Press the enter key.

The program will then validate the data, checking that there is sufficient stock and that the charge details are valid. If an error is found an appropriate error message is displayed. If the data is valid a requisition is printed in the stores, the data base is amended with the quantity issued and data requisition details are 'logged' ready to be passed forward to the CG CM stock system where they will be recorded on the stores issues history file.

The action then taken by the stores personnel is described in section 4.7.

The program stores the charge details entered by the user and will pre set them on the screen for the next requisition. This speeds up requisitioning when several items have to be ordered against the same code. To sign off the user presses the Clear Key, all data stored for him is cleared and the Menu screen is displayed awaiting the next user.

4.6. Commodity Information



Three screens of commodity information are available:

The Buying Screen	4.6.1.
Supplier Address Screen	4.6.2.
Commodity Details Screen	4.6.3.

4.6.1. The Buying Screen

Accessedby entering a commodity code and the option B. The stock information displayed is for the store number entered in STORE on the screen. As the Buyers often search through whole groups and classes the system was designed to accept a partial commodity code, the program then enters zero's in the remaining positions and display the screen for this item or the next item on the file.

The Buying screen contains a vast amount of information, requiring a large number of accesses to the Materials Control data base. As all the information is not normally required, the screen is displayed in 4 sections, allowing the user to 'build up' the parts of the screen he requires. This method of display reduces the amount of computer C.P.U. time required and improves the response time on the remote terminals. The division of the screen was devised with the assistance of the Buying Department Staff.

The 4 sections are:-

i. On entry - figure 4.6.1.
The basic stock information is displayed.

ii. Press the PA2 key on the keyboard - figure 4.6.2.
The usage figures, statistics and stock information are added to the screen.

iii. Press the PA2 key for a second time - figure 4.6.3.
The suppliers name is added.

iv. An N is entered in Option and enter pressed - figure 4.6.3.
The stock at the other Tyre Division stores is detailed for each store.

BUYING SCREEN (ON ENTRY)

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X  31-10-1003 *1        DEPR    0  *2         AVE  £0.84549  EACH *7     *9  X
X  SINGLE ROW RADIAL BALL BEARING *3          STD  £0.84500  EACH  1.0000    X
X  EXTRA LIGHT - BRE SERIES                   N/Y  £0.00000 *6               X
X  ORDERS          *10     *11  *12          *13    *14     *15 *16          X
X  569695/0537313 211278    50    0.84500      0       50  0                 X
X  569695/0429263 010878    50    0.84500     50        0  1                 X
X  569695/0385483 250578    50    0.78975     50        0  2 C *17           X
X  569695/0297953 070278    50    0.78975     50        0  1                 X
X  569695/0230723 251077    50    0.74100     50        0  1                 X
X  569695/0165243 280777    50    0.71825     50        0  1                 X
X                                                                            X
X                                 *18    *19         *20                     X
X                                STR  STOCK    WKLY USE                      X
X                                01       55        1.35                     X
X                                         36 *21                             X
X                                                                            X
X                                                   CODE                     X
X                                                   OPT   B    STORE 01      X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

THIS SCREEN IS OBTAINED BY ENTERING PART/FULL COMMODITY CODE & OPTION B

DETAIL

------

*1 COMMODITY CODE - 2-2-4-3

*2 DEPRECIATION - ITEMS DEPRECIATED 25% EACH YEAR NO USAGE. - DEPR

*3 COMMODITY DESCN - TWO LINE DESCRIPTION.

*4 AVERAGE PRICE - PER STOCK UNIT TO 5 DECIMAL PLACES OF A £.- AVE

*5 STANDARD PRICE - PER STOCK UNIT TO 5 DECIMAL PLACES OF A £.- STD

*6 NEXT YEAR PRICE - PER STOCK UNIT TO 5 DECIMAL PLACES OF A £.- N/Y
HELD FOR CMS STOCK ITEMS ONLY.

*7 ORDER UNIT - UNIT ITEM IS ORDERED IN.

*8 STOCK UNIT - UNIT OF ISSUE.

FIGURE 4.6.1

```
*9  CONVERSION FACT.-  NUMBER OF STOCK UNITS IN AN ORDER UNIT
                       (TO 4 DECIMAL PLACES).

*10 SUPP./ORDER NO. -

*11 DATE OF ORDER   -  DDMMYY.

*12 ORDER QUANTITY  -  IN ORDER UNITS.

*13 NET PRICE       -  TO 5 DECIMAL PLACES OF A £ (IN ORDER UNITS).

*14 QUANTITY DELD.  -  IN STOCK UNITS.

*15 QTY OUTSTANDING -  IN STOCK UNITS.

*16 LEAD TIME       -  IN WEEKS.

*17 COMMITTED STOCK INDICATOR.

*18 STORE NUMBER    -  SEE PAGE 5.

*19 QTY IN STOCK    -  IN STOCK UNITS.

*20 AVE WKLY USAGE  -  IN STOCK UNITS TO 2 DECIMAL PLACES.
*21 OTHER STOCK     -  TOTAL STOCK IN TYRE DIVISION STORES OTHER

                       THAN THE STORE SELECTED.
```

FIGURE 4.6.1 Continued.

BUYING SCREEN (EXTRA DETAIL)

```
31-10-1003            DEPR    0                    AVE   £0.84549   EACH
SINGLE ROW RADIAL BALL BEARING                     STD   £0.84500   EACH   1.0000
EXTRA LIGHT - BRE SERIES                           N/Y   £0.00000
ORDERS
569695/0537312 211278    50    0.84500        0        50  0
569695/0429263 010878    50    0.84500       50         0  1
569695/0385483 250578    50    0.78975       50         0  2 C
569695/0297953 070278    50    0.78975       50         0  1
569695/0230723 251077    50    0.74100       50         0  1
569695/0165243 280777    50    0.71825       50         0  1
SUPPLIER *21
569695        *22       *23       *24       *25       *26       NET PRICE    R.O.Q.
           2.60000   67.50-                                 =    0.84500         50


                    MONTHLY USAGE    STR   STOCK    WKLY USE
R.O.L.       20          0       58   01       55        1.35
O.LEV         4          0       11            36
DEL.P    2              24       10
AV,LT    1               7       10
  ISS 280279             9        0
  REC 040179             1       15
  S/C 070279        TOTAL       145                          CODE
                    M.T.D        10                          OPT   B    STORE 01
```

OBTAINED BY PRESSING PA2 KEY FOR THE FIRST TIME AFTER OBTAINING BUYING SCREEN.

DETAIL

*21	SUPPLIER NUMBER -	THE SUPPLIER REFERENCE FROM WHERE THE ITEM IS NORMALLY OBTAINED.
*22	PURCHASE PRICE -	IN ORDER UNITS.
*23, *24, *25	DISCOUNTS	TO TWO DECIMAL PLACES OF A PERCENT.
*26	CARRIAGE -	TO TWO DECIMAL PLACES OF A £ - HELD FOR CMS STOCK ITEMS ONLY.
*27	NET PRICE -	PURCHASE PRICE LESS DISCOUNTS PLUS CARRIAGE (PER ORDER UNIT).
*28	RE-ORDER QUANTITY -	THE NUMBER OF ORDER UNITS NORMALLY RE-ORDERED. R.O.Q.
*29	DATE PRICE EFFECT -	DATE FROM WHICH THE PRICE DETAILS ARE TO BE APPLICABLE.

FIGURE 4.6.2

*30 RE-ORDER LEVEL - IN STCCK UNITS. R.C.L.

*31 DANGER LEVEL - IN STOCK UNITS. D.LEV

*32 DELIVERY PERIOD - IN WEEKS. DEL.P

*33 AVERAGE LEAD TIME - IN WEEKS. AV.LT

*34 DATE OF LAST ISSUE ISS

*35 DATE OF LAST RECEIPT REC

*36 DATE OF LAST STOCK CCUNT S/C

*37 MONTHLY USAGE IN STOCK UNITS SHOWN AS:-

```
        JANUARY          JULY
           |               |
          JUNE         DECEMBER
```

USAGE CURRENT YEAR IS DISPLAYED IN HIGH BRIGHTNESS.

*38 TOTAL USAGE IN LAST 12 MONTHS (IN STOCK UNITS). TOTAL

*39 USAGE IN STOCK UNITS IN CURRENT MONTH TO DATE. M.T.D.

FIGURE 4.6.2 Continued

BUYING SCREEN (EXTRA SUPPLIER AND OTHER STORE DETAILS)

```
31-10-1003          DEPH    0                 AVE  £0.84549  EACH
SINGLE ROW RADIAL BALL BEARING                STD  £0.84500  EACH  1.0000
EXTRA LIGHT - BRE SERIES                      N/Y  £0.00000
ORDERS
569695/0537213 211278    50    0.84500     0        50  0
569695/0429263 010878    50    0.84500    50         0  1
569695/0365483 250578    50    0.78975    50         0  2 C
569695/0297953 070278    50    0.78975    50         0  1
569695/0230723 251077    50    0.74100    50         0  1
569695/0165243 280777    50    0.71825    50         0  1
SUPPLIER                                           NET PRICE  R.O.Q.
         2.60000  67.50                       =     0.84500       50
569695 M B S BEARINGS  *40


                    MONTHLY USAGE   STR  STOCK    WKLY USE
R.O.L.       20          0       58  01       55       1.35
O.LEV         4          0       11  30 *41   34  *42  0.69 *43
DEL.P    2              24       10  40        2       0.08
AV.LT    1               7       10
  ISS 280279             9        0
  REC 040179             1       15
  S/C 070279       TOTAL        145                    CODE
                   M.T.D         10                    OPT  B   STORE 01
```

THE SUPPLIER NAME IS OBTAINED BY PRESSING THE PA2 KEY FOR THE SECOND TIME AFTER OBTAINING BUYING SCREEN.

OTHER STORE DETAILS ARE OBTAINED BY KEYING IN OPTION 'N' AND PRESSING ENTER.

DETAIL

*40 SUPPLIER NAME

*41 STORE NUMBER

*42 STOCK - IN STOCK UNITS.

*43 AVERAGE WEEKLY USAGE - IN STOCK UNITS.

FIGURE 4.6.3

The Option on the screen is pre set to B, as several Buying screens are normally selected in one session. The next item on the file can be obtained by pressing the PA1 key. Paging through the file is not encouraged as it is an inefficient use of the computer but it is accepted that the Buyers need this facility when working on a section of the file.

To look at the Buying information held for another store, the stores number is keyed into STORE and the enter key pressed. The Buying screen will then be reformatted to show the data held for the item at the 'new' store. It is therefore possible to obtain Buying information for any item stocked at any UK Tyre Division store from any terminal. This enables buyers at Fort Dunlop to compare Inchinnans stock quantities, usage, prices, suppliers performance etc., for an item with their own data and vice versa. An IBM line printer is installed in the Buying Department and a hard copy of any screen can be made by pressing the 'screen print' key on the V.D.U., keyboard.

4.6.2. The Supplier Address Screen

The Buying Screen shows the supplier's name and a number (figure 4.6.3 Detail * 40). The supplier number is a unique identification given to each of Dunlops Tyre Division's suppliers by the Purchase Accounts Department at Fort Dunlop. The number is used as the 'Key' to the supplier information held on a 'Supplier Address' file on the computer which is accessed by the Spares system to provide the Supplier Address screen. As a supplier can have several depots supplying goods to Tyre Division factories, each depot is given a different 6th digit on a common 5 digit stem. Payments are only made to one address which is set as the "Master Record" (indicated by a 6th digit set by a check digit routine).

Example	59228	Martonair Limited
	59228	is the stem
	592280	is the master record
	592281)	are depot codes ,up to
	592282)	9 can be held on the
	592283)	file.

The Supplier Address screen is obtained by entering the supplier code number in CODE and an option of A. If the master code was used the screen is formatted as in figure 4.6.4., if a 'depot' code was entered the screen is formatted as in figure 4.6.5. The information held for the other depots can be obtained by entering the supplier code and changing the option to an A. The 'master' address is always displayed to provide the Buyers with the invoicing address when raising or confirming orders.

The normal use made of this screen is to obtain the full address for a supplier code on the buying screen, the address screen therefore has the Option pre set at B. If"enter"is pressed on the Address screen with no code entered,the program uses the last commodity code (stored within the program) and re displays the Buying screen. If the supplier screen is required again, entering an option of A with no code will re display the supplier screen as the program also stores the last valid supplier number.

4.6.3. Commodity Details Screen

The commodity details screen has been included to assist the Coding Clerks in maintaining the stores catalogue. Each item on file can be displayed by entering the commodity code and an option of C, the screen (figure 4.6.6.) is then displayed. Pressing the PA1 key will

SUPPLIER SCREEN - DISPLAY 1

```
 *1      *2      *3
CARR    SETT    SUPPNO                 *4
 99      80     592280  MARTONAIR LTD,
                        ST MARGARETS ROAD,
                        TWICKENHAM,
                        MIDDLESEX.



  *9     *10       *11
 99      80     592281
 99      80     592282
  0      84     592283



                                                    CODE
                                                    OPT   B    STORE 01
```

THIS SCREEN IS OBTAINED BY ENTERING A VALID 6 DIGIT SUPPLIER CODE AND OPTION 'A'. THE SUPPLIER SHOWN IS A P.A. MASTER (I.E. THE ADDRESS TO WHICH PAYMENTS MUST BE MADE).

DETAIL

```
*1    DELIVERY TERMS CODE       )
*2    SETTLEMENT TERMS CODE     )
*3    SUPPLIER CODE NUMBER      ) INVOICE PAYMENT ADDRESS.
*4    SUPPLIER ADDRESS          )

*9    DELIVERY TERMS CODE       ) SUPPLIER CODE NUMBERS AGAINST WHICH
*10   SETTLEMENT TERMS CODE     ) ADDRESSES FROM WHENCE GOODS CAN BE
*11   SUPPLIER CODE NUMBER      ) OBTAINED ARE HELD.
```

FIGURE 4.6.4

SUPPLIER SCREEN - DISPLAY 2
==========================

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X   *1      *2      *3                                               X
X  CAPR    SETT    SUPPNO              *4                            X
X   99      80     592280  MARTONAIR LTD,                            X
X                          ST MARGARETS ROAD,                        X
X                          TWICKENHAM,                               X
X                          MIDDLESEX.                                X
X   *5      *6      *7                 *8                            X
X   99      80     592281  MARTONAIR LTD,                            X
X                          84, KILBIRNIE STREET,                     X
X                          GLASGOW C5.                               X
X                                                                    X
X   *9      *10       *11                                            X
X   99      80     592282                                            X
X    0      84     592283                                            X
X                                                                    X
X                                                   CODE             X
X                                                   OPT  B  STORE 01 X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

THIS SCREEN IS OBTAINED BY ENTERING A VALID 6 DIGIT SUPPLIER CODE AND OPTION = A. THE SUPPLIER SHOWN IS A P.A. MASTER (I.E. THE ADDRESS TO WHICH PAYMENTS MUST BE MADE) FOLLOWED BY A DELIVERY ADDRESS.

DETAIL

```
*1    DELIVERY TERMS CODE        )
*2    SETTLEMENT TERMS CODE      ) ADDRESS TO WHICH INVOICE PAYMENTS
*3    SUPPLIER CODE NUMBER       ) ARE MADE.
*4    SUPPLIER ADDRESS           )

*5    DELIVERY TERMS CODE        )
*6    SETTLEMENT TERMS CODE      ) SUPPLIER DETAILS WHEN THE CODE NUMBER
*7    SUPPLIER CODE NUMBER       ) KEYED IN IS NOT FOR AN INVOICE PAYMENT
*8    SUPPLIER ADDRESS           ) ADDRESS

*9    DELIVERY TERMS CODE        ) FURTHER SUPPLIER CODE NUMBERS HELD
*10   SETTLEMENT TERMS CODE      ) AGAINST THE ABOVE INVOICE ADDRESS
*11   SUPPLIER CODE NUMBER       ) FROM WHENCE GOODS CAN BE OBTAINED.
```

FIGURE 4.6.5

COMMODITY DETAILS SCREEN

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X   11-10-1003   *1                          CROSS REFS   *4              X
X   SINGLE ROW RADIAL BALL BEARINGS  *2      10-41-4064                   X
X   EXTRA LIGHT - BRE SERIES                 10-97-5108                   X
X   3/8" BORE X 7/8" OD X 7/32" WIDE         12-15-3315                   X
X   SKEFKO REF: EE3                          12-20-1014                   X
X   BS REF: BRE 3/8                          12-21-1021                   X
X   RHP REF: KLNJ 3/8                        12-30-1009                   X
X                                            12-35-1266                   X
X                                            12-63-2106                   X
X                                            12-85-1001                   X
X                                            15-23-1013                   X
X                                      *3    15-23-1017                   X
X                                            51-30-6851                   X
X                                   051278  *5                EACH  *7    X
X   LOCATIONS  *6                                             EACH  1.0000X
X   FD  WS  SP  I    PAN FW  GRG SK  H   ID                    *8    *9   X
X   WA  PED PE  TDL IS  M    N   SA  LS  TR                               X
X   Z                                                                     X
X                                                                         X
X                                                     CODE                X
X                                                     OPT  C   STORE 01   X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

THIS SCREEN IS OBTAINED BY ENTERING PART/FULL COMMODITY CODE & OPTION C.

DETAIL

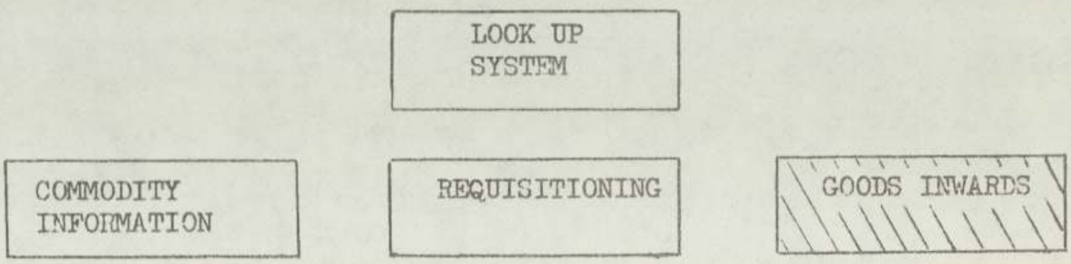
- *1 COMMODITY CODE.
- *2 COMMODITY DESCRIPTION (UP TO 10 LINES).
- *3 ADDITIONAL LINES OF DESCRIPTION (UP TO 2).
- *4 CROSS REFERENCES (UP TO 12).
- *5 DATE INFORMATION LAST AMENDED.
- *6 OTHER FACTORY LOCATIONS WHERE THIS ITEM IS STOCKED (A FULL LIST OF FACTORIES ACCORDING TO CODE CAN BE FOUND IN THE USER MANUAL'S APPENDIX
- *7 STOCK UNIT (UNIT OF ISSUE).
- *8 ORDER UNIT (UNIT OF ORDER).
- *9 CONVERSION FACTOR = NUMBER OF STOCK UNITS IN AN ORDER UNIT (TO 4 DECIMAL PLACES).

FIGURE 4.6.6

'page on' to the next item on the file. Partial commodity codes can also be used and the program will enter zeros in the remaining character positions and display this item or the next item on file.

The screen gives the full commodity description, a list of factories using the item, the stock and order unit and a list of cross reference codes. The cross reference has been explained in the Look Up System section 4.4. Entering a commodity code, which is cross referenced, will always result in the display of the commodity screen for the master code. The cross reference can have two additional lines of description held for it and these are displayed on the screen (Detail *3 on figure 4.6.1.). An example of the type of additional information held would be a warning such as "refer to machine manual when fitting this bearing".

4.7. Stores Procedures and the Goods Inwards Screen



4.7.1. Requisitions

Requisitions entered on any factory terminal are printed on two part stationery by the stores line printer. The requisition figure 4.7.1., is torn from the printer by the storeman (photograph 4.7.1.) and actioned. The requisition has the quantity, commodity code number, description and stores bin number printed on it, to help the storeman

PHOTOGRAPH 4.7.1

A STOREMAN TEARING OFF A PRINTOUT OF SEVERAL REQUISITIONS

SAMPLE STORES REQUISITION PRINT

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X        *1                              *2                *3            X
X    84/01  STORES REQUISITION  10.30  29.03.79  00305                   X
X                                                                        X
X                                                                        X
X                                                                        X
X                         *4                               *5            X
X    REQ/NO    QTY    R/DEPT CHARGE DETAIL JOB/REF INIT +-               X
X    V79134     50     0106     30  872        213561   SRT              X
X                                                                        X
X                                                                        X
X                                                                        X
X                                   *6             *7                    X
X    47-31-1404        VAN DELIVERY  S R THOMPSON  *9                    X
X    (E/C5 )              50  EACH   P'FITTERS. 2904                     X
X                                               *8    *                  X
X                                                                        X
X    1/2" ROUND ELBOWS. BLACK HEAVYWEIGHT.                               X
X                                                                        X
X                                                                        X
X                                                                        X
X    ISSUED BY:                                                          X
X                                                                        X
X                                                                        X
X                                                                        X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

DETAIL

- *1 DATA TYPE/STORE NUMBER.
- *2 TIME OF REQUISITION.
- *3 PRINT SEQUENCE NUMBER (FOR USE IN REQUESTING REPRINT IN THE EVENT OF PRINTER BREAKDOWN ETC).
- *4 REQUISITIONING DEPT.
- *5 INITIALS OF REQUISITIONING AUTHORITY.
- *6 METHOD OF COLLECTION ENTERED BY REQUISITIONING DEPT AS FOLLOWS:-
  - . C = COLLECT.
  - . V = VAN DELIVERY.
  - . A = ADJUSTMENT (TO COVER RETURNS TO STOCK OR SHORT DELIVERIES).
- *7 REQUISITIONING AUTHORITY NAME.
- *8 REQUISITIONING DEPT NAME.
- *9 TELEPHONE EXTENSION NUMBER.

N.B DETAILS 5, 7, 8, AND 9 ARE HELD WITHIN THE COMPUTER ACCORDING TO REQUISITIONING AUTHORITIES SIGN ON CODE.

FIGURE 4.7.1

to quickly find the item. If the part is to be delivered by Van (Detail *6 on figure 4.7.1) it is placed in a delivery bin for collection by the van driver. Items to be collected by hand are placed in a rack next to the stores counter to await collection. The requisition top copy is retained in the stores and the bottom copy is sent with the goods. The van delivery service operates hourly between 0800 hours and 1600 hours using 2 vans. The route is fixed and the van arrives at each workshop at approximately the same time every hour. The user can therefore decide whether to have an item collected or have it delivered by van.

If there is insufficient stock to meet the requisitioned quantity the storeman uses the stores V.D.U., and keyboard to input an adjustment. This situation can arise if the actual stock held does not correspond to that listed by the computer. The requisitioning screen for the item is obtained and the charge details from the requisition are keyed in, the quantity is entered as the difference between the issued and requisitioned quantities preceded by a minus sign. Items returned to the stores are treated in the same manner, the department returning the goods being credited with their value. The data base stock is amended and an adjustment requisition is printed (see figure 4.7.1., detail *6).

4.7.2. Goods Inwards Procedures

The spares system allows all goods receipts, returns and inter store stock transfers at Fort Dunlop to be recorded directly on to the computer stock records. The Central General Stores V.D.U., and keyboard are used by the stores clerk to input the receipts (photograph 4.7.2). The procedure is to obtain the Goods Inwards screen by entering

PHOTOGRAPH 4.7.2

A STORES CLERK ENTERING A GOODS RECEIPT ON HER V.D.U.

the commodity code and an option of 'G' and the store number. The screen (figure 4.7.2.) displays the last 6 orders placed by the Buying Department for the item, the clerk compares the order number on the advice note with those displayed:-

If the order number is found the procedure is to:-

i. Enter the order position number under ORD (the VDU curser is positioned here)
ii. Enter the quantity received in stock units under QTY (an order unit can be 1 gross, the stock unit dozens ∴ 12 would be entered)
iii. The suppliers advice note number is entered under ADVNO
iv. If the order is complete a C is entered under C.

If the order number is not found.

i. The order position indicator is entered as a 9
ii. The quantity, supplier number and complete indication (if applicable) are entered
iii. The supplier number is entered under SUPPNO
iv. The order number is entered under ORDERNO.

All the data required above is available on the Advice Note sent with the goods.
The stores line printer produces a goods inwards note (figure 4.7.3.) on the same stationery as the requisition. One copy is filed away in the stores office with the advice note and a copy of the order. The other copy is kept with the goods to be used by the storeman when

GOODS INWARDS SCREEN

```
31-10-1003
SINGLE ROW RADIAL BALL BEARING
EXTRA LIGHT - BRE SERIES
*1                  *2                  *3        *4*5
1 569695/0537313 210379        50        50 C M B S BEARINGS
2 569695/0429263 010878        50         0
3 569695/0385483 250578        50         0
4 569695/0297953 070278        50         0 C
5 328649/0203723 251077        50         0   FAG BEARING COMPANY LTD
6 569695/0165243 280777        50         0


ORDER EACH            *6
STOCK EACH            *7
C/F        1.0000 *8
    ORD     QTY      ADVNO     C    SUPPNO    ORDERNO




                                                   CODE
                                                   OPT  G    STORE 01
```

THIS SCREEN IS OBTAINED BY KEYING AND ENTERING A FULL COMMODITY CODE AND OPTION "G".

DETAIL

*1 ORDER POSITION NUMBER.

*2 SUPPLIER/ORDER NUMBER.

*3 QUANITY ON ORDER (IN ORDER UNITS).

*4 QUANTITY OUTSTANDING (IN STOCK UNITS).

*5 COMMITTED STOCK INDICATOR.

*6 UNIT ITEM IS ORDERED IN.

*7 UNIT ITEM IS STOCKED IN.

*8 CONVERSION FACTOR = NUMBER OF STOCK UNITS IN AN ORDER UNIT.

FIGURE 4.7.2

SAMPLE GOODS INWARDS PRINT

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X                                                               X
X       *1                      *2                   *3         X
X    80/12  STORES RECEIPT  14.25  30.03.79  00197              X
X                                                               X
X                 *4                    *5                      X
X    GOODS INWARD STORES HANDLING COPY                          X
X                                                               X
X                                                               X
X                                                               X
X                                                               X
X    75-37-3040          STKU     30000     SETS                X
X    (GE 17) *7          ORDU         3.00 THOUS.SETS           X
X    SUPP 637792 ORD 0370965  GAN 79135 ADV 01962 COMP          X
X                                                               X
X                                                               X
X    SETS OF FOUR GOODS ACCEPTANCE NOTES SIZE                   X
X    8.1/2" X 5.1/2". 1ST COPY ACCOUNTS. 2ND                    X
X    STOCK CONTROL. 3RD STORES. 4TH ADVANCE                     X
X                                                               X
X                                                               X
X                                                               X
X                                                  *6           X
X            **  ORDER NOT ON VDU STOCK FILE     **             X
X                                                               X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

TWO COPIES OF THIS NOTE (ONE FOR STORES HANDLING AND ONE FOR STORES FILE USE) ARE PRINTED FOR EACH VALID RECEIPT DETAIL KEYED AND ENTERED THROUGH A VDU SCREEN.

DETAIL

*1 DATA TYPE/STORE NUMBER.

*2 TIME RECEIPT ENTERED INTO TERMINAL.

*3 PRINT SEQUENCE NUMBER (FOR USE IN REQUESTING REPRINT IN THE EVENT OF PRINTER BREAKDOWN ETC).

*4 FORM TITLE. = "GOODS INWARD" FOR RECEIPTS FROM SUPPLIERS/
"GOODS RETURN" FOR RETURNS TO SUPPLIERS.

*5 COPY TITLE = "STORES HANDLING COPY" FOR USE IN PUTTING GOODS AWAY/
"STORES FILE COPY" FOR FILE AND RECORDING PURPOSES.

*6 ACTION STATEMENT "ORDER NOT ON VDU FILE" IS ONLY PRINTED WHERE SUPPLIER/ORDER NUMBER IS KEYED IN ON RECEIPT DETAIL WHERE NO ORDER IS SET UP. IT IS OF THE UTMOST IMPORTANCE IN THESE CASES TO FORWARD THE STORES HANDLING COPY TO STOCK CONTROL SECTION, BUYING DEPT FOR ACTION TO BE TAKEN TO ENSURE THE ORDER DETAIL IS INSERTED ON TO THE COMPUTER RECORD.

*7 BIN NUMBER

FIGURE 4.7.3

putting the goods away. The note is then placed in a rack at the end of the bin row to be used by the stock checking clerks. In cases where the order was not on the computer file the stores handling copy is forwarded to the Buying Department to ensure the order details are inserted on the computer file (Detail *6 on figure 4.7.3., the Goods inwards print).

Goods returned to a supplier are input in the same way but the quantity is entered as a negative figure. The goods returned print uses the same format as goods inwards (figure 4.7.3.) but is retitled, the goods handling copy being returned with the items and a copy filed.

Stock transferred from other stores at Fort Dunlop and from other factories is recorded using the Goods Inwards screen. The Supplier number being the despatching store number. Two copies of the Stock Transfer print (figure 4.7.4.) are produced, one for filing and one to be used by the storeman to put the goods away.

The computer data base is therefore updated with receipts, returns and stock transfers as they occur. Each morning the mainframe prints a list of Goods Acceptance notes for the Financial Accounts Department (figure 4.7.5.). The notes are used for clearing invoices and payment of the suppliers. The stock control system is controlled by the Buying Department at Fort Dunlop and they require a list of all stock transfers and receipts/returns booked in on the terminals. A list (figure 4.7.6.), is therefore printed daily at the computer centre and forwarded to the Buying Department.

SAMPLE STOCK TRANSFER PRINT
===========================

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X                                                                  X
X       *1                         *2              *3              X
X    76/01  TRANSFER RECEIPT  12.15  30.03.79  00151               X
X                                                                  X
X    GOODS INWARD                                                  X
X                                                                  X
X                                                                  X
X                                                                  X
X                                                      *4          X
X    51.04.1352     STKU      6  EACH  SUPP STORE 30               X
X    (5E17 )                                                       X
X                                                                  X
X                                                                  X
X                                                                  X
X                                                                  X
X    12" HALF ROUND FILES.                                         X
X    FINE CUT. DIAMOND EDGE.                                       X
X    SPEAR AND JACKSON REF NO. 63C/12.                             X
X                                                                  X
X                                                                  X
X                                                                  X
X                                                                  X
X                                                                  X
X                                                                  X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

THIS PRINT IS ONLY PRODUCED WHEN TRANSFER RECEIPTS ARE RECORDED THROUGH THE TERMINAL. IN NORMAL CIRCUMSTANCES THESE RECEIPTS ARE AUTOMATICALLY PRODUCED AND ACTIONED WITHIN THE COMPUTER.

DETAIL
------

*1 DATA TYPE AND RECEIVING STORE CODE NUMBER.

*2 TIME OF INPUT OF TRANSACTION INTO SYSTEM.

*3 PRINT SEQUENCE NUMBER (FOR USE IN REQUESTING REPRINT IN THE EVENT OF PRINTER BREAKDOWN ETC).

*4 SUPPLYING STORE NUMBER.

FIGURE 4.7.4

SAMPLE PRINT OF FINANCIAL ACCOUNTS GOODS ACCEPTANCE NOTE
==

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X                                          *1                 X
X PROGRAM NO. CG550    GOODS ACCEPTANCE NOTE    DATE 30 03 79 X
X                                     *2                      X
X FINANCIAL ACCOUNTS DEPT, FORT DUNLOP.                       X
X                                                             X
X SUPPLIER MOORE PARAGON (UK) LIMITED                         X
X                                                             X
X RECEIVING STORE NO.  12                                     X
X                                                             X
X SUPPLIER/ORDER NO.    637792/0370965                        X
X                                                             X
X ADVICE NOTE NO.       01962                                 X
X                                                             X
X GOODS ACC. NOTE NO.  79135  *3                              X
X                                                             X
X QTY RECEIVED IN STOCK UNITS    30000      SETS              X
X QTY RECEIVED IN ORDER UNITS        3.00   THOUS.SETS        X
X                                                             X
X 75 37 3040      SETS OF FOUR GOODS ACCEPTANCE NOTES SIZE    X
X                 8.1/2" X 5.1/2". 1ST COPY ACCOUNTS. 2ND     X
X                 STOCK CONTROL. 3RD STORES. 4TH ADVANCE      X
X                                                             X
X                                                             X
X                                                             X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

THESE NOTES ARE PRINTED DAILY WITHIN COMPUTER CENTRE AND ARE FOR USE BY FINANCIAL ACCOUNTS DEPT IN INVOICE CLEARANCE FOR PAYMENT ROUTINES. A SEPARATE NOTE IS PRINTED FOR EACH RECEIPT/RETURN BOOKED IN VIA COMPUTER TERMINAL.

DETAIL

```
*1  REPORT TITLE    =  "GOODS ACCEPTANCE NOTE" FOR RECEIPTS.
                       "GOODS RETURNED NOTE" FOR RETURNS.

*2  FACTORY TITLE   =   PRINTED ACCORDING TO STORE OF RECEIPT:-

                           . 01 - 19  =  FORT DUNLOP.
                           . 20 - 29  =  WASHINGTON.
                           . 30 - 39  =  SPEKE.
                           . 40 - 49  =  INCHINNAN.

*3  G.A.NOTE NO.    =   FIRST TWO DIGITS  =  YEAR.
                        LAST THREE DIGITS =  DAY OF YEAR.
```

FIGURE 4.7.5

SAMPLE PRINT OF BATCH INPUT LIST

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
X                                                                 X
X PROGRAM NO. CG55C  BATCHES TO BE INPUT TO CM01 DATE 30 0379X
X                                            *1                   X
X STOCK CONTROL, BUYING DEPT, FORT DUNLOP.                         X
X                   *2                                            X
X   BATCH LEADER 301                                              X
X                              *3                                 X
X                         BATCH    NUMBER     STORE  DATA         X
X                         NUMBER   OF ITEMS   CODE   TYPE         X
X                                                                 X
X                          1001       23       01     80          X
X                          1002        5       12     80          X
X                          1003       50       01     84          X
X                          1004       50       01     84          X
X                          1005       50       01     84          X
X                          1006       29       01     84          X
X                                                                 X
X                                                                 X
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

THIS LISTING IS PRINTED DAILY WITHIN COMPUTER CENTRE, CONTAINS DETAILS OF ALL BATCHES OF RECORDS INPUT VIA TERMINALS WHICH ARE TO BE INCLUDED IN THE NEXT CM01 RUN, AND IS FOR USE BY STOCK CONTROL SECTION, BUYING DEPT TO MONITOR INPUT INTO THE TWICE WEEKLY BATCH RUNS.

DETAIL

*1 FACTORY TITLE ATTACHED ACCORDING TO BATCH LEADER TYPE:-

. 301	STORES 01 - 12	FORT DUNLOP.
. 302	STORES 20 - 28	WASHINGTON.
. 303	STORES 30 - 38	SPEKE.
. 304	STORES 40 - 48	INCHINNAN.
. 305	STORE 19	CMS FORT DUNLOP.
. 306	STORE 29	CMS WASHINGTON.
. 307	STORE 39	CMS SPEKE.
. 308	STORE 49	CMS INCHINNAN.

*2 BATCH LEADER ATTACHED ACCORDING TO STORE NUMBER AS ABOVE.

*3 BATCH NUMBER ATTACHED AND MADE UP AS FOLLOWS:-

- .FIRST DIGIT = LAST DIGIT OF BATCH LEADER CODE.
- .SECOND DIGIT = SECOND DIGIT OF DAILY DATE.
- .THIRD & FOURTH DIGITS = SEQUENTIAL NUMBER IN RANGE 01 - 99.

FIGURE 4.7.6

4.8. Summary

The Engineering Spares System contains 10 VDU screen formats, each screen type is obtainable from any other screen providing sufficient code and the option are entered. Figure 4.8.1,shows the system summary diagram.

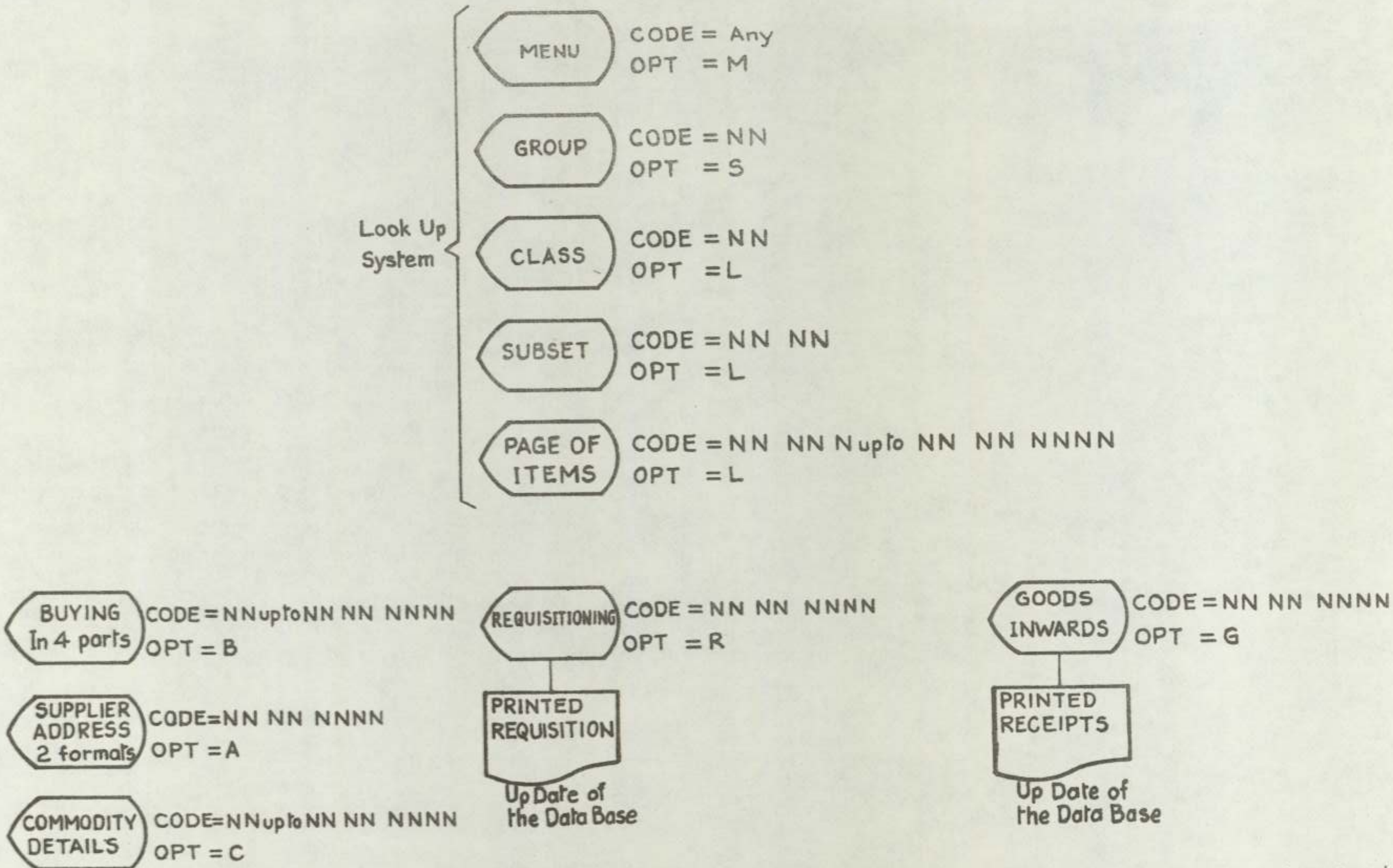
The Engineering Spares System Users Manual, is available at the Fort Dlp's Computer Centre (Ref. 126). The thesis has expanded the information given in the manual but for the sake of brevity certain aspects of the system have not been included.

i. Store Numbers
ii. Signing Off
iii. How to enter requisition charge details
iv. Delivery and Settlement terms codes used on the Supplier Address screen
v. The Factory Location indicators used on the Commodity Details Screen
vi. Glossary of Buying Department terms
vii. The error messages returned to the screens, and their interpretation

4.9. The Computer Programs

4.9.1. Introduction

The spares system was programmed from program specifications written to Dunlop Management Services, Computer Centre standards. The system was fully documented, all specifications manuals and programs being filed



Note :- Any Screen Being Obtainable From Any Other Screen.

FIGURE 4.8.1

THE ENGINEERING SPARES SYSTEM SUMMARY

in the program library at the Computer Centre at Fort Dunlop. The program listings and specifications have not been included as they now run to several hundred pages.

The Spares System exists in parallel with the Central General(CG) and Crude Materials (CM) stores suites. Figure 4.9.1., shows the relationships. The CG CM suites are run on Monday and Wednesday nights. After all the data has been processed a Materials Control data base is created, which is then used by the Engineering Spares System to provide the information displayed on the VDU's. The terminal transactions up date the data base with stores issues, receipts, returns and stock transfers. Each transaction is also logged and then combined with 'paper' input data, such as stock checks, any paper requisitions, supplier amendments etc., and input to the next CG CM suites run.

The Engineering Spares System therefore does not directly 'up date' the stores system it provides stores information and keeps the information current by up-dating its own Materials Control data base, with all stores transactions occurring between the batch CG CM suite runs.

The Spares System is therefore a compromise between a full on-line system and a batch system.

A batch stores system can only provide information and perform tasks, such as recording items, using data submitted prior to the computer run. The information provided and tasks performed will, therefore, be as current as the last transaction submitted. An on-line system will always provide current information and can also perform tasks as the need occurs (e.g., an order is printed as the stock passes through the pre set re order level). The Engineering Spares System provides stock

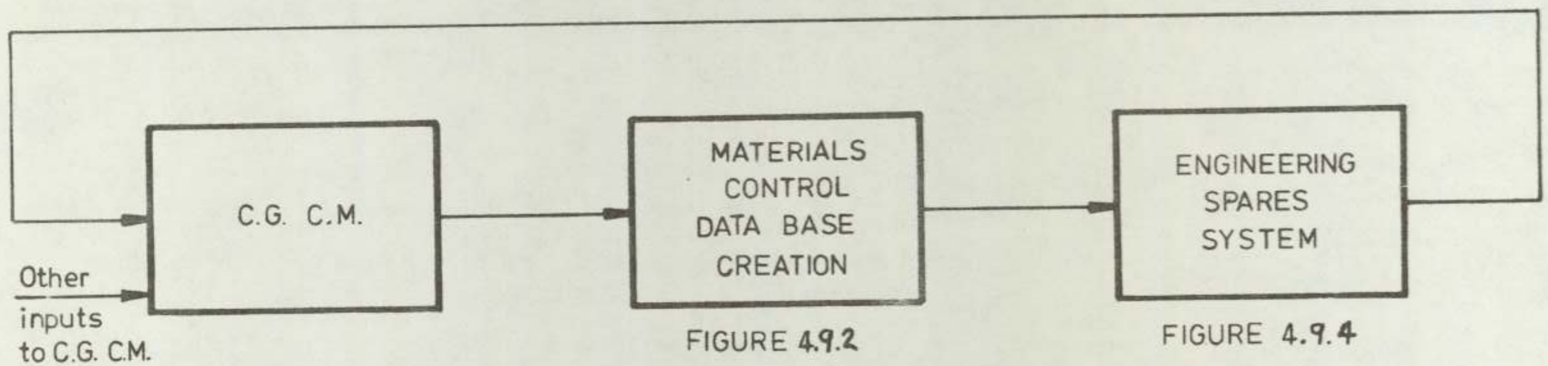


FIGURE 4.9.1

THE ENGINEERING SPARES SYSTEM.

Showing the relationship with the original C.G. C.M. Computer system.

information on line, up dating it as transactions occur but leaves the batch system to carry out the 'management' side of the stores system - printing the orders, setting up new stores items, etc. The benefits of on-line information have been made available, without the considerable cost of completely re programming the stock control systems as data base systems.

4.9.2. CG. CM. The Central General and Crude Materials Stores Suites

All Dunlop Tyre Divisions'stock files are held on the Fort Dunlop main frame computer. The CG suite maintains a stock file for General and Stationery items held in stores at Fort Dunlop, Washington, Inchinnan and Speke. There are approximately 20,000 stock records. The CM stock file is maintained as a separate suite, it contains approximately 2,500 crude materials stocked in Tyre Division factory stores.

The CM and CG suites perform the following functions:-

Stock Control

Receipts, issues, transfers despatches and stock checks are recorded against a stock balance for each store at which a commodity is stocked.

Orders

Orders are automatically produced by the computer when the stock reaches or falls below a manually set reorder level. Manual orders can also be raised throughout the system. Commodities can be held at 'sub stores' within a factory and be replenished by transfer from the main factory store. In these cases, the main stores is regarded as the supplier.

The CM suite has certain commodities set for manual orders. The computer produces an 'order required' report for the buyers, who then raise the order.

A danger level is also set for each item. When the stock reaches or falls below this level, a warning report is printed.

Receipts

Goods are booked into the stores against their order numbers. A report is produced if an item goes overdue, an advised lead time being held.

The actual lead time is calculated for each supplier by averaging the actual lead times over the last 6 orders.

Issue Reports

All issues are recorded on an Issues History File. Reports are produced weekly and monthly detailing all issues, by chargeable factory department (the department the cost is recovered against). The Works Engineers receive a series of reports showing all issues to each engineering workshop.

Supplier Performance

A performance record is held for each supplier for each commodity. Details of all receipts are held (value, quantity, number of receipts within the month and a year to date figure). The current average stock price is calculated after each receipt and can be compared with the price at the start of the year which is also held. The number of overdue deliveries is also recorded.

Supplier Invoices

The CM system passes details of orders and receipts directly to the Purchase Accounts computer suite enabling invoices to be automatically certified. The CG system requires the certification to be performed manually and an output report is produced.

Frequency of Operation

The CG and CM suites are run twice a week, on Monday and Wednesday nights. The Monday run also performs the weekly, monthly, quarterly and year end runs as required. The data to be input is subjected to a combined data validation, the CM suite is then run followed by the CG run. The CM suite is run first as it maintains the supplier address file required by both systems.

The Purchase Accounts suite is run following the Wednesday night CG run as it uses order and delivery information produced by the Monday and Wednesday nights CG CM runs.

4.9.3. The Engineering Spares System Sources of Data

Two data bases and an index file are used:-

Materials Control Database MCDB

As previously stated this is created after each CG.CM suite run.

Table Data Base

This is a shared database holding tables of data required by several systems. The tables accessed by the Spares system all originate from the CM batch system, insertions and deletions being passed to the Table Data Base.

The tables used are:-

. User information	-	the list of users, their password, which sections of the system they can use and the data required, when printing a requisition - name, telephone number etc.
. Sanction Numbers	-	list of current valid sanctions.
. Machine Number	-	list of factory machines and their cost centres.
. Sections	-	list of the Groups falling into each section (On Menu screen).
. Group, Class, Subset	-	the catalogue data for the look up screen headings.
. Department Code	-	list of valid factory department charge codes.

Supplier Address file (indexed sequentially)

This file is maintained by the CM suite and contains the supplier name, address carriage charges and payment details (discounts given). The file is held indexed sequentially by supplier number.

4.9.4. Materials Control Data Base Creation

The CG and CM stock files are reformatted into a data base by program CG152. The CM file is input directly to the program but the CG file has to be 'expanded' by first passing it through CG150 (See figure 4.9.2.).

Program CG150

The CG stock file contains a series of records for each item stocked by Tyre Division, they are:-

- Main Store Record - the items stocked and supplier record for each store.
- Sub Store Record - details of stock transferred from the main store.
- Commodity Record - description and all data held for Coding and Standards.
- Stores Description Record - stock value etc.
- Heading Record
- End Record.

CG150 reads this file looking for any commodity with cross reference codes listed as part of the Commodity Record. These commodities have one stock record at the factory but are used on more than one machine (up to 12), each machine requiring a separate commodity code for the same item. The program creates an output file containing the Commodity Code (i.e., each cross reference code found) the description and the 'Stock' commodity code.

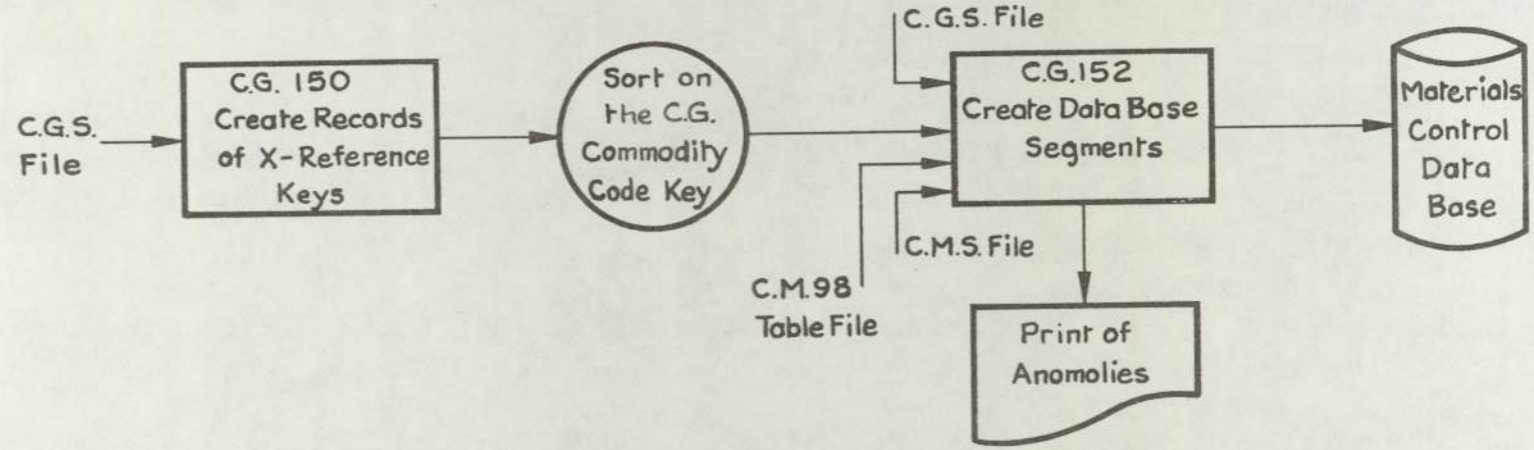


FIGURE 4.9.2

MATERIALS CONTROL DATA BASE CREATION

(Sub-system Diagram)

e.g., input	30 10 1002	-	Stock commodity code
	Big end bearing	-	description
	12 15 1033 21 16 1044	}	x references

output	12 15 1033 Big end bearing 30 10 1002	and	21 16 1044 Big end bearing 30 10 1002

The stock commodity code is included to enable the spares system to find the stock information when accessing a cross reference code.

Program CG152

This program performs a 3 file match between the

- CGS file
- CMS file
- CGS cross reference file.

The CGS cross reference file is first sorted into commodity code order, the files are then read and the data base created by inserting the data into segments in strict sequence of

Commodity (Basic details) root segment

Description

Store, Suppliers orders, store notes (Separate set of segments for each store)

Cross references

Header

The data base structure is shown in figure 4.9.3. and the data base contents are given in Appendix 4A.

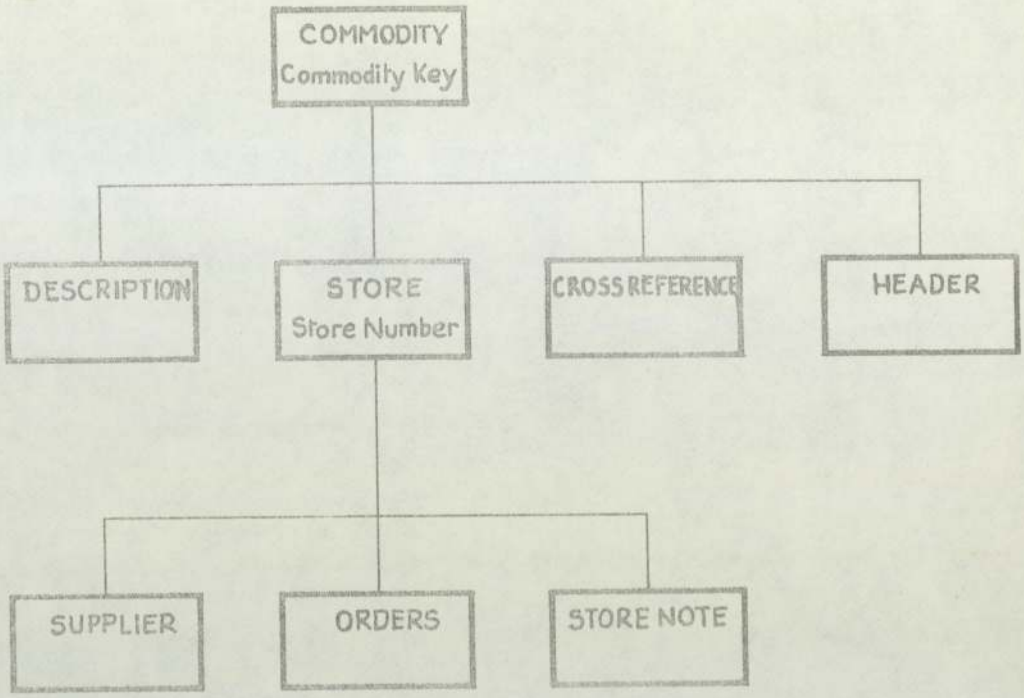


FIGURE 4.9.3

THE MATERIALS CONTROL DATA BASE STRUCTURE.

When the computer obtains a cross reference code from CG150 only the commodity basic details and description segments are inserted in to the data base. An indicator is set in the basic details to signify that the item is cross referenced and the stock commodity code is included to provide a pointer to the full commodity record.

Any anomolies between the files are printed on a report. A table file from the CM file (CM98) is used to convert the factory location codes into abbreviated factory names, simplifying the report and avoiding a manual conversion.

4.9.5. Engineering Spares System Programs (figure 4.9.4.)

The programs that output the visual display unit (V.D.U.) screens' content have been kept small. This has two advantages, the response time of the system is improved, as C.P.U. space can be easily obtained and program maintenance is simplified. Each program has one or two screens in it, depending on the program length. (≃6K). Its operation can best be described by detailing the programs contents.

CG500

This program is the heart of the system; it receives all input messages from the screens, checks the validity of the input, outputs the menu screen or passes control to the relevant program to output the other screen types. Common data required by the system is held in a "workfile" set up by CG500. This file is passed by CG500 to the program in control and provides the data required to output the screen. It is then updated by that program (including returned, error messages) and returned CG500.

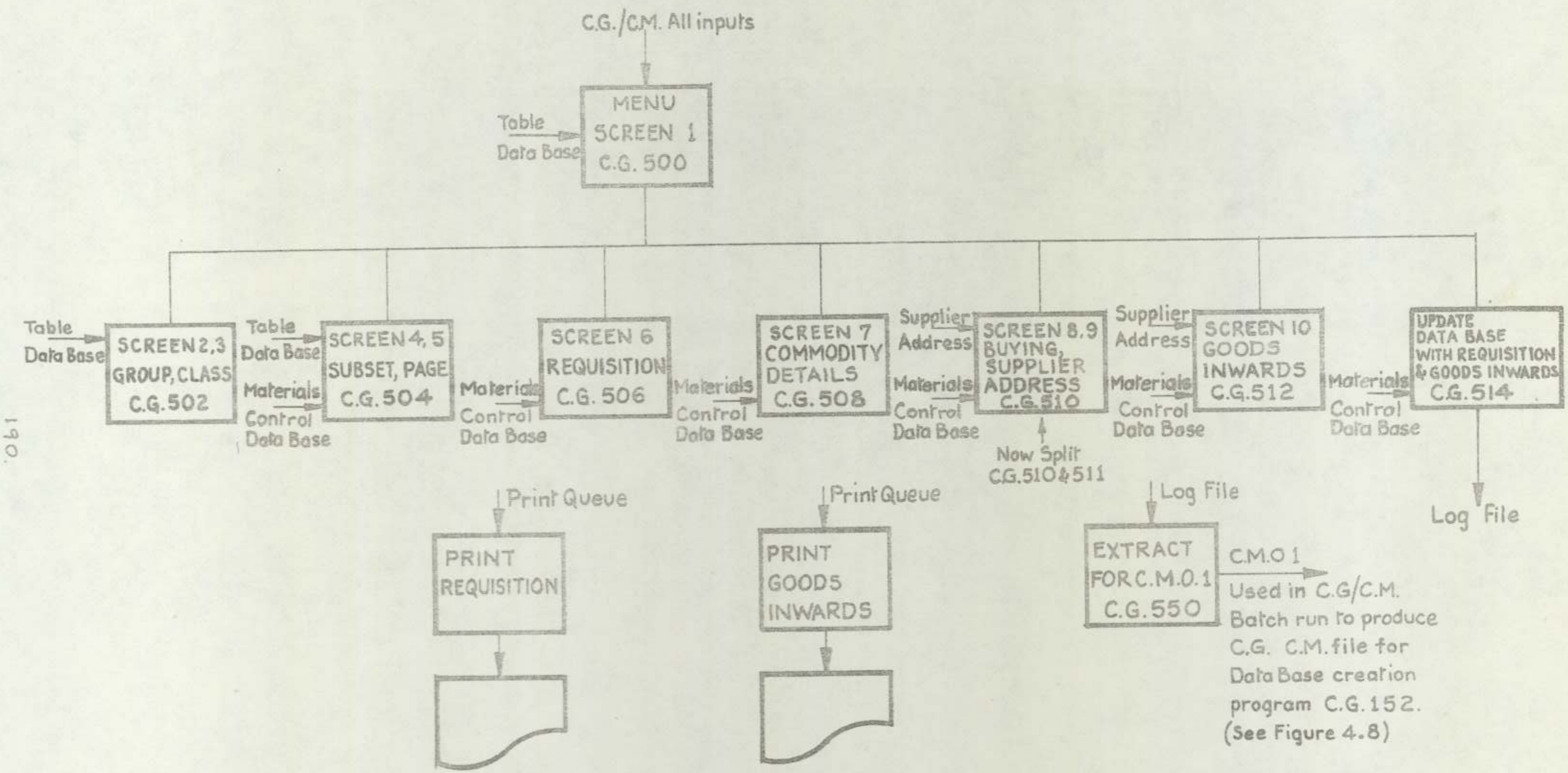


FIGURE 4.9.4

ENGINEERING SPARES SYSTEM

(Sub-system Diagram)

The system sign on/sign off and the user authority sign on/sign off are also controlled by CG500.

CG502 - 512

These programs output the VDU screens. They access the table data base, the Materials Control data base and the supplier address file as required. The CG510 program required 21K of C.P.U., and was causing delays to the system (it was difficult to obtain 21K of C.P.U., as a single block), the program was therefore divided into two programs - CG510 and CG511 after the system implementation.

The requisitioning screen CG506 passes requisition details to CG500 where they are validated and then passed to CG514, to update the data base. A requisition is then output to the print queue for printing in the stores. CG512 passes "goods inwards" details to CG500 and again after vetting to CG514 and to the "goods inwards" print queue.

CG514

This program updates the data base with all requisitions and "goods inwards" receipts, returns and transfers. It also outputs the system log file to CG550.

Batch input to the CM/CG system - CG550 Figure 4.9.5.

This program reads the log file from CG514, containing returns and receipts from outside suppliers, stock transfers and requisition issue records. The file is sorted, then CG550's function is to:-

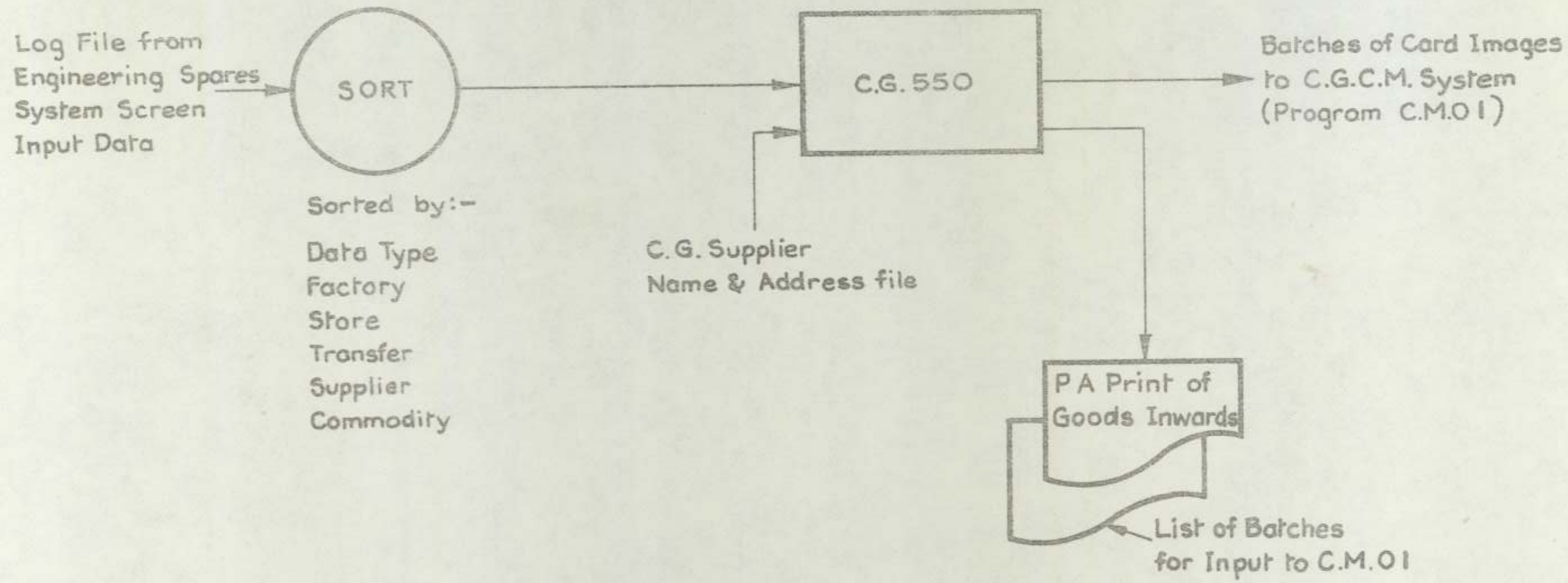


FIGURE 4.9.5

EXTRACT OF DATA FROM ENGINEERING SPARES SYSTEM

FOR INPUT TO THE C.G.C.M. BATCH SYSTEM.

- Print goods receipts for Financial Accounts, where they are used as proof of delivery when clearing invoices. These receipts are only required for Central General Stores items as Crude Materials booked into the system are passed to the Purchase Accounts computer system for automatic certification. The supplier address file is used by the program to enable the full name and address to be printed on the receipt rather than simply printing the supplier number.

- Batch up receipts, transfers and issue data for input to the batch CM/CG system. The CM/CG files are updated by programs run in batch mode on Monday and Wednesday nights each week. These programs expect data in batches according to data type and factory store number in maximums of 50 transactions between batch leader cards. The data from the spares system therefore has to be formatted as if it was paper input to be acceptable to these 'old' programs.

- Print a list of batches

  These lists of batches input to the CM/CG system are printed as a record for the stock control section of the Buying Department to show them what has been automatically entered to the update runs.

4.10 Justification

All capital expenditure has to be authorised by the Director Tyres - UK. In order to obtain authorisation for the Engineering Spares System a Sanction Application and a justification report had to be produced. The

Date [illegible] PRODUCTION SECTION OR DEPARTMENT WORKS ENGINEERING SANCTION TOTAL £ 37,425

Application Ref 11.6702/332 75.36.1078

SCL 9683

CAPITAL REQUIREMENTS		FINANCIAL RESULTS	Year 1 19	Year 2 19	Year 3 19	Year 4 19	Year 5 19
Transfers from Assoc. Cos.							
Other Expenditure							
SANCTION TOTAL	37,425	Net Turnover					
Less Revenue Items Rental	28,800	Gross Contributions and or Savings					
Capital Expenditure Required	8,625	Less Depreciation					
Other related Capital Expenditure (a) Sanctioned (b) To be Sanctioned		Additional Per od Expenses					
TOTAL CAPITAL EXPENDITURE	8,625	Revenue Items A&R etc.					
Less Government Grant		Taxation					
Sub-Total	8,625	Net Profit Loss					
		Cash Flow					

The commencing date should be that in which payments are first expected to be made and the yearly periods should run from that date.

NET WORKING CAPITAL (Normal Year)

Net Yield (after tax) on Additional Net Capital Employed Normal Year

ADDITIONAL NET CAPITAL EMPLOYED 8,625

Pay-back period based on Total Capital Expenditure Years

CAPACITY	Existing per week	Additional per week	Sales Extra per week
Quote unit used e.g. lbs. feet etc.			

PLANT REDUNDANCY OBSOLESCENCE ARISING	Year of Purchase	Net Book Value £	Scrap Value £

DATES

Estimated date when equipment will be ready for use: 12 months

Date for closing Sanction: 18 months

COMPARISON WITH MANAGEMENT PLAN 19 78 19 80 Project Ref. No.

Half Yearly Expenditure Forecast (excluding Revenue)

			78	79	80		
SANCTION			8,625				

ALLOCATIONS

FINANCIAL ACCOUNTS HEADINGS	Amounts	DEPRECIATION Additional p.a.
Additions – Plant	£ 8,625	£863
Rental	£28,800	

EXPENDITURE GROUPS Nos.	Amounts
4 Maintenance and Modernisation	£ 8,625

NATURE OF PROPOSALS AND REASONS

ENGINEERING SPARES PROJECT

It is proposed to rent and install nine computer terminals to be connected to the main frame IBM computer by co-axial cable in order to provide an Engineering Spares Control System. The facilities that will be available are

for Engineering Workshops

(a) Immediate access to information currently contained in the Dunlop Stores Code Catalogue.

(b) Immediate access to stock figures for engineering spares.

(c) Ability to raise requisitions for those spares.

and for Central General Stores

As above plus a printer to produce a hard copy of the remotely raised requisitions.

There are many advantages arising from the implementation of this proposal, but the main justification is in the more effective control of Engineering Spares which will eliminate many hours of engineering time currently spent in waiting, fetching and carrying, and will therefore yield more time available for effective maintenance work throughout the factory. This is only one of many projects to be put forward to improve systems which together with the re-structured management and improved supervision will enable the engineering operations at Fort Dunlop to be carried out with a reduced labour force.

Implementation of this proposal will accrue an estimated saving of £92,380 arising from a once off spares saving of £48,000 and improved utilisation of Engineering Labour at £44,380 per annum.

Annual rental charges will be as follows:-

	£
Engineering Workshops in Tyres 1, 2, 4, 5 and Tubes	
Seven – IBM 3278 Visual Display Units @	3,696
Central General (Main) Stores	
One – IBM 3278 Visual Display Unit @	528
One – IBM 3287 Printer @	1,536
Total rental charges per annum	5,760

Total rental charges for an initial period of five years will therefore be £28,800. In addition, there will be a once-off capital cost of £8,625 for the supply and installation of cabling.

Authorisation is requested for the expenditure of £37,425.

Supporting Signatures

Production Director – Tyre Division

Works Director – Fort Dunlop

Accounting Director – Tyre Division

Financial Controller – Tyre Division

Manager, Management Services – Tyre Division

Buying Manager – Tyre Division

Authorisation by

Director, Tyres – U.K.

Authorisation No. [illegible]

FIGURE 4.10.1
SANCTION APPLICATION

sanction is shown as figure 4.10.1., the financial justification and non-tangible benefits are available in full in the justification report (Ref 127). This section highlights the costs and benefits.

Financial Justification Fort Dunlop

The system was justified as part of a total engineering re-organisation involving the voluntary redundancy of some 240 engineering tradesmen and mates. After discussion with the Financial Controller, Tyre Division and the Chief Engineer, a justification was produced based on the following:-

- 166,622 requisitions were processed by the Central General Stores in 1977. Of these 69% (115,305) came from engineering sources, the rest from production departments.

- An analysis of the source of the engineers requisitions showed that 82% came from 5 areas - the 4 factory production zones workshops and the Machine Tool Department. (figure 4.10.2.).

- A further analysis of the commodities requisitioned by the engineers revealed that 13 commodity groups received 82% of the requisitions, (figure 4.10.3.). These items were not machine spares but consumables used by the engineers and not normally required on a breakdown basis.

- Only 10.7% of the engineers requisitions were for machine spare parts that could be expected to be used on breakdowns. This

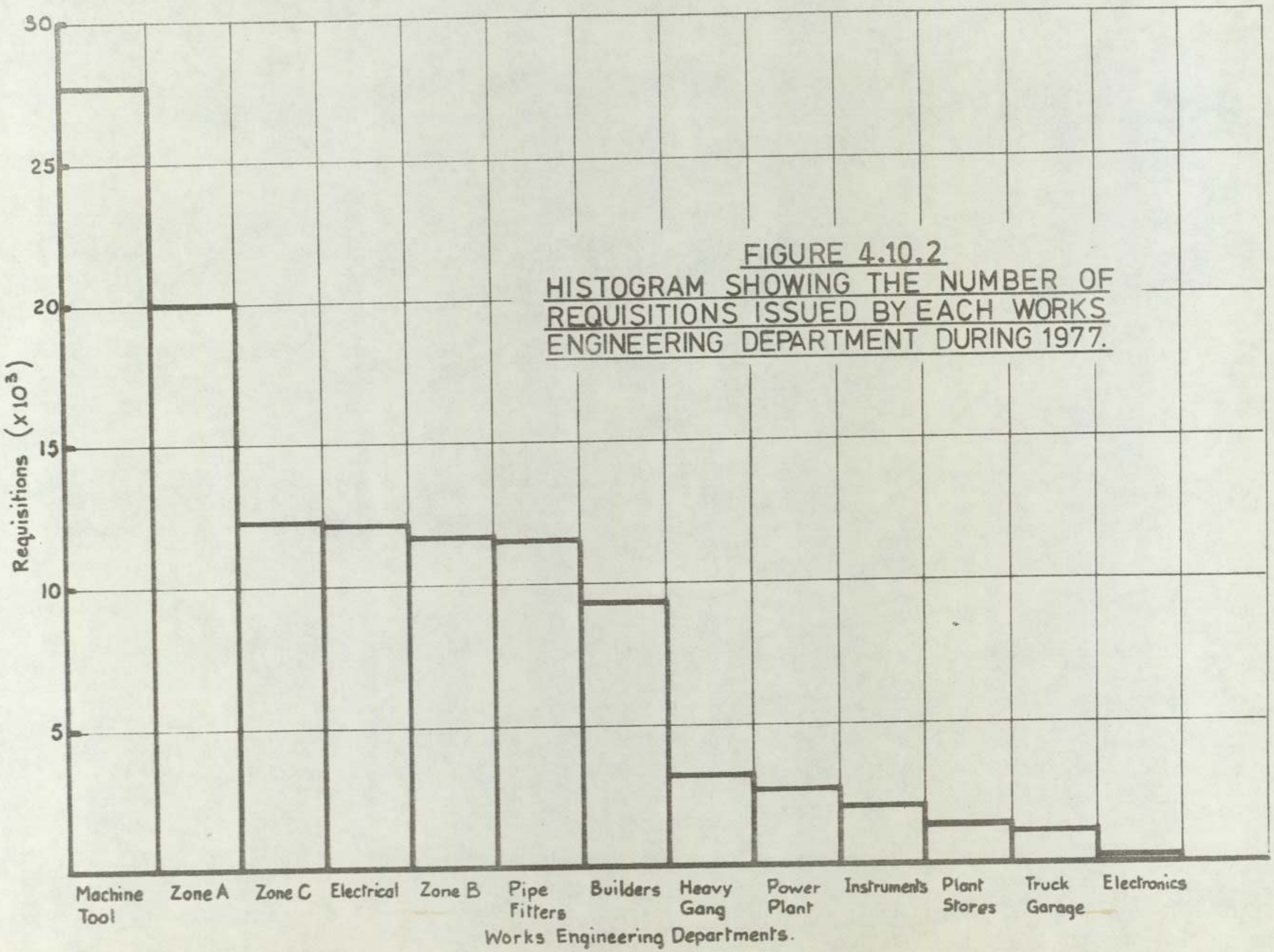


FIGURE 4.10.2
HISTOGRAM SHOWING THE NUMBER OF REQUISITIONS ISSUED BY EACH WORKS ENGINEERING DEPARTMENT DURING 1977.

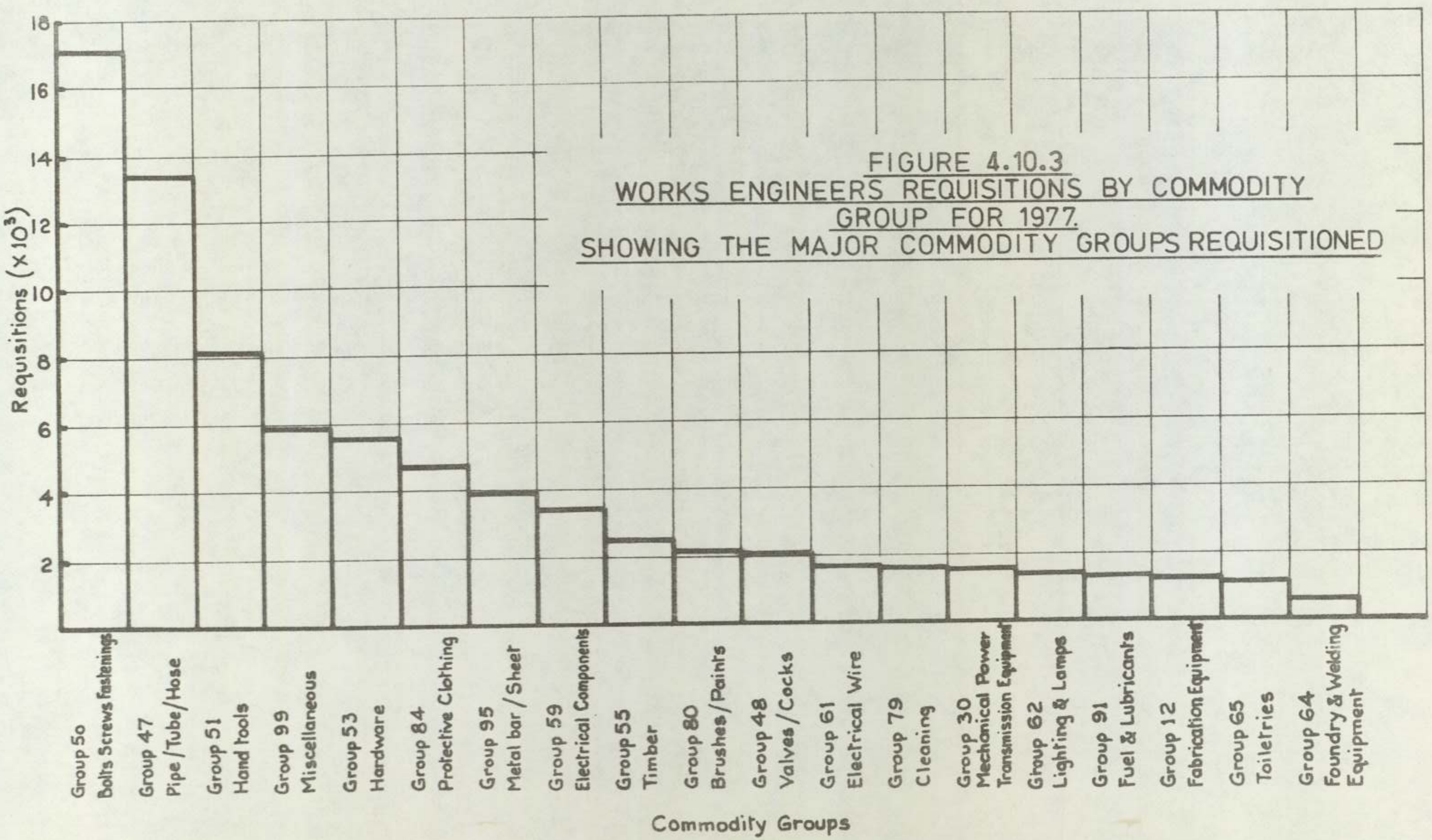


FIGURE 4.10.3
WORKS ENGINEERS REQUISITIONS BY COMMODITY GROUP FOR 1977.
SHOWING THE MAJOR COMMODITY GROUPS REQUISITIONED
Requisitions ($\times 10^3$)
18
16
14
12
10
8
6
4
2
Group 50 Bolts Screws Fastenings
Group 47 Pipe/Tube/Hose
Group 51 Hand tools
Group 99 Miscellaneous
Group 53 Hardware
Group 84 Protective Clothing
Group 95 Metal bar/Sheet
Group 59 Electrical Components
Group 55 Timber
Group 80 Brushes/Paints
Group 48 Valves/Cocks
Group 61 Electrical Wire
Group 79 Cleaning
Group 30 Mechanical Power Transmission Equipment
Group 62 Lighting & Lamps
Group 91 Fuel & Lubricants
Group 12 Fabrication Equipment
Group 65 Toiletries
Group 64 Foundry & Welding Equipment
Commodity Groups

represented 12,321 requisitions and excluded the Machine Tool Department.

. The Central General Stores had two vans for delivering items to the factory workshops. The vans had fixed rounds picking up requisitions and delivering goods, the service operated from 8 in the morning until 4 in the afternoon. A record of the use the engineers made of the van was made by the Stores Manager during one week:-

87% of goods requested were collected by hand
9.2% were delivered by the van
and the other 3.8% were out of stock
and their source was not recorded.

(Pro rating the 3.8% for out of stock gives 90.4% by hand and 9.6% by van).

When the CGS van delivery service was first introduced over 75% of requisitions raised were for items to be delivered by van. The system was now being abused by the engineering workforce as an excuse for leaving the workshop and walking across the site. Maximising the use of the van service would release engineering labour for more valuable work and improve the turn round time for the jobs; the part being delivered whilst tradesmen continue the job.

It was agreed by the engineering foremen and stores management that the 75% van delivered level could be realised again. Only the 10.7% of engineering requisitions for machine spares required for breakdowns could justify the collection by the tradesman. It was also agreed that Machine Tool Department could have most of their parts delivered by the

CGS van.

The labour wasted in collecting these parts could be either redirected to more productive tasks or a labour reduction was possible.

To be conservative in the savings the following assumptions were made:-

1. Currently 10% of requisitions were raised for van delivery, 90% were collected by hand.
2. A round trip to the stores takes one man 20 minutes and he takes on average 2 requisitions. (Agreed by stores and engineering foremen).
3. An improvement of van deliveries could be made and 75% of engineers requisitions could be delivered by van.
4. 75% of requisitions would be sent via the computer link.

Savings

i. Engineering time

An engineering tradesmen/mate average cost = £3.16p hr (includes variable O/head - source Engineering Methods Office, Fort Dunlop).

With an improvement of 65% (10-75) in van delivery level.

$$115{,}305 \text{ (requisitions) } \times \frac{65}{100} = 74{,}948$$

$$\frac{74{,}948\ (\text{requisitions}) \times 3.16\ \left(\frac{£}{hr}\right)}{2\ \left(\frac{\text{requisitions}}{\text{trips}}\right) \times 3\ \left(\frac{\text{trips}}{hr}\right)} = \underline{£39{,}472}$$

say £39,500

or a potential saving of 6 men (40 hr week 50 weeks a year).

ii. Wasted stores visits when the part is out of stock

Assumptions

1. The VDU will show that the item is out of stock.
2. 90% of these requisitions are 'walked' to the stores.
3. 115,305 requisition represents 96.2% of the batch issued (3.8% obtain no item).

$$\frac{115{,}305\ (\text{requisitions}) \times 0.38}{0.962} = 4554 \text{ requisitions}$$

$$\frac{4554\ (\text{requisitions}) \times 0.9 \times 3.16\ \left(\frac{£}{hr}\right)}{6\ \left(\frac{\text{requisitions}}{hr}\right)} = \underline{£2158}$$

say £2150

iii Reduced Use of Requisition Books

115,305 + 4554 requisitions = 119,859
50 requisitions per book at 42p each
with 75% of all requisitions coming via the terminal
the saving = £755
say £750

iv. Reduced Data Preparation Cost

A requisition entered at a terminal is recorded directly on the computers' issue log file. The cost of data preparation needed when using paper requisitions is therefore saved. Assuming

1. 75% of requisitions come via terminal

2. Punching cost = £22 per 1000 cards

3. Punch girls take up other work

$$.75 \times 115{,}305 \text{ (requisitions)} \times \frac{22}{1000} \left(\frac{£}{\text{Requsitions}}\right) = £1900$$

v. Stock - Holding Reduction

A once off saving of £48,000 was possible if the engineers returned part of their unnecessary "safety" stocks to the main store. The figure was calculated by a Dunlop working party of Engineering Management, trades union representatives and foremen. (Works Engineers Project Team 1 Report). This system would give them the confidence to reduce this stock.

Total Savings

Engineering time	39,500
Out of stock items	2,150
Reduced use of reqns.	750
Data preparation	1,900
	£44,300 per annum

Once off from returned spares

£48,000

Expenditure

The cost of developing the system has been approximately £35,000, this can be divided as follows:-

Authors salary and fringe cost	£14,000
Computer systems development (Programming and Systems Analysis charge)	£21,000

Then capital expenditure sanctioned:

Co-axial cable and installation	£8,625 once off '78
8 IBM 3278 VDU's rented	£4,224 per annum
1 IBM 3287 Line Printer	£1,536 per annum

Operating cost - Data Processing charge £10,000 per annum (Contribution to Computer Operating cost based on C.P.U. time).

The sanction application therefore asked for a capital expenditure of £8,625 for cabling and a revenue expenditure of £28,800 for 5 years equipment rental. The sanction was authorised on the 10th October 1978. (Figure 4.10.1).

In summary the expenditure and savings claimed were:-

Expenditure Sanctioned £37,425

Consisting of £28,800 (revised) for 5 years rental of computer hardware (£5,760 per annum) and a once of capital expenditure of £8,625 for the supply and installation of cabling.

Additionally

Software development cost	£35,000
Annual computer operating cost	£10,000

Savings Claimed

Annual

Improved utilisation of engineering labour	£41,650
Reduced use of requisitions and Data Preparation savings	£ 2,650
	£44,300

Once Off (first year)

Returning surplus spares to stores	£48,000

The development and cabling costs are recovered within the first year and subsequently annual savings of £44,300 are claimed compared with an annual expenditure of £15,760 for terminal rental and operating costs.

These costs are only applicable to Fort Dunlop. If another organisation was to consider developing and implementing a similar system the following points should be considered:-

The author spent 2 years designing, developing and implementing the system, this involved the use of University of Aston facilities such as information retrieval systems and, of major importance, the time of lecturers who acted as 'unpaid' consultants to the company.

(Tuition fees were paid by the company to the University but these were negligible compared with the lecturers time given to the project).

The commodity code was already in use and was established throughout the company. The code is highly structured and readily adaptable to use within a computer system. Considerable expenditure would be required to implement a similar coding system else-where.

The systems development cost of £21,000 represents approximately 540 man days, the division of work being shown in figure 4.2.1. The cost of systems analysis and programming varies considerably between companies. The programming at Fort Dunlop is done 'in house' without the use of contract staff.

Cost Justification Discussion

The application of marginal costing to this project were discussed with the Financial Cost Control at Fort Dunlop. The conclusions arrived at were that the principles of the technique could be used in the circumstances since fixed costs would not be effected (i.e. cost of management, workshops, etc). The problem was complicated by stating that the labour savings claimed were on a man hour basis as no men were used as full time stores messengers.

The cost saving could either be calculated using the tradesmens marginal cost (hourly rate and fringe cost - which is 40% of hourly rate), or on the increase in maintenance hours available by estimating the value of decreased downtime to the company, (engineering downtime was estimated at £6.5 million loss of sales for 1979). The cost of downtime was not used as the company policy at this time, was to reduce maintenance labour with as little disruption to production as possible. The hours saved by this system therefore allowed six men to be released without reducing the overall efficiency of the maintenance organisation.

A common method of justifying computer systems is to make a conservative estimate of the improvements possible. If a 1% improvement in machine downtime was made at Fort Dunlop £65,000 worth of extra tyres would be produced (1979 figures). This technique was discussed but was discarded in favour of the marginal costing method.

A discounted cash flow was not required for the Fort Dunlop sanction application as the project was expected to repay its cost within the first 12 months and then provide an income exceeding operating cost and terminal rental from then on.

Unquantified Benefits

The system was justified financially without attempting to quantify the benefits of improved information. The Chief Engineer showed that he could endorse the labour utilisation approach but it was impractical to attempt a justification based on the value of improved information. This would appear to reduce the significance of the stores item usage data collected by the system, which was, and still is, the main purpose of introducing the Engineering Spares System.

The information and method of work improvements, were listed in the justification report and are now reproduced in more detail:-

Works Engineers Benefits

- Provide immediate access to current stock information including the current charge price.

- Simplify stores requisitioning procedure.
- Provide a history file of requisitions showing on which machine the part had been used.
- Provide stock position within UK Tyre Division.
- Provide a list of Dunlop factories using the same item.
- Provide a cross - referencing facility showing which other machines within Tyre Division use the same part.
- Foremen can access all the Buying Department data and can have reorder levels, stock levels etc, charged for the machinery they maintain.

Central General Stores

- Requisitions printed by the computer link are clear, legible, accurate and include the items' location. The paper requisition often only gave a vague description and the storemen, who have no engineering training, often could not find the part or supplied the wrong item.

- The requisition is raised against stock shown on the computer, so reducing the number of requisitions that can not be satisfied.

- The engineering foreman will have increased confidence in the stores system by having full knowledge of the current position on any stores item.

- The storemen will be more effectively used in delivery parts by van, than issuing one or two items at a time, over the stores counter.

Buying Department - Stock Control

- Screens give rapid access to any items stock records.
- Engineers have the same information as buyers and so can confer, using the same information.
- The stock position of any item at each of the UK Tyre Division factories is available, as is the total UK stock figure.
- A hard copy of an information screen is available.

Coding and Standards Section

- The V.D.U., system provides an "up to date" stores catalogue for the UK Tyre Division.

- Dunlops factories can now have their own computer printed stores catalogue. The table of Groups, classes and subsets are used to provide headings and an index for the catalogues, and the commodity information gives the cross reference and location (factory using the item) information.

General Benefits

- The Engineering spares system is the first "shop floor" terminal system used in the UK Tyre Division and will provide the platform to launch other factory computer systems.

- The spares system will contribute to savings against the 1979 Fort Dunlop budgets for:-

  Engineering Maintenance -£5.3 million
  Contribution lost due to Engineering downtime -£6.5 million
  Losses due to scrap and downgraded tyres -£1.9 million
  (1979 Management Plan, Fort Dunlop)

4.11 System in Operation

The system has been operating for 3 months at the time of writing. The terminals have been accepted as part of the furniture in the engineering workshops and Machine Tool Department. Analysis of the system's use is encouraging, with a steady stream of requisitions being produced and considerable use being made of the information screens.

The spares system is used by both staff and hourly paid employees. The Engineering foremen are members of the Association of Scientific and Managerial staff (ASTMS), the coding and stores staff belong to the Technical and Salaried Staff union (TASS). The Storemen are members of the General and Municiple Workers Union (GMWU).

The Engineering foremen have accepted the terminals with no demand for extra payment for using 'new technology'. The storemen asked for Industrial Engineering to investigate the new system and measure the increased productivity with a view to increased payment. This study resulted in an agreement that storekeeper who left the company at the end of August 1979 will not be replaced and in return stores rates will be increased by 6.5p/hour or 4.5p/hour dependent on grade.

The van delivery service is proving successful and will be closely monitored. The issues history file is now recording the issue date and the foremen will be 'encouraged' to make further use of the Machine Identify Code when the Request Card system is introduced in 1980 (See Chapter 5). Many of the foremen share their user identity code with their leading hand, allowing him to requisition in his foreman's absence. This practise is being encouraged by the management as it makes better use of the system and the foreman's time.

As with all new developments there are several refinements that should now be included in the system and these are detailed in Chapter 6.

4.12 System Expansion to the Washington and Inchinnan Factories

Both these factories have G.P.O. links to Fort Dunlop's I.B.M. mainframe and now use the Buying information and 'look up' screens in their Buying Departments. The requisitioning and goods inwards facilities will be provided on a terminal placed on the stores counter. The terminal (V.D.U. and Keyboard) will be used by the storeman as a 'cash register' booking all goods into and out of the stores by using the requisitioning and goods inwards screen. This is practicable at these factories, as at each, the maintenance department strength is approximately 50 working on 3 shifts. All machines will be coded using the same system as used at Fort Dunlop and issues will be recorded against these codes allowing analysis of issues on a machine by machine basis. This will also enable interfactory comparisons of the use of spares to be made. This work is being carried out by analysts from Tyre Divisions Computer Centre.

CHAPTER 5 THE ENGINEERING REQUEST CARD

5.1. Overview

The Engineering Request Card will replace the Work Authorisation Note (Section 2.5.) as the means of issuing work to Fort Dunlop's engineering tradesmen and mates. The "Request Card" has been designed as a computer input document. It requires the issuing foreman, and tradesmen completing the job, to record details of the work given and undertaken. The card will also be used to 'operate' an incentive bonus scheme. The data from the cards will be input to a suite of computer programs (the E.R. suite) which will perform the calculations for the incentive scheme and process the engineering data, producing reports on machine downtime, labour utilisation and 'bonus' earned. The data from the cards will be stored on a history file and will be available for analysis purposes, providing a comprehensive plant history.

It is planned to introduce the Request Card prior to implementing the incentive bonus scheme early in 1980.

5.2. Background

The need to collect data on the frequency and nature of all work undertaken by the Engineering tradesmen was accepted by the Chief Engineer and his senior management. Actually introducing such a system was originally not thought to be a practical proposition, as it was predicted that the tradesmen would refuse to complete any form of documentation.

During the spring of 1979 a working party of Works Engineering managers, foremen and shop stewards was set up to highlight possible financial savings within the Department. Any savings realised would then form part of a 'productivity pool' to be divided between the tradesmen and the company. The Working Party tried to ascertain the cost of machine downtime and the total cost of maintenance for specific machines. The lack of any detailed engineering information (described in Chapter 2), became apparent to the Working Party, the author was invited to attend one of their meetings and describe how engineering data could be collected, analysed and stored to provide a plant history. The possibility of introducing a 'job card' and the benefits it would provide was discussed with the Working Party. The concept was well received and several meetings took place to design a card that would be acceptable to the 'shop floor' and provide the data required for an adequate plant history. The Working Party's final report was issued May 1978, and one of its recommendations was that the Works Authorisation Note should be replaced by a job card, and that engineering data from the card should be held on the computer, providing a plant history. The recommendation was not acted upon and the development work on the computer system ceased. See Section 3.6.

A new Chief Engineer was appointed at Fort Dunlop in May 1978 and under his direction a rationalisation of the Works Engineers took place. P.A. Management Consultants were appointed to assist with this exercise and in the compilation of a "Plant Agreement" for the Works Engineers, linked to the introduction of an incentive payment scheme. The engineering workforce was reduced from 846 to 606 by voluntary redundancy. Having obtained the lower labour force, the Departments efficiency had to be improved. A comprehensive Plant Agreement is planned, providing a 'rule book' and incentive payment scheme within which the trades unions and management would operate. This agreement is still subject to negotiation but an "Interim Agreement" between the Engineering Management and the Trade Unions has been signed. This document provides for changes in restrictive working practices, a new engineering department structure, relaxation of demarcation, the acceptance of industrial engineering techniques and the use of a 'job card' for the issue and reporting back of all engineering work.

The "Interim Agreement" allows management to make a number of changes in organisation and, method of work and permits the management consultants to carry out the work study required to install the incentive scheme.

5.2.1. The Engineering Incentive Payment Scheme

P.A. had installed incentive schemes based on categorised work values for the maintenance departments at Pirelli tyre factories at Burton On Trent and Carlisle. These schemes were working successfully and it was decided to adopt the same scheme at Fort Dunlop.

"Categorised Work Values" is also known as Comparative Estimating (BS 3138) and is a means of measuring work in a non repetitive environment,making it well suited to a maintenance application. The technique has two basic principles:-

- Jobs are not given specific time values but are placed within a range of time or category
  - as an example, 1½ to 3 hours.

- Jobs are placed in the appropriate category by comparing them with standard jobs of know work content. These standard jobs are called Bench Mark jobs and contain provisions for preparation time,travel time and allowances.

Using this method the estimator judges the category on the work content and not on the time he expects the job to take. This avoids the estimators judgement being 'coloured' by extraneous factors such as:-

The tradesman's skill

The effort expected

Whether or not the job is trouble free.

The category band widths to be used at Fort Dunlop will be established from the data obtained when the work study exercise is completed. The Pirelli, Burton On Trent scheme uses the following times and it is expected that Fort Dunlop categories will be the same.

Job Time	0 - ½	½ - 1½	1½ - 3	3 - 5	5 - 7½	7½ - 10½	10½ - 14	14 - 18
Category	A	B	C	D	E	F	G	H
Standard hours given	0.333	1.000	2.250	4.000	6.250	9.000	12.250	16.000

Waiting time = W all hours x 0.74 = Standard hours

Unmeasured work = U all hours x 0.80 = Standard hours

(Work that can not be categorised).

The Bench mark jobs are detailed for each trade in each workshop on a spread sheet, having been set by an appropriate work study technique. An example of a spread sheet is given in figure 5.2.1. If a job is designated as needing 2 or 3 men the spread sheet shows this and the

Increasing Time Within a Category Band →

0 HRS. CATEGORY A JOB DURATION TIME = 0·33 SH'S 0·5 S.H.	RENEW SPARK PLUG		RENEW ROCKER COVER GASKET	RENEW OIL PRESSURE VALVE	
0·51 S.H. CATEGORY B JOB DURATION TIME = 1·00 S.H. 1·50 S.H.		CHANGE TRACK ROD END AND RE-ALIGN STEERING	REMOVE WHEEL BEARING ONE SIDE		REMOVE AND REPLACE DISC PADS ON BOTH FRONT WHEELS
1·51 S.H. CATEGORY C JOB DURATION TIME = 2·25 S.H. 3·00 S.H.	REMOVE ENGINE		COMRLETE 6,000 MILE SERVICE		RENEW CLUTCH AND ADJUST
3·01 S.H. CATEGORY D JOB DURATION TIME = 4·00 S.H. 5·00 S.H.	RENEW CYLINDER HEAD GASKET	COMPLETE 12,000 MILE SERVICE			REPLACE ONE PAIR OF REAR ROAD SPRINGS
5·01 S.H. CATEGORY E JOB DURATION TIME = 6·25 S.H. 7·50 S.H.	DE-CARBONIZE CYLINDER HEAD -RENEW AND GRIND IN VALVES			REMOVE OVERHAUL REPLACE GEARBOX	

FIGURE 5.2.1

CATEGORISED WORK VALUES SPREAD SHEET

AN EXAMPLE FOR CAR MAINTENANCE.

standard hours are calculated by multiplying the standard hours by the number of men i.e., B3 provides 3 standard hours though the job should be completed between ½ and 1½ hours.

The bonus is then calculated by devising an index of

$$\frac{\text{Standard hours (from the job category)}}{\text{Total Clocked Hours}}$$

It is intended to group the engineering workers by department area - the Bonus Group. The index will be in the form of a %, calculated for the previous month and applied to the hours worked in each week for the next month. In this way the system will be 'damped', not producing exceptionally high or low bonuses. The engineering worker, therefore, requires a category for every job. He should also report to his foreman when he has no work, to be placed on a waiting time category. This category contributes standard hours to the top line of the equation at the average performance range (i.e., waiting time cards pay no bonus). Allowed absence is also categorised in this way and again no bonus is paid. The index has still to be negotiated but, if the Pirelli, Burton on Trent factory scheme is taken as an example, an index of 0.74 or less pays no bonus and the scheme has a cut off at an index of 1.00, where a bonus of 40% on basic rates is paid.

It was decided to calculate the index weekly, for each 'Bonus Group' and announce the figures each Thursday for the previous week. In the consultants experience showing the bonus percentage accrued improves the groups productivity. A computerised system was the only practical way of handling the expected volume of data, (10,000 cards a week) and performing the calculations.

5.3. The Computer System Design

Several possible ways of recording the engineering data and the job category were discussed. The limiting factor was the availability of computer programmers. Given unlimited resources an on line system, such as that operated by Pedigree Pet Foods Ltd. at their Melton Mowbray (Ref 134) factory, would provide the best solution. This company uses an IMB 3270 mini computer with VDU's in the engineering workshops. The tradesman completes a report card for each job, which is then checked by the foreman and entered to the computer, on a workshop terminal. The mini computer stores one months'job records. The data are then transferred to a central company mainframe. Standard analysis routines are available on the mini and reports can be requested from the work shops terminals for display on the V.D.U., or as hard copy. Further analysis is available on 24 hours notice from the mainframe. It was agreed that this type of system was desirable at Fort Dunlop but the work involved would be considerable, and it was known that the computer centre did not have sufficient staff to undertake such a project. It was therefore decided to compromise and design a batch system with a report card (the Engineering Request Card) whose data could, at a later date, be input to an online system using the terminals and keyboards supplied for the Engineering Spares System (Chapter 4). The Request card would replace the Work Authorisation Note (Section 2.5.) and as such would be completed by Production Foremen as requests for engineering work. The Engineering foremen would use the card to provide job instructions for their own men and to record waiting time and "allowed absence" as part of the incentive scheme.

The card was therefore designed to be easy to complete using codes to reduce the amount of writing. This, in turn, would reduce the data preparation time. The data content of the card and the computer programs are described in sections 5.4. and 5.5. respectively. The programs were written in one man month using COBOL, and the total development cost is not expected to be in excess of £5,000. The operating cost will be around £30,000 a year due to the high cost of data preparation.

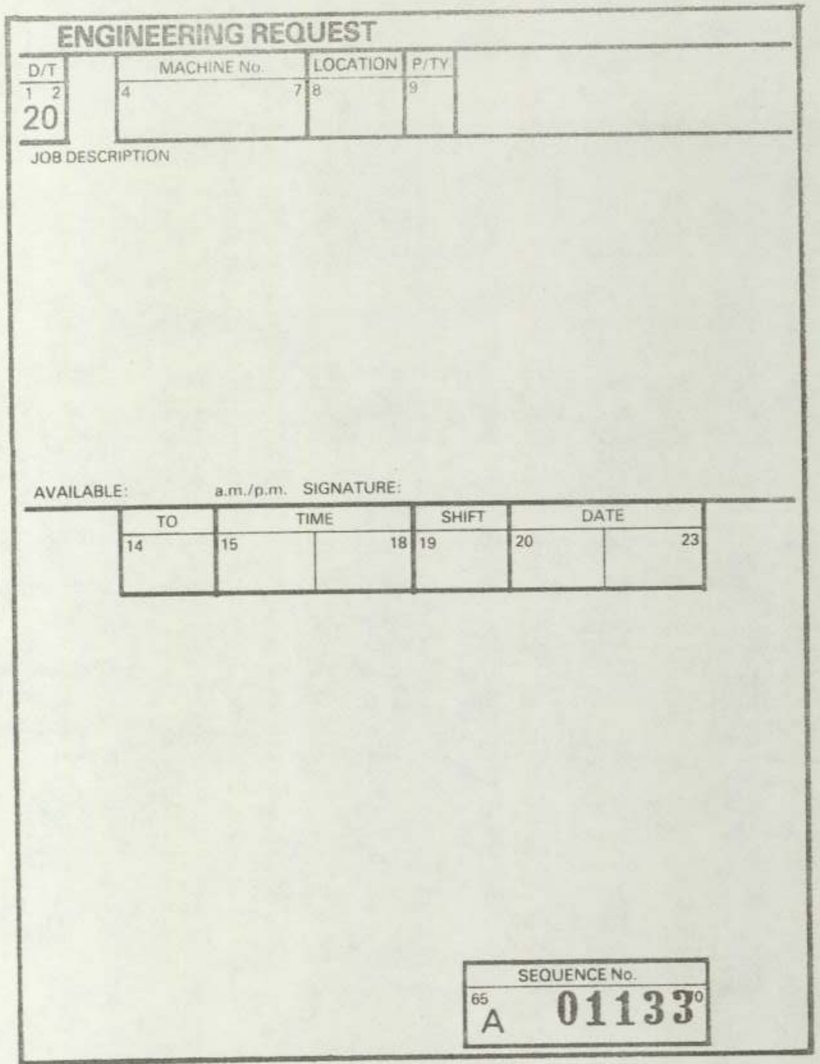
5.4. The Request Card

This section covers the completion of the card for 'normal' categorised work, and has been extracted from the User manual (see reference 128). The User manual explains the full operation of the card and has been issued to engineering and production foremen and managers. A sample card is shown in figure 5.4.1.

The Engineering Request is a two piece document bound together in books of 50. The top, (paper) copy is bound in the book, the bottom (card) copy tears out and is passed to the tradesmen. N.C.R., paper has been specified which avoids the use of carbon paper. The top copy is completed by the instigator providing the following information (the numbers in brackets refer to the character positions printed on the card).

Machine Number and Location (4 - 8)

All production machines have been coded using a 4 character machine code, and a single character location indicator. In addition 10 general code numbers are available for recording general maintenance, not specifically allocated to a production machine. A description of the coding system is given in Appendix 5.A. The full table currently has 1600 entries. A sample page from the listing is included as figure 5.4.2.



ENGINEERING REQUEST

D/T 1 2 20 | MACHINE No. 4 7 | LOCATION 8 | P/TY 9

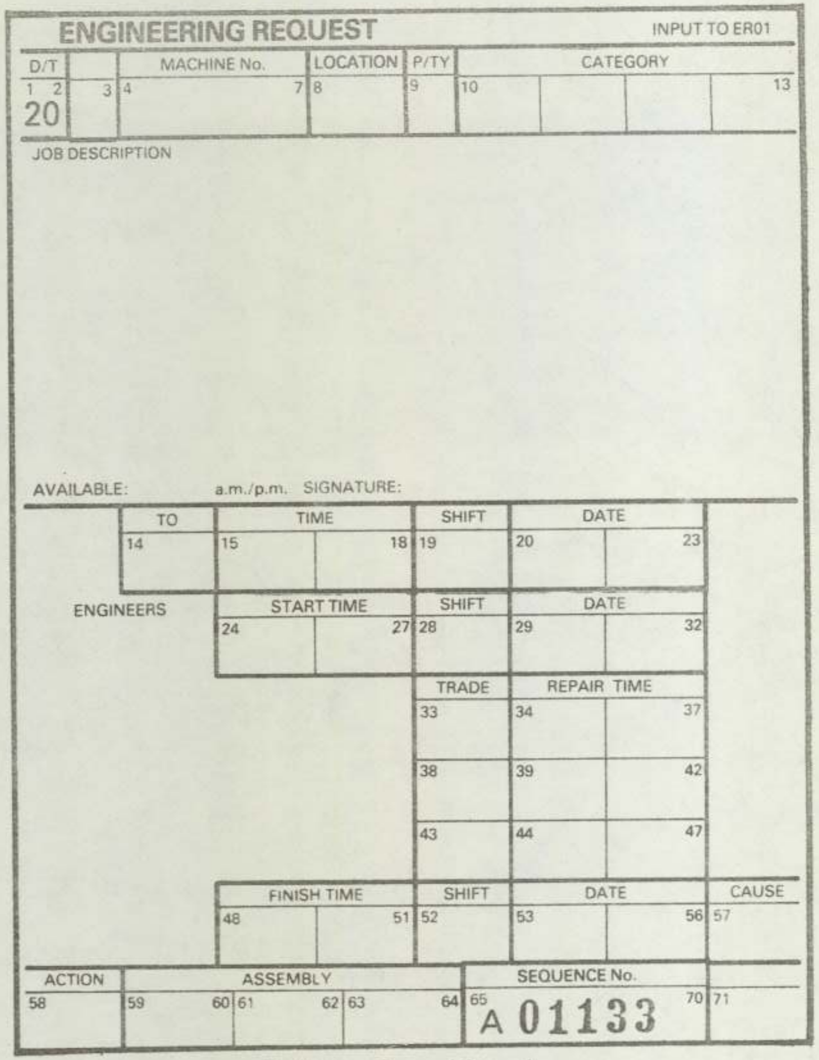
JOB DESCRIPTION

AVAILABLE: a.m./p.m. SIGNATURE:

TO	TIME		SHIFT	DATE	
14	15	18	19	20	23

SEQUENCE No. 65 A 01133 70

Top Copy (Paper)
Retained in the book.



ENGINEERING REQUEST INPUT TO ER01

D/T 1 2 20 3 | MACHINE No. 4 7 | LOCATION 8 | P/TY 9 | CATEGORY 10 13

JOB DESCRIPTION

AVAILABLE: a.m./p.m. SIGNATURE:

TO	TIME		SHIFT	DATE	
14	15	18	19	20	23

ENGINEERS

START TIME		SHIFT	DATE	
24	27	28	29	32

TRADE	REPAIR TIME	
33	34	37
38	39	42
43	44	47

FINISH TIME		SHIFT	DATE		CAUSE
48	51	52	53	56	57

ACTION	ASSEMBLY				SEQUENCE No.	
58	59	60 61	62 63	64	65 A 01133 70	71

Bottom Copy (Card)

FIGURE 5.4.1

ENGINEERING REQUEST FORM.

C198 PROGRAM TABLES FOR CDS/CMS SUITES DATE 17 07 79 PAGE 030

TABLE NUMBER 140 11 VALID MACHINE IDENTITIES
SIZE 2000 (CONTINUED)

TABLE ENTRY KEY		
1 5 PA03		0872 1335 NO. A3 42" BCM PRESS
1 5 PA04		0872 1335 NO. A4 42" BCM PRESS
1 5 PA05		0872 1335 NO. A5 42" BCM PRESS
1 5 PA06		0872 1335 NO. A6 42" B.O.M. PRESS
1 5 PA07		0872 1335 NO. A7 42" B.C.M. PRESS
1 5 PA08		0872 1335 NO. A8 42" B.O.M. PRESS
1 5 PA09		0872 1335 NO. A9 42" B.C.M. PRESS
1 5 PA10		0872 1335 NO. A10 42" B.O.M. PRESS
1 5 PA11		0872 1335 NO. A11 42" B.O.M. PRESS
1 5 PA12		0872 1335 NO. A12 42" B.O.M. PRESS
1 5 PA13		0872 1335 NO. A13 42" B.O.M. PRESS
1 5 PA14		0872 1335 NO. A14 42" B.C.M. PRESS
1 5 PA15		0872 1335 NO. A15 42" B.C.M. PRESS
1 5 PA16		0872 1335 NO. A16 42" B.O.M. PRESS
1 5 PA17	O	0872 1335 NO. A17 46" A/F PRESS
1 5 PA17	I	0872 1310 NO. A17 46" A/F PRESS.
1 5 PA18	O	0872 1335 NO. A18 46" A/F PRESS
1 5 PA18	I	0872 1310 NO. A18 46" A/F PRESS.
1 5 PA19	O	0872 1335 NO. A19 46" A/F PRESS
1 5 PA19	I	0872 1310 NO. A19 46" A/F PRESS.
1 5 PA20		0872 1310 NO. A20 40.5" A/F PRESS
1 5 PBC1		0872 TAKEWAY CONVEYOR B&C LINES
1 5 PB01		0872 1310 NO.B1 40.5" A/F PRESS
1 5 PB02		0872 1310 NO.B2 40.5" A/F PRESS
1 5 PB03		0872 1310 NO.B3 40.5" A/F PRESS
1 5 PB04		0872 1310 NO.B4 40.5" A/F PRESS
1 5 PB05		0872 1310 NO.B5 40.5" A/F PRESS
1 5 PB06		0872 1310 NO.B6 40.5" A/F PRESS
1 5 PB07		0872 1310 NO. B7 40.5" A/F PRESS
1 5 PB08		0872 1310 NO. B8 40.5" A/F PRESS
1 5 PB09		0872 1310 NO. B9 40.5" A/F PRESS
1 5 PB10		0872 1310 NO. B10 40.5" A/F PRESS
1 5 PB11		0872 1310 NO. B11 40.5" A/F PRESS
1 5 PB12		0872 1310 NO. B12 40.5" A/F PRESS
1 5 PB13		0872 1310 NO. B13 40.5" A/F PRESS
1 5 PB14		0872 1310 NO. B14 40.5" A/F PRESS
1 5 PB15		0872 1310 NO. B15 40.5" A/F PRESS
1 5 PB16		0872 1310 NO. B16 40.5" A/F PRESS
1 5 PC01		0872 1310 NO. C1 40.5" A/F PRESS
1 5 PC02		0872 1310 NO. C2 40.5" A/F PRESS
1 5 PC03		0872 1310 NO.C 3 40.5" A/F PRESS
1 5 PC04		0872 1310 NO. C4 40.5" A/F PRESS
1 5 PC05		0872 1310 NO. C5 40.5" A/F PRESS
1 5 PC06		0872 1310 NO. C6 40.5" A/F PRESS
1 5 PC07		0872 1310 NO. C7 40.5" A/F PRESS
1 5 PC08		0872 1310 NO.C8 40.5" A/F PRESS
1 5 PC09		0872 1310 NO.C9 40.5" A/F PRESS
1 5 PC10		0872 1310 NO.C10 40.5" A/F PRESS
1 5 PC11		0872 1310 NO.C11 40.5" A/F PRESS
1 5 PC12		0872 1310 NO. C12 40.5" A/F PRESS
1 5 PC13		0872 1310 NO.C13 40.5" A/F PRESS
1 5 PC14		0872 1310 NO.C14 40.5" A/F PRESS
1 5 PC15		0872 1310 NO.C15 40.5" A/F PRESS
1 5 PC16		0872 1310 NO.C16 40.5" A/F PRESS
1 5 PDC1		0872 TAKEWAY CONVEYOR 'D' LINE.

FIGURE 5.4.2
VALID MACHINE IDENTITIES

The machines are coded to a fixed format incorporating the machines 'current' identification number when ever practicable e.g., Press A10 in Tyre 5 is now coded:-

5 PA10

5 = Tyre 5

P = Tyre Presses

A = A line

10 = Press number

The structured Machine Identity allows the analysis program to select data at different levels:-

All presses at Fort Dunlop		P			
All press in Tyre 5	5	P			
All presses in A line	5	P	A		
Press 10 in A line, Tyre 5	5	P	A	1	0
All machines in Tyre 5	5				

The Machine Identity Code listings were produced for the Engineering Spares system, to provide a means of recording the issue of spares and general items to individual machines. Using the same code on the Request Card enables the two systems to be linked. This provides information on machine downtime, the nature of all work undertaken, labour utilisation, the use of spares and the overall cost of maintaining a machine.

The instigator writes the machine number (or general code), and location on the card and the computer will record all the data on the card against that code.

Priority (9)

The priority indicator has a dual purpose. It shows the engineers the importance of the job and is used by the computer programs to distinguish the type of work being recorded.

The indicators are:-

1 = Production is being lost

S = Safety Job

W = Weekend Work

H = Shutdown Work

P = Planned Work

= Any other

The indicator '1', Production is being lost, is used when the machine is stopped or producing below its capability. The indicators for Weekend, Shutdown and planned work are only used by the engineering foremen.

TO - Workers Group (14)

Each group of workers within the engineers' incentive scheme has been given an alphabetic identification character. The character is used, by the programs, to allocate the 'standard hours' on the card to the appropriate workers group. Only workers from the same group book on the same card.

Time, Shift, Date (15 - 23)

The time the job was reported, is written, using the 12 hour clock and a shift indicator:-

M = Morning A = Afternoons N = Nights D = Days	in box 19

the date is written numerically as days and month.

Job Description

The job is described and the card signed. If the plant or machine is not immediately available, the time when the tradesman can commence work is given.

The cardcopy is then torn from the book and placed on the maintenance workshop loading board. The remainder of the card is then completed by the Works Engineers.

Category (10 - 13)

The Engineering foreman categorises the job, (see 5.2.) and initials the card. The category and number of men are written within one box, the category being written first:-

Category A for 2 men

	Category		
A2			

A second category can be entered

	Category		
A2	C2		

If a change is necessary the box is crossed through and the new category and number of men written in:-

	Category		
A2	C~~2~~	D2	

Up to three men work on a Request card, if more are required, a second card is raised by the engineering foreman, reproducing the machine number, location, priority, and the reported time, shift and date from the original card. This 'common' data is used by one of the systems programs (ER1Ø) to combine the data from two or more request cards into a single record of the work undertaken.

Start Time, Shift Indicator, Date (24 - 32)

The tradesman or engineering foreman writes in the time, shift and date the tradesman was despatched to the jobs. (Not the time the job was physically started).

Trade and Repair Time (33 - 47)

Each tradesmen working on the card enters his trade letter and repair time.

Examples being:-

M Millwright	)	listed as Mechanical trades on the output reports
P Pipefitter	)	
T Machinist	)	
R Rigger	)	
E Electrician	)	listed as Electrical
I Instruments	)	
S Scale fitter	)	
O Oilers/mates	)	listed as Oilers

The repair time is entered as hours and minutes.

Finish Time, Shift Indicator, Date (48 - 56)

The time and date the machine or plant was handed back to production or , for general work, the time the job was completed.

Cause (57) and Action (58)

A letter corresponding to the cause and action taken, chosen from the lists in Table 5.1.

Assembly (59 - 64)

The major assemblies for production machinery and plant have been listed and coded. The tradesman writes in the code for the assembly worked on. (A full list of codes is given in the user manual. Ref.128). Up to three assembly codes can be used to describe the assembly.

e.g.,	Pneumatic Valve	2A	2M
	Motor Connections	1A	3B

If the assembly is not listed the general codes are used:-

1X	Mechanical
2X	Services
3X	Electrical

Sequence Number (65 - 70)

Each card has a pre printed sequence number. Engineering foremen use Request Cards with an all numeric sequence, all other cards have an alphabetic lead character. This enables engineering raised cards to be distinguished on the system history file.

Box 71

This box has a dual purpose, the engineering foreman enters an 'X' if he has categorised the work after the job has been completed. The Engineering Methods Office clerks who manage the system also use the box to control the data being added to the history file. Depending on the character, the following program operations are performed:-

Blank or X - All data is checked and if no errors are found all the data is accepted.

A - A partial verification is carried out. Only the Machine number, location ,categories and workers group are verified. If no errors are found, these fields are taken on to the file and any engineering data is ignored.

C - Only the sequence number is checked and taken on to the history file.

Y - As for an A, but the Y indicates that the job had previously been post categorised.

A partial validation (A and Y) is used when the Methods Office clerks can not correct a card rejected by the validation programs.

Box '3' Deletions

If data from a card held on the history file is found to be in error it can be amended by making out a duplicate card with a 'D' in box 3. The program ER01 will then set the working times bonus and visits to negatives. A new card is then completed with the appropriate amendment. This procedure results in the history file holding three cards with different 'sequence numbers'. Any analysis will obtain the result of a calculation where two cards cancel each other out and the third card provides the correct data.

Unmeasured Work

The card is completed as for normal categorised work but the category is set to U. The program then multiplies each workers' repair time by the agreed standard hours for inclusion in the incentive scheme.

Waiting Time

When the worker has more than 15 minutes between jobs he should go to his foreman and ask to be placed on a waiting time card. The foreman uses a Request Card, writes the mans name on it, enters the category a 'W', and writes in the Workers Group character (box 14) and fills in the "Engineering start time, shift and date" (Box 24 - 32). When the men is given his next job he is signed off the card by the foreman filling in the "Engineering finish time shift and date" (Box 48 - 56).

5.5. The Computer Programs

5.5.1. Introduction

The Engineering Request Card computer suite flow chart is shown in Figure 5.5.1. The program contents and operation are explained in detail in this section. The flow chart makes the system appear more complex than it is in practice. Each step in the validation, analysis, report compilation and printing has been written as a separate program. This approach has been used because it:-

i. Simplifies program amendments and additions.
ii. Gives short program listings which are quickly understood.

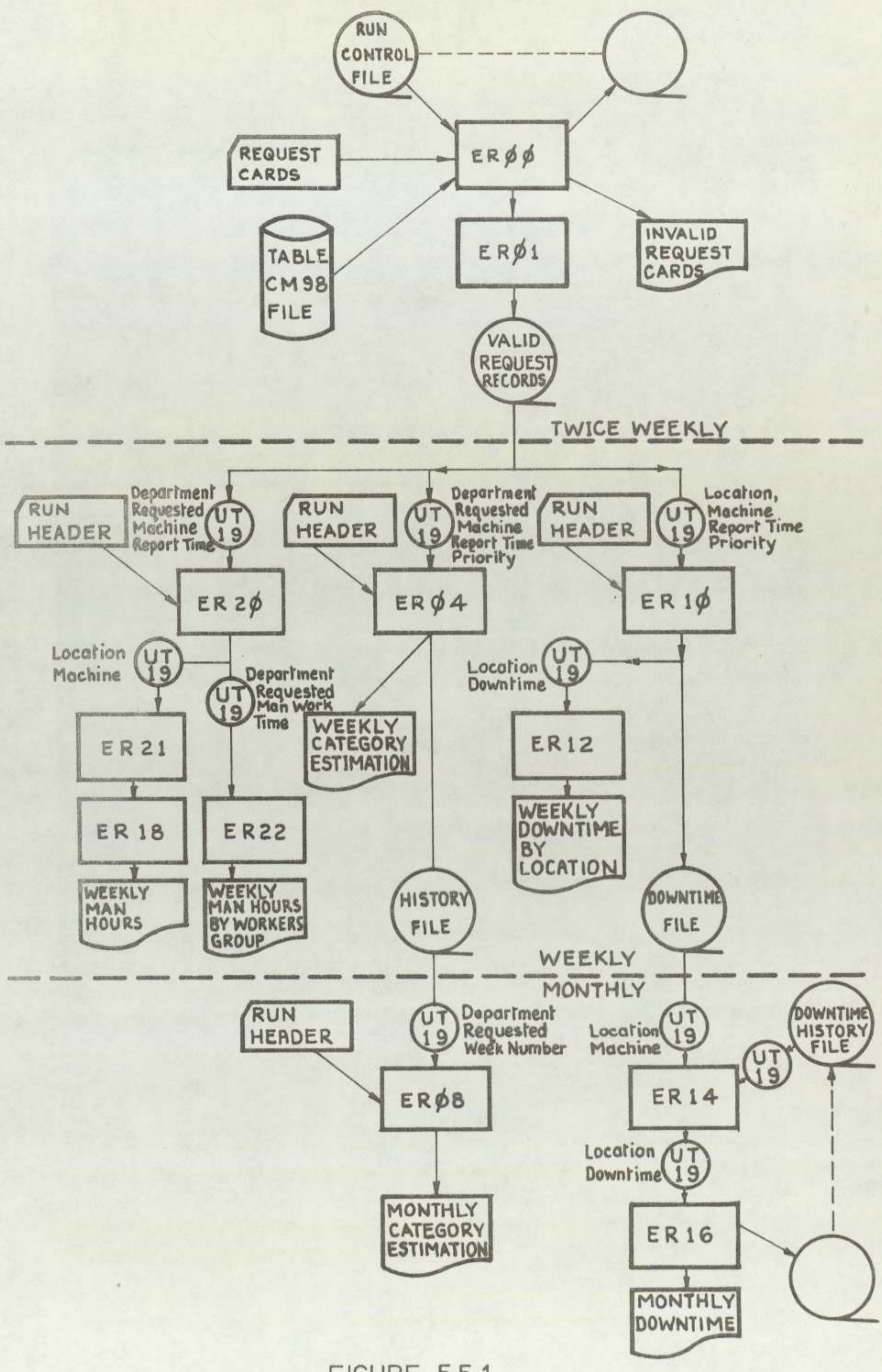


FIGURE 5.5.1

ENGINEERING REQUEST CARD SUITE OF COMPUTER PROGRAMS

iii. Provides clear documentation, consisting of input details, processing details and output details for each program. A suite flow chart then shows how all the programs are linked.

The Request Card system was programmed from program specifications written to Dunlop Management Services, Computer Centre Standards. The system has been fully documented, all specifications, programs and the user manual are filed in the program library at Fort Dunlop Computer Centre. All programs were written in COBOL.

5.5.2. Frequency of Operation (proposed)

The Request cards are sent each day to the Data Preparation section at Fort Dunlops Computer Centre for punching (Key to disc). Computer runs take place on Monday and Thursday nights. The Thursday night's run produces a file of valid card records which are passed forward to the Monday night run.

The Monday run consists of a data validation run for cards submitted between Thursday morning and the Monday morning. The 'valid' data from the Monday run is then added to the file output from the Thursday run and used as the input to the report programs (see the suite flow chart figure 5.5.1.).

The Engineering Method Office clerks 'control' the system. They request computer program runs, ensure that all Request Cards are processed and correct cards rejected by the data validation program.

5.5.3. The Programs

Program ERØØ Data Validation

The data from the card is checked against tables providing the acceptable ranges, as an example, the month entered must be between 1 and 12. The CM98 table file from the Stores system is used to check that only valid machine numbers and general maintenance codes are used. Any errors found are indicated by printing the data from the card and underscoring the characters in error with stars. In cases where the error is not obvious an error number is also printed.

The data from cards passing this stage are then subjected to a series of logic tests. The dates and times are converted to an IBM data time format and tested e.g., is the job start time before the finish time etc., any errors are printed out with the appropriate error number and the cards data rejected.

Valid data is passed to program ER01, a reconciliation report listing the batch numbers of Request Cards submitted, and the number of cards accepted and rejected is produced. This report is used by the Methods Office clerks to confirm that all cards submitted to the run have been processed.

A run control file (a tape) is updated at the end of each run with the run date and number. ERØØ reads this tape at the start of each run to ensure that the run numbers are sequential and no runs have been omitted.

Program ER01

The output record from ERØØ is expanded to provide data to be used in the analysis reports.

- The 'Bonus Credits' on the record (the data from a card) are calculated (the Alphabetic characters were converted to standard hours and multiplied by the number of men allowed). The Standard hours given are compared with the actual repair time and any jobs falling outside set limits of mis-categorisation are indicated.

- The trades repair times and number of jobs are summed under general trade headings of 'Mechanical, Electrical, Oiler/mate'. As an example, a record showing 3 hour of Millwrights time and 1 hour of Electricians time would be recorded as 'Mechanical Working Time' 3 hours 'Mechanical Visits' 1, 'Electrical Working Time' 1 hour, 'Electrical visits' 1.

- The 'down time' is calculated on records where the 'priority' is set as 1. The reported time and date are subtracted from the finish time and date and the results recorded in hours.

The results of these calculations are added to the ERØØ output record to produce the 'Engineering-Job-Record'. The record content is listed in Appendix 5.B.1. This tape is passed from run to run of ERØ1, building up a "year to date" file of valid request cards records.

Provision has been made to keep a security copy of the tape and to hold 5 years tapes for analysis purposes. After the time, condensing the stored data will be considered.

Program ER20

This program extracts data from the output Engineering-Job-Record to enable two engineering labour utilisation reports to be produced.

Records from the current weeks run are first sorted into a sequence of

Department Requested (Workers Group)

Machine

Reported Time

This arranges the records so that the data is nested together:-

As an example

```
Workers Group A (Machine 1  (reported 1000 6/12/79
                            (reported 1100 6/12/79
                (Machine 2
                (Machine 3
                (Machine 4
Workers Group B (Machine 2
                (Machine 5
                (Machine 7
```

The program then accumulates the following values for each machine worked on by each Group during the previous week.

Mechanical Working Time

Electrical "

Oiler/Mate "

Mechanical Visits

Electrical "

Oiler/Mate "

Each record is read and the times and visits summed into the appropriate field. When a change of workers group or machine is encountered the working times are totalled. The Department Requested (Workers Group), Machine Identity and location, the above accumulated times and visits are then output to a Group-Record file. Appendix 5.B.2., gives the record content.

Program ER21

This program re-arranges the output file from ER20, enabling program ER18 to print a report showing which machine the works engineers worked on in each factory department and the time spent working on these machines. ER20 output file records are arranged as follows:-

Workers Group A (Machine 1
Machine 2

Workers Group B (Machine 1
Machine 3

Several records can occur for a machine as several groups could have worked on the machine during the week.

The file is sorted by

LOCATION (Department)

MACHINE

The following records are then accumulated for each machine:

Mechanical Working Time
Electrical " "
Oiler/Mate " "
Mechanical Visits
Electrical "
Oiler/Mate "

and on change of machine the working time is totalled. The output files record content is therefore identical in content to the input file from ER20.

Program ER18

The program prints the weekly Engineering Working Time Report for each factory department. The output file from ER21 is sorted by:

Location (Department)

Total Working Time

This arranges the records firstly by Department and then within the department by decreasing order of working time. ER18 then prints the report, figure 5.5.2. The first 30 records are used to print the "top 30" machines, the remaining records for the department are summed and used to print the 31st line on the report. The report shows (left to right) the machine number, the times spent by each type of trade during the week working on the machine (for any purpose), a total working time figure and the number of men from each of the trade groupings who worked on the machine. A league position is given to the 30 machines printed.

Program ER22

This program produces a weekly Engineering Working Time report for each workers group. The records on the output file from ER20 are sorted by

Department Requested (Workers Group)

Mqn Work Time (Total Working Time)

This arranges the records by Workers Group and then decreasing order of

PROG ERIS   ENGINEERING WORKING TIME REPORT FOR FORT DUNLOP   TYPE 5   WEEK ENDING 8 / 5 / 79

M/C CODE	TIMES MECH	ELEC	OILER	MAN HRS	VISITS MECH	ELEC	OILER	NCW
PA02	30.7	25.3	19.4	75.4	6	6	4	1
PA04	21.7	22.7	24.8	69.2	7	7	7	2
PA06	16.0	21.4	30.0	67.4	5	5	5	3
PA13	24.0	16.9	24.0	64.9	5	5	4	4
PA03	19.4	18.4	15.0	52.8	4	4	3	5
PA08	20.2	13.0	13.5	46.7	4	4	4	6
PD11	19.4	24.9	0.0	44.3	6	6	0	7
PA05	9.4	15.6	12.8	37.8	4	4	4	8
PB03	12.0	12.0	12.0	36.0	2	2	2	9
PA09	15.6	9.5	10.1	35.2	3	3	3	10
PA10	7.2	13.4	8.6	29.2	2	2	2	11
PA18	8.4	10.0	6.0	24.4	2	2	1	12
PA01	12.5	7.2	1.7	21.4	3	3	2	13
PD12	9.3	9.5	0.0	18.8	2	2	0	14
PD06	8.2	9.9	0.0	18.1	3	3	0	15
M1M3	6.0	6.0	6.0	18.0	1	1	1	16
M1C1	6.0	6.0	6.0	18.0	1	1	1	17
PC03	6.0	6.0	6.0	18.0	1	1	1	18
PB13	6.0	6.0	6.0	18.0	1	1	1	19
PA12	6.0	5.0	6.0	17.0	2	2	1	20
PD13	7.8	7.6	0.0	15.4	2	2	0	21
A100	6.0	3.3	6.0	15.3	1	1	1	22
PD01	6.8	7.6	0.0	14.4	2	2	0	23
PA14	6.0	2.0	6.0	14.0	1	1	1	24
M1M2	6.0	1.0	6.0	13.0	1	1	1	25
PD14	5.4	5.3	0.0	10.7	1	1	0	26
PD05	5.8	4.6	0.0	10.4	2	2	0	27
PA15	3.0	1.0	6.0	10.0	1	1	1	28
PD02	3.4	6.3	0.0	9.7	1	1	0	29
PD07	4.8	4.8	0.0	9.6	2	2	0	30
	24.6	22.8	0.2	47.6	6	6	1	

FIGURE 5.5.2

ENGINEERING WORKING TIME REPORT FOR EACH FACTORY DEPARTMENT.

total working time within that Working Group. The program then prints the report shown on Figure 5.5.3. The first 30 records are formatted and printed giving the top 30 machines worked on by the Group, the remaining records are summed providing the 31st Line, the totals for the other machines worked on during the week. The Groups waiting time is available in the total working time field of the record with a machine identity of '0000'. This figure is printed as the 32nd line. The program sums all the figures before printing them and prints this grand total as the 33rd line on the report.

The report therefore shows the machines worked on by a Workers Group during the previous week and the times and visits are as detailed on ER18 report with the addition of waiting time and a grand total line.

Program ER04

This progress produces a weekly category estimation report for each workers group and a history file of the data output on these reports.

Records from the current weeks output file from ER01 are first sorted into a sequence of:-

Department Requested (Workers Group)
Machine
Reported Time
Priority

This arranges the records by workers group, allowing the program to accumulate the data required to print the reports.

PROG ER22 ENGINEERING WORKING TIME REPORT FOR FORT DUNLOP A======================= WEEK ENDING 8 / 5 / 79

M/C CODE	TIMES MECH	TIMES ELEC	TIMES OILER	MAN HRS	VISITS MECH	VISITS ELEC	VISITS OILER	NOW
5PA02	30.7	25.3	15.4	75.4	6	6	4	1
5PA04	21.7	22.7	24.8	69.2	7	7	7	2
5PA06	16.0	21.4	30.0	67.4	5	5	5	3
5PA13	24.0	16.9	24.0	64.9	5	5	4	4
5PA03	19.4	18.4	15.0	52.8	4	4	3	5
5PA08	20.2	13.0	13.5	46.7	4	4	4	6
5PD11	19.4	24.9	0.0	44.3	6	6	0	7
5PA05	9.4	15.6	12.8	37.8	4	4	4	8
5PB03	12.0	12.0	12.0	36.0	2	2	2	9
5PA09	15.6	9.5	10.1	35.2	3	3	3	10
5PA10	7.2	13.4	8.6	29.2	2	2	2	11
5PA18	8.4	10.0	6.0	24.4	2	2	1	12
5PA01	12.5	7.2	1.7	21.4	3	3	2	13
5PD12	9.3	9.5	0.0	18.8	2	2	0	14
5PD06	8.2	9.9	0.0	18.1	3	3	0	15
5M1M3	6.0	6.0	6.0	18.0	1	1	1	16
5M1C1	6.0	6.0	6.0	18.0	1	1	1	17
5PC03	6.0	6.0	6.0	18.0	1	1	1	18
5PB13	6.0	6.0	6.0	18.0	1	1	1	19
5PA12	6.0	5.0	6.0	17.0	2	2	1	20
5PD13	7.8	7.6	0.0	15.4	2	2	0	21
5A100	6.0	3.3	6.0	15.3	1	1	1	22
5PD01	6.8	7.6	0.0	14.4	2	2	0	23
5PA14	6.0	2.0	6.0	14.0	1	1	1	24
5M1M2	6.0	1.0	6.0	13.0	1	1	1	25
5PD14	5.4	5.3	0.0	10.7	1	1	0	26
5PD05	5.8	4.6	0.0	10.4	2	2	0	27
5PA15	3.0	1.0	6.0	10.0	1	1	1	28
5PD02	3.4	6.3	0.0	9.7	1	1	0	29
5PD07	4.8	4.8	0.0	9.6	2	2	0	30
	24.6	22.8	0.2	47.6	6	6	1	
				3.5				
	343.6	325.0	232.1	904.2	84	84	51	

FIGURE 5 5 3

ENGINEERING WORKING TIME REPORT FOR EACH WORKERS GROUP

Figure 5.5.4., shows the report format; the program reads each record for the Group and:-

i. Sums the number of jobs in each category A to H.

ii. Sums the credits (standard hours) earned from cards worked on during the previous week and sums the credits from cards worked on in any other period.

iii. Sums separately the credits for unmeasured work for the previous week and from any other period.

When all the records for a group have been processed the report is printed. The figures in brackets are the totals of credits for working time, unmeasured work and waiting time from any earlier period than the previous week. The other credit figures printed are the total credits on cards, submitted to the run i.e., they include the figures in brackets. The grand total of credits is calculated and the percentage of waiting time and unmeasured work credits in this grand total figure are calculated and printed.

The totals of the category counts (A-H), the total credits, waiting credits and unmeasured credits and a week number are output to a History file for each Workers Group, this file (Appendix 5.B.3) is passed forward to program ER08 to supply the data required to print the Month End Category Estimation Report.

Program ER08

This program produces the Month End Category Estimation Report for each workers group, (figure 5.5.5.). The month can contain 4 or 5 weeks as the factory statistical months are used by the system. The records on

[illegible] ER04   CATEGORY ESTIMATION REPORT FOR FORT DUNLOP   A************************ WEEK ENDING 8 / 5 / 79

A	B	C	D	E	F	G	H
222	48	13	18	12	21	3-	168

TOTAL CREDITS	3149.576		(	60.747)
WAITING TIME	3.428	0.1 %	(	-0.750)
UNMEASURED	49.640	1.5 %	(	14.400)
GRAND TOTAL	3202.74.			

FIGURE 5.5.4

WEEKLY CATEGORY ESTIMATION REPORT.

PROG ER08   CATEGORY ESTIMATION REPORT FOR FORT DUNLOP   D************************MONTH ENDING 31 / 12 / 79

A	B	C	D	E	F	G	H
2	0	5	0	3	0	0	0

TOTAL CREDITS	30.660	
WAITING TIME	0.400	1.1 %
UNMEASURED	5.220	14.3 %
GRAND TOTAL	36.28	

FIGURE 5.5.5

MONTHLY CATEGORY ESTIMATION REPORT.

ER04 output file are first sorted by,

Department Requested (Workers Group)

Week Number

The program then prints out the 4 or 5 weeks category counts to be included, and sums the

Total credits

Waiting Time

Unmeasured Work

for these weeks and then calculates the Grand Total of credits. The percentage of waiting time and unmeasured work on the Grand Total is calculated and all these figures printed. After the final workers group report has been printed a Factory Total report, summing together all the credits passed by all workers groups, is printed to the same format.

Program ER10

This program calculates each machines production downtime and outputs a file used by program ER12 to produce a weekly downtime report for each department. The file is saved each week and then used by programs ER14 and ER16 to print the month end report.

The current weeks Job Record' file from ER01 is first sorted by

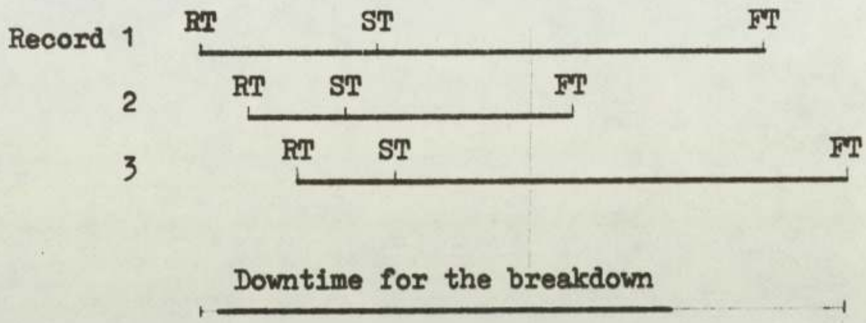
Location (Department)

Machine

Reported Time

Priority

Records containing downtime have the Priority set to '1'. Downtime is calculated by taking the Reported Time and Date from the Finish Time and Date. This is complicated when several cards have been submitted for the same breakdown. The sort is used to group records for the same machine in increasing order of time:-



The program then calculates the downtime for each breakdown (Records 1 - 3) and produces a total downtime figure for each machine for the week. The totals of:-

Mechanical Working Time }
Electrical " " } Summed to produce a Total Working Time figure.
Oiler/mates " " }

Mechanical Visit

Electrical "

Oiler/mates "

are also accumulated from all the records included in the downtime figure.

The machine number and location together with the calculated data are then output to a Downtime file (Record Contents Appendix 5.B.4.). An indicator is set on the file to show whether the data refers to downtime occurring during the current week or an earlier period.

(The weekly downtime report only shows downtime occurring during the previous week).

Program ER12

This program prints weekly downtime reports for each factory department. The report (figure 5.5.6.) lists the machines in decreasing order of downtime and to obtain the records in this order the file is sorted by

Location (Department)
Downtime

The program then prints(to the format shown in figure 5.5.6.) the contents of the first 30 records for the current week (see ER10). This gives the 'top 30' machines in the department in decreasing order of downtime for the week. The remaining records hours and visits for the current week are summed to produce the 31st 'Totals' line.

Program ER14

The output file from ER10 is built up over the 4 or 5 weeks within the month. At the month end a monthly downtime report is printed for each department. The report includes figures from the previous 5 months, giving the machines' downtime league position and total downtime for the last six months (the current month and the total for the last 5 months). ER14 is closely linked with program ER16 (see figure 5.6.1) as they both use and update a Downtime history file, which stores the last 5 months figures for each machine.

Program ER14 is therefore used to merge the 'Downtime - History' file

PROG ER12 ENGINEERING DOWN TIME REPORT FOR FORT DUNLOP TYRE 5 WEEK ENDING 9 / 5 / 79

M/C CODE	TIMES MECH	ELEC	OILER	D/TIME	VISITS MECH	ELEC	OILER	NOW
PA03	19.4	18.4	15.0	15.0	4	4	3	1
PA09	15.6	9.5	10.1	13.0	3	3	3	2
PA15	3.0	1.0	6.0	11.0	1	1	1	3
PA08	20.2	13.0	13.5	11.0	4	4	4	4
PA04	21.7	22.7	24.8	10.0	7	7	7	5
PD11	19.4	24.9	0.0	9.8	6	6	0	6
PA13	24.0	16.9	24.0	9.1	5	5	4	7
PD12	9.3	9.5	0.0	8.8	2	2	0	8
PD05	5.8	4.6	0.0	8.8	2	2	0	9
PD04	2.0	2.0	0.0	8.8	0	0	0	10
PA05	9.4	15.6	12.8	8.1	4	4	4	11
PA12	6.0	5.0	6.0	8.0	2	2	1	12
PD14	5.4	5.3	0.0	7.8	1	1	0	13
CP81	2.6	6.0	0.2	7.2	1	1	1	14
PB03	12.0	12.0	12.0	7.1	2	2	2	15
PA11	3.8	2.5	0.0	7.0	1	1	0	16
PA10	7.2	13.4	8.6	7.0	2	2	2	17
PA16	4.0	2.0	0.0	7.0	1	1	0	18
PA14	6.0	2.0	6.0	7.0	1	1	1	19
PC03	6.0	6.0	6.0	7.0	1	1	1	20
PB13	6.0	6.0	6.0	7.0	1	1	1	21
PA06	16.0	21.4	30.0	7.0	5	5	5	22
PA02	30.7	25.3	15.4	7.0	6	6	4	23
PA01	12.5	7.2	1.7	7.0	3	3	2	24
M143	6.0	6.0	6.0	7.0	1	1	1	25
M142	6.0	1.0	6.0	7.0	1	1	1	26
M101	6.0	6.0	6.0	7.0	1	1	1	27
PD16	6.4	1.3	0.0	6.8	1	1	0	28
PD13	7.8	7.6	0.0	6.8	2	2	0	29
PA17	2.4	3.0	0.0	6.3	1	1	0	30
	41.0	47.9	12.0	27.8	12	12	2	

FIGURE 5.5.6

WEEKLY DOWN TIME REPORT BY DEPARTMENT.

(containing the last 5 months figures see Appendix 5.B.6., for data contents) with the current months 'Downtime' file output by ER10. The two files records are first separately sorted by

Location

Machine

The program has to cater for three conditions:

i. The machine is on both files. The two records are merged having first summed together all the working times and visits and downtime on each record for the machine for this month.

ii. The machine is on the current months file but has no entries on the history file. All times and visits on this months records for the machine are accumulated, and output. The league positions and last 5 months downtime figures are then set to zeros on the output file.

iii. The machine is on the history file but has no record on this months file. This months figures are set to zeros on the output file. The history file data is then copied on to the output file.

The record content of the output file is included in Appendix 5.B.5.

Program ER16

This program prints the month end downtime report for each department.

(Figure 5.5.7.). The Downtime History file is then updated with each machines downtime figure and league position.

The output file records from ER14 are first sorted by:-

Location (Department)

Down Time (current months total)

The program then prints the first 30 records according to the layout (figure 5.5.7), summing the 6 separate monthly downtime figures to print the "Downtime Last 6 months" figure and giving each line a league position. As each line is printed the data are written out to a 'Downtime - History' file (record contents in Appendix 5.B.6). The remaining machines 'details' are then summed together and printed as a 31st report line. As each machines data are accumulated it is given a league position and written out to the 'Downtime - History' file. Thus only the top 30 machines are shown in detail on each report but the down time history file holds the remaining machines data and league position for the month.

NOTE. When writing the downtime file only the current month and the previous 4 months data are included .

5.6. Further Analysis

The data from the cards are stored on tape for analysis purposes. (The 'Job-Record' file Appendix 5.B.1., shows the record contents). The report programs provide single page reports informing management of the machineries and labours performances. The Job-record file and downtime history file are both available for more detailed analysis

PROG ER16 ENGINEERING DOWN TIME REPORT FOR FORT DUNLOP TYRE 5 MONTH ENDING 8 / 5 / 75

M/C CODE	MONTHLY FIGURES TIMES MECH	ELEC	OILER	D/TIME	VISITS MECH	ELEC	OILER	NOW	LEAGUE POSITION 1	2	3	4	5	DOWN TIME LAST 6 MONTHS
PA03	19.4	18.4	15.0	15.0	4	4	3	1	0	0	0	0	0	15.0
PA09	15.6	9.5	10.1	13.0	3	3	3	2	0	0	0	0	0	13.0
PA15	3.0	1.0	6.0	11.0	1	1	1	3	0	0	0	0	0	11.0
PA06	20.2	13.0	13.5	11.0	4	4	4	4	0	0	0	0	0	11.0
PA04	21.7	22.7	24.8	10.0	7	7	7	5	0	0	0	0	0	10.0
PC11	19.4	24.9	0.0	9.8	6	6	0	6	0	0	0	0	0	9.8
PD05	5.8	4.6	0.0	9.2	2	2	0	7	0	0	0	0	0	9.2
PA13	24.0	15.9	24.0	9.1	5	5	4	8	0	0	0	0	0	9.1
M100	6.0	6.0	6.0	9.0	1	1	1	9	0	0	0	0	0	9.0
FD04	5.4	5.3	0.0	8.8	1	1	0	10	0	0	0	0	0	8.8
PD12	9.3	9.5	0.0	8.8	2	2	0	11	0	0	0	0	0	8.8
M1C3	3.0	1.2	0.6	8.3	1	1	1	12	0	0	0	0	0	8.3
PA05	9.4	15.6	12.8	8.1	4	4	4	13	0	0	0	0	0	8.1
PA12	6.0	5.0	6.0	8.0	2	2	1	14	0	0	0	0	0	8.0
PAC6	16.0	21.4	30.0	7.8	5	5	5	15	0	0	0	0	0	7.8
PC14	5.4	5.3	0.0	7.8	1	1	0	16	0	0	0	0	0	7.8
M1M2	6.0	1.0	6.0	7.6	1	1	1	17	0	0	0	0	0	7.6
PA02	30.7	25.3	19.4	7.4	6	6	4	18	0	0	0	0	0	7.4
PA16	4.0	2.0	0.0	7.3	1	1	0	19	0	0	0	0	0	7.3
PA14	6.0	2.0	6.0	7.3	1	1	1	20	0	0	0	0	0	7.3
CPE1	2.6	6.0	0.2	7.2	1	1	1	21	0	0	0	0	0	7.2
PBC3	12.0	12.0	12.0	7.1	2	2	2	22	0	0	0	0	0	7.1
PB07	6.0	6.0	6.0	7.0	1	1	1	23	0	0	0	0	0	7.0
PC05	6.0	6.0	6.0	7.0	1	1	1	24	0	0	0	0	0	7.0
PC03	6.0	6.0	6.0	7.0	1	1	1	25	0	0	0	0	0	7.0
PB13	6.0	6.0	6.0	7.0	1	1	1	26	0	0	0	0	0	7.0
M1M3	6.0	6.0	6.0	7.0	1	1	1	27	0	0	0	0	0	7.0
M1C1	6.0	6.0	6.0	7.0	1	1	1	28	0	0	0	0	0	7.0
PA01	12.5	7.2	1.7	7.0	3	3	2	29	0	0	0	0	0	7.0
PA11	3.8	2.5	0.0	7.0	1	1	0	30	0	0	0	0	0	7.0
	67.8	76.4	20.6	47.8	19	19	4							

FIGURE 5.5.7

MONTHLY DOWN TIME REPORT BY DEPARTMENT.

when the regular reports highlight a problem or when management require detailed engineering information. Two methods of obtaining this information are available:-

i. Quest

Dunlop Computer Centre has a utility program QUEST that can search the 'Job-Record' file select data to pre determined criteria, perform calculations and produce an output report. As an example, QUEST can be used to search for all breakdowns involving a Tyre Press where an electrician worked for more than 2 hours. Any of the fields on the job record can be specified in whole or part as search criteria. The machine identity code (described in 5.4.), can therefore be used to provide information by factory, department, machine type, machine line, or individual machine.

To obtain a QUEST report, details of the information required are given to the Computer Control Section clerks who will devise the QUEST and produce the report, normally within 24 hours. The programming knowledge required to use QUEST can be acquired in an afternoon, making it possible for engineering managers or foremen to submit their own Quests via a terminal.

ii. A Computer Program

If the required report is beyond the scope of QUEST, a program will be written to produce the report. If the information is required on a regular basis, the program can be added to the ER suite and run with the Monday night report programs.

5.7. Development

Figure 5.7.1., shows the various stages in the systems development during 1978 and 1979. Each stage is now briefly explained.

1. The information required, data needed to produce the information and the 'Card' needed to collect the data were discussed and agreed with the Engineers' Working Party (see Background section 5.2.).

2. The system was resurrected to operate the incentive payment scheme for the Works Engineers. The card was redesigned and, after considerable debate, a layout and document size were agreed by the Engineering foremen, Production foremen and Engineering tradesmens representatives. The specifications for the data validation program and the program producing the valid request card file were specified.

3. The programs specified in 2 were written and tested and then systems tested (stage 4).

5. When specifying the file output program (stage 2) it was thought that the utility analysis program QUEST would be used to produce the weekly and monthly reports. QUEST proved impractical, and a suite of report programs were specified.

6. The report programs were written.

7. The User Manual was written.

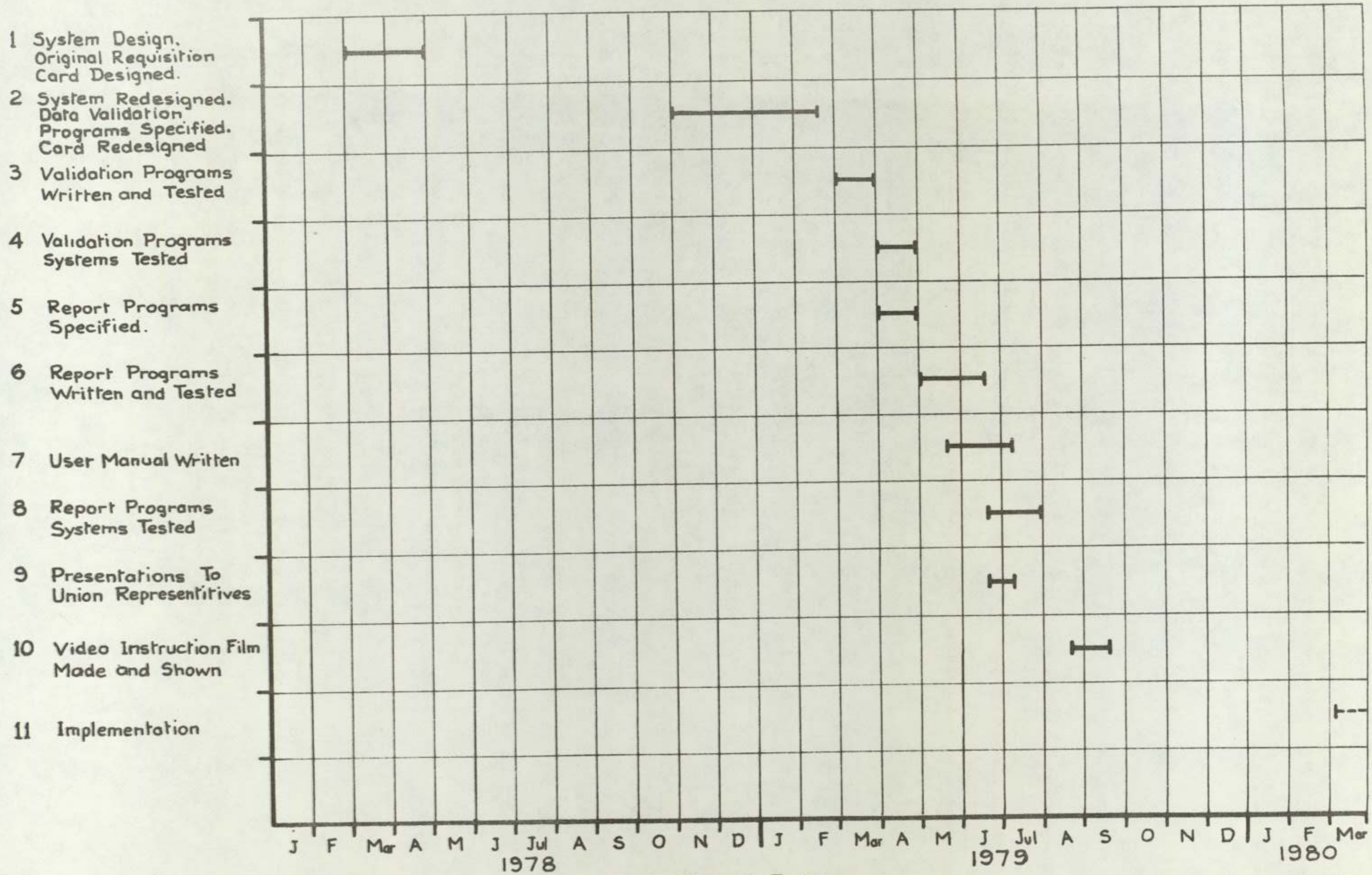


FIGURE 5.7.1
THE ENGINEERING REQUEST CARD DEVELOPMENT TIME SCALE.

8. Report program systems tested.

9. Presentations were made to engineering union representatives and engineering foremen and managers, explaining the principles of the card and how it would be used to operate the incentive payment scheme.

10. A video instruction film was made and used to instruct 800 engineering and production personnel in the systems' operation.

5.8. Discussion

The request card provides a means of collecting shop floor data on machine breakdowns, maintenance activities and labour utilisation. Other systems are in use but are not widely publicised. The IBM/ Alitalia airline's, Maintenance and Management Information System (MEMIS) (Ref 2) and the R.A.F's System (Ref 25) are reasonably well documented.

The design of 'Job Cards' and the type of information required varies from company to company. One of the simplest systems was described by BENNETT and BRASSINGTON (Ref 27) and is operated by J.C. Bamford Excavators Ltd. The system uses a job repair requisition filled out by the production/engineering foremen describing:-

The plant description
Machine number *
The requisition number *
Foremans signature
Date reported *
Time reported

The tradesmen complete the requisition with

Initials (x 2 men)	*
Trade	*
Date completed	*
Time completed	*
Repair time	*

* Denotes items which are input to the factory computer.

The requisition is not used as a direct punching document (though it appears to be designed as such), but the data is retyped on to computer input forms by the Works Engineers secretary. This form which lists each job in plant number order, gives brief details of the work, times and dates. The weekly computer runs provide more detailed information and a plant history.

The Maintenance Management by computer conference papers (Ref 27 & 28) contain several examples of 'job card' based data collection systems and are briefly described below:

R.A.F. Maintenance Data Centre, Swanton Morley.

This system is used to record defects in airframes, engines and equipment. The data is entered by a tradesman on a job card every time a defective part is found. Over 1 million cards a year are sent to Swanton Morley for data processing. The data from these cards together with more detailed reports on special defects provide a data bank, which is used for reliability analysis, calculation of spares levels, manpower, test equipment requirements, isolation of defect trends and mathematical modeling for logistics support.

Completion of the job card is a legal requirement to certify the work done. The accuracy of the data is difficult to check and the R.A.F. estimate that 2% of cards raised do not reach the Maintenance Data Centre.

The data is held as sequential files on magnetic tape, which is proving time consuming as analysis routines can only be run once a day. A random access (data base) system is being considered but this will be expensive to implement.

Eastern Electricity

Since 1972 the Eastern Electricity Board have operated a computerised system of planned maintenance for plant (transformers and switchgear). The system provides information on hard copy for:-

Budget preparation

Work programming including the issue of jobs

Achievement monitoring

Overdue maintenance monitoring

Appraisal of information returned from 'the field'

Details of idle plant.

The job order printed indicates the location and identity of the unit to be maintained, the maintenance procedure and the standard time. Any remarks made on previous visits are printed along with the equipment specification and specialised data such as oil acidity. The tradesman completes the card, by ticking boxes indicating the nature of the work done and providing readings, such as counter indicators and oil acidity readings.

Pedigree Pet Foods

Pedigree Pet foods operate a comprehensive computer based maintenance information system. A job report card provides the data input from the shop floor to an on line IBM 3790 mini computer.

The job card makes extensive use of numeric codes for ease of computer analysis and to reduce the writing required from the tradesman to an absolute minimum. The tradesman may write a comment about the job (max 20 characters) which is incorporated in the plant history file.

The data from the card is entered by the foreman from shop floor terminals which are also used to interrogate the data base on the IBM 3790. A link to an IBM 370 is available to provide more detailed analysis facilities and extended file capacity.

British Steel Corporation, Teeside Division

The Teeside Division operate an on line computer system providing:-

- A shift based engineering information system performing three functions:-
    - 1) Access to specialised engineering information.
    - 2) Resource availability (equipment, spares and labour).
    - 3) Management reporting.
- Works Engineering planning and control providing documentation and control over all maintenance tasks.

The system is complex and covers all aspects of operating a steel plant. The main method of collecting shop floor data is a pre-printed work order, completed by the tradesmen, the data being 'fed back' to the computer system.

Kodak Limited - Chemical Division

A Senior Systems Analyst from Kodak Patrick Homs used the 1980 Maintenance Management by Computer Conference (Ref 28) to describe a theoretical maintenance information system. The paper presented is worthy of consideration as it provides a guide to maintenance information system design.

The data requirements of companies vary, in general they fall in three areas:-

data on costs

data on plant

data on resources.

The method of collecting this data again depends on the company - shop floor data entry or a remote method using a punching document. In general the reader is recommended to use a simple digital code "as these are the most convenient way in which to set up an information system. This convenience is of particular use to the computer but it also forces all concerned to employ unambiguous and standard descriptions of plant, faults, conditions etc".

Shop floor data collection systems based on forms would appear to require the following features if they are to be readily acceptable to the tradesman who is the vital link in the system:-

1) A minimum of writing;
2) The use of simple numeric/alphanumeric codes;
3) Ergonomically designed forms;
4) Feedback of the information generated to the tradesmen providing the data.

The request card, when fully implemented will be a major breakthrough for the Engineering Management as it will provide information on the machinery and how the engineering labour is being utilised. The data recorded can be combined with data held on the commodity issue history file of the Engineering Spares System as both systems use the same machine identity code. This allows analysis of the nature of work undertaken and the frequency of use of stores items.

The design of the Computer system was complicated by the management consultants not being able to specify exactly how the incentive system was to operate. This was overcome by agreeing only to use the computer to calculate the standard hours for each group of workers. The actual bonus index calculation being performed by the Industrial Engineering Department, who input a percentage uplift to the engineering payroll, producing the bonus payment.

The data entered on the card has been kept as simple as possible and codes have been used for flexibility and speed of entry. A simple table modification within the computer programs allows the addition or removal of any code entry. (e.g., the expansion of Cause and Action codes and the addition or removal of Machine Assembly codes).

The possibility of introducing the categorised work value incentive bonus scheme and the Engineering Request Card at the Tyre Group Inchinnan Factory is now being considered. The flexibility of the system design would make this a relatively simple exercise, only requiring the addition of the Inchinnan Factory machine code numbers and the Bonus Group indicators. The cards would be punched at Inchinnan and transmitted to the IBM mainframe at Fort Dunlop. The reports would be transmitted back to Inchinnan's line printer. The same analysis facilities as provided at Fort Dunlop would be available to the Inchinnan Engineers.

CHAPTER 6 FUTURE DEVELOPMENTS

6. Future Developments

This chapter first describes the short-term developments planned for the next 12 months and explains how the full Maintenance Information system should be developed. Long term systems developments (in excess of 5 years) are then described.

6.1 Short-Term Developments

6.1.1 Engineering Spares System Expansion at Fort Dunlop

The maintenance workshops are being reduced to 17 work centres over the next few years. It is planned to install VDU's in all these work centres but as a temporary measure VDU's will be provided for any maintenance foremans office justifying the installation. Currently 5 further VDU's have been requested.

A VDU and keyboard will be installed in the Fort Dunlop Engineering Training School to be used as a teaching tool and to requisition stores items. It is hoped that apprentices will come to regard a computer terminal as an important aid to their trade and accept the value of inputting data on line and interrogating a computer for information.

Production and non-factory departments (Tyre Technical Centre, Research Centre etc,) also requisition Central General Stores items (51, 317 requisitions in 1977). A study is to be carried out to ascertain the financial justification for installing VDU's for the production foremen and non-factory departments. The van delivery service could then be expanded to include the areas.

6.1.2. Issue and Receipts of Raw Materials

The issue and receipt of crude materials and chemicals are not recorded by the Engineering Spares System. The principles are exactly the same and the Buying Manager for Tyre Division has requested that the booking of materials receipts should be done on a terminal in the crude materials store. The requisitioning of crude materials should also be considered especially if the Spares System is expanded to include production departments.

6.1.3. Stores Catalogue

The stores catalogue data held for the coding and standards section can be formatted as commodity code book pages by a computer program and printed on the high speed main frame printers. This facility can be used to provide a full code book for any of the factories using the system (currently 64). In addition, sections of the catalogue can be produced, for example a booklet listing the bearings held at the Hanau (Germany) factory can be printed.

Producing the catalogue as microfiche is being considered. A magnetic tape containing the code book data is output from the IBM main frame at Fort Dunlop and sent to a specialist company producing the microfiche sheets. The economies of supplying each code book recipient with a microfiche reader and the cost of producing the sheets is being compared with the cost of printing the catalogues. Preliminary figures show considerable savings using microfiche.

6.1.4. Standardisation and Optimisation of stock

The common information shared between the Engineering Foremen, the buyers, the stores personnel, stock controller and coding clerks has led to a level of co-operation between those departments that had not previously existed. This has resulted in several unforeseen benefits, such as:

i. Identification of items that are obsolete
ii. Identifying those items stocked in the stores under several different code numbers
iii. The setting of revised stock levels, in line with current usage
iv. Correcting errors and omissions in the commodity listings.

This has led towards optimising the stock, but a more formal exercise should now be carried out.

The lack of any standardisation of machine parts within the company can be seen on the SUBSET screens of the spares system. As an example 47 makes of electrical contacts are stocked (figure 6.1.1) Adoption of a limited number of preferred makes for general items should now be considered.

6.1.5. Automatic amendment of re-order levels and quantities

The practicality of programming the computer to re set re-order levels and order quantities to reflect current usage and delivery periods is to be investigated.

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C490 PROGRAM TABLES FOR COS/CMS SUITES     DATE 30 08 79  PAGE 14

TABLE NUMBER 115      02 COMMODITY CODE BOOK TITLES/SUB
SIZE   10000                                    (CONTINUED)

TABLE ENTRY KEY
61092110 X            SPARES FOR CROMPTON PARKINSON
61095001 X            SPARES FOR GEC
6110     S            MOTOR CONTROL EQUIPT,DISTRIBUTION PANELS.
61101150 X            AEI SPARES
61101700 X            BROOKHIRST IGRANIC SPARES
61101950 X            ALAN BRADLEY SPARES
61102015 X            BTH SPARES
61102300 X            CONTACTOR SWITCHGEAR SPARES
61104000 X            ELECTRIC CONSTRUCTION CO SPARES
61104200 X            ELLIOT BROS SPARES
61104650 X            LEEDS & NORTHRUP SPARES
61105010 X            PYE T.V.T. LTD SPARES
61107001 X            THORN AUTOMATION SPARES
61108200 X            WATFORD SPARES
61108540 X            WESTOOL SPARES
61108570 X            WIDNEY DORLEC SPARES
6111     S            ELECTRICAL CONTACTS
61110200 X            AEI & BTH
61111400 X            ARROW
61111450 X            ALLEN BRADLEY
61111470 X            BRITISH KLOCKNER SWITCHGEAR
61111510 X            B.U.S.M.C.
61111560 X            BROOK.
61111600 X            BHI/CUTLER HAMMER
61112010 X            BRUSH
61112100 X            BUFREL
61112170 X            CLECO ELECTRICAL INDUSTRIES
61112300 X            CONTACTOR SWITCHGEAR (NOW MTE)
61112700 X            CRABTREE
61112800 X            CROMPTON PARKINSON
61112950 X            DEWHURST PARTNER (DUPAR)
61113100 X            DONOVAN
61113310 X            ELECTRICAL CONSTRUCTION CO (ECC)
61114310 X            GEORGE ELLISON
61114610 X            ETCHELLS CONGDON & MUIR
61114650 X            FELCO
61114810 X            GEC
61115210 X            G.W.B. FURNACES LTD
61115410 X            ERSKINE HEAP
61115670 X            G.W. KING
61115800 X            LANCASHIRE DYNAMO & CRYPTO (LDC) NOW THO
61115850 X            LONDEX
61116001 X            MCGEOCH
61116150 X            MATHER & PLATT
61116175 X            M & C ELECTRICAL
61116190 X            MEDWAYS LIFTS
61116200 X            MEM
61116300 X            MTE (SEE ALSO CONTACTOR SWITCHGEAR)
61116510 X            METROPOLITAN VICKERS
61116710 X            MORGANITE
61116800 X            H. MORRIS
61116900 X            MODEL ELECTRICAL CO
61117020 X            A REYROLLE
61117090 X            SPECHER & SCHUH
61117120 X            SATCHWELL CONTROLS
```

FIGURE 6.1.1

ELECTRICAL CONTACTS.

CM98 PROGRAM TABLES FOR CDS/CMS SUITES DATE 30 06 7

TABLE NUMBER 115 02 COMMODITY CODE BOOK TITLES/S0S (CONTINUED)
SIZE 10000

TABLE ENTRY KEY	
61117140 X	SQUARE 'D'
61117450 X	SUNVIC (AEI)
61117550 X	SWITCHGEAR ACCESSORIES LTD
61118010 X	TECN AUTOMATION
61118030 X	TELEMECANIQUE
61118050 X	TELEMECANIQUE
61118070 X	VAUGHAN CRANE
61118400 X	WADSWORTH
61118440 X	WATFORD ELECTRICAL & MFG CO LTD
61118470 X	WAYGOOD OTIS
61118600 X	ALLEN WEST
61118900 X	R TWIST
61119500 X	MAKES UNKNOWN
6114 S	THYRISTOR DRIVES
61144100 X	GEC GEMINI
6115 S	GENERATORS.
61151250 X	DYNAMIC EXCITER UNITS
61156710 X	LAMPHOLDER LOCKING RINGS
6117 S	MOTOR STARTERS.
61170500 X	D-O-L A.C.E.C PUSH BUTTON TYPE
61170700 X	D-O-L BROOK MOTORS
61171010 X	D-O-L CRABTREE A15 (OIL BREAK)
61171050 X	D-O-L CRABTREE B15 (AIR BREAK)
61171085 X	D-O-L CRABTREE BO15 (AIR BREAK)
61171125 X	D-O-L CRABTREE B35 (AIR BREAK)
61171180 X	D-O-L CRABTREE BO35
61171190 X	D-O-L CRABTREE ET150C
61171200 X	D-O-L CRABTREE 'D' HAND OPERATED
61171225 X	D-O-L CUTLER-HAMMER A25
61171300 X	D-O-L DONOVAN A35
61171445 X	D-O-L DONOVAN A32
61171605 X	D-O-L E.A.C. AUTO SWITCHES
61171800 X	D-O-L GEC ELLIOT NON REVERSING
61172010 X	D-O-L BHI CONTACTOR TYPE
61172070 X	D-O-L BHI MINISTART
61172300 X	D-O-L MEM 'AUTOLINE'
61172380 X	D-O-L MEM 'MEMLINE 00'
61172400 X	D-O-L MEM 'AUTO MEMOTA' SERIES 5
61172420 X	D-O-L MEM 'MEMOTA' SERIES 5
61172450 X	D-O-L MEM 'AUTO MEMOTA' SERIES 435
61172470 X	D-O-L MEM'AUTO MEMOTA'SERIES 6.HAND RES
61172500 X	D-O-L MEM'AUTO MEMOTA'SERIES 6 AUTO RESE
61172590 X	D-O-L MEM 'STARTET'
61172700 X	D-O-L MTE SERIES DOL
61172910 X	D-O-L SQUARE 'D'
61173010 X	D-O-L ALLEN WEST AIR BREAK
61173110 X	ALLEN BRADLEY REVERSING
61173220 X	BHI REVERSING
61173500 X	CRABTREE B15 REVERSING
61173620 X	CRABTREE BO15 REVERSING
61173840 X	DONOVAN A35 REVERSING
61174510 X	DEWHURST PARTNER DRUM TYPE REVERSING
61174610 X	E.A.C. DRUM TYPE REVERSING
61175100 X	GEC REVERSING CONTACTOR TYPE
61176320 X	SQUARE 'D' DRUM TYPE REVERSING

FIGURE 6.1.1 Continued.

6.1.6. Inter Factory Stores

Currently, each Tyre Division factory holds its own stock of machine spares. This has resulted in several low use expensive items being held in duplicate or triplicate. The Group Purchasing Management are considering either holding a single spare at one factory to be transported to the other Tyre Division factories as required for a breakdown, or setting up a spares warehouse central to the three factories. The Engineering Spares system could be used to display the stock held and to requisition the item.

6.2. Maintenance Information System

The 'full' maintenance information system required by Fort Dunlop can now be developed. The time scale is seen as approximately 3 years. The applications are:-

6.2.1. On Line Job Recording

The Engineering Request Card should be developed as an on line system the data being input to the computer via the Spares System workshop terminals. An on line report facility should also be provided enabling the VDU to be used to access the plant history file. (See Equipment data base).

The Request card would be completed as at present but instead of being sent for data preparation, the card would be checked by the foreman or leading hand and the data keyed in at the workshop terminal. The additional work involved is not excessive, for the 49 foremen and 606 men the volume would be:-

$\frac{606}{49}$ 13 men who normally work in gangs of 2

∴ 7 gangs per foreman

The average job time is 1-1.5 hours (P.A. Management Consultants figure).

∴ 7 x 5 jobs per shift

= 35 jobs

The data from the card takes approximately 1.5 minutes to check and input, thus the foreman and leading hand will have to spend approximately 30 minutes each per shift. This time has to be compared with the time currently spent at the start and finish of each shift completing logs and handing over to the next shift, currently estimated at 40 minutes per shift. The engineering management rely on verbal reports of the major incidents occurring over night or during the week end. The Maintenance Engineers each hold a meeting first thing each morning with their day shift and morning shift foremen to collate this information for their own benefit and then pass a condensed version on to their Maintenance Manager, who collates the information from each of his maintenance engineers before passing a condensed version to the Chief Engineer. Having this information available on a VDU, would therefore improve the accuracy and completeness of the information and reduce the amount of management time currently expended on this activity.

The data input at the terminal would have to be validated at the time of input and then stored on a data base. (See Equipment data base 6.2.1.). A series of analysis routines would then be used to display basic machine and department reports on the V.D.U. (As examples downtime by machine over the previous shift, and a display of the full data content of any card). More detailed analysis could be obtained by requesting a report from the computer centre (24 hours notice) or by writing a simple analysis program and submitting it via the workshop terminal (using a standard data base analysis program package). This facility would allow foremen, and hopefully tradesmen, to look at a machines plant history and use this information to assist in the diagnosis of faults.

The principles of this system have been discussed with the Computer Centre Management and it has been agreed that data preparation for the Request Card will only be required for the next 18 months (up to August 1981) and at that time an on line job recording system should be available.

6.2.2. Equipment Data Base

To provide the engineering information required 'on line' will necessitate the creation of an Equipment data base. As the production machine is the 'basic unit' in the factory, production and quality control systems will also access the data base and possibly store their data within the structure. A full data analysis will have to be undertaken to design the data base but, to illustrate the principles, a possible structure is shown in figure 6.2.1., and is explained below:-

Machine Type

The type of machine eg., Bag-o-matic Tyre Press, a 60" mill line etc. Each machine of the type will have its own record, under Machine Identification, but common data is held at the Machine Type 'Level':

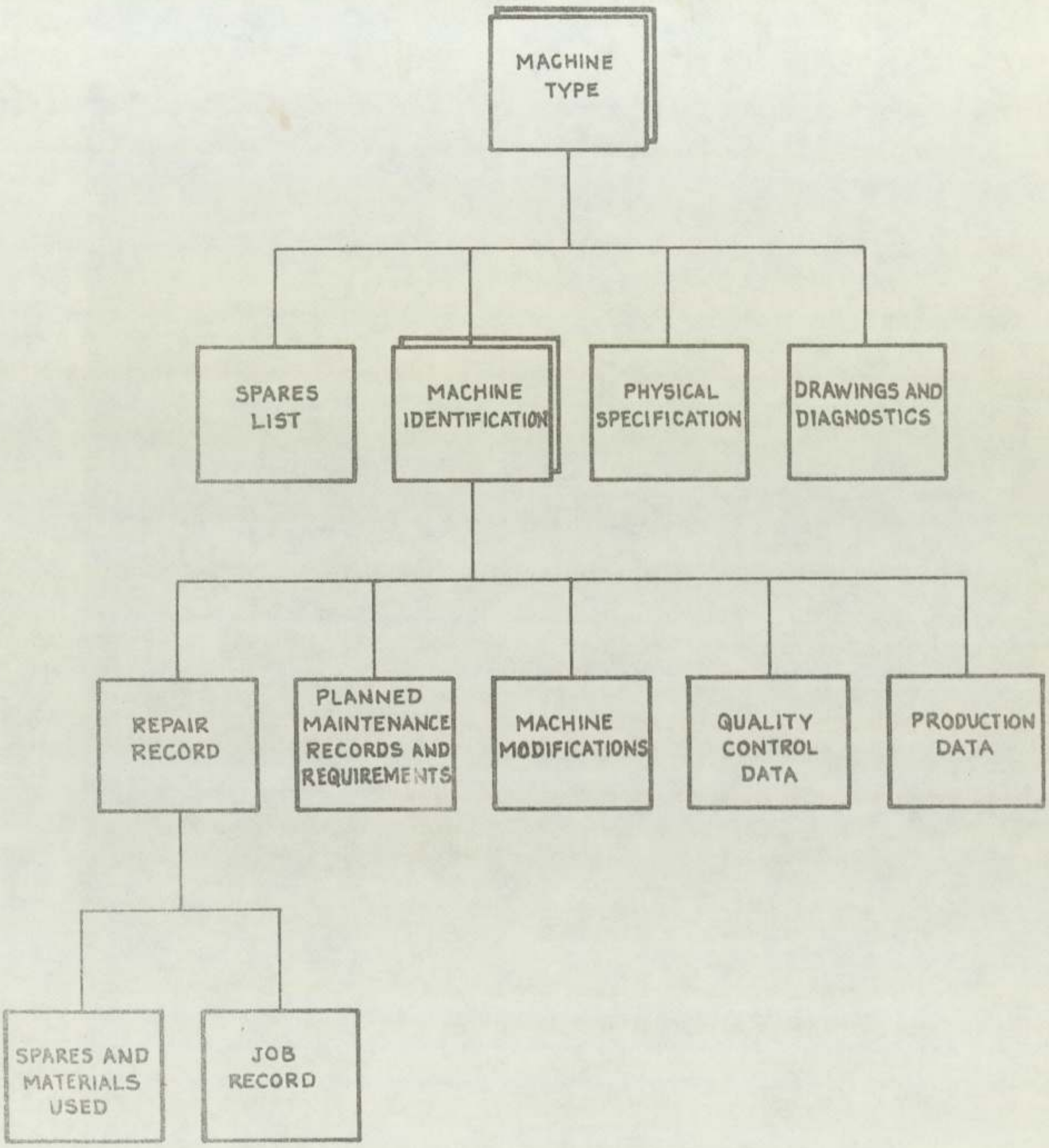

FIGURE 6.2.1
EQUIPMENT DATA BASE.

Spares List

A pointer to the Materials Control (the Engineering Spares System) data base on the machines commodity code (Group and Class).

Physical Specifications

The machines specification (production and engineering) and installation requirements e.g., services, environment etc.

Drawings, Diagnostics

An index to the machines drawings and possibly diagnostic routines set out in the firm of questions with multiple answers, to assist the tradesmen in tracing faults.

The next level of the data base heralds details applicable to individual machines.

Machine Identification

The machine identity code (developed for the Engineering Spares System and used on the Request Card) is the key to the data held for each machine. The identification 'segment' will hold such general information as:-

Installation data and cost
Manufacturer and Supplier
Order Number
Capital Cost
Total depreciation (+ method in use)
Total Costs of labour, materials and purchases
for planned and unplanned maintenance.

The other segments of data held are:-

<u>Spares and Materials Used</u>

The record of an issue of a part to be used on the machine, obtained from the Engineering Spares System. A record of a purchase made against the machine.

<u>Job Record</u>

The record of each job undertaken from the on line job recording system (excluding planned preventive maintenance).

<u>Repair Record</u>

Data from the spares and materials and job record segments are summed to provide totals such as:-

total downtime + lost contribution repair time + cost materials + purchases cost etc.	for current month and year to date

<u>Planned Maintenance Records and Requirements</u>

Possibly held as a separate data base it would provide the schedules to be undertaken, drawing numbers, labour, safety requirement, time required, parts required and the interval between jobs.

The record of completed schedules and outstanding work would also be held. The record of completed work being provided by the on line job recording system.

Machine Modifications

This segment would list any modifications made to the machine and would hold drawing numbers or descriptions of the modifications.

Quality Control Data

This segment would hold the quality control data. This would include the machines production defects records and any critical machine settings related to quality when the machine was working in partnerships with another machine or as part of a production chain.

Production Data

Possibly held as a separate data base the production data would include;

Cycle times

Capabilities (e.g., range of tyres, mould sizes and types)

Size related equipment (e.g., former number or mould number)

Size being built

Shift count

Current Operations identification

The engineering data held would thus enable on line analysis reports to be produced for engineering management as envisaged in on line job recording (6.2.1) and enable the planned preventive maintenance system to be developed as an on line system.

6.2.3. On Line Planned Preventive Maintenance

The computer systems currently developed (Spares System and Request Card) will allow a planned preventive maintenance system to be manually operated and later developed as part of the Equipment data base. The principles of setting up and operating a planned maintenance system were described in Chapter 3.

6.2.4 On Line Materials Control - full Data Base

The Engineering Spares is a hybrid system, part on line and part batch. When resources allow, the justification for rewriting the whole system as a data base and performing all functions on line, should be considered. The high cost of financing the stock of raw materials and general items may prove sufficient cost saving to undertake the system development. An on line system would save approximately 2 days of stock (time between batch runs of CG CM system producing orders).

6.2.5 Engineering Work Scheduling

The scheduling of shutdown work, weekend work and major maintenance work should be undertaken using the computer. If jobs are preplanned with details of manpower, estimated time, earliest and latest start and finish dates, details of materials, drawings, related activities, safety precautions, special tools etc., the computer can be used to schedule the work and record its progression.

6.3. Long Term Developments

Dunlop intends to develop computer systems in the manufacturing area. Work is currently being carried out to define the manufacturing systems requirements. The engineering systems described in section 2 will form an integral part of the system. The longer term development related to maintenance are now described.

6.3.1. Automatic machine monitoring and down time recording

The increased use of microprocessors for machine control enables new methods of machine monitoring to be considered. Measurements of current, temperature, speeds. pressures etc, used as control parameters by the microprocessors can also be used to signal impending faults. All future applications of microprocessor control should include facilities for logging these 'maintenance' outputs. The machines' down time, running time, and working time can also be recorded and included in the preventive maintenance system. Schedules could then be spaced at intervals of running hours instead of using fixed time periods.

6.3.2. On line requests for Maintenance

The method of requesting maintenance work by writing a Request Card containing data that can be provided automatically should be reconsidered. It would be possibleto use a terminal to enter the job details (the time and date being provided by the computer). The job details are then passed to an engineering planners VDU, when the work would be estimated and passed on to a workshop VDU. Here a tradesmen would record his acceptance of the job (the date and time being recorded), complete the work and return to the terminal to record the work details.

A system of this type would remove all paper work from the system and provide a full complete record of all work undertaken.

CHAPTER 7 CONCLUDING DISCUSSION

7. Concluding Discussion

7.1. The design, development and implementation of computer systems

7.1.1. The Engineering Spares System

The Engineering Spares System was the only computer system implemented in the Tyre Division in 1979 (excluding the Computer Centres' own system enhancements). Other systems were completed but are not being used due to Union resistance. This failure to realise the potential benefits from expensive computer systems developments brings into question the techniques used in both system design and the selection of projects for computerisation. The demand for new computer systems and modifications to existing systems currently exceeds the programming and systems analysis resources available at Fort Dunlop's computer centre. This situation is expected to continue as there is a national shortage of qualified programmers and analysts. Several new techniques were used in the design and implementation of the Spares System and Request Card and are worthy of consideration when undertaking a similar systems development.

Discussion with the computer centres analysts and project managers gave three general reasons for systems failing.

1. Senior management not 'selling' the system to the personnel in their department who will actually use the system.
2. Bad system design making the job more complicated or frustrating then before.
3. Industrial relations problems where the computer system was designed to reduce the staff required, or where a payment is

demanded for using 'new technology' and increasing output.

These problems appear to have occurred in the past, because the systems' potential users, (clerks, production workers, foremen) were not involved early enough in the system design. The systems' analysts worked with the management in the department requiring the system but only involved the employees who were supposed to use the system at the implementation stage. To avoid a repetition of these problems with the Spares System, it was decided that the involvement of all 'users' was essential. A good working relationship had been forged between the engineering foremen and the author during the first year of the project and their information requirements were known. The stores, buying department and coding and standards personnel were now approached and the purpose of the envisaged system was explained. Their requirements were identified and included in the system design.

The Spares System V.D.U., screen layouts were then designed to provide a demonstration system. The management from the 'User' departments were first shown the system in operation, and then an open invitation to see the system was given to all engineering foremen, stores personnel, buying department personnel and coding and standard clerks. The response was overwhelming and several hours were spent showing the demonstration system to small groups. These sessions consisted of 20 minutes at the V.D.U., followed by a discussion of the screen design and the systems' operation. Comments from these sessions led to several significant improvements in the system and showed up a number of errors. The comments from the people destined to use the system proved more constructive than those from the management. The screens and method of operation were then amended and further demonstrations given. The systems' potential users were kept informed of the projects' progress and were extremely co-operative when approached with queries or additional work directly related to the Spares System such as the machine identity coding exercise (Engineering foremen) and the tabulations of all subsets within the commodity codes (coding clerks). Several of the 'users' expressed an interest in the mainframe and were given a tour of the installation and the machines operation was explained.

The majority of the potential users had never operated a VDU keyboard and there was a noticeable reluctance to use the terminal during the demonstration sessions. The reason for this was apparently the fear of the consequences of entering erroneous data. To overcome this problem, an instruction lecture was given to each group of users, on their own terminal at the time of installation. These sessions explained how the system worked, showed how errors were detected by the programs and how to interpret the error messages returned to the VDU, in these circumstances. These sessions were followed up a few days later with another visit to discuss any problems that may have occurred. In addition, a computer programmer and a systems analyst were available to answer queries. The long term benefits of the acceptance of the spares system could be considerable. The Workshop VDU's are the first used within the factory. The leading hands are already using the terminals for information and to requisition stores items, which is theoretically outside their job descriptions. The scene would therefore appear to be set to implement further computer applications and the foremen are now asking for an on line job recording system. (See Future Developments).

Considerable care has also been taken in the design to provide a system which neither frustrates the experienced user nor confuses the inexperienced. In an attempt to learn from other peoples'mistakes, several interactive systems sold as computer packages and the systems in use at Fort Dunlop were examined and the following points noted:-

i. Headings and titles on VDU displays are not looked at, the user quickly learns where the information is on the screen and ignores the caption information.

ii. Explanations of how to operate the system displayed on the screen are not read after the first few sessions.

iii. Users become frustrated with a system that provides a fixed path to the required screen, e.g., the user wants screen 3b (he remembers this from the last time he used the system). The system forces him to access screen _1_ then screen _2_ then screen _3_ then screen _3b_.

The system is permanently catering for the inexperienced user.

iv. Light pens can provide a fast means of making a selection but are often used as a gimic. The advantages should be considered against the cost - £10 per month per terminal.

v. The system response time must be better than 6 seconds, (the time from pressing enter to receiving the information from the computer).

The Engineering Spares System has incorporated all those findings, i.e., few headings have been used, operating instructions are provided in a manual, any screen can be obtained from any other screen, light pens were experimented with for screen selection but rejected and the response time is within tolerance. (The largest screen, the Buying information, consists of 2 programs and is displayed in 4 sections to obtain a fast response).

All headings and captions sent to a screen are overheads on the system, having to be stored within the program and transmitted to the terminal.

7.1.2. The Engineering Request Card

The Request Card should have been the first development, its data being potentially more useful than the Engineering Spares Systems. The system has to await the introduction of the management consultants incentive payment scheme (Chapter 5) but should then provide sufficient information to set up the planned preventive maintenance system at Fort Dunlop.

The Request card will be used by some 800 people in the engineering and production areas. To involve them all was obviously impossible. The card design and the data content were agreed with the engineering management and management consultants, but a representative group of production foreman and managers were then approached to ensure there would be no objections to replacing the Work Authorisation Note with the new card.

The Request card will be used by employees who are members of several different unions:-

Engineering and Production Foremen and Managers

- Members of the Association of Scientific and Managerial Staff.

Engineering Tradesmen

- Amalgamated Union of Engineering Workers.
- Electrical, Electronic, Telecommunication and Plumbing Trades Union.
- National Union of Sheet Metal Workers, Coppersmiths, Heating and Domestic Engineers.
- Union of Construction and Allied Trades.
- National Union of General and Municiple Workers.

The only objection raised about the Request card came from the Production Foremen who pointed out that the original sample cards were too large to fit in a pocket. The card layout was amended and a more convenient sized card was tested and approved by the Foremen.

As described in Chapter 5 all the engineering workers, production and engineering foremen and managers had to be shown how to complete the card (800 in all). A video training film was made and shown as part of a series of ½ day seminars given by the management consultants. Video had not previously been used as a trading medium for computer systems. The success of the film has led the Computer Centre management to consider the use of this medium for future project work.

7.2. Spin Off effects

The compilation of the justification report for the Spares System highlighted the number of requisitions being raised for consumable items such as soaps, brushes, clothing, hand tools. (See figure 4.10.3) Expenditure on these items has now been restricted by realistic budget allocations and by closer scrutiny of the use.

The analysis of requisitions showed that 23,888 requisitions were raised by the Works Engineers and Machine Tool Department for items in commodity Group 50 the Nuts, Bolts and Fastening group. The total value of the requisitioned items was £16,466 giving an average requisition value of 69p. Tradesmen were arriving at the stores with requisitions for 2 or 3 nuts and bolts, having walked across the factory to obtain them. The works accountant and engineering management were informed of this practice and it was agreed that common sizes of nuts, bolts and washers should be made "free issue" in the workshops having been requisitioned in bulk from the stores, via the Spares Terminal, delivered by van and placed in plastic bins in the workshop. A Computer Centre Systems' Analyst analysed the previous years issues of nuts, bolts and washers to each workshop, selected the 50 most frequently used items and setup for each workshop, a reorder number and reorder level. The reorder number, is the stock quantity or a multiple of the quantity (e.g., if washers are stocked by the gross, the reorder number is a multiple of a gross). The 'free issue' stock is charged against the Production Department and not against cost centres or machine numbers.

The presence of a member of the Engineering Department, namely the author, based in the Computer Centre for two years has led to much greater co-operation between the two functions. The Computer Centre had previously concentrated on developing 'accountancy' systems (see Chapter 3). Several programmers and analysts had never been in the tyre factory, so informal factory tours were arranged with engineering foremen acting as guides and explaining the production process. Engineering management and foremen now have a much greater understanding of what the computer can offer.

This co-operation was recently shown to be of great benefit when negotiating a bonus percentage payment for engineering workers. The engineering management realising that changes in the payroll system must be required, requested Computer Centre Personnel to advise them on what was practicable throughout the negotiations. The computer programs were altered and the bonus paid on time. This may not seem extraordinary outside Dunlop, but even two years ago the negotiations would have taken place and the bonus method agreed before discussing the practicality of actually amending the payroll with the Computer Centre.

7.3. Fort Dunlops' Maintenance Information System

The Spares and Request Card Systems have provided the maintenance management with the means of collecting, storing and analysing data relating to the performance of the machinery and the efficiency of the Maintenance Department. The maintenance staff reductions that have taken place during the last 3 years now make a planned maintenance system imperative. The work of the tradesmen remaining must be organised if the production machine availability is to be increased and a reduction in the cost of maintenance per Kg of tyres produced obtained. The extra workload involved in implementing a planned maintenance system has been acknowledged by the Chief Engineer. To overcome this problem he has created the new role of Process Engineer, 12 will be appointed initially and given the task of "optimising the manufacturing process". The Planned Maintenance System will be implemented by these engineers in co-operation with the maintenance foremen and managers.

The Cost of Developing the Computer Systems

The total capital expenditure for the Spares System and Request Card has been a little over £9000 at Fort Dunlop. System development has cost £40,000 and operating costs are £40,000 per year(£30,000 for the Request Card). The savings are difficult to quantify but the information made available will allow the maintenance management to improve the efficiency of the plant, the stores operation is now simplified and the Request Card will allow an incentive bonus scheme to be operated, all providing savings for the company.

APPENDICES PAGE

FL 38 FACTORY FORT DUNLOP RUN 17

COST CONTROL REPORT W/E 20 04 79
DISPOSAL OF COST

COST CENTRE 998020 MAINT. MANAGER

COST CENTRE CODE	DESCRIPTION	LABOUR & OHDS ABSORB £	LABOUR & OHDS ACTUAL £	---C.G.S.--- ABSORB £	---C.G.S.--- ACTUAL £	--PURCHASES-- ABSORB £	--PURCHASES-- ACTUAL £	UNDER - /OVER + ABSORBED £	
	PLANT MAINTENANCE								
001000	COMPOUND PREPARATION	6345	4881	1291	233	2067	18000	-13411	99
002000	WASTE PROCESSING	5	246	3		3		-235	99
005000	COMPOUND PREP.WEST	1210	1360	215	208	835	14	678	99
010000	FABRIC PREPARATION	1616	2046	176	41	456		161	99
015000	TYRE 4	7528	4491	2362	1242	2644		6801	99
030000	TYRE 2	9013	6650	1734	829	2030		5298	99
040000	TYRE 7	1551	826	399	223	424		1325	99
050000	FLAPS	11675	9141	1913	2111	2331		4667	99
053000	TYRE 8		27		56			-83	99
060000	TYRE 6	2068	2143	870	895	1593		1493	99
070000	CENTRAL INSPECTION		294					-294	99
080000	TUBE	2643	2614	513	114	835		1263	99
095000	RUBBER COMPONENTS				8			-8	99
096000	CURING BAG	494	122	183	104	229		680	99
98000	I.T.MANUFACTG.SVICE.	69			21			48	99
	TOTAL PRODUCTION	44217	34841	9059	6085	13447	18014	9383	99
100000	SERVICE ELECTRICAL		304					-304	99
109000	AREA ONE ENGINEERS	10		1		1		12	99
110000	AREA TWO ENGINEERS	11		1		1		13	99
111000	AREA THREE ENGINEERS	12		1		1		14	99
112000	AREA FOUR ENGINEERS	12		1		2		15	99
171000	AUTO.CALL.W/LESS.U/L	91		22		34		147	99
139000	COMMERCIAL&N/OFFICES	68		2		65		135	99
136000	COMMERCIAL&N/OFFICES	88		2		84		174	99
144000	ELECTRICITY		642		12			-654	99
148000	GAS.BOILER.		365		24			-389	99
157000	HYDRAULIC.PUMP.				41			-41	99
159000	HOT.WATER.PLANT.TY4.	71	238	32		34		-101	99
160000	HOT.WATER.PLANT.TY6.	76	88	63	4	135		182	99
161000	HOT.WATER.PLANT.TY7.	169	143	55		173		254	99
162000	HOT.WATER.PLANT.TY8.		135			418		283	99
195000	FACTORY TECHNICAL					2		2	99
204000	CPU.BATCH TESTING.					5		5	99
211000	REMOVALS-PLANT&FURN.		135	7		3		-125	99
226000	WORKS ENGRS.ADMIN.					10		10	99
228000	MACHINE SHOP	2						2	99
232000	CRUDE MATERIAL STORE			1	4			-3	99
241000	STATIONERY STORES					1		1	99
299000	DINING CLUB CO.ACC.		56			8		-48	99
212000	U.S.S.C.CO.ACCOUNT			4		1		5	99
274000	[illegible]					5		5	99
276000	WELFARE					5		5	99
302000	TECHNICAL [illegible]					9		9	99
306000	TYRE TECH.LABS.		24	4		24		4	99
309000	TEST FLEET			2		22		24	99
310000	TYRE GRAN.LAB.			1				1	99

Cost Control Disposal of Costs

Appendix 2A

COST CONTROL REPORT W/E 28 04 79

COST CENTRE 998020 MAINT. MANAGER

COST TYPE	WEEKLY COST ACTUAL £	BUDGET £	VARIANCE £	MONTH TODATE COST ACTUAL £	BUDGET £	VARIANCE £
CHARGEABLE MATERIALS						
01 CGS ISSUES RECHARGEABLE	5267	5267		30217	30217	
02 PURCHASES RECHARGEABLE	18128	18128		46872	46872	
TOTAL	23395	23395		77089	77089	
PART A LABOUR						
11 DIRECT-MANUFACTURING	20727	14901	-5826	65479	59695	-5784
15 OTHER ALLCES-SHIFT ETC.	11249	9038	-2211	45241	35654	-9587
16 OVERTIME PREMIUM		1070	1070	3040	7506	4466
17 INDIRECT LABOUR	359	949	590	1317	3818	2501
18 FRINGE COST	11964	9902	-2062	42581	39469	-3112
TOTAL	44299	36660	-7639	157658	146142	-11516
PART B MATERIALS						
20 RUBBER COMPONENTS.	1096		-1096	3932		-3932
22 CGS, ISSUES	118	305	187	612	1241	629
27 STATIONERY	23	6	-17	64	24	-40
28 CWN PURCHASES		133	133	262	532	270
29 CANTEEN	322	90	-232	1310	377	-933
TOTAL	1559	534	-1025	6180	2174	-4006
PART C ENGINEERS						
31 PLANT MAINT. LAB & O/HDS	679	360	-319	2551	1413	-1138
34 PLANT MAINT. CGS.		22	22	50	75	25
35 PLANT MAINT. PURCHASES		74	74	89	287	198
TOTAL	679	456	-223	2690	1775	-915
PART C MACHINE TOOL						
31 PLANT MAINT. LAB & O/HDS		15	15	32	57	25
34 PLANT MAINT. CGS.	10	1	-9	10	3	-7
35 PLANT MAINT. PURCHASES		4	4		17	17
TOTAL	10	20	10	42	77	35
PART D SERVICES						
41 POWER-ELECTRICITY	43	18	-25	182	72	-110
42 STEAM.	750	414	-336	3597	1693	-1904
43 WATER-TOWN.	2	1	-1	7	3	-4
46 GAS	15	5	-10	65	15	-50
TOTAL	810	438	-372	3851	1783	-2068
TOTAL ACTUAL V STANDARD	70752	61503	-9249	247510	229040	-18470

Cost Control Report

Appendix 2B

PROG C031 REFNO 048 FORT DUNLOP C.G.S ISSUES TO ALL ENGINEERS FOR ALL DEPARTMENTS-BREAKDOWN WEEK ENDING . . .

WORKS ENGINEERS DEPT FORT DUNLOP PAGE 7

DEPT EFOB	C/C	JOB NO.	DESCRIPTION	COMMODITY CODE NUMBER	BATCH NO.	REQUISITION NUMBER	DATE	QUANTITY	STORES £.P	SERVICE £.P	REQUIS. DEPT
30	90		14"STILLSON WRENCHES.	51 20 2614	15	26139	050379	1	4.25		112
30	90			99 55 0001	LA9	146061	090379	20	1.34		106
30	90			99 55 0002	LA7	172613	050379	1	1.02		112
30	91		1/4" X 3/4" BLACK HEXAGON HEAD SE	50 01 1159	12	172526	050379	200	4.55		112
30	91		5/16" X 1.1/2" BRIGHT STEEL HEXAGON	50 01 2215	13	172521	050379	20	1.10		112
30	91		3/8" X 1.1/2" BRIGHT STEEL HEXAGON	50 01 2265	113	172763	090379	20	1.35		112
30	91		1/2" X 1" BRIGHT STEEL HEXAGON	50 01 2361	12	172525	050379	20	1.66		112
30	91		1/2" X 1.1/2" BRIGHT STEEL HEXAGON	50 01 2365	12	172524	050379	20	2.27		112
30	91		1/2" X 2" BRIGHT STEEL HEXAGON	50 01 2369	72	172753	090379	20	2.70		112
30	91		5/16" BRIGHT STEEL HEXAGON NUTS.	50 58 1007	113	172768	090379	100	1.07		112
30	91		3/4" BRIGHT STEEL HEXAGON NUTS.	50 58 1013	72	172754	080379	20	2.29		112
30	91		5/16" NOMINAL X 15SWG SMALL BRIGH	50 60 1037	113	172769	090379	200	1.61		112
30	91		10" FLAT SECOND CUT FILLS	51 04 1350	32	166100	060379	2	1.87		112
30	91		10" HALF ROUND SECOND CUT FILES	51 04 1550	32	172534	060379	2	2.63		112
30	91		8" FLAT NOSED COMBINATION PLIERS W	51 14 4532	109	172771	090379	1	2.61		112
30	91		PLASTIC HANDLE SCREWDRIVERS WITH 8"	51 19 2126	111	113459	090379	1	1.46		112
30	91		PLASTIC HANDLE SCREWDRIVERS WITH 8"	51 18 2126	109	172770	090379	1	1.46		112
30	91		10" GORDON ADJUSTABLE SPANNERS.	51 18 3065	73	172759	080379	1	4.84		112
30	91		5/16" X 3/8" WHIT CROME HARDENED RI	51 18 6118	112	163841	090379	1	1.13		112
30	91		18"STILLSON WRENCHES. RECORD NO.300	51 20 2416	35	152609	060379	1	5.10		112
30	91		FLAT STEEL KEYED 6 LEVER METAL LOC	53 06 5350	31	163833	060379	1	1.26		112
30	91		OXYGEN. 240 CUBIC FEET PER CYLINDER	68 94 3050	102	166742	090379	3	2.73		112
30	91		GALVANISED DUST BINS WITH RUBBER LI	72 40 1815	127	172772	090379	1	6.98		112
30	91		BEST LIGHT COLOURED WASTE RAG.GUARA	79 21 1550	127	172535	090379	45	5.36		112
30	91		SIZE NO.18 2.3/8" OUT 1.1/8" DIA	80 20 5318	13	166335	050379	2	1.09		112
30	91		SHELL ROTELLA TX 20/40 MULTIGRADE M	91 51 4809	9	80121	200279	1	1.23		112
30	91			99 55 0002	LA7	172519	050378	2	2.06		112
30	92		EMERGENCY PUSH SWITCHES ELLISON LIS	59 31 6507	13	168616	050379	1	30.77		106
30	92		100/150 W BULK HEAD FITTINGS TYPE	62 10 1775	15	168156	050379	1	13.02		106
30	92		'UNISTRUT' SPLICE PLATE CLEVIS. STO	71 25 6777	72	158851	080379	6	3.57		106
30	94		P.V.C. INSULATED SINGLE CORE CONDUC	61 70 3610	114	168864	090379	100	3.68		106
30	99			5C44/ 33508			200279		0	237.31	106
30	99		2.1/2" X NO.8 STEEL COUNTERSUNK	50 27 1217	31	168160	060379	120	1.19		106
30	99		PLASTIC HANDLE SCREWDRIVERS WITH 8"	51 18 2126	15	156860	050379	1	1.44		112
30	99		100 AMP HRC CARTRIDGE FUSE LINK	59 20 0941	42	158876	010379	10	16.32		106
30	99		150 AMP HRC CARTRIDGE FUSE LINK	59 20 1265	112	158899	090379	10	30.61		106
30	99		315 AMP FUSES HRC CARTRIDGE E/E TKF	59 20 1278	111	158900	090379	10	50.39		106
30	99		10 AMP CARTRIDGE FUSES BS1362 M.K.6	59 20 2005	12	168812	050379	20	1.15		106
30	99		20 MM CONDUIT INSPECTION ELBOWS (CH	59 74 9505	107	168774	110379	6	1.50		106
30	99		P.V.C. INSULATED SINGLE CORE CONDUC	61 70 3612	72	168865	080379	100	5.67		106
30	99		P.V.C. INSULATED SINGLE CORE CONDUC	61 70 3662	72	168863	080379	100	5.67		106
30	99		P.V.C. INSULATED SINGLE CORE CONDUC	61 70 3912	33	168653	060379	200	11.05		106
30	99		P.V.C. INSULATED SINGLE CORE CONDUC	61 70 3912	72	168862	080379	100	5.53		106
30	99		240 VOLTS 150 WATT PAR 38 PRESSED G	62 41 7338	106	168870	110379	1	1.67		106
30	103			50 76 7236	133	166223	120379	1	291.91		112
30	104		SINGLE THRUST BALL BEARINGS.	31 13 1413	13	172523	050379	2	7.56		112
30	105			00	74	163936	080379	1	11.31		112
30	105		N.S.SLIDING SLEEVE.	11 83 3068	114	163839	090379	1	46.00		112

C.G.S. Issues to All Engineers

Appendix 2C

PROG CG31 REPNO 046 FORT DUNLOP   C.G.S ISSUES TO AREA A ENGRS   FOR ALL DEPARTMENTS-BREAKDOWN WEEK ENDING .. 03 79

WORKS ENGINEERS DEPT FORT DUNLOP   PAGE 2

DEPT CHGE	C/C	JOB NO.	DESCRIPTION	COMMODITY CODE NUMBER	BATCH NO.	REQUISITION NUMBER	DATE	QUANTITY	STORES £.P	SERVICE £.P
30	90		14"STILLSON WRENCHES.	51 20 2414	15	26139	050379	1	4.25	
30	90			99 55 0002	LA7	172613	050379	1	1.02	
30	91		1/4" X 3/4" BLACK HEXAGON HEAD SE	50 01 1159	12	172526	050379	200	4.55	
30	91		5/16" X 1.1/2" BRIGHT STEEL HEXAGON	50 01 2215	13	172521	050379	20	1.10	
30	91		3/8" X 1.1/2" BRIGHT STEEL HEXAGON	50 01 2265	113	172763	090379	20	1.35	
30	91		1/2" X 1" BRIGHT STEEL HEXAGON	50 01 2361	12	172525	050379	20	1.66	
30	91		1/2" X 1.1/2" BRIGHT STEEL HEXAGON	50 01 2365	12	172524	050379	20	2.27	
30	91		1/2" X 2" BRIGHT STEEL HEXAGON	50 01 2369	72	172753	080379	20	2.70	
30	91		5/16" BRIGHT STEEL HEXAGON NUTS.	50 58 1007	113	172768	090379	100	1.07	
30	91		3/4" BRIGHT STEEL HEXAGON NUTS.	50 58 1013	72	172754	080379	20	2.29	
30	91		5/16" NOMINAL X 15SWG SMALL BRIGH	50 60 1007	113	172769	090379	200	1.61	
30	91		10" FLAT SECOND CUT FILES	51 04 1250	32	166100	060379	2	1.87	
30	91		10" HALF ROUND SECOND CUT FILES	51 04 1350	32	172534	060379	2	2.63	
30	91		6" FLAT NOSED COMBINATION PLIERS W	51 14 4532	109	172771	090379	1	2.61	
30	91		PLASTIC HANDLE SCREWDRIVERS WITH 8"	51 18 2125	111	113459	090379	1	1.46	
30	91		PLASTIC HANDLE SCREWDRIVERS WITH 8"	51 18 2126	109	172770	090379	1	1.46	
30	91		10" GORDON ADJUSTABLE SPANNERS.	51 16 3065	70	172759	080379	1	4.84	
30	91		5/16" X 3/8" WHIT CROME HARDENED FI	51 16 6116	112	163841	090379	1	1.13	
30	91		18"STILLSON WRENCHES. RECORD NO.300	51 20 2416	35	152609	060379	1	5.10	
30	91		FLAT STEEL KEYED & LEVER METAL LOC	53 06 5350	31	163833	060379	1	1.26	
30	91		OXYGEN. 240 CUBIC FEET PER CYLINDER	68 94 3050	109	166342	090379	3	2.73	
30	91		GALVANISED DUST BINS WITH RUBBER LI	72 40 1815	127	172772	090379	1	6.98	
30	91		BEST LIGHT COLOURED WASTE RAG.GUARA	79 21 1550	127	172535	090379	45	5.36	
30	91		SIZE NO.18 2.3/8" CUT 1.1/8" DIA	80 20 5318	13	166335	050379	2	1.09	
30	91		SHELL ROTELLA TX 20/40 MULTIGRADE M	91 51 4809	9	80121	200279	1	1.23	
30	91			99 55 0002	LA7	172519	050379	2	2.04	
30	99		PLASTIC HANDLE SCREWDRIVERS WITH 8"	51 18 2126	15	156860	050379	1	1.46	
30	103			50 76 7236	133	166223	120379	1	-201.91	
30	104		SINGLE THRUST BALL BEARINGS.	31 13 1413	13	172523	050379	2	7.56	
30	105			00	74	163836	080379	1	11.31	
30	105		M.S.SLIDING SLEEVE.	11 83 3068	114	163839	090379	1	46.00	
30	105		M.S.DOG CLUTCH.3" D.D.1.5/8" OVERAL	11 83 5005	114	163838	090379	1	48.50	
30	105		DOUBLE CRANK LINKS PT. NO. 30 FOR	30 20 2125	72	173515	080379	5	1.06	
30	107			99997 985C9			190179		0	92.94
30	107		1" ROUND ELBOWS. BLACK HEAVYWEI	47 31 1406	107	172778	110379	5	6.38	
30	107		1" FORGED STEEL UNIONS WITH STE	47 31 5406	107	172777	110379	2	4.28	
30	107		1" BRONZE GLOBE VALVES	48 29 2260	107	172775	110379	2	36.54	
30	107		10"STILLSON WRENCHES.	51 20 2412	70	163837	080379	1	2.93	
30	108		STRIP KNIVES 3.5/8" O/ALL	11 83 3010	15	172522	050379	20	40.09	
30	214		GRUNDFOS TYPE PUMPS 22 MM VALVED	10 43 6915	114	166197	090379	1	22.97	
30	214		25 X 6 MM BLACK MILD STEEL	95 10 1232	48	173516	060379	18	1.75	
30	433		ROLLER END BALL BEARINGS	31 14 1015	13	172520	050379	20	6.41	
30	651		CONNECTING LINK SINGLE	30 20 2035	109	173518	090379	10	1.10	
30	651		3/4" MILD STEEL PIPE SCREWED AND	47 10 1206	12	166333	050379	2	8.21	
30	651		3/4" HIGH PRESSURE FLANGES.	47 38 2305	13	166334	050379	5	7.50	
30	651		3/4" SCREWED E.S.P. GUNMETAL CL 15	48 26 1443A	37	171635	060379	1	5.09	
30	651		3/16" X 3/4" BRIGHT STEEL HEXAGON	50 01 2109	107	166199	110379	30	1.26	
30	652		3/8" OD X 1/4" ID COPPER TUBE. HARD	47 11 4040	31	166346	060379	29	4.27	

C.G.S. Issues to Area A Engineers

Appendix 2D

To: Mr J A BLADON - CHIEF ENGINEER - FORT DUNLOP

from: Mr D T PENDLEBURY

ENGINEERING DOWNTIME

Appendix 2E

DTP/AW
8.4.77

INTRODUCTION

Downtime figures are produced weekly by Zones A, B, & C. Their analysis sheets list only 'major' breakdowns on the critical items of plant in the sector (see Appendix).

SOURCE OF STATISTICS

All statistics on the sheets can be traced back to the production foreman's record sheets. The engineering foreman has no real means of knowing the downtime and has to rely on the production record.

'B' & 'C' Shifts engineering figures are 'agreed' with the production foreman in order to tie together the Shift Engineers reports with the production downtime report. 'A' shift figures are also obtained from the production foreman.

McLloyd and Bag-o-Matic figures are not accurate as production foreman only record downtime in excess of one hour and then only if the press is required. This is applicable to all 'excess' machines. (See Appendix, Zone A sheet, no downtime for press lines).

To complicate matters some of the figures listed on the zone analysis sheets inclued electrical and service downtime, others do not. In addition Zone 'A' & 'C' base the week on 112 hours (correct), Zone 'B' basis is 120 hours, the old working week.

The Service and E & I Zones do not produce an analysis sheet. E & I Zone have a report log from the 'B' & 'C' Shift foremen, but this only lists breakdowns, normally, only if they are in excess of one hour.

CONCLUSION

The figures as presented should be viewed with scepticism. They do not include all the downtime or list all the plant. The figures probably show a worse picture for the long (one hours +) plant breakdowns than is actually occuring, they are from a production source. They do not show the numerous short breakdowns that, in normal engineering maintenance, make up the 'bulk' of downtime; nor do they show downtime when an 'excess' of machinery is available. The nature of the fault recorded, mechanical, electrical or services is only the production foremans assessment and therefore the division of time between trades cannot be reliable.

MAJOR PLANT

ZONE B

Week No. 12.

Week Ending 25-3-77.

TYRE 1	HOURS DOWN		%
Tread Extruder, D & E Mill Lines	19	15	16·04
Cold Feed Extruders	3	25	2·84
Low Angle Banner	—	45	0·62
No.1 Banner	—	—	—
No.2 Banner	2	15	1·86
Dual Calender Line	—	—	—
36" Calender Line	1	45	1·45
Pirelli Cutter No. 1 COMMISSIONING.	—	—	—
2	12	50	10·69
3	10	50	9·02.

CURING BAG DEPT		HOURS DOWN		%
C Line Mills & Extruder	(2 shift)	—	—	—
96" Pan		—	—	—

FABRIC PREPARATION DEPT		HOURS DOWN		%
Litzler	(1 shift)	—	—	—
No. 3 Calender Nos. 5, 6, 7 Mill Lines	(2 shift)	—	—	—
No. 8 Impregnator	(2 shift)	—	—	—
No. 5 Calender Nos. 8 & 9 Mill Lines	(1 shift)	—	—	—
No. 7 Impregnator	(2 shift)	—	—	—
No. 2 Calender No. 3 Mill Line	(1 shift)	—	—	—
No. 4 Calender No. 2 Mill Line	(3 shift)	—	—	—
Cold Calender	(3 shift)	—	—	—

TYRE 5	HOURS DOWN		%
Low Angle Banner	—	—	—
Profile Calender Line & 84" Mill Line	—	—	—

NOTE: Times shown are total times. Often plant may only be partially inoperative during this time, as for instance in the case of a batching station on a Banner, which would be included in the above figures, but would not render the plant totally unproductive. Times include time down to Scheduled maintenance.

T J Walton 29.3.77

T J WALTON

TJW/AM

No. 712

Ending 26-3-71

MAJOR PLANT

ZONE C

TYRE 2		Plant Hr Available	Hours Down	% Down Time	Schedule Hours	Sched Hrs. %
Extruder & 60" & 84" Mill Lines	1x112	112	10.5	10.0	10.0	
~~Extruder & No.2 & No.4A Mill Lines~~	1x80	80	1.0	1.0	5.0	
Extruder & No.3 Mill Line	1x112	112	40.0	35.0	5.0	
-Cure, Calender & Mills	3x112	336			5.0	
1, 2 & 3 Chafer Buffing Units ..	1x112	184			5.0	
1 Bead Machines	4x112	448	9.0	2.0	4.0	
Cutters						
nders: (No.1) (SS) (No.2) (SS) (No.3) (4 Bowl)	2x112	224	1.5	1.0	4.0	

TYRE 7			Hours Down	%	Schedule Hours	%
Banner	1x112	112	.5	.44	4.0	
Hose Boxes & Shapers, Mullers, etc.	10x112	1120	1.0	.10	2.0	
Water Pump Room	1x112	112	–		10.0	
Extractors	2x112	224			4.0	

TYRE 6			Hours Down	%	Schedule Hours	%
5 Mills	1x112	112			.25	
ner Bias Cutters and Pocket Tables	9x112	1008	2.0	.20	15.0	
/ Mills	1x112	112			.25	
Curing Units	10x112	1120				
" Curing Units	3x112	336	16.6	7.1	2.5	
H Presses	2x112	224			1.25	
Coil Shapers	2x112	224				
rhead Cranes	15x112		8.5	2.5	1.0	
d Feed Extruder	3x112	336				
Water Pump Room	1x112	112				

CID AND STORES			Hours Down	%	Schedule Hours	%
M Machines	5x112	560	2.0	2.0		
ting and Balancing Machines ..	11x112	1232	2.0	1.6		
ters and Stackers	7x112	784	3.0	.4		
sing & Repair Section..						
formity machines	2x112	224				

MENTS

M A J O R P L A N T

Week No. 75 12

DOWNTIME SUMMARY

Z O N E A

TYRE 4 PLANT	Plant Hours Available	Breakdown Hours	%	Schedule Hours	%
GR Making	1456	27.6	1.8		
GR Shaping	— " —	111.9	7.6		
No. 2 Extruder	112	2.0	1.8		
No. 3 Extruder	—	—	—		
No. 4 Extruder	—	—	—		
No. 5 Extruder	—	—	—		
No. 6 Extruder	112	2.0	1.8		
McLloyd Presses	—	—	—		
Bago-O-Matics	—	—	—		
Disc Cutters	672	44.0	6.5		
Bead Machine.	448	10.8	2.4		

B.O.M 7 MODIFICATION TO DOME GLAND. 112 HRS.

PROGRAM NO.PA14

SECT NO	SECTION	NO. IN SECT.	AT WK	NO. ABS	ACT. HRS WORKED	AVE HRS	O/T HRS	TOTAL WAGES	TOTAL ALLOW	GRS. WAGES EX HOL PAY	AVE. WAGE	HOLIDAY PAY	HRS SANCT	WAGES SANCT
6	NEW MILL.	8.0	8.0	0.0	310.0	38.75	37.00	967.180	405.370	826.360	103.295	140.820		0.000
8	TYRE 4.	59.0	53.0	6.0	2107.6	39.76	172.70	6532.140	2548.680	5508.710	103.937	1023.430		0.000
9	COMPOUND PREP.	42.0	41.0	1.0	1693.2	41.29	215.50	5057.440	2233.720	4563.540	111.305	493.900		0.000
5	TYRE 5.	24.0	20.0	4.0	825.8	41.29	86.60	2317.310	925.650	2086.710	104.335	230.600		0.000
11	TYRE 8	9.0	6.0	3.0	227.2	37.86	6.00	640.700	241.680	562.820	93.803	77.880		0.000
14	TYRE 1.	39.0	34.0	5.0	1398.1	41.12	117.20	3564.600	1434.980	3399.900	99.997	164.700		0.000
16	FABRIC PREP.	11.0	10.0	1.0	462.0	46.20	76.50	1412.540	550.430	1186.130	118.613	226.410		0.000
12	BASE STORES.	10.0	8.0	2.0	317.9	39.73	37.40	779.500	324.630	749.280	93.660	30.220		0.000
17	TYRE 2 MAKING	26.0	22.0	4.0	884.0	40.18	79.30	2369.740	941.570	2208.150	100.370	161.590	95.7	135.970
18	TYRE 2 MOULDING.	28.0	26.0	2.0	1045.4	40.20	103.10	3033.810	1224.810	2705.280	104.049	328.530		0.000
20	RESEARCH.	11.0	9.0	2.0	366.9	40.76	31.10	824.070	306.470	810.660	90.073	13.410		0.000
29	K-BLOCK GARAGE.	7.0	6.0	1.0	240.0	40.00	0.00	494.890	158.790	494.890	82.481	0.000		0.000
30	TYRE 6	16.0	14.0	2.0	562.6	40.18	63.40	1419.460	587.920	1373.390	98.099	46.070		0.000
7	MAIN BLOCK INST.	14.0	13.0	1.0	512.0	39.38	15.50	1377.880	483.290	1219.300	93.792	158.580	30.0	43.210
22	MAINTENANCE INST.	33.0	31.0	2.0	1270.2	40.97	142.40	3517.940	1461.870	3266.200	105.361	251.740	16.0	23.060
23	S. ELECTRICIANS.	57.0	51.0	6.0	2204.9	43.23	371.60	6122.570	2520.640	5608.900	109.978	513.670		0.000
24	ELECTRONICS.	1.0	1.0	0.0	32.0	32.00	0.00	61.050	10.790	61.050	61.050	0.000		0.000
25	N. ELECTRICIANS.	50.0	49.0	1.0	2216.4	45.23	407.30	6056.100	2538.960	5644.060	115.184	412.040		0.000
31	POWER PLANT ELECT.	8.0	7.0	1.0	413.3	59.04	156.30	1094.140	470.030	1077.030	153.861	17.110		0.000
32	TRUCK GARAGE	22.0	15.0	6.0	704.5	44.03	95.10	1952.180	800.120	1749.600	109.350	202.580		0.000
33	SCALEFITTERS	8.0	8.0	0.0	332.3	41.53	43.30	1104.950	431.330	909.320	113.665	195.630		0.000
10	INSTALLATIONS	3.0	3.0	0.0	123.0	41.00	10.50	306.480	119.050	294.940	98.313	11.540		0.000
15	BUILDING.	15.0	12.0	3.0	482.7	40.22	9.70	996.880	338.430	996.880	83.073	0.000		0.000
19	HEAVY GANG.	9.0	7.0	2.0	313.4	44.77	50.00	748.700	279.490	723.020	103.288	25.680		0.000
21	POWER PLANT (OTHER	15.0	14.0	1.0	600.9	42.92	81.40	1657.010	691.560	1519.240	108.517	137.770		0.000
26	PIPEFITTERS.	30.0	30.0	0.0	1409.5	46.98	282.20	3505.570	1381.320	3376.750	112.558	128.820	421.2	594.440
28	PLANT STORES.	30.0	27.0	3.0	1122.3	41.56	132.40	3107.960	1242.580	2857.200	105.822	250.760		0.000
34	POWER PLANT ATTDS.	18.0	16.0	2.0	887.0	55.43	314.00	2721.290	1120.480	2376.150	148.509	345.140		0.000
35	STEEL ERECTORS	1.0	1.0	0.0	40.0	40.00	0.00	89.700	30.810	89.700	89.700	0.000		0.000

Engineers Payroll

Appendix 2F

FROM: Works Engineering Dept	REQUEST FOR ENGINEERING STORES	TO: Stock Control, Buying Department

Date ....

REQUESTED BY ....

ZONE ....

MACHINE TYPE / TITLE ....

Please arrange to QUOTE for the following items to be held in CGS Stock

Quote only

DESCRIPTION	DRAWING No./MAKERS No./ PART No.	NUMBER REQUIRED

FROM: Buying Department

TO: Works Engineering Dept

BUYER ....

ZONE MANAGER .... ZONE ....

Date ....

With reference to your request for a QUOTE for the above

COST OF ITEMS AS BELOW

DESCRIPTION	DRAWING No./MAKERS No./ PART No.	QUANTITY	PRICE

FROM: Works Engineering Dept

TO: Stock Control, Buying Department

BUYER ....

DEPARTMENT ....

Date ....

Please arrange to STOCK the following items in CGS Stores

DESCRIPTION	DRAWING/MAKERS/ PART No.	NUMBER REQUIRED	ESTIMATED USAGE MONTHLY/WEEKLY	MINIMUM STOCK LEVEL

APPROVED:

ZONE MANAGER ....

WORKS ENGINEER ....

NOTE: FINAL COPY TO BE TAKEN FOR BUYING DEPT RECORDS. ORIGINAL RETAINED BY WORKS ENGINEERS DEPT.

Date ....

FROM: Buying Department

TO: Works Engineering Dept

BUYER ....

ZONE MANAGER .... ZONE ....

The above items have now been accepted as a CGS Stock item

STORES CODE No. ....

BUYER ....

Request for Engineering Stores

Appendix 2G

DUNLOP STORES CODE

ELECTRICAL CONTACTORS.

M.T.E.

CODE	Ref & Type	Where Used.	LOCATION
61-11-6310	AU/ 1S02 fixed contacts. (Main contact Kits.).	UC/2 Contactors.	SM
61-11-6311	AU/1S02 Moving contacts. (Main Contact Kit).	UC/2 Contactors.	SM
61-11-6320	D5/1822 Main fixed contacts		I
61-11-6322	D5/1831 Main moving contact		I
61-11-6330	MC 7/1 Fixed contacts.	Starter No. J3702	SP
61-11-6331	MC 8/1 Moving contacts.	Starter No. J 3702.	SP
61-11-6340	MC 1006/6 Aux. Moving contacts.	Contactor No. J.5583.	SP
61-11-6341	MSK 329/2 Aux. fixed contacts.	Contactor No. J 5583	SP
61-11-6350	80000279001 Moving contacts.	Contactor.	SP
61-11-6351	80000280001 fixed contacts.	Contactor.	SP
61-11-6355	01000050 BOO set of contacts.	Asbestos lift.	SM
61-11-6360	01-23-28 Fixed contact.		O/Z.O/TR
61-11-6361	01-23-29 Moving contacts.		O/Z.O/TR
61-11-6363	01-51-0 Pack 8 Size 203 Auxiliary contact attachment.		O/Z.ID.FD. O/TR
61-11-6364	01-51-2 Pack 8 Size 20L Auxiliary contact attachment.		O/N O/Z.O/N
61-11-6365	01-051-3 Auxiliary contact attachment.		O/Z.O/TR
61-11-6366	01-052-3 Auxiliary contact attachment		O/Z.M/C
61-11-6367	01-052-4 Auxiliary contact attachment.		O/TR
61-11-6370	01-000006-016 fixed and moving contacts (Main kit)	UC15 Contactor.	SK
61-11-6371	MPN 17759 Moving Contacts.	Series 1 Ref. 26 Contactor.	O/Z
61-11-6372	MPN 17774 Moving Contacts.	Series 31 Contactor.	O/Z
61-11-6375	PN 57064 Moving Contacts.		O/Z
61-11-6377	LPN 57172 Moving Contacts		O/Z
61-11-6379	OPN 57202 Fixed Contacts		O/Z
61-11-6381	WPN 57205 Auxiliary Moving Contacts		O/Z
61-11-6382	VPN 57206 Auxiliary Fixed Contacts		O/Z
61-11-6395	54/1A 461B Fixed Contacts. 1.1/16" wide.		O/Z
61-11-6405	54/5A 388 Moving Contacts 7/8" wide.		O/Z
61-11-6410	54/5A 1241 Moving Contacts 3/4" wide.		O/Z
61-11-6430	90-4380-0 Fixed Contacts.		O/Z
61-11-6435	90-4397-0 Moving Contacts.		O/Z

Electrical Contracts - Page from Stores Catalogue

Appendix 2H

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******************************************************************************************
*                                                  * 04.09.79     PAGE:     2 *
*  D U N L O P   T Y R E   D I V I S I O N         ****************************
*                                                  * SOFTWARE PRODUCTS          *
*
******************************************************************************************
```

SYSTEM CONTROL PROGRAMS
=======================

OS/VS1		6.0E PTF 7801	
* VM/370		3.0 PLC 13	

PROGRAM PRODUCTS
================

CICS/VS	5740/XX1	1.4 PTF 601	567.35
COBOL/VS	5740/CB1	2.1 PTF 5	175.65
DATA DICTIONARY	5740/XXF	2.1	458.15
DISTRIBUTED SYSTEMS EXEC.	5748/XXG	1.0	110.40
FORTRAN IV (G1) COMPILER	5734/FO2	2.0	45.05
FORTRAN LIBRARY (MOD 1)	5734/LM1	2.0	34.15
IMS/VS DB	5740/XX2	1.1.4 PTF 2	529.40
OS ASSEMBLER H	5734/AS1	5.11.53	118.55
PL/1 RESIDENT LIBRARY	5734/LM4	3.0 PTF 16	27.70
PL/1 TRANSIENT LIBRARY	5734/LM5	3.0 PTF 14	17.25
PROJACS	5740/XP1	1.4	241.85
SPMII	5798/CFT	1.4	84.00
VS/1 PT	5796/PGL	2.0	226.00
CA-SORT		77.5.0	789.00#
COMPAKTOR			460.00#
FDR/DSF		4.1	732.00#
UNIPAY			

FIELD DEVELOPED PROGRAMS
========================

CICS ON-LINE TEST DEBUG	5796/AEF		
CICS/VS FORWARD RECOVERY	5798/CJF		
CICS/VS PA II	5798/CFP	1.2	48.00
DBPROTOTYPE/VS	5796/PCX		
IMSMAP/VS	5796/PCM		
PAYE TAX ROUTINES	5799/AHS		

* NOT IN CURRENT USE

INTERNAL CHARGE MADE ANNUALLY BY GMS.

Dunlop Tyre Division Software

Appendix 3A

****
* DUNLOP TYRE DIVISION * 04.09.79 PAGE: 1 *
* CENTRAL HARDWARE *
****

CENTRAL HARDWARE
================

M/C	DESCRIPTION	QTY	MODEL	ADDRESS	FEATURES
3158	PROCESSING UNIT	1	U34		1433,7840,8740
3213	CONSOLE PRINTER	1	001	01F	4450
2821	PRINTER CONTROLLER	1	003		2 X 3615,8637,8638
1403	PRINTER 1100 LPM	2	N01	00E-00F	8640,1416(QM)
2501	CARD READER 1000 CPM	1	B02	014	
1442	CARD PUNCH 100 CPM	1	N02	00A	
3274	VDU CONTROL UNIT (NDS)	1	B01	040-05F	7802,7803,6901, 6902,6903
3274	VDU CONTROL UNIT (NDS)	1	B01	0C0-0DF	6901,6902,6903
3704	COMMUNICATION CONTROLLER	1	A04	080	1642,2X4714,1541
1270	MEMOREX T C U	1		060-07F	16 X BI-SYNCH & 16 X ASYNCH.
38031	CDC TAPE CONTROLLER	1			DUAL DENSITY
33420	CDC TAPE DRIVE 320 KB	4	007	380-383	DUAL DENSITY
38301	CDC DISK STORAGE CONTROLLER	2	001		
33301	CDC DISK STORAGE 100 MB	16	001	150-157 250-257	

ON ORDER - DELIVERY DECEMBER 1979
========

M/C	DESCRIPTION	QTY	MODEL	ADDRESS	FEATURES
3803	TAPE CONTROL UNIT		001		5310 (9 TRK NRZI)
3420	TAPE DRIVE	4	004	300-303	6425 (1600 BPI)
3420	TAPE DRIVE	1	003	304	3550 (800 BPI)
3830	DISK STORAGE CONTROLLER	2	002		2150,2151,6111
3350	DISK STORAGE	2	A2	100-101 200-201	
3350	DISK STORAGE	4	B2	102-105 202-205	

Dunlop Tyre Division Hardware

Appendix 3A

```
    COPY XMCDSEGM.
 01 XMCDSEGM.
*                           *********************
*                           * MATERIALS CONTROL *
*                           *     DATA BASE     *
*                           * COMMODITY - BASIC *
*                           *   DETAILS (ROOT)  *
*                           *********************
    03 XMCDKEYF.
*                                        KEY FIELD
      07 XMCDGRUP            PIC X(2).
*                                        GROUP
      07 XMCDCLAS            PIC X(2).
*                                        CLASS
      07 XMCDSUBS            PIC X(4).
*                                        SUBSET
      07 XMCDSUFF            PIC X(3).
*                                        SUFFIX
    03 XMCDLEVL              PIC X.
*                                        LEVEL IND (A OR T)
    03 XMCDOUTI              PIC X.
*                                        REF. IND. (OUTWARD)
*                                             ( Y OR N )
    03 XMCDFIL1.
     05 XMCDORDU             PIC X(12).
*                                        ORDER UNIT
     05 XMCDSTKU             PIC X(5).
*                                        STOCK UNIT
     05 XMCDCONV USAGE COMP-3
                             PIC S9(5)V9(4).
*                                        CONVERSION FACTOR
     05 XMCDDEPR USAGE COMP-3
                             PIC S9(3).
*                                        DEPRECIATION %
     05 XMCDDATE             PIC X(6).
*                                        LAST AMENDED DATE
*                                           (YYMMDD)
     05 XMCDLOCG.
      07 XMCDLOCS OCCURS 65 INDEXED BY XMCDIND1
                             PIC X.
*                                        LOCATION INDICATORS
     05 XMCDFILR REDEFINES XMCDLOCG.
      07 XMCDLOCN OCCURS 65  PIC X.
*                                        LOCATION INDICATORS
*                                         ( WITHOUT INDEXING )
     05 XMCDXRFI             PIC X.
*                                        ANY XREFS ?
*                                         ( Y OR N )
     05 FILLER               PIC X(1).
    03 XMCDFIL2 REDEFINES XMCDFIL1.
     05 XMCDXREF             PIC X(11).
*                                        COMMODITY REF ( XREF )
     05 XMCDXLEV             PIC X.
*                                        LEVEL IND ( XREF )
     05 XMCDDESC OCCURS 2 INDEXED BY XMCDIND2
                             PIC X(40).
*                                        XREF ADDITION DESC
     05 FILLER               PIC X(5).
    03 FILLER                PIC X(2).
```

Materials Control Data Base

Appendix 4A

```
    COPY XMSTSEGM.
 01 XMSTSEGM.
*                         **********************
*                         * MATERIALS CONTROL  *
*                         *     DATA BASE      *
*                         *       STORE        *
*                         **********************
     03 XMSTSTOR                 PIC X(2).
*                                              STORE NO.
*                                               ( KEY FIELD )
     03 XMSTLOCA                 PIC X(5).
*                                              LOCATION
     03 XMSTSTOK USAGE COMP-3 PIC S9(7).
*                                              STOCK BALANCE
     03 XMSTAVPR USAGE COMP-3 PIC S9(4)V9(5).
*                                              AVERAGE PRICE
     03 XMSTSTPR USAGE COMP-3 PIC S9(4)V9(5).
*                                              STANDARD PRICE
     03 XMSTNYPR USAGE COMP-3 PIC S9(4)V9(5).
*                                              NEXT YEAR PRICE
     03 XMSTREOR USAGE COMP-3 PIC S9(7).
*                                              RE-ORDER LEVEL
     03 XMSTDANG USAGE COMP-3 PIC S9(7).
*                                              DANGER LEVEL
     03 XMSTDELV USAGE COMP-3 PIC S9(3).
*                                              DELIVERY PERIOD
     03 XMSTAVLD USAGE COMP-3 PIC S9(3).
*                                              AVERAGE LEAD TIME
     03 XMSTDTIS                 PIC X(6).
*                                              DATE LAST ISSUE
*                                               ( YYMMDD )
     03 XMSTDTRC                 PIC X(6).
*                                              DATE LAST RECEIPT
*                                               ( YYMMDD )
     03 XMSTDTSC                 PIC X(6).
*                                              DATE LAST STOCK CHECK
*                                               ( YYMMDD )
     03 XMSTCMUS USAGE COMP-3 PIC S9(7).
*                                              CURRENT MONTH'S USAGE
     03 XMSTLMUS OCCURS 12 INDEXED BY XMSTIND1 USAGE COMP-3
                                 PIC S9(7).
*                                              LAST 12 MONTHS' USAGE
     03 XMSTWKUS USAGE COMP-3 PIC S9(7)V9(2).
*                                              AVERAGE WEEKLY USAGE
     03 XMSTDELI                 PIC X.
*                                              PSEUDO DELETE IND
*                                                  ( Y OR N )
     03 XMSTFLAG                 PIC X.
*                                              STOCK CHECK FLAG
*                                                  ( Y OR N )
     03 XMSTSTKT USAGE COMP-3 PIC S9(7).
*                                              TOTAL STOCK
     03 FILLER                   PIC X(1).
```

Materials Control Data Base - Cont.

```
    COPY XMDNSEGM.
 01  XMDNSEGM.                                                          00000
*                        **********************                          00000
*                        * MATERIALS CONTROL *                           00000
*                        *     DATA BASE     *                           00000
*                        *    DESCRIPTION    *                           00000
*                        **********************                          00000
    03 XMDNSGNO                 PIC X.                                   00000
*                                             SEGMENT NO.                00000
*                                              ( KEY FIELD )             00000
    03 XMDNDESC OCCURS 3 INDEXED BY XMDNIND1                             00001
                                PIC X(40).                               00001
*                                             DESCRIPTION                00001
    03 FILLER                   PIC X(7).                                00001
```

Materials Control Data Base - Cont.

```
 COPY XMCRSEGM.
 XMORSEGM.
                        *********************
                        * MATERIALS CONTROL *
                        *     DATA BASE     *
                        *       ORDER       *
                        *********************
   03 XMORSUPP               PIC X(6).
                                        SUPPLIER NO.
   03 XMORORDN               PIC X(7).
                                        ORDER NO.
   03 XMORDATE               PIC X(6).
                                        DATE OF ORDER
   03 XMORDISC USAGE COMP-3 PIC S9(4)V9(5).
                                        DISCOUNT PRICE
   03 XMORIMPS USAGE COMP-3 PIC S9(4)V9(5).
                                        IMPORT SURCHARGE PRICE
   03 XMORCARR USAGE COMP-3 PIC S9(4)V9(5).
                                        CARRIAGE PRICE
   03 XMORORDQ USAGE COMP-3 PIC S9(7).
                                        ORDER QUANTITY
   03 XMORQTYD USAGE COMP-3 PIC S9(7).
                                        QUANTITY DELIVERED
   03 XMORLEAD USAGE COMP-3 PIC S9(3).
                                        LEAD TIME
   03 XMORMANC               PIC X.
                                        MANUAL/COMMITTED IND
   03 XMORCOMP               PIC X.
                                        COMPLETE IND
                                         ( Y, N OR S )
   03 FILLER                 PIC X(2).
```

```
 COPY XMSUSEGM.
01  XMSUSEGM.
*                       *********************
*                       * MATERIALS CONTROL *
*                       *     DATA BASE     *
*                       *     SUPPLIER      *
*                       *********************
   03 XMSUSUPP               PIC X(6).
*                                       SUPPLIER NO.
   03 XMSUPRIC USAGE COMP-3 PIC S9(4)V9(5).
*                                       PURCHASE PRICE
   03 XMSUCARR USAGE COMP-3 PIC SV9(5).
*                                       CARRIAGE VALUE
   03 XMSUDIS1 USAGE COMP-3 PIC S9(3)V9(2).
*                                       DISCOUNT % 1
   03 XMSUDIS2 USAGE COMP-3 PIC S9(3)V9(2).
*                                       DISCOUNT % 2
   03 XMSUDIS3 USAGE COMP-3 PIC S9(3)V9(2).
*                                       DISCOUNT % 3
   03 XMSUORDQ USAGE COMP-3 PIC S9(7).
*                                       ORDER QUANTITY
   03 XMSUDATE               PIC X(6).
*                                       DATE PRICE EFFECTIVE
   03 FILLER                 PIC X(7).
```

Material Control Data Base - Cont.

```
    COPY XMSNSEGM.
 01 XMSNSEGM.
*                       *********************
*                       * MATERIALS CONTROL *
*                       *     DATA BASE     *
*                       *    STORE  NOTE    *
*                       *********************
    03 XMSNDESC               PIC X(40).
*                                            DESCRIPTION
```

```
    COPY XMXRSEGM.
 01 XMXRSEGM.
*                       *********************
*                       * MATERIALS CONTROL *
*                       *     DATA BASE     *
*                       *  CROSS REFERENCE  *
*                       *********************
    03 XMXRCOMM.
*                                            COMMODITY CODE
     05 XMXRGRUP              PIC X(2).
*                                            GROUP
     05 XMXRCLAS              PIC X(2).
*                                            CLASS
     05 XMXRSUBS              PIC X(4).
*                                            SUBSET
     05 XMXRSUFF              PIC X(3).
*                                            SUFFIX
    03 FILLER                 PIC X(5).
```

```
    COPY XMHDSEGM.
 01 XMHDSEGM.
*                       *********************
*                       * MATERIALS CONTROL *
*                       *     DATA BASE     *
*                       *      HEADER       *
*                       *********************
    03 XMHDRUNO               PIC X(5).
*                                            CG/CM RUN NO.
    03 XMHDDATE               PIC X(6).
*                                            DATE CREATED
    03 XMHDRTYP               PIC X.
*                                            CG/CM RUN TYPE
    03 XMHDMNTH               PIC X(2).
*                                            MONTH
    03 FILLER                 PIC X(2).
```

Material Data Base - Cont.

ENGINEERING SPARES INFORMATION SYSTEMS

MACHINE IDENTITY CODE

INTRODUCTION

In order to more closely monitor plant performance a machine identity code is to be introdcued. This will consist of a 4 digit identity number followed by a one digit shop identity code, and will be entered on to stores requisitions.

The four digit identity number has been broken down as follows:-

- 1st character - must be alpha - Main Items of Equipment
- 2nd character - alpha or numeric - Line Reference or Type of Machine
- 3rd character - alpha or numeric - Sub Division of Equipment or Identity Number
- 4th character - must be numeric - Identity Number

The code must always be entered in full.

MAIN ITEMS OF EQUIPMENT (1ST CHARACTER)

The main items of equipment are grouped as follows:-

A = Autoclaves

B = Banburys

C = Calenders

D = Dipping

E = Extruders

F = Folders

G = Guillotines/Bale Cutters

H = Hot Strip Winders

I = Intermixers

L = Lifting

K = Bias Cutters

M = Mill Lines

P = Press Lines

Q = Quantity/Inspections

R = Releasant Sprayers

S = Shapers

T = Tyre Builders

U = Curing Units

V = Various Miscellaneous

LINE REFERENCE OR TYPE OF MACHINE (2ND CHARACTER)

This can be a line machine reference or a type of machine.

Line references used are either alpha or numeric and normally refer to Mill or Extruder Lines. Type of machine is always alphabetical, used within two main items of equipment,

- Tyre Building Machines (T)
- Presses (P)

and is always followed by a two numeric machine number.

SUB DIVISION OF EQUIPMENT/IDENTITY NUMBER (3RD CHARACTER)

This character is used to identify a sub division of equipment or as an identity number within Press and Tyre Building Machine groupings.

Where used as a sub division the following code is applied:

B = Batch Up

C = Conveyors

D = Dipping Unit

F = Finishing

G = Guillotines

H = Hand Building

J = Joining Machines

M = Mills

R = Reel Off

S = Scales

T = Tread Cutters/Recutters

U = Under Tread Calenders

V = Vacuum Boxes

W = Water Tanks

IDENTITY NUMBER (4TH CHARACTER)

This is a number to identify individual machines.

Code Examples

Examples of Codes Are:

MCØØ 'C' MILL LINE
MCM1 NO.1 MILL, 'C' LINE
B3C1 NO.1 Conveyor, No.3 Banbury
TN13 No.13 NRM Tyre Building Machine

SHOP CODE INDICATOR FD

The following are allocated to define the shop in which the machinery is allocated.

1 = Tyre 1

2 = Tyre 2

3 = Tyre 3

4 = Tyre 4

5 = Tyre 5

6 = Tyre 6

7 = Tyre 7

8 = Tyre 8

C = Compounds Prep - Central (Old Mill)

W = Compounds Prep - West (New Mill)

F = Fabric Prep Dept

Q = CID

T = Tubes

B = Curing Bag

P = Waste Processing

R = Rubber Components

A = Accessories Assembly

I = Internal Transport

A sample page is included overleaf:-

TABLE NUMBER 140 11 VALID MACHINE IDENTITIES (CONTINUED)
SIZE 2000

TABLE ENTRY KEY			
1 4 TS14	0217		NO. 14 GR SHAPING MACHINE
1 4 TS15	0217		NO. 15 GR SHAPING MACHINE
1 4 VGC1	0097		SLAT CONVEYOR TO FINISHING.
1 4 VGC2	0097		INCLINE CONVEYOR TO FINISHING.
1 4 VGC3	0097		DRIVEN BEND CONVEYOR.
1 4 VGC4	0097		GRAVITY TRACK CONVEYOR.
1 4 VGC5	0097		SLAT CONVEYOR TO DECK.
1 4 VGC6	0097		FLAT CONVEYOR TO DECK.
1 4 VGE1	0321		BAG EXTRACTOR.
1 4 VGF1	0326		SIDEWALL BUFFING MACHINE
1 4 VGF2	0112		CHAFER BUFFING MACHINE
1 4 VGV1	0321		NO. 1 54" VACUUM SHAPER.
1 4 VGV2	0321		NO. 2 54" VACUUM SHAPER.
1 4 V089	0089		GNRL MAINT-FACTORY INSPECTOR
1 4 V090	0090		GNRL MAINT-CLOTHING,SOAP,ETC
1 4 V091	0091		GNRL MAINT-SHOP MAINTENANCE
1 4 V092	0092		GNRL MAINT-LIGHTING
1 4 V093	0093		GNRL MAINT-LIFTS
1 4 V094	0094		GNRL MAINT-LIFTING TACKLE
1 4 V095	0095		GNRL MAINT-CRANES
1 4 V096	0096		GNRL MAINT-TRUCKS
1 4 V097	0097		GNRL MAINT-CONVEYORS
1 4 V098	0098		GNRL MAINT-STILLAGES ETC
1 4 V099	0099		GNRL MAINT-SHOP SERVICES
1 4 WA01	0110		APEX RB6 FITTING MACHINE
1 4 WDC1	0111		NO. 1 DUAL BEAD CREEL
1 4 WDC2	0111		NO. 2 DUAL BEAD CREEL
1 4 WNC1	0111		NATIONAL STANDARD CREEL
1 4 WR01	0110		NO. 1 RB6 WRAPPING MACHINE
1 4 WR02	0110		NO. 2 RB6 WRAPPING MACHINE
1 4 WR03	0110		NO. 3 RB6 WRAPPING MACHINE
1 4 WR04	0110		NO. 4 RB6 WRAPPING MACHINE
1 5	0050		TYRE V
1 5 A100	0081		NO1 FLATPAN (AUTOCLAVE)
1 5 A200	0081		NO2 FLAT PAN (AUTOCLAVE)
1 5 CPB1	0765		BATCHING UNIT-PROFILE CALENDER
1 5 CPG1	0765		GUILLOTINE-PROFILE CALANDER.
1 5 CPW1	0765		COOLING TANK, PROFILE CALENDER
1 5 CPC0	0765		PROFILE CALENDER LINE
1 5 GAA1	0885		MOULD CLEANING MACHINE (VACUBL
1 5 M1C1	0765		NO.1 CONVEYOR-84" MILL LINE
1 5 M1C2	0765		NO.2 CONVEYOR, 84" MILL LINE.
1 5 M1C3	0765		NO.3 CONVEYOR, 84" MILL LINE.
1 5 M1M1	0765		NO.1 MILL-84" MILL LINE
1 5 M1M2	0765		NO.2 MILL-84" MILL LINE
1 5 M1M3	0765		NO.3 MILL-84" MILL LINE
1 5 M1C0	0765		84" MILL LINE.
1 5 PAC1	0872		TAKEWAY CONVEYOR 'A' PRESSLING
1 5 PAP1	0872		NO1 300 HYDRAULIC PUMP
1 5 PAP2	0872		NO2 300 HYDRAULIC PUMP
1 5 PAP3	0872		NO 1 COOLING WATER PUMP.
1 5 PAP4	0872		NO.2 COOLING WATER PUMP.
1 5 PAP5	0872		COOLING WATER FILM UNIT.
1 5 PA01	0872	1335	NO. A1 42" BOM PRESS
1 5 PA02	0872	1335	NO. A2 42" BOM PRESS

```
    SKIP3
 FD ENGINE-JOB
       BLOCK CONTAINS 0 RECORDS
       RECORDING MODE F
       LABEL RECORDS STANDARD
       DATA RECORDS ARE  ENGINEERING-HEAD-RECORD,
                         ENGINEERING-JOB-RECORD,
                         ENGINEERING-END-RECORD.
*****                                 *  *  *  *  *  *  *  * *  *
*****                                 * ENGINEERING JOB REQUEST *
*****                                 *     HEADING RECORD      *
*****                                 *  *  *  *  *  *  *  * *  *
 01  ENGINEERING-HEAD-RECORD.
       05          ENG-SORT-FILLER      PIC X(1).
*****                                                              *
       05          ENG-NAME             PIC X(5).
*****                                      (BLANK) ER01            *
       05          ENG-RUN-DATE.
*****                                      RUN DATE                *
           10      ENG-YEAR             PIC X(2).
*****                                        YEAR                  *
           10      ENG-MONTH            PIC X(2).
*****                                        MONTH                 *
           10      ENG-DAY              PIC X(2).
*****                                        DAY                   *
       05          ENG-RUN-NUMBER       PIC S9(5) COMP-3.
*****                                        RUN NUMBER            *
       05          ENG-FILLER-1         PIC X(79).
*****                                 *  *   *    *    *    *    *
*****                                 * ENGINEERING JOB REQUEST *
*****                                 *     JOB-RECORD  (1)     *
*****                                 *  *   *    *    *    *    *
 01  ENGINEERING-JOB-RECORD.
       05          ENG-MCID.
           10      ENG-MC-DPT     PICTURE X(1).
           10      ENG-MC-CODE    PICTURE X(4).
*****                                         MACHINE ID           *
       05          ENG-JOBNO      PICTURE X(6).
*****                                         JOB NUMBER           *
       05          ENG-RECTYPE    PICTURE X(1).
*****                                         RECORD TYPE          *
*****
*****                                 DATA-TYPE = 20 ,             *
*****                                 RECORD TYPES                 *
*****                                  1 = ALL VET                 *
*****                                  3 = PART VET                *
*****                                  5 = DUMMY CARD              *
*****                                 DATA-TYPE = 200,             *
*****                                 RECORD TYPES                 *
*****                                  2 = ALL VET                 *
*****                                  4 = PART VET                *
       05          ENG-RUNNO      PICTURE S9(5) COMP-3.
*****                                         RUN NUMBER           *
       05          ENG-PRIORITY   PICTURE  9(1).
*****                                         PRIORITY CODE        *
       05          ENG-CATEGORY.
*****                                         JOB CATEGORIES       *
           10      ENG-CATE-1     PICTURE  X(2).
*****                                         POSITION 1 CATEGORY  *
           10      ENG-CATE-2     PICTURE  X(2).
*****                                         POSITION 2 CATEGORY  *
       05          ENG-DPTREQ     PICTURE  X(1).
*****                                         DEPARTMENT REQUESTED *
       05          ENG-PRODDATE.
           10      ENG-PRODYEAR   PICTURE  9(2).
```

Engineering Job Record (output by Program ER01)   Appendix 5B1

```
                  10   ENG-PRODDAY     PICTURE  9(2).
     *****                          YYMMDD     PRODUCTION REQ DATE   *
           05          ENG-PRODTIME    PICTURE  S9(2)V9(3) COMP-3.
     *****                                NN.N HRS  PRODUCTION REQ TIME  *
           05          ENG-STDATE.
                  10   ENG-STYEAR      PICTURE  9(2).
                  10   ENG-STMONTH     PICTURE  9(2).
                  10   ENG-STDAY       PICTURE  9(2).
     *****                          YYMMDD      ENG START DATE        *
           05          ENG-STTIME      PICTURE  S9(2)V9(3) COMP-3.
     *****                                      ENG START TIME        *
           05          ENG-TRADES.
     *****                                      TRADES WORKED ON JOB  *
                  10   ENG-TRADE1      PICTURE  X(1).
     *****                                                            *
                  10   ENG-TRADE2      PICTURE  X(1).
     *****                                                            *
                  10   ENG-TRADE3      PICTURE  X(1).
     *****                                                            *
           05          ENG-TIMEWORKED.
     *****                         NN.N HRS  TIME WORKED ON JOB       *
                  10   ENG-TIME1       PICTURE  S9(2)V9(3) COMP-3.
     *****                                                            *
                  10   ENG-TIME2       PICTURE  S9(2)V9(3) COMP-3.
     *****                                                            *
                  10   ENG-TIME3       PICTURE  S9(2)V9(3) COMP-3.
     *****                                                            *
           05          ENG-FINDATE.
                  10   ENG-FINYEAR     PICTURE   9(2).
                  10   ENG-FINMONTH    PICTURE   9(2).
                  10   ENG-FINDAY      PICTURE   9(2).
     *****                          YYMMDD    ENG FINISH DATE         *
           05          ENG-FINTIME     PICTURE S9(2)V9(3) COMP-3.
     *****                                    ENG-FINISH TIME.        *
           05          ENG2-CAUSE      PICTURE  X(1).
     *****                                    CAUSE OF BREAKDOWN.     *
           05          ENG2-ACTION     PICTURE  X(1).
     *****                                    ACTION TAKEN.           *
           05          ENG2-ASSEMBLIES.
     *****                                    ASSEMBLIES WORKED ON.   *
                  10   ENG2-ASSEM1     PICTURE  X(2).
     *****                                                            *
                  10   ENG2-ASSEM2     PICTURE  X(2).
     *****                                                            *
                  10   ENG2-ASSEM3     PICTURE  X(2).
     *****                                                            *
           05          ENG2-ELEC       PICTURE  S9(3)     COMP-3.
     *****                                    ELECTRICAL VISIT.       *
           05          ENG2-MECH       PICTURE  S9(3)     COMP-3.
     *****                                    MECHANICAL VISIT.       *
           05          ENG2-ELECHRS    PICTURE  S9(4)V9  COMP-3.
     *****                                    ELECTRICAL HRS WORKED*
           05          ENG2-MECHHRS    PICTURE  S9(4)V9  COMP-3.
     *****                                    MECHANICAL HRS WORKED*
           05          ENG2-BONUS      PICTURE  S9(4)V9(3) COMP-3.
     *****                                    BONUS CREDITS.          *
           05          ENG2-DOWN       PICTURE  S9(4)V9  COMP-3.
     *****                                    ENGINEERING DOWNTIME.*
           05          ENG2-REPAIR     PICTURE  X(1).
     *****                                    REPAIR TIME INDICATOR*
     *****                                    0 = OK                  *
     *****                                    1 = OVER                *
     *****                                    2 = UNDER               *
           05          ENG2-REPST      PICTURE  X(3).
     *****                                    REPORT STRUCTURE (M/C)*
```

Engineering Job Record - Cont.

```
      05         ENG2-OILERV   PICTURE  S9(3)       COMP-3.
*****                                       MATE/OILER VISIT          *
      05         ENG2-OILERH   PICTURE  S9(4)V9(1) COMP-3.
*****                                       MATE/OILER HOURS          *
*
*
*****                              *    *    *    *    *    *    *
*****                              *        ENGINEERING JOB        *
*****                              *           END RECORD          *
*****                              *    *    *    *    *    *    *
 01  ENGINEERING-END-RECORD.
        05   ENG-END-CODE                PICTURE  X(5).
*****             THIS CODE SHOULD BE 99999                           *
        05   ENG-END-RUN-DATE.
*****                                    YYMMDD RUN DATE              *
              10  ENG-END-YEAR           PICTURE  X(2).
              10  ENG-END-MONTH          PICTURE  X(2).
              10  ENG-END-DAY            PICTURE  X(2).
*****                                    NO OF RECORDS ON FILE        *
        05   ENG-END-NORECORDS           PICTURE S9(5) COMP-3.
*****                                                                 *
        05   ENG-FILLER-2                PICTURE X(80).
        SKIP3
```

Engineering Job Record - Cont.

```
       SKIP3
 FD    GROUP-TIME
       RECORDING MODE F
       BLOCK CONTAINS 0 RECORDS
       LABEL RECORDS STANDARD.
       SKIP2
 01    GROUP-FILE.
       SKIP2
       05           GROUP-HEADER.
       SKIP1
         10         GROUP-DATYPE          PIC  X(2).
*****                                     DATA TYPE    LOW VALUES          *
         10         GROUP-FILLER1         PIC  X(3).
*****                                     FILLER AREA LOW VALUES           *
         10         GROUP-SOURCE-PROG     PIC  X(4).
*****                                     SOURCE PROGRAM ER20              *
         10         GROUP-FILLER2         PIC  X(15).
*****                                                                      *
         10         GROUP-DATE            PIC  9(6).
*****                                     DUMMYY DATE                      *
         10         GROUP-RUNNO           PIC S9(5)        COMP-3.
*****                                     DOWN RUN NUMBER                  *
         10         FILLER                PIC  X(3).
       SKIP2
       05           GROUP-RECORD REDEFINES GROUP-HEADER.
       SKIP1
         10         GROUP-WORK            PIC  X(1).

         10         GROUP-DEPT            PIC  X(1).
*****                                     DOWN DEPARTMENT                  *
         10         GROUP-MCNO            PIC  9(4).
*****                                     MACHINE NUMBER                   *
         10         GROUP-MCTIME          PIC  S9(6)V9     COMP-3.
*****                                     MECHANICAL TIME                  *
         10         GROUP-ELTIME          PIC  S9(6)V9     COMP-3.
*****                                     ELECTRICAL TIME                  *
         10         GROUP-OLTIME          PIC  S9(6)V9     COMP-3.
*****                                     OILER TIME                       *
         10         GROUP-MCVIST          PIC  S9(4)       COMP-3.
*****                                     MECHANICAL  VISITS               *
         10         GROUP-ELVIST          PIC  S9(4)       COMP-3.
*****                                     ELECTRICAL  VISITS               *
         10         GROUP-OLVIST          PIC  S9(4)       COMP-3.
*****                                     OILER VISITS                     *
         10         GROUP-TWTIME          PIC  S9(7)V9     COMP-3.
*****                                     TOTAL WORKING TIME               *
         10         FILLER                PIC  X(4).
       SKIP2
       05           GROUP-END REDEFINES GROUP-HEADER.
       SKIP1
         10         GROUP-ENDDT           PIC  X(2).
*****                                     END DATA TYPE   HIGH VALUES      *
         10         GROUP-FILLER4         PIC  X(3).
*****                                     FILLER  AREA    HIGH VALUES      *
         10         GROUP-FILLER5         PIC  X(15).
*****                                                                      *
         10         GROUP-RECOUNT         PIC  S9(5)       COMP-3.
*****                                     RECORD COUNT                     *
         10         FILLER                PIC  X(13).
```

Group Record (output by Program ER20)

Appendix 5B2

```
       SKIP3
 FD  HIST-FILE
       BLOCK CONTAINS 0 RECORDS
       RECORDING MODE F
       LABEL RECORDS STANDARD.
       SKIP2
 01  HIST-RECORDS.
       SKIP1
       05          HIST-HEADER.
*****                                  HISTORY HEADER RECORD              *
           10      HIST-DATYPE         PIC  X(2).
*****                                  DATA TYPE       LOW-VALUES         *
           10      HIST-FILLER1        PIC  X(3).
*****                                  FILLER  AREA    LOW-VALUES         *
           10      HIST-SOURCE-PROG    PIC  X(4).
*****                                  SOURCE PROGRAM ER04                *
           10      HIST-FILLER2        PIC  X(15).
*****                                                                     *
           10      HIST-DATE           PIC  9(6).
*****                                  DDMMYY DATE                        *
           10      HIST-RUNNO          PIC S9(5)        COMP-3.
*****                                  HISTORY RUN NUMBER                 *
           10      FILLER              PIC  X(20).
       SKIP1
       05          HIST-MRECORD   REDEFINES  HIST-HEADER.
*****                                  HISTORY MAIN RECORD                *
           10      HIST-WKNO           PIC  9(2).
*****                                  WEEK NUMBER                        *
           10      HIST-WORKNO         PIC  X(1).
*****                                  WORK GROUP NO.                     *
           10      HIST-CATSCOUNT.
*****                                  CATEGORY COUNTS (A-H)              *
             15    HIST-CATSC          PIC  S9(6)       COMP-3 OCCURS 8
                                             INDEXED BY CATEGS.
           10      HIST-TCREDITS       PIC  S9(7)V9(3) COMP-3.
*****                                  TOTAL CREDITS                      *
           10      HIST-WTIME          PIC  S9(7)V9(3) COMP-3.
*****                                  WAITING TIME                       *
           10      HIST-UNMEAS         PIC  S9(7)V9(3) COMP-3.
*****                                  UNMEASURED                         *
       SKIP1
       05          HIST-ENDREC    REDEFINES HIST-HEADER.
*****                                  HISTORY END RECORD                 *
           10      HIST-ENDDT          PIC  X(2).
*****                                  END DATA TYPE   HIGH-VALUES        *
           10      HIST-FILLER6        PIC  X(3).
*****                                  FILLER  AREA    HIGH-VALUES        *
           10      HIST-FILLER7        PIC  X(15).
*****                                                                     *
           10      HIST-RECCUNT        PIC  S9(4)       COMP-3.
*****                                                                     *
           10      FILLER              PIC  X(30).
```

Category Estimation History Record (ER04)

Appendix 5B3

```
       SKIP3
 FD    DOWN-TIME
       RECORDING MODE F
       BLOCK CONTAINS 0 RECORDS
       LABEL RECORDS STANDARD.
       SKIP2
 01    DOWN-FILE.
       SKIP2
       05            DOWN-HEADER.
       SKIP1
           10        DOWN-DATYPE              PIC  X(2).
*****                                         DATA TYPE    LOW-VALUES          *
           10        DOWN-FILLER1             PIC  X(3).
*****                                         FILLER AREA LOW-VALUES           *
           10        DOWN-SOURCE-PROG         PIC  X(4).
*****                                         SOURCE PROGRAM ER10              *
           10        DOWN-FILLER2             PIC  X(15).
*****                                                                          *
           10        DOWN-DATE                PIC  9(6).
*****                                         DDMMYY DATE                      *
           10        DOWN-RUNNO               PIC S9(5)          COMP-3.
*****                                         DOWN RUN NUMBER                  *
           10        FILLER                   PIC  X(3).
       SKIP2
       05            DOWN-RECORD REDEFINES DOWN-HEADER.
       SKIP1
           10        DOWN-DEPT                PIC  X(1).
*****                                         DOWN DEPARTMENT                  *
           10        DOWN-MCNO                PIC  9(4).
*****                                         MACHINE NUMBER                   *
           10        DOWN-CURRENT             PIC  X(1).
*****                                         CODE FOR CURRENT WEEK TEST       *
*****                                         C = CURRENT WEEK                 *
*****                                         P = PAST (PREVIOUS WEEKS)        *
           10        DOWN-MCTIME              PIC  S9(6)V9       COMP-3.
*****                                         MECHANICAL TIME                  *
           10        DOWN-ELTIME              PIC  S9(6)V9       COMP-3.
*****                                         ELECTRICAL TIME                  *
           10        DOWN-OLTIME              PIC  S9(6)V9       COMP-3.
*****                                         OILER TIME                       *
           10        DOWN-DWTIME              PIC  S9(6)V9       COMP-3.
*****                                         DOWN TIME                        *
           10        DOWN-MCVIST              PIC  S9(4)         COMP-3.
*****                                         MECHANICAL VISITS                *
           10        DOWN-ELVIST              PIC  S9(4)         COMP-3.
*****                                         ELECTRICAL VISITS                *
           10        DOWN-OLVIST              PIC  S9(4)         COMP-3.
*****                                         OILER VISITS                     *
           10        DOWN-TWTIME              PIC  S9(7)V9       COMP-3.
*****                                         TOTAL WORKING TIME               *
       SKIP2
       05            DOWN-END REDEFINES DOWN-HEADER.
       SKIP1
           10        DOWN-ENDDT               PIC  X(2).
*****                                         END DATA TYPE    HIGH-VALUES     *
           10        DOWN-FILLER4             PIC  X(3).
*****                                         FILLER  AREA     HIGH-VALUES     *
           10        DOWN-FILLER5             PIC  X(15).
*****                                                                          *
           10        DOWN-RECCNT              PIC  S9(5)         COMP-3.
*****                                         RECORD COUNT                     *
           10        FILLER                   PIC  X(13).
```

Down-time Record (ER10)
Appendix 5B4

```
       SKIP3
 FD    DOWN-MONTH
       RECORDING MODE F
       BLOCK CONTAINS 0 RECORDS
       LABEL RECORDS STANDARD.
       SKIP2
 01    DOWN-M-FILE.
       SKIP2
       05          DOWN-M-HEADER.
       SKIP1
         10        DOWN-M-DATYPE          PIC  X(2).
*****                                     DATA TYPE   LOW VALUES             *
         10        DOWN-M-FILLER1         PIC  X(3).
*****                                     FILLER AREA LOW-VALUES             *
         10        DOWN-M-SOURCE          PIC  X(4).
*****                                     SOURCE PROGRAM ER14                *
         10        DOWN-M-FILLER2         PIC  X(8).
*****                                                                        *
         10        DOWN-M-3FILLER         PIC S9(7)          COMP-3.
*****                                                                        *
         10        DOWN-M-4FILLER         PIC  X(3).
*****                                                                        *
         10        DOWN-M-DATE            PIC  9(6).
*****                                     DDMMYY DATE                        *
         10        DOWN-M-RUNNO           PIC S9(5)          COMP-3.
*****                                     DOWN MONTH RUN NUMBER              *
         10        FILLER                 PIC  X(32).
       SKIP2
       05          DOWN-M-RECORD REDEFINES  DOWN-M-HEADER.
       SKIP1
         10        DOWN-M-DEPT            PIC  X(1).
*****                                     DOWN DEPARTMENT                    *
         10        DOWN-M-MCNO            PIC  X(4).
*****                                     MACHINE NUMBER                     *
         10        DOWN-M-MLTIME          PIC S9(6)V9        COMP-3.
*****                                     MECHANICAL TIME                    *
         10        DOWN-M-ELTIME          PIC S9(6)V9        COMP-3.
*****                                     ELECTRICAL TIME                    *
         10        DOWN-M-OLTIME          PIC S9(6)V9        COMP-3.
*****                                     OILER      TIME                    *
         10        DOWN-M-DWTIME          PIC S9(6)V9        COMP-3.
*****                                     DOWN       TIME                    *
         10        DOWN-M-MLVIST          PIC S9(4)          COMP-3.
*****                                     MECANICAL VISITS                   *
         10        DOWN-M-ELVIST          PIC S9(4)          COMP-3.
*****                                     ELECTRICAL VISITS                  *
         10        DOWN-M-OLVIST          PIC S9(4)          COMP-3.
*****                                     OILER      VISITS                  *
         10        DOWN-M-LEAGUE.
           15      DOWN-M-FILLER3         OCCURS  5 INDEXED BY  POSIT.
             20    DOWN-M-POSITION        PIC  9(3).
*****                                     LEAGUE POSITION                    *
         10        DOWN-M-LMONTHS.
           15      DOWN-M-FILLER4         OCCURS  5 INDEXED  BY  MONTHS.
             20    DOWN-M-LMNTH           PIC S9(6)V9        COMP-3.
*****                                     LAST 5 MONTHS DOWN TIME            *
       SKIP2
       05          DOWN-M-END  REDEFINES  DOWN-M-HEADER.
       SKIP1
         10        DOWN-M-ENDDT           PIC  X(2).
*****                                     END DATA TYPE  HIGH-VALUES         *
         10        DOWN-M-FILLER6         PIC  X(3).
*****                                     FILLER AREA    HIGH-VALUES         *
         10        DOWN-M-FILLER7         PIC  X(4).
```

Down-time Record (ER14) Appendix 5B5

```
*****                                   RECORD CONT                              *
          10    DOWN-M-FILLER8          PIC  X(5).
*****                                                                            *
          10    DOWN-M-FILLER9          PIC S9(7)           COMP-3.
*****                                                                            *
          10    FILLER                  PIC  X(42).
```

Down-time Record - Cont.

```
       SKIP3
 FD    MCHIST-FILE
       RECORDING MODE F
       BLOCK CONTAINS 0 RECORDS
       LABEL RECORDS STANDARD.
       SKIP2
 01    MCHIST-RECORDS.
       SKIP1
       05          MCHIST-HEADER.
*****                                  HISTORY DOWN TIME RECORDS
          10       MCHIST-DATYPE       PIC  X(2).
*****                                  DATA TYPE   LOW-VALUES             *
          10       MCHIST-FILLER1      PIC  X(3).
*****                                  FILLER AREA LOW-VALUES             *
          10       MCHIST-SOURCE       PIC  X(4).
*****                                  SOURCE PROGRAM ER16                *
          10       MCHIST-FILLER2      PIC  X(15).
*****                                                                     *
          10       MCHIST-DATE         PIC  9(6).
*****                                  DDMMYY DATE                        *
          10       MCHIST-RUNNO        PIC S9(5)       COMP-3.
*****                                  M/C HISTORY NRUN NUMBER            *
          10       FILLER              PIC  X(7).
      SKIP2
            05 MCHIST-RECORD REDEFINES  MCHIST-HEADER.
*****                                  MAIN DOWN MIST RECORD              *
          10       MCHIST-DEPT         PIC  X(1).
*****                                  DEPARTMENT                         *
          10       MCHIST-MCNO         PIC  X(4).
*****                                  MACHINE NUMBER                     *
          10       MCHIST-LEAGUES.
             15    MCHIST-FILLER4      OCCURS 5  INDEXED BY  MCLEAGUE.
                20 MCHIST-POSITION     PIC  9(3).
*****                                  LEAGUE POSITION                    *
          10       MCHIST-LTIMES.
             15    MCHIST-FILLER5      OCCURS 5  INDEXED BY  MCDTIME.
                20 MCHIST-LDOWN        PIC S9(6)V9      COMP-3.
*****                                  LAST 5 MONTHS DOWN TIME            *
       SKIP2
       05          MCHIST-END   REDEFINES  MCHIST-HEADER.
*****                                  END RECORD                         *
          10       MCHIST-ENDDT        PIC  X(2).
*****                                  END DATA TYPE   HIGH-VALUES        *
          10       MCHIST-FILLER6      PIC  X(3)
*****                                  FILLER AREA     HIGH-VALUES        *
          10       MCHIST-FILLER7      PIC  X(15).
*****                                                                     *
          10       MCHIST-RECCUNT      PIC S9(5)        COMP-3.
*****                                  RECORD COUNT                       *
          10       FILLER              PIC  X(17).
```

Machine Down-time History Record (ER16)

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