THE POLYTECHNIC OF WALES
IN COLLABORATION WITH
STANDARD TELEPHONES AND CABLES PLC
TEACHING COMPANY PROGRAMME

A MATERIALS HANDLING PROJECT: TO MINIMISE THE COST AND COMPLEXITY OF THE MATERIALS HANDLING SYSTEMS AT THE CABLE PRODUCTS DIVISION OF STANDARD TELEPHONES AND CABLES, NEWPORT.

BY

N.J. PERRY, B.Sc.,C.ENG., M.I.PROD.E.

A THESIS SUBMITTED IN PURSUANCE OF THE REQUIREMENTS OF THE COUNCIL FOR NATIONAL ACADEMIC AWARDS FOR THE AWARD OF THE DEGREE OF MASTER OF PHILOSOPHY.

// A B S T R A C T

This project arose due to the need for rationalisation and a medium to long term strategy for materials handling at Standard Telephones and Cables, (S.T.C.) Cable Products Division, Newport. The project was initiated through a teaching company programme set up by The Polytechnic of Wales and S.T.C. The objective was to minimise the cost and complexity of the handling systems by means of individually cost effective sub-projects, tackled with flexibility and the overall strategy maintained throughout.

The first phase of the project was to prepare a data base of materials handling statistics gathered from departmental records, and where possible from the Company's four year business plan. All departments were analysed, encompassing raw materials, work in progress, finished goods and scrap clearance.

The second phase of the project was the rationalisation of internal transport, which consisted mainly of fork lift trucks. Various alternative methods of handling and storage were analysed, including pneumatic, floor and overhead conveying; cranes; automated storage and retrieval systems; and automated guided vehicles. However, the fork lift truck was found to be the most flexible and effective medium term solution under S.T.C.'s present circumstances with pending business and consequent method changes. The fork lift truck analyses determined the number and capacity mix, (by means of analytical and simulation techniques) methods of acquisition, choise of supplier, mode of operation and financial analysis (discounted cash flow) over the planned period.

The recommendations were :- A four year rental contract with full contract maintenance included. The current fleet of 42 trucks to be reduced to 27, inclusive of 12 new trucks rented from Lansing Bagnall. 11 of these to be electric, with 1 diesel for outdoors at a total net cost of approximately £200,000. Gradual replacement of the older trucks, 3 each year, to update the total fleet by the end of the planned period; costing approximately £90,000 per annum. Further work necessary to minimise costs and progress the aim of producing a fully integrated handling system, is discussed in the conclusions.

A C K N O W L E D G E M E N T S

The author wishes to thank all those who have contributed their time and knowledge in helping to complete this project. These include:

STANDARD TELEPHONES AND CABLES plc

My tutor, Mr.N.L.Rees; Mr.V.Jones and the staff of the Production Control Department; Mr.K.Lovell; Mr.W.Holloway; Mr.K.Gripton; Mr.M.J.O'Toole and all those involved with running and controlling the internal transport fleet. Mr.S.Villars and Mr.R.Price whose accountancy knowledge I found invaluable. Mr.O.G.Erasmus and Mr.D.Nicholls of the Industrial Engineering Department for their commitment in helping to achieve computer simulations and formulate work study data. Last, but not least, much appreciation and thanks to Lesley and Gail who have shown both courage and patience in attempting to decipher scrawl and transform it into this M.Phil. Project Thesis.

THE POLYTECHNIC OF WALES

Mr.Howells and staff of the Computer Department for their guidance with the Computer programming, members of staff of the Department of Mechanical and Production Engineering, Electrical and Electronic Engineering and in particular, my project tutor, Mr.J.A.Smith and Dr.M.B.Basset whose experience and guidance have been unlimited and most appreciated.

I would like also to thank my wife Denise for her understanding, patience and willingness to help me complete this thesis.

C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

NOMENCLATURE

ABBREVIATION	DESCRIPTION	UNITS
W.I.P.	Work in Process	
S.T.C.	Standard Telephones and Cables	
C.P.D.	Cable Products Division	
M/C	Machine	
F/T	Full Time	
P/T	Part Time	Metres per
TXE4	Telephone Exchange Equipment No. 4	second
F.L.T.	Fork Lift truck	squared
Accn.	Acceleration	(+) M/S^2
Decn.	Deceleration	(-) M/S^2
A/C	Account	
N.P.V.	Net Present Value	
D.C.F.	Discounted Cash Flow	
S.M.V.	Standard Minute Value	
M.C.M.'s	Million Conductor Metres	
K.W.H.	Kilo-watt Hour	
Insg.	Insulating	
I.B.M.	International Business Machines	
I.E. &. M.	Industrial Engineering and Management.	
B.P.O.	British Post Office	
I.R.	Industrial Relations	
Spec.	Specification	
S.T.	Strander	
D.T.	Drum Twister	
L.T. No.	Lift Truck Number	
P.A.R.	Project Appropriation Request	
C/B	Counterbalanced	
M.P.H.	Miles per Hour	
H.V.	High Voltage	

CHAPTER 1

INTRODUCTION (GENERAL)

In order to provide a background to the materials handling project work herein a brief description of the Teaching Company Scheme, the company involved and how materials handling has evolved within it is presented below as at July 1982.

1.1 TEACHING COMPANY SCHEME

Funded by the Science and Engineering Research Council and the Department of Industry, the Teaching Company Scheme was established some six years ago to develop active partnerships between academic institutions and manufacturing industry. These partnerships are called programmes and associates are appointed to act as catalysts between industry and academia helping to solve industrial problems while furthering both parties in the appreciation of each others problems. Each programme is of two years duration for the associates who work on one or more projects gaining valuable project and general industrial experience.

In July 1982 there were more than fifty programmes in operation in the United Kingdom. The Polytechnic of Wales in Treforest and Standard Telephones and Cables in Newport was one such Teaching Company Programme which was set up in 1980. Two associates were appointed in July/August of that year, the author being one.

The programme received the full co-operation of both parties from the General Manager Mr. F. Mann in Standard Telephones and Cables to Deputy Director Dr. F. J. Hybart and The Dean of the Faculty of Engineering and Head of the Department of Electrical and Electronic Engineering Mr. G. H. Thompson.

Regular reviews at Management Committee Meetings were conducted on a three monthly basis; these acted as a progress reporting session for the associates. The aforementioned people together with other representatives of both parties were present as a part of the Teaching Company Management Committee.

The associates have both an academic and industrial supervisor which ensures that work carried out is both technically sound and follows the direction and timescales desired by the Company.

1.2 THE FORMATION OF STANDARD TELEPHONES AND CABLES

The history of Telecommunications as we know it started with the invention of the telephone by Alexander Graham Bell in 1876. This led to the formation of the Bell Telephone Association in 1877.

In 1882 the Western Electric Company which was an amalgamation of firms including the Western Union Telegraph Co., obtained the sole manufacturing rights of the American Bell Telephone Company (later to become American Telephone and Telegraph Company). Also in 1882 Western Electric sent an American engineer Francis Welles to Europe, where he set up the Bell Telephone Manufacturing Company in Antwerp.

A year later Welles appointed J.E.Kingsbury as Western Electric's agent in England and an office was opened in Moorgate with a staff of three. During its first few years it acted as a selling organisation for factories in Chicago, Antwerp, Paris and Berlin, but with increasing sales it eventually became necessary to have a manufacturing plant in this country. To this end the company purchased the Fowler-Waring Cable Company at North Woolwich in 1897.

Two years later the factory was destroyed by fire and the opportunity was taken to rebuild the factory on more modern lines, consequently, in 1910 the Western Electric Co. in London was formed into a separate English company.

In 1920, Sosthenes Behn founded the International Telephone and Telegraph Corporation with the purpose of developing the telephone industry in Europe. Shortly afterwards on 30th September,1925, The International Telephone and Telegraph Corporation purchased all Western Electric's European manufacturing and research facilities. To avoid confusion the name of the Western Electric Company in England was changed to Standard Telephones and Cables Limited.

1.3 AN INTRODUCTION TO STANDARD TELEPHONES AND CABLES

Although many people will be familiar with the name of Standard Telephones and Cables, they are possibly unaware of the extent of the Company's involvement in telecommunications. The Company is one of the world's largest concerns involved in the manufacture of communications equipment and employs 42,000 people at 22 major manufacturing locations in the British Isles, together with a number of smaller works and offices.

The main businesses of the Company are its telephone switching operation, undersea telephone cable systems, transmission systems, the manufacture of telephone and communications cable and the production of specialised electronic equipment, including complete exchanges and their installation.

1.4 THE CABLE PRODUCTS DIVISION - NEWPORT

1.4.1 GENERAL

The Cable Products Division (C.P.D.) in Newport covers a total area of approximately 44,400 square metres and employs around 950 people involved in accounting, administration, engineering, quality, marketing, production, purchasing, supply and site services. This Division is concerned with the manufacture of a range of: communications, industrial, and specialist cables, for customers around the world.

1.4.2 ORGANISATION

The main volume of Cable Products Division business is in telephone cable which is of standard manufacturing specification, and shows low profitability. Hydrospace cable is high technology, shows high profitability but is currently low volume as is optical cable, which is gaining ground in the replacement of conventional telephone cable, but still under development for the replacement of all cable types. 1982 sales figures show that Cable Products Division export 17% of their business and produce 83% for the Home market.

The Newport factory can be considered as three distinct production facilities:- Telephone Cable; Hydrospace Cable; and Optical Cable.

Telephone Cable

Telephone Cable (conventional copper and aluminium cable for telecommunications) is by far the major portion of the business by value and physical space requirements. (85% by value, 77% by area) Telephone Cable production is standard and conducive to a dedicated handling system encompassing the complete product range.

Hydrospace Cable

The Hydrospace workload and range of products is continually changing; the wide variety of specifications and technical complexity encountered, requires a high degree of materials handling system flexibility. This set-up is not conducive to a dedicated handling system for the Division as a whole but does require much smaller dedicated handling systems for certain products within the Division.

Optical Cable

Optical Cables is a relatively small division with only two production machines currently on site. It does not take much imagination, however, to realise the potential for Optical Cables in the future of communications. The present facility for Optical Cable production is under improvement and is to be incorporated into the main production area with four production machines to its credit. (Planned completion December 1982).

CHAPTER 2

MATERIALS HANDLING

2.1 GENERAL

The future of any company lies in the efficient and cost effective:

a) Manufacture of present day requirements and

b) Adaptation to change and implementation of new technology.

Cable manufacture is capital intensive. Labour is principally utilised in setting up, machine monitoring and materials handling. With the increasing introduction of automated process equipment and improved production scheduling techniques, materials handling is becoming a more significant cost activity in terms of labour utilisation. "The major, untapped source of savings in the business system still lies in the cost of handling through processing and distribution." SIMS.E.R (1)

The field of materials handling is a broad segment of industrial engineering, it includes problems related to plant layout, storage, mechanical equipment design, automation, management, production control, industrial relations, cost reduction and many more. This is highlighted in (3) and (55)

Standard Telephones and Cables has, in the past, seen the piece-meal growth of materials handling without an overall long term strategy. This has arisen due to the organisational structure within Standard Telephones and Cables. (S.T.C.).

No position in the structure exists for a materials handling engineer or for the scope of materials handling to be covered by a materials manager. As a result, the problems now associated with interfacing a variety of handling methods and machine input/ output stations results in a labour intensive system with a mixture of materials handling equipment. Sims E.R. aptly sums up this situation in the following extract:

"The importance of soundly engineered and planned production processes is accepted without question, yet the means and methods of achieving process to process flow, marshalling and storage, whilst of equal importance has not received the attention or investment warranted. In general, in-plant materials handling, inter-plant transportation, warehousing, shipping and receiving have been ommited from management's cost reduction efforts. One reason for these omissions can be found in the nature of cost accounting systems. Materials handling costs are generally included in indirect labour charges while manufacturing costs are segregated in the accounting system. This failure to identify the large segment of labour costs attributable to materials handling has hidden its effect from management."

Because materials handling (manual in particular) is non-productive adding only cost and not value, the objective should be to eliminate it. However, this would imply the need for continuous flow line production which is not practical while STC (CPD) provide the market with a wide variety of cables for a wide variety of applications and conditions. Materials handling will therefore play an important role in the efficiency with which the plant transforms input into output. Throughout the project, the systems approach has been followed and has been defined by Sims E.R. as:

"The analysis of functional business problems on the bases of the total economics and logistics of the industry or company being examined. In other words the organisation as a whole must be studied and materials handling system design, engineered as a plan to fit future business changes, thereby being a total integrated system and not a piece meal evolution of departmental optimisations."

S.T.C. became aware of the piecemeal growth of its facilities in the early 1970's. The original S.T.C. cable making factory in Woolwich was soon to close down with much of the plant and equipment to be transferred to Newport. Therefore, plans were prepared for improved factory layout encompassing the expected equipment transfer. In 1978, a major rationalisation of facilities was completed in which machines were arranged to enhance good work flow from receiving to shipping. However, the long standing problem which was not resolved during rationalisation and which has gradually worsened to the present day, is that associated with the means and space required for transporting, storing and marshalling work between processes. It is for this reason that this project entitled "Materials Handling" originated.

2.2 OBJECTIVE

To minimise the cost and complexity of the materials handling systems at the cable products division (C.P.D.) Newport. The aim being to produce recommendations for a fully integrated handling system for the site as a whole, accomplished by means of inter-related individually cost-effective sub-projects; each of these to be tackled with flexibility and an overall strategy maintained throughout.

2.3 PROCEDURE

Methods of analysis were reviewed which included the use of the computer (1)(2)(27) and (55). The initial method adopted, the P.Q.R.S.T. approach (Product, Quantity, Routing, Services and Time.) is explained in the Management Services Publication - An Algorithmic Approach to Materials Handling (5). This can be seen in the examples of detailed analysis sheets Tables 5,6 & 7 Pages 33,34 & 37. To begin, the factory layout was analysed in depth to assess the current and possible future methods of handling and storage. Some of the methods of layout planning analysed were:

a) The computer, indicated by R.J. Heisterberg (54) and D.L. Kelly (53) with further details illustrated in (51) and (52):

b) Modelling using miniature Lego and a magnetic board with magnetic cards (8).

With consideration for cost and time, the latter was adopted to experiment with layouts when investigating new methods of storage and handling - ref. Appendix 10.

Each stage in the handling system was analysed and assessed for possible improvements (1) and (55) such as:

a) Elimination of a particular handling method/procedure.

b) Increased effeiciency by alternative handling methods.

c) Increased efficiency by better use of existing equipment and methods.

Some of the methods assessed included: conveyors (42)(43)(50) and (43) for transportation of reels; floor and overhead conveyors, including computer control (48) and (49). There were many details which had to be investigated due to the space limitations, (44)(45) and (46). Conveying was also analysed with respect to plastic compound handling, in this case pneumatic handling was well described by Simms E.R. (1). Further details were noted in (34) (35)(39)(40) and (41), again detail was necessary due to the initial capital expenditure and short payback periods required, (32)(36) and (38). Less expensive methods of plastic granulate movement were studied including mini bulk and container packaging, (33) and (37). Driverless trucks and automatically guided vehicles were another interesting alternative to the present fork lift truck service, (25)(47) and (56).

Another interesting option was computer controlled cranes for handling and storage of heavier drums in an organised fashion (26). This concept was noted on a visit by the author to Nokia machine manufacturer and cable makers in Finland, together with their automatic storage and retrieval systems for reels. Various methods of central storage with manual and automatic input/output was investigated (4)(6)(31) and (55).

It was appreciated at this stage that by improving the handling methods in each area individually, using some of the methods suggested above, the piecemeal growth of materials handling would continue with no overall strategy and an inflexible system with interfacing problems between equipment, departments and people would result. Therefore, the fork lift truck should be the base of Newport's flexible handling facility and remain until further detailed work and an ultimate strategic plan could be formalised.

Fork lift trucks were analysed in depth from design and types available (15)(17)(18)(19) and (21) through economics and methods of propulsion (11)(12)(13)(22)(23) and (24) to human aspects (14) and the details of truck/job suitablility and fitness for purpose (16)(20) and (29).

Simulation was again investigated for truck movements and organisation, some very useful papers were found relating to computer simulation of fork lift trucks (26)(27) and (28).

During these investigations and analyses, cost justification was inevitable. Discounted cash flow was considered to be the most realistic and acceptable method of calculation. Michael Bromwich, (9) and a Polytechnic of Wales publication (10) proved sound references for this purpose.

Finally, good use was made of the Institution of Production Engineers publication (8) throughout this thesis, not only for methods of analyses and recording, but also for presentation techniques.

CHAPTER 3

THE NEWPORT PLANT

3.1 GENERAL

The range of possible cable types which can be manufactured at the cable products division Newport is vast but Table 1, page 16 illustrates the major types. A typical trunk quad cable is illustrated in Plate 1 page 15, which shows the groups of cores individually wound with identification tapes, stranded together to give the total number of pairs required. Also visible is the paper insulating tape, polythene coated aluminium for screening and outer polythylene jacket. A typical distriubution cable specification and production edit (or routing layout) are available on request. These documents together with Figures 1 and 2 pages 17 and 18, provide a brief overview of the current situation. A detailed description of procedures involved in producing a cable is laid out below 3.2. A photograph taken of the factory layout, produced using a magnetic display board with magnetic card cut to scale to represent equipment is illustrated in Plate 2, Appendix 10 With reference to all the above information, the scene is now set to investigate and discuss the materials handling problems.

3.2 CABLE PROCESS DESCRIPTION (TELEPHONE CABLE ONLY)

(ref. Fig. 1 page 17, factory layout by letter representation)

A. S.T.C. takes delivery of 8mm diameter copper rod by packs into the receiving department (K) . When inspected it is stored behind the rod breakdown machines (J).

B. The rod breakdown machines draw the rod down to 2.5mm diam. onto internal packs.

C. Options are then available as follows:

1. Tinning (J)
2. Secondary drawing within wire drawing (J)
3. Transport to insulation machines (J)

If tinned, then secondary drawing is adopted before delivery on reels to insulation (J).

If secondary drawing only is adopted within wire drawing, it is to optimise schedules during capacity mix problems, or to manufacture fine wire: in this case further fine wire drawing machines are used (J).

D. The wire in packs, delivered to insulation (Point 3 above) is further drawn and insulated on combined insulation/drawing machines (tandem lines) down to 0.3 - 0.9mm dia. excluding insulation. The wire already secondary drawn, whether tinned or not, (Points 2 and 3 above) is insulated on insulation machines only (mono lines).

E. Once insulated, the single core, in one of ten possible colours, is handled on small plastic reels (or bobbins-10"x16"dia.) and stored on stillages. These stillages are the means of transport for bobbins until the cores are laid into cables; they take up to 8 bobbins and are stackable up to 4 high.

F. Stillages are taken from insulation to twinning (J) or quadding (O) so that the single cores can be twisted together as pairs or as quads. (Mostly pairs). Pairs are made up to a standard colour code for various size cables.

G. The pairs and quads are also handled on small plastic bobbins and stored on stillages. 100% inspection is conducted at this stage (J).

H. The pairs/quads are now marshalled, stillages are stacked in available spaces to await full sets of the right colours and sizes.

I. When sets are ready and they are next in the queue, the pairs or quads are laid up into cables using one of two stranding techniques: (concentric stranding) or (drum twisting) (I).

J. In concentric stranding, all supply bobbins rotate concentrically around the centre cable axis, the take up drum does not turn about the cable axis. (I)
In drum twisting, as the name suggests, all supply bobbin - positions are fixed and the take up drum rotates about the cable axis. (I)

K. In many cases where large cables are required, groups are laid up as above and then the groups themselves are processed through a larger drum twister. (up to 4,800 pairs). (I)

L. The cables, now on metal process drums of many different shapes and sizes are again 100% tested and marshalled in queues to await sheathing (H). If the cable fails test, it is transported to rewind and repair (C).

M. Sheathing machines are a large capacity insulation machine and can put a plastic jacket over the many different cable sizes. When processed through sheathing the cable can be completed (final sheath) or ready for further processing (initial/inner sheath) (G & H). If inner sheath, then:

1. Armouring - where tapes (paper, metal or wires - steel or nylon) are used either for screening or protection from damage, or for strength. (B)

2. Braiding - A form of armouring. (D) Once the inner - sheathed cable has been armoured etc., it will come back to the queue awaiting final sheathing. (H)

N. After final sheathing (currently onto metal process drums) the finished cable would go for final inspection (E) (if required in the batch sampling schedule) and/or the cable is cut (if required) and rewound onto wooden shipping drums. (E) Again, if the cable is found to be faulty during this period it is sent to rewind and repair (C).

O. At this stage the cables await battening (E) ready for shipping (F) or storage (outside).

PLATE 1.

TYPICAL TRUNK-QUAD CABLE

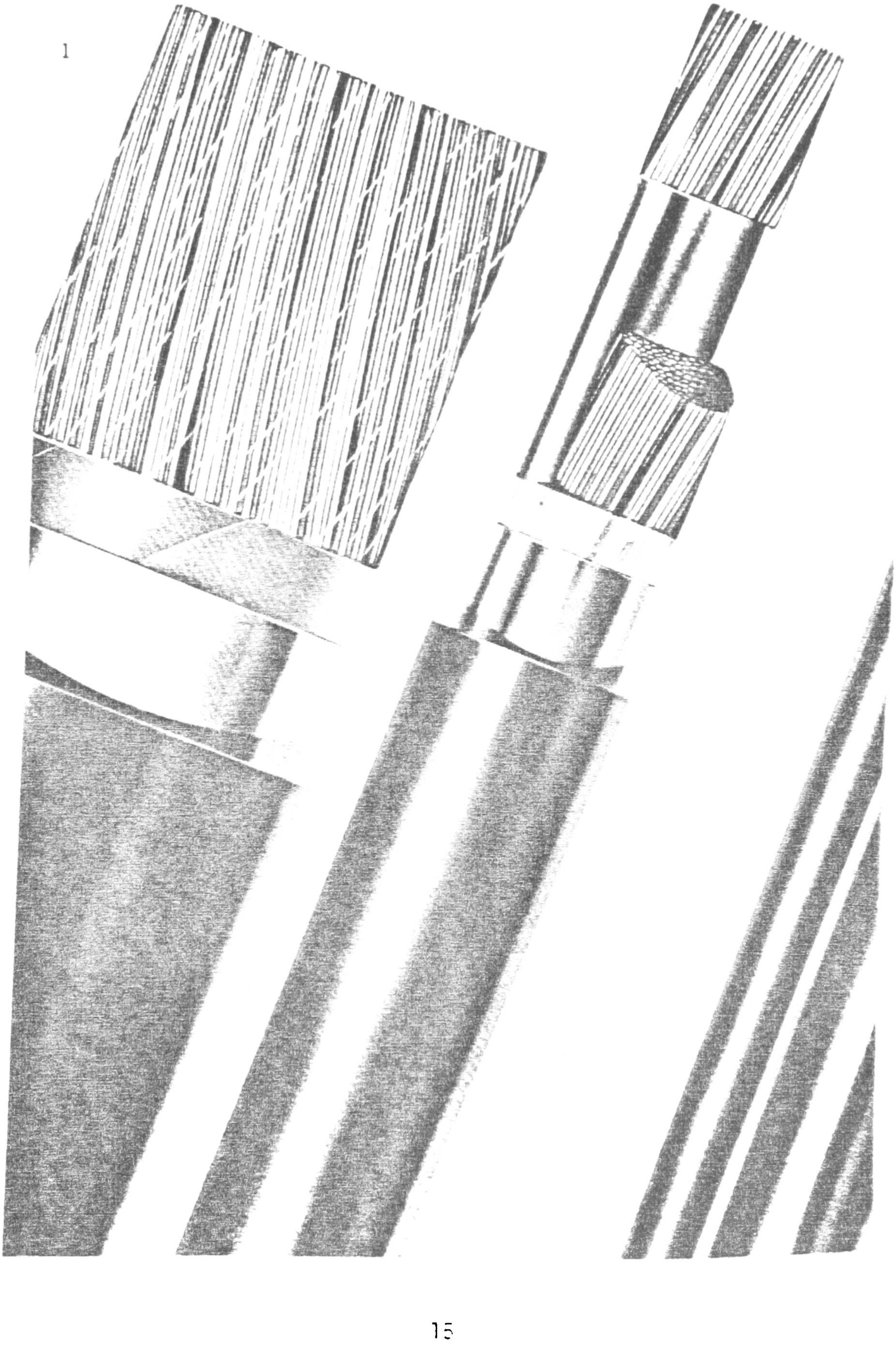


TABLE 1

MAIN TELEPHONE CABLE TYPES

DESCRIPTION	CONSTRUCTION	APPLICATION
UNIT TWIN	POLYETHYLENE INSULATED PLAIN COPPER WIRE CORES TWINNED AND BUNCHED IN: 25,50 & 100 PAIR UNITS POLYETHYLENE/ALUMINIUM TAPE SCREEN, BLACK POLYETHYLENE SHEATH. 100 PAIR TO 4800 PAIR	EXCHANGE TO SUBSCRIBER JUNCTION
DISTRIBUTION	POLYETHYLENE INSULATED PLAIN COPPER WIRE CORES TWINNED AND CONCENTRICALLY STRANDED. BLACK POLYETHYLENE SHEATH. 5 PAIR TO 100 PAIR.	SUBSCRIBER JUNCTION TO SUBSCRIBER TELEPHONE
CATENARY (ASSC)	AS DISTRIBUTION CABLE BUT WITH STRANDED GALVANISED STEEL WIRE STRAIN MEMBER	AERIAL SUBSCRIBER
TRUNK QUAD	CELLULAR POLYETHYLENE INSULATION, QUADDED, CONCENTRIC STRANDED, PAPER TAPE, POLYETHYLENE/ALUMINIUM TAPE SCREEN, BLACK POLY-ETHYLENE SHEATH, 1 QUAD TO 520 QUAD	INTER-EXCHANGE TRUNK ROUTES USED FOR MULTIPLEXED CALLS

FIG. 1

ACTUAL FACTORY LAYOUT BY LETTER REPRESENTATION

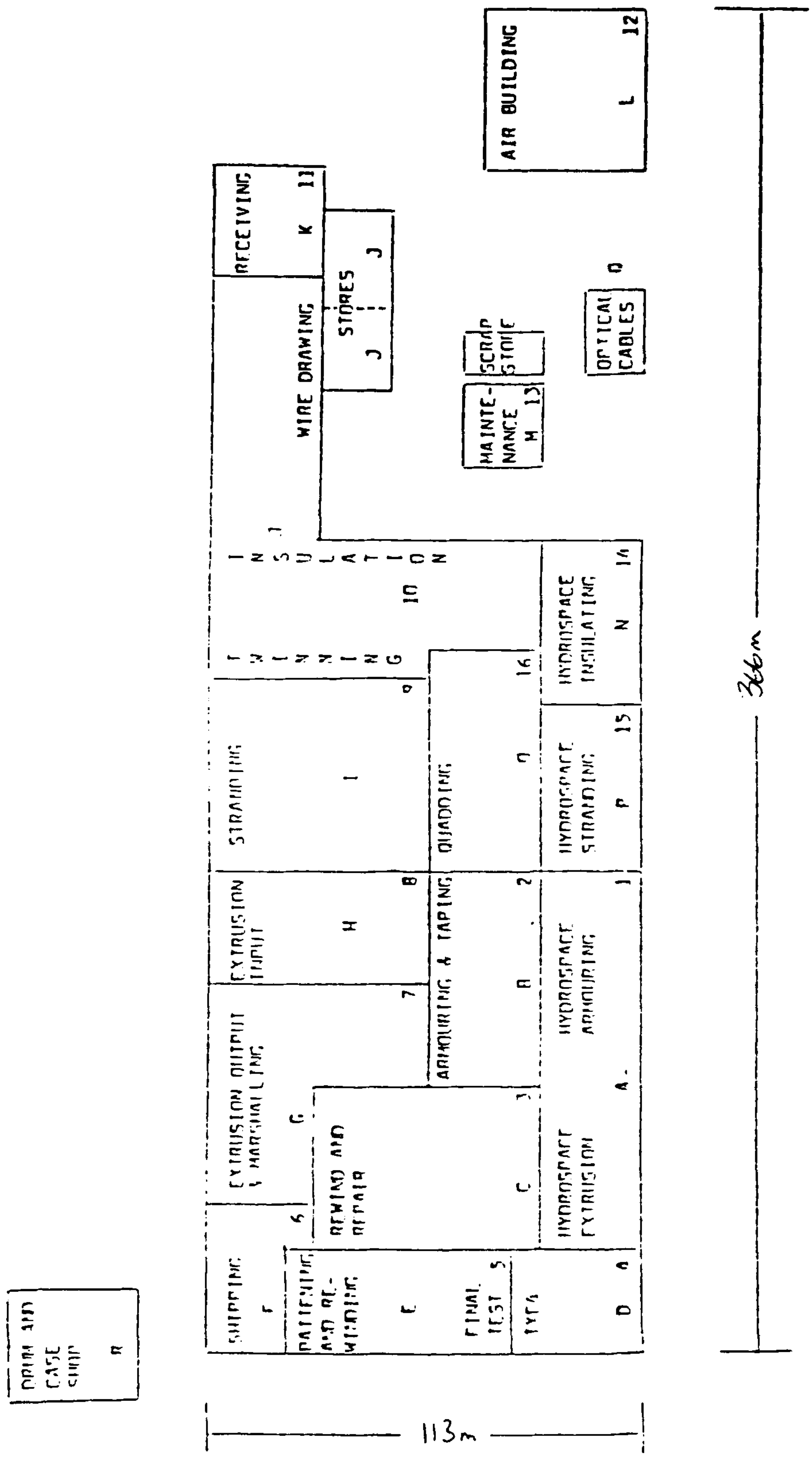
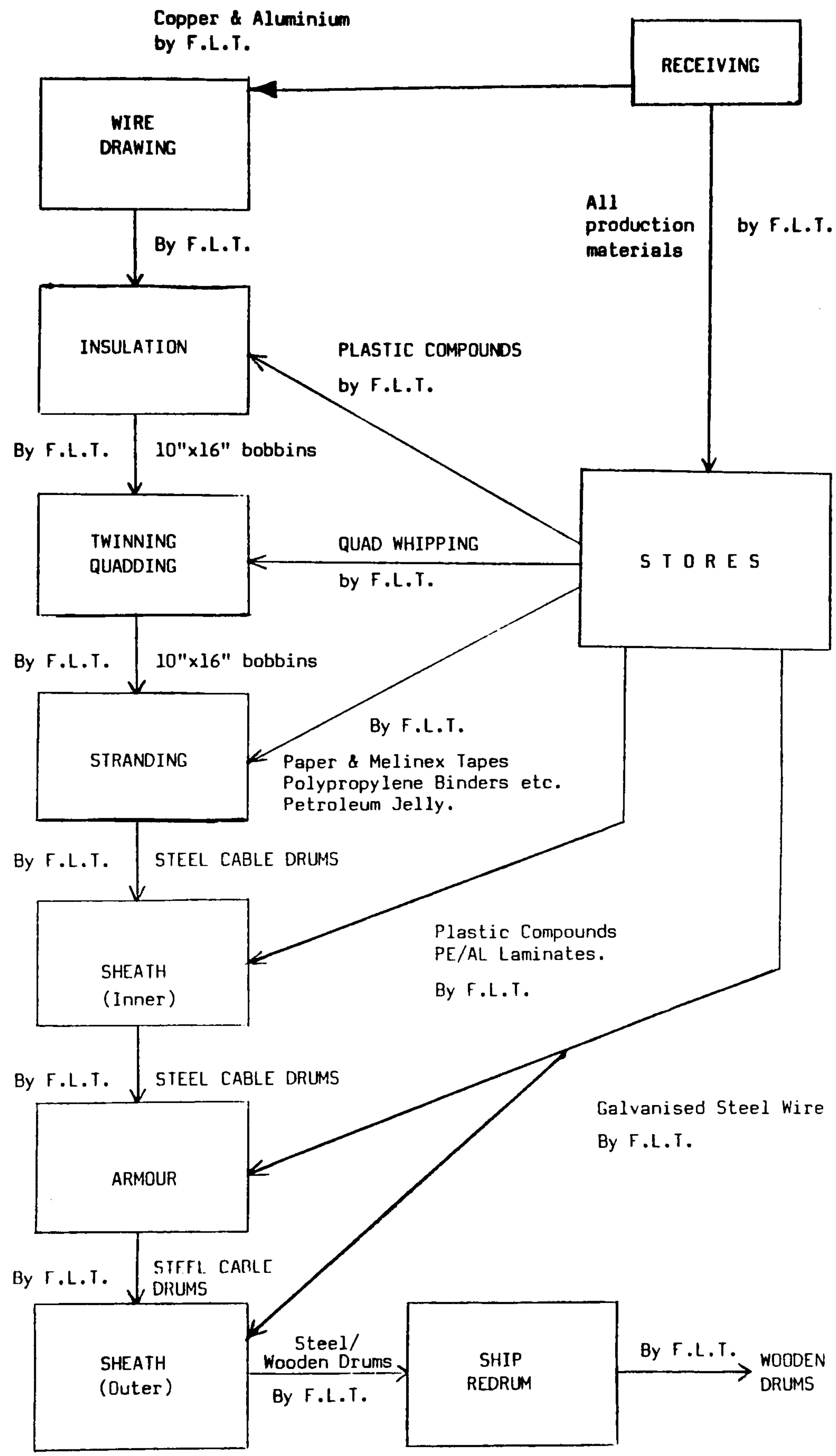


FIG. 2

RAW MATERIAL & W.I.P. FLOW (SIMPLIFIED)



CHAPTER 4

BASE DATA STUDY

4.1 INTRODUCTION

The first phase of the project was to analyse the time taken for handling and movement of materials through the factory. The Company's 4 year business plan (1980-84) containing a cable sample breakdown for the first year; an example of which is shown in Appendix 1, and historical records were used to calculate the material handling statistics for 1980. Mechanical handling and manual handling distances and times were separated to illustrate more clearly, the scope and direction of possible savings. Included in this thesis are mechanical handling analyses only, as all manual handling was carried out by machine operators as inside cycle time. The manual handling analysis was retained for future projects, in particular, automated storage and retrieval.

To put materials handling at S.T.C.into context, from approximately 2000 products live at any one time, and a total product range of approximately 5000, a few of the most common cable spesifications varying in machine usage and routing were chosen. These were analysed in detail to estimate the ratio of time spent handling to time spent manufacturing: The result was approximately 10%. Analysis sheets are shown in Appendix 2.

To appreciate the complexity and problems associated with the present materials handling systems, an in depth investigation into product flow, volume, routing and methods of handling was undertaken. The aim was to achieve a detailed package of statistics which would provide the base data for further projects. The investigation was divided into four distinct parts:-

1. Raw materials.
2. Work in progress (W.I.P.).
3. Final operations.
4. Scrap clearance.

Results calculated from the Company's 4 year business plan were compared with information collected from Departmental records/log books to verify the accuracy of the plan for forecasting future years materials handling levels. Block diagrams showing the process of actual and theoretical information retrieval are illustrated in figs. 3 and 4 Pages 21 & 22 below, and are explained as follows:

Actual information was calculated as follows:

Daily entries of actual products moved, or manufactured and subsequently moved, were extracted from departmental/machine log-books. Actual material flow/throughput was therefore calculated by transforming all figures to the same time base (i.e. whatever the period of analysis short or long depending upon availability and validity of records, each was averaged to provide the movement per shift or day). Distances were calculated by pedometer for all possible transportation routes and the time taken was arrived at by studying the methods of movement and estimated handling speed.

Theoretical information was calculated as follows:

A list was made of all the cable specifications on the cable sample breakdown together with total predicted order quantities. Using the layouts (routing masters) for each specification, the materials, standard lengths, reels/drums and preferred machines were noted. Given the standard length corresponding to a particular reel/drum size and the total order quantity, the number of reels/drums per order could be calculated. Again all movement, distance, and time information was similar to the actual information retrieval method previously described. Because analysis of the cable sample breakdown covers one year, without any indication of peaks and troughs in demand through that year, the total number of shifts worked per year was used to calculate an average throughput and consequently time for movement of reels/drums per shift. This explanation will become clear with reference to an example of the detailed analysis illustrated in Table 5, Page 33.

FIG. 3

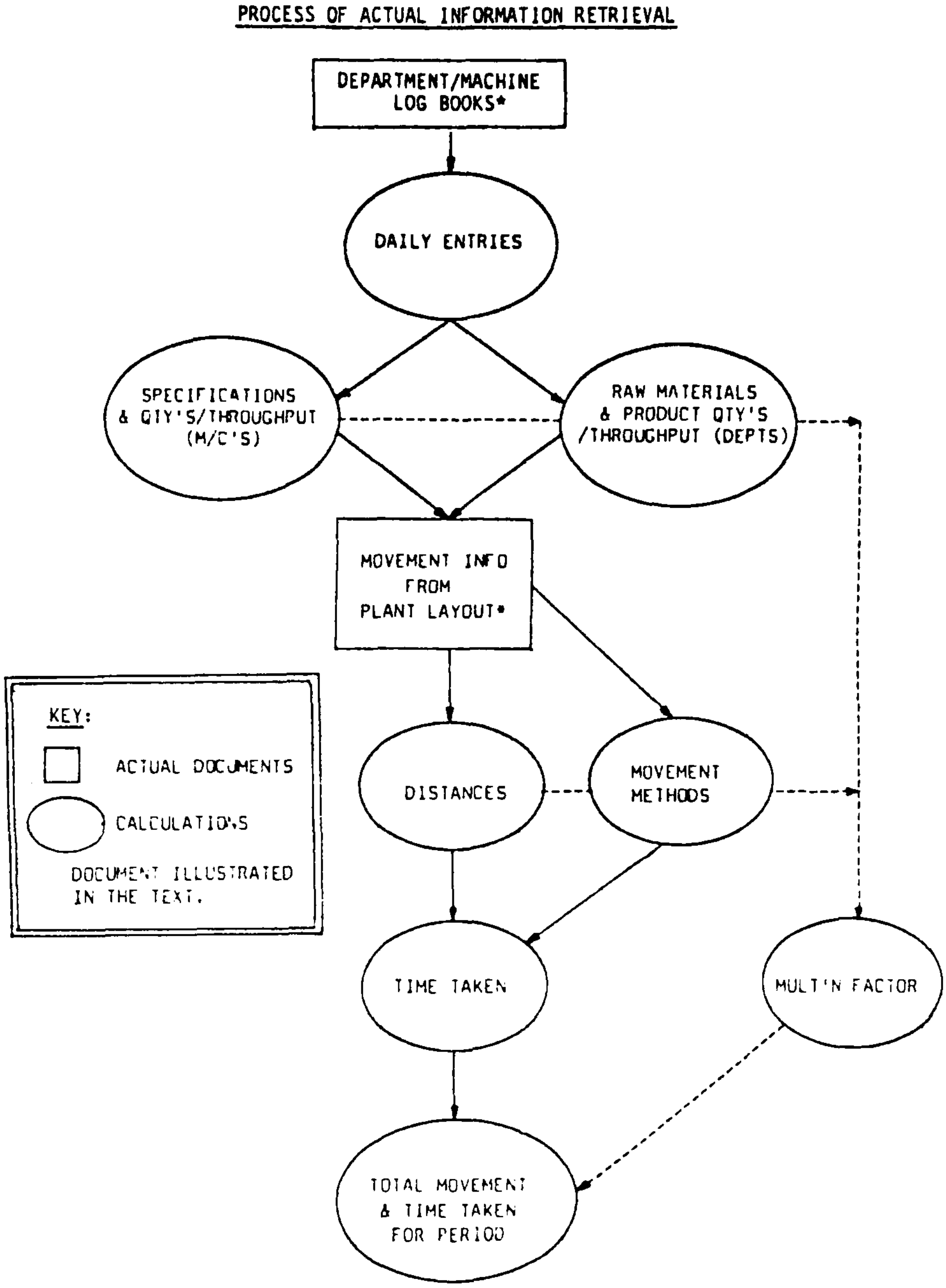
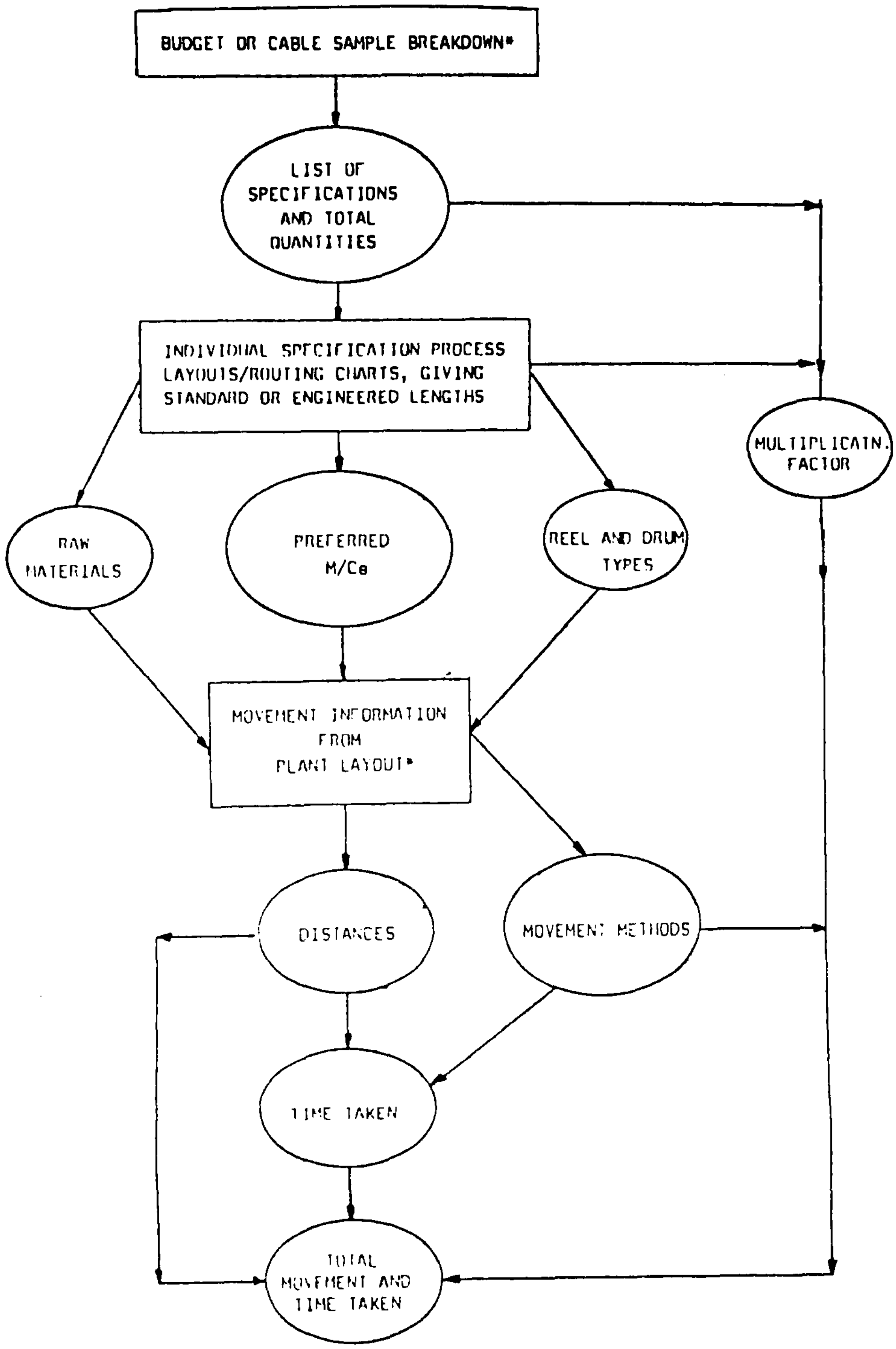

PROCESS OF ACTUAL INFORMATION RETRIEVAL
DEPARTMENT/MACHINE LOG BOOKS*
DAILY ENTRIES
SPECIFICATIONS & QTY'S/THROUGHPUT (M/C'S)
RAW MATERIALS & PRODUCT QTY'S /THROUGHPUT (DEPTS)
MOVEMENT INFO FROM PLANT LAYOUT*
KEY:
ACTUAL DOCUMENTS
CALCULATIONS
DOCUMENT ILLUSTRATED IN THE TEXT.
DISTANCES
MOVEMENT METHODS
TIME TAKEN
MULT'N FACTOR
TOTAL MOVEMENT & TIME TAKEN FOR PERIOD

FIG. 4

PROCESS OF THEORETICAL INFORMATION RETRIEVAL



4.2 ANALYSIS

The four areas stated previously: Raw materials; work in progress; finished goods and scrap clearance, were analysed as follows: ref. Factory Layout and Simplified materials flow diagram Figs. 1 and 2 reproduced on Pages 24 & 25.

Raw materials encompassed mainly receiving, wire drawing and stores movements calculated from historical documents (log book entries).

Work in process encompassed insulation; twinning and quadding; stranding; sheathing and armouring; TXE 4 connectorisation area; test and repair; rewinding; final test, and battening. W.I.P. calculations were covered by both the 4 year Business Plan/cable sample breakdown -(Theoretical Analysis) and, Historical Records - log book entries - (actual analysis) and compared to achieve confidence limits for future use of the Business Plan.

Finished Goods included the drum and case shop work and covered all material transported from battening outdoors for shipment or storage. These movements were calculated from historical data (departmental records) - actual analysis.

Scrap clearance covered the scrap stores internal work and the pick up points around the factory in all departments, again, movements were calculated from historical data (log book entries) - actual analysis.

As described in the previous pages, distance measurement was calculated using a pedometer and the number of movements multiplied by distances was converted into time taken by material movement method analysis. In the case of manual movement, analytical estimating was the basis for calculations, and in the case of mechanical equipment, i.e. fork lift trucks - (F.L.T.) operational data was obtained from the National Materials Handling Centre. - ref. Appendix 3.

FIG. 1

ACTUAL FACTORY LAYOUT BY LETTER REPRESENTATION

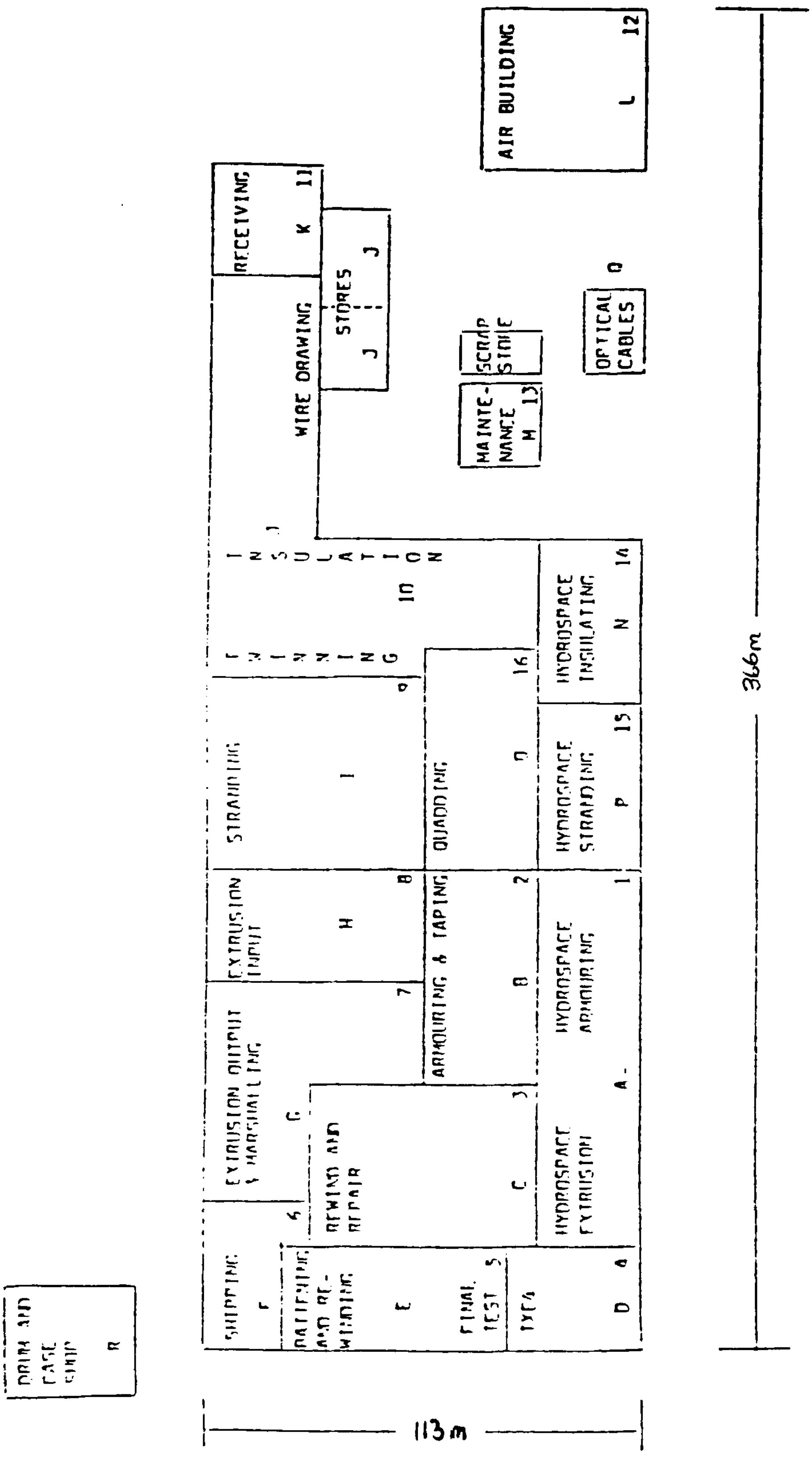
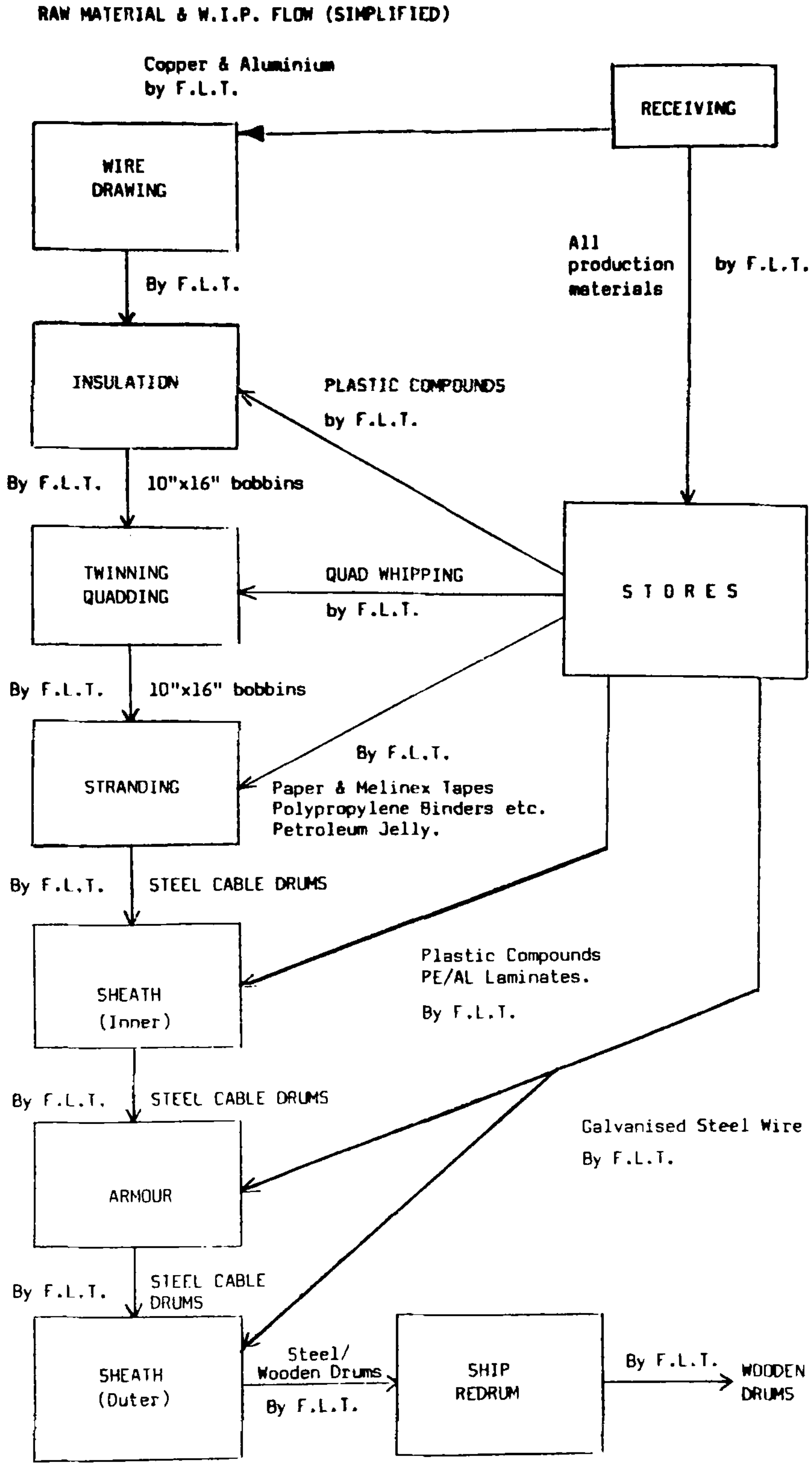


FIG. 2



Fork Lift Truck (F.L.T.)

4.2.1 RAW MATERIALS

Handling was carried out totally by fork lift trucks and was analysed using historic records for number of movements per unit time, distances travelled and thus the time taken; an example of the detailed analyses is shown in Tables 2, 3 and 4, Pages 27, 28 & 29 below.

Receiving was analysed over a 19 day period and the total materials throughput was tabulated - Table 2, to illustrate the item, its weight, the number of journeys required to complete movement of that item and the routing - ref. Fig. 1, Page 24.

The stores was analysed in exactly the same way using departmental log book entries and over a similar period.
An analysis was also carried out using the information available from Production Control (stock record card movements over a much longer period, 203 working days) in order to confirm that the above sample period was representative. The result is illustrated in Table 3, Page 28.

Calculating the time taken for mechanical movement by fork lift trucks, Table 4, was achieved by separating out all the elements within a journey for which there are known speeds/times (i.e. stop starts, straight travel, 90 bends, lift and lower etc.).

4.2.1.1 Results

Total time taken for movement through receiving mainly to stores was 2.2 hours per day.

Total number of trips made from stores to all parts of the factory per day: (By departmental log sample) 31, (By production control stock records) 33, with a total time taken of 2.5 hours per day. This comparison is quite acceptable considering that the production control sample is taken over 203 working days while the departmental log book sample is taken over 1 month.

TABLE 2

RECEIVING DEPT MATERIAL MOVEMENT

(SUMMARY SHEET)

DESCRIPTION	WEIGHT	NO. OF JOURNEYS	LOCATION (BY CODE REF.)
Aluminium foil	450 Kg	1	K - J
Lubricant	180 Kg x 12	12	K - J
Equipment	50 Kg	1	K - O
Copper rod	8473 Kg	6	K - J
Electrical supplies	1500 Kg	2	K - M
Compound	14 x 14 Kg	1	K - J
Acid	100 Kg	1	K - Q
Machine parts	4000 Kg	1	K - B
Flanges	1500 Kg	5	F - F
End weld	145 Kg	1	K - J
Sockets	200 Kg	1	K - J
Parts	100 Kg	1	K - H
Rewind line	2000 Kg	1	F - E
Binder tape	57 Kg	1	K - J
Paper tape	100 Kg	1	K - J
Galv wire	1990 Kg	1	K - J
Stapling equipment	100 Kg	1	K - J
Seals	76 Kg	1	K - J
Coils	178 Kg	2	K - J
Harness assemblies	100 Kg	1	K - J
Liquid	100 Kg	2	K - J
Galv wire	728 Kg	2	K - J
Power cable	280 Kg	1	K - J
Nylon	466 Kg	1	K - J
Outlets	1000 Kg	1	K - D

TABLE 3

STORES MATERIAL MOVEMENT

(SUMMARY SHEET)

MATL DESCRIPTION	WEIGHT/ QTY.	DESTINATION (BY CODE REF.)	NO. OF JOURNEYS
Chip flanges	500 Kgs	J - E	1
Stranded wire	1,140 Kgs	J - G	1
Aluminium foil	126 Kgs	J - H	1
Tinned copper wire	64 Kgs	J - B	1
1.5 mm P.V.C. string	7,500 mts	J - I	1
0.5 mm T.C.W.	420 Kgs	J - J	1
Paper tape	18 Kgs	J - J	1
Amp. housing blocks	10,000	J - D	1
Cream compound	2,000 Kgs	J - G	2
P.V.C. (S.F.2.)	3,000 Kgs	J - J	3
Schulmans	2,000 Kgs	J - H	2
Welvic	1,000 Kgs	J - G	1
I.C.I. Black	1,000 Kgs	J - G	1
BXL Poly	2,000 Kgs	J - H	2
BXL Poly	1,000 Kgs	J - N	1
Aluminium foil	84 Kgs	K - H	1
2.252 Al. wire	684 Kgs	J - J	2
Plywood flanges	200	J - E	1

TABLE 4

RAW MATERIALS DISTANCE AND TIME STUDY

(SUMMARY SHEET)

(Routing K - J)

Element of Journey	Number of Journeys and Distances	Speed and Time
Av. circuit distance	102m	
Total no. of journeys	611	
Total straight distance travelled	62,322m	
Truck data		2.0 m/sec.
Total straight travel time		8.7 hours
Av. no. of 90 turns at speed	6	
Total turns at speed	3666	
Truck data turns		0.047 min/turn
Total time for turns		2.87 hours
Stop/starts per journey	4	
Total stop/starts (i.e. accn./decn.)	2444	
Truck data accn./decn.		0.06 min per occasion
Total time (accn./decn.)		2.4 hours
No. of lift/lower and turn through 90 ready for straight travel (Off loading at start of journey 5')	600	0.4 min per occasion
Total time		= 4 hours.
(Drop to floor at end of journey 1')		0.3 min per occasion
Total time		= 3 hours.
Total time for K - J movement over the 1 month sample period.		21 hours

4.2.2 WORK IN PROCESS (W.I.P.)

The Departments involved in processing the raw materials into finished goods were mentioned in the previous pages and cover from wire drawing to battening.
All of these department's mechanical movements are again carried out by fork lift trucks, therefore the previous analysis methods were adopted.

4.2.2.1 Wire Drawing Results

Copper and aluminium are the input materials to the wire drawing area. Historical results, i.e. actual usage; and theoretical results, i.e. Business Plan calculations, were compared as shown below:

MATERIAL	USAGE (Te)	AV.WT/UNIT (Te)	PERIOD TAKEN	RESULTANT HAND'G
		(Actual Usage)		
COPPER	4029	3.1/PACK	203 DAYS	6.4 PACKS/DAY
ALUMINIUM	150	.128 /REEL	203 DAYS	5.8 REELS/DAY
		(1980 Budget Calculations)		
COPPER	4357	3.1/PACK	230 DAYS	6.1 PACKS/DAY
ALUMINIUM	65.31	.128 /REEL	230 DAYS	2.2 REELS/DAY

The copper actual and predicted comparison was very close but the aluminium comparison was particularly poor which indicated the caution needed when using the Business Plan for future predictions. The reasons for this difference were:

(1) Copper was quickly replacing aluminium as S.T.C.'s only telecommunication conductor, faster obviously than predicted in the business plan.

(2) Aluminium that remained in production was ordered in the diameter required for the insulation lines and therefore did not require wire drawing.

From the above 6.4 packs/day input to wire drawing, normal output was achieved with the following split:

6.4 supply packs of copper/day produce 16 internal packs/day. 75% i.e. 12 of the internal packs are output per day to tandem lines. (Combined wire drawing and insulating machines). The other 25% i.e. 4 are further worked to produce:

(a) Secondary drawn wire for the mono lines (insulating machines only).

(b) Tinned copper wire and fine wire for bunching and stranding.

A breakdown of the throughput capacities within the wire drawing section is shown in appendix 5.

The total time spent on the above movement by F.L.T. was:

1.3 hrs./day.

4.2.2.2 Insulation Through To Stranding Results

The areas involved with the movement of insulated core: twin and quad i.e. (insulation - twinning/quadding and stranding/lay up) were grouped together and analysed for total movement on 10"x 16" bobbins and the time taken.The end result being output from stranding on drums, in layed up cable form, example sheets are included overleaf, Tables 5 and 6 Pages 33 and 34. These detailed sheets are the theoretical analysis taken from the 1980 cable sample breakdown.

A flow diagram showing the routing and procedures involved between insulation and stranding/lay up is included in fig. 5, Page 35. Each handling stage in Fig. 5 was analysed and the total number of 10" x 16" bobbin moves per shift from beginning to end was:

778.

These bobbins were transported on stillages by F.L.T. and the total time taken for this movement was:

2.05 hrs/day.

However, this time does not include additional marshalling work (occasionally undertaken due to lack of space).

TABLE 5

ASSUMPTIONS: ALL ORDERS ARE EQUALLY DISTRIBUTED OVER THE YEAR
46 WEEKS/YEAR: 15 SHIFTS/WEEK
TOTAL BOBBINS MOVED PER SHIFT IS AN AVERAGE FIGURE

CORE BOBBIN MOVES PER SHIFT (INS^{G} TO STRAND^{G} & BACK)

	X			A	B	AB	C	ABC	2X.A B.D.	D	(Pairs) (2) X.A. B.C.D.		Pairs x 4 Moves Av (3) X.A. B.C.D.
Spec I.D.	No. of Pairs	Core Diam. (mm)	Max Length Per Bobbin (km)	Order Length (Per 1980 budget) (km)	Average Set Length (m) km	No. of Set Lengths per order (Not whole sets)	Shifts/Year	No. of Sets Per Shift	No. of Bobbins Per Order	No. of Sets Lengths per Bobbin	No. of Core Bobbins/Shift (Ins-Twin)	Total No. of Bobbin Moves (Mechanical)	Total Bobbins Moves/Shift
FA 0508 PLW/CELL	5	0.5	14	1300	7000 = 7	185.714	690	0.269	929	2	1.346	4	5.383
FA 0550 PLW/CELL	50	0.5	14	900	7	128.571	690	0.186	6429	2	9.317	4	37.267
FA 0600 PLW/CELL	100	0.5	14	595	7	85	690	0.123	8500	2	12.319	4	49.275
FA 7010 A1/CELL	10	0.5	24	400	12000 12	33.333	690	0.048	334	2	0.483	4	1.932
FA 7020 A1/CELL	20	0.5	24	350	12	29.167	690	0.042	584	2	0.846	4	3.382
FC 3450 PLW/CELL	50	0.5	14	80	7	11.429	690	0.016	572	2	0.828	4	3.313
FC 7100 A1/CELL	100	0.5	24	15	12	1.25	690	0.002	125	2	0.181	4	0.725
FB 0550 PLW/CELL	50	0.5	14	100	7	14.286	690	0.021	715	2	1.035	4	4.141
FB 0600 PLW/CELL	100	0.5	14	125	7	17.857	690	0.026	1786	2	2.588	4	10.348
FB 7100 A1/CELL	100	0.5	24	75	12	6.25	690	0.009	625	2	0.906	4	3.623
FC 3420 PLW/CELL	20	0.5	14	25	7	3.571	690	0.005	72	2	0.104	4	0.414
FD 1953 PLW/CELL	10	0.5	14	150	7	21.429	690	0.031	429	2	0.311	4	1.242
*ZZ 0693 PLW/CELL	50	0.5	14	80	7	11.429	690	0.017	572	2	0.829	4	3.313
FD 1958 PLW/CELL	75	0.5	14	60	7	8.571	690	0.012	643	2	0.932	4	3.727
FD 1959 PLW/CELL	100	0.5	14	50	7	7.143	690	0.010	715	2	1.035	4	4.141
ZZ 0614 PLW/POLY	50	0.5	14	80	7	11.429	690	0.017	572	2	00.828	4	3.313
FD 2115 PLW/CELL	15	0.5	14	125	7	17.857	690	0.026	268	2	0.388	4	1.553
FD 2150 PLW/CELL	50	0.5	14	50	7	7.143	690	0.010	358	2	0.518	4	2.07
*FD 2200 PLW/CELL	100	0.5	14	30	7	4.286	690	0.006	429	2	0.621	4	2.486
FA 1550 PLW/CELL	50	0.9	4	100	2000 2	50.00	690	0.073	2500	2	3.623	4	14.493
FA 7820 A1/CELL	20	0.7	12	150	6000 6	25.00	690	0.036	500	2	0.725	4	2.900
FA 78 0 A1/CELL	50	0.7	12	60	6	10.00	690	0.015	500	2	0.725	4	2.900
FA 3520 PLW/CELL	20	0.63	8	125	4000 4	31.25	690	0.045	625	2	0.906	4	3.623
FC 3810 PLW/CELL	10	0.9	4	500	2000 2	250.00	690	0.362	2500	2	3.623	4	14.493
FB 1550 PLW/CELL	50	0.9	4	20	2	10	690	0.015	500	2	0.725	4	2.900
FB 1830 PLW/CELL	30	0.9	4	33	2	16.5	690	0.024	495	2	0.717	4	2.87
AF 00271 TLW/PVC	Single	0.4	25	23000	25000 25	920	690	1.333	920		1.333	2	2.666

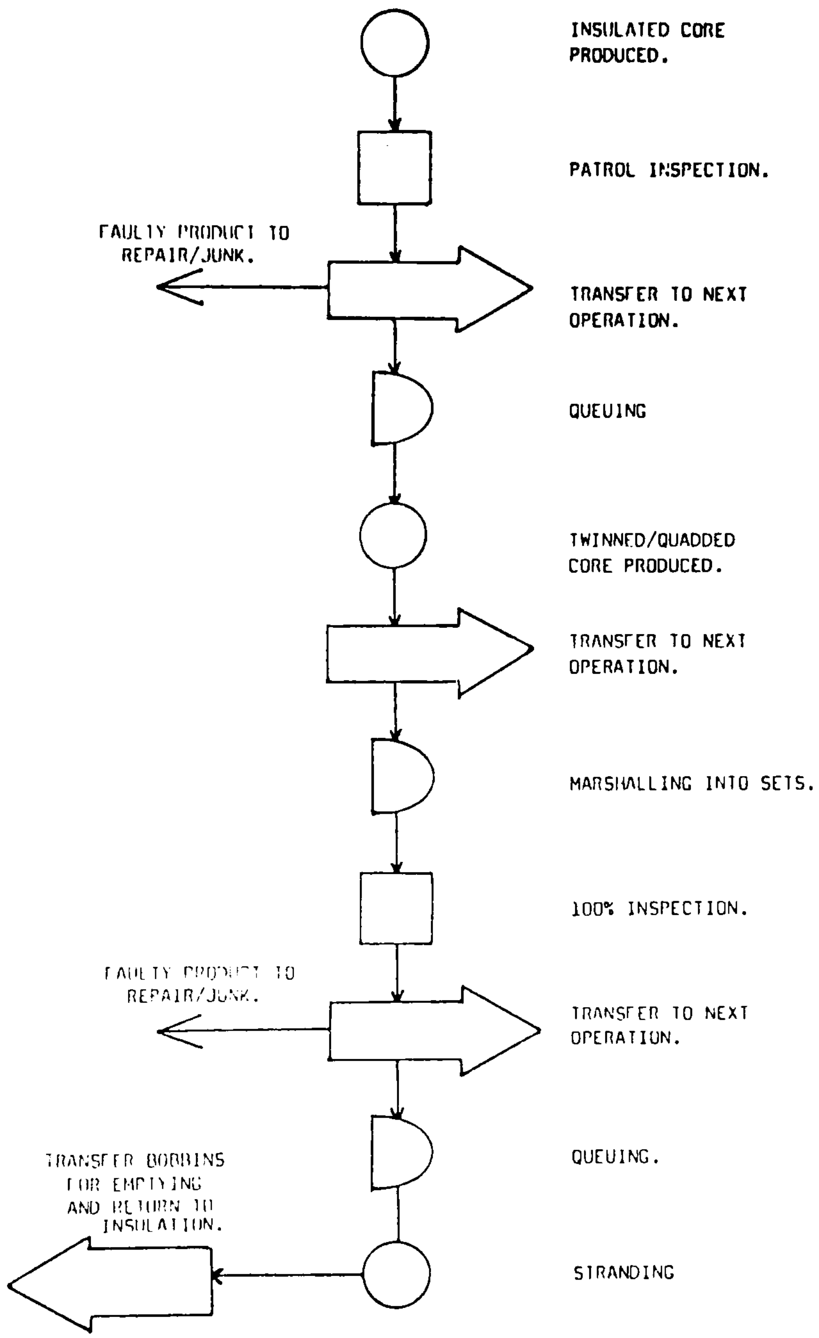
TABLE 6

1.2 MECHANICAL HANDLING DISTANCES & TIMES (INSULATING - STRANDING)

SPEC. I.D.	NO.OF PAIRS	CORE DIAM	NO. OF CORE BOBBINS TO MOVE/SHIFT	MACHINE CONCERNED	DISTANCE TO TRAVEL	DERATED TIME TAKEN PER JOURNEY	MACHINE CONCERNED	DISTANCE TO TRAVEL	TIME TAKEN	MACHINE CONCERNED
FA 0505	5	0.5	1.346	09 TL	13	0.014	D1 - 14 TW	47	0.050	05 ST
FA 0550	50	0.5	9.317	09 TL	13	0.098	D1 - 14 TW	158	1.141	02 ST
FA 0600	100	0.5	12.319	09 TL	13	0.130	D1 - 14 TW	158	1.508	02 ST
FA 7010	10	0.5	0.483	09 TL	13	0.005	D1 - 14 TW	12	0.005	11 ST
FA 7020	20	0.5	0.845	09 TL	13	0.009	D1 - 14 TW	12	0.008	11 ST
FC 3450	50	0.5	0.828	09 TL	13	0.0087	01 - 14 TW	158	0.101	02 ST
FC 7100	100	0.5	0.181	09 TL	13	0.002	01 - 14 TW	158	0.022	02 ST
FB 0550	50	0.5	1.035	09 TL	13	0.011	01 - 14 TW	158	0.127	02 ST
FB 0600	100	0.5	2.588	09 TL	13	0.027	01 - 14 TW	158	0.317	02 ST
FB 7100	100	0.5	0.906	09 TL	13	0.009	01 - 14 TW	158	0.111	02 ST
FC 3420	20	0.5	0.104	09 TL	13	0.001	01 - 14 TW	12	0.001	11 ST
FD 1953	10	0.5	0.311	09 TL	13	0.003	D1 - 14 TW	12	0.003	11 ST
ZZ 0693	50	0.5	0.828	09 TL	13	0.008	D1 - 14 TW	158	0.101	02 ST
FD 1958	75	0.5	0.932	09 TL	13	0.010	D1 - 14 TW	158	0.114	02 ST
FD 1959	100	0.5	1.035	09 TL	13	0.011	D1 - 14 TW	158	0.127	02 ST
ZZ 0614	50	0.5	0.828	09 TL	13	0.009	01 - 14 TW	158	0.101	02 ST
FD 2115	15	0.5	0.388	09 TL	13	0.004	01 - 14 TW	12	0.004	11 ST
FD 2150	50	0.5	0.518	09 TL	13	0.005	01 - 14 TW	158	0.063	02 ST
FD 2200	100	0.5	0.621	09 TL	13	0.006	01 - 14 TW	158	0.076	02 ST
FA 1550	50	0.9	3.623	14 TL	13	0.038	01 - 14 TW	158	0.444	02 ST
FA 7620	20	0.7	0.725	02 TL	17	0.010	01 - 14 TW	12	0.888	11 ST
FA 7650	50	0.7	0.725	02 TL	17	0.009	D1 - 14 TW	158	0.888	02 ST
FC 3520	20	0.63	0.906	13 TL	50	0.035	D1 - 14 TW	12	0.009	11 ST
FC 3610	10	0.9	3.623	14 TL	50	0.142	D1 - 14 TW	12	0.035	11 ST
FB 1550	50	0.9	0.725	14 TL	50	0.028	D1 - 14 TW	158	0.888	02 ST
FB 1530	30	0.9	[illegible]	14 TL	50	0.028	D1 - 14 TW	158	0.088	02 ST
AF 0027	SINGLE	0.4	1.333	21 ML						
						0.661			7.22	

FIG. 5

WORK FLOW (INSULATION - STRANDING)



4.2.2.3 Stranding Through To Battening Results.

The movement of materials from stranding through to battening was carried out by fork lift trucks (F.L.T.) and manual handling, and analysed in the same fashion as the previous section (insulation through to stranding). An example sheet is included below Table 7 Page 37. A flow diagram illustrating the routing is also included, Fig. 6, Page 38.

Within this area of W.I.P. doubt arose as to the validity of the theoretical or predicted throughput and hence materials handling. Therefore historical records in the form of machine log books were checked for a representative sample of the year, an example sheet is illustrated in Table 8 Page 39. The results were compared to the budget predictions and are explained as follows:

The result of the budget/cable sample breakdown analsyis was a total of:

49 drum moves per shift.

carried out jointly by F.L.T. and manual handling. The total time taken by F.L.T. only was:

10.2 hrs/shift.

Actual number of drums per shift across all stranders:

(15.4)

Theoretical number of drums per shift across all stranders:

(11.23)

The difference 4.17 drums per shift represented 27% of the actual movement which took place. The reasons for this variance and the proposed actions are shown in appendix 6.

For the purpose of the Data Base, the stranding through to final operations figures will include the 27% variance, i.e. will reflect what actually happens and the total moves and time taken will be:

Total drum moves by F.L.T./Shift:	62
Total time taken:	13.0 hrs.

TABLE 7

CABLE DRUM MOVES PER SHIFT (STRANDING ON TO REDRUM)
(SHIPPING DRUMS NOT INCLUDED)

Spec	I.D.	No. of Pairs	Core Diam. (mm)	Order Length (km)	Length Per Drum (km)	Drum Spec. (Code)	No. of Drums Per Order	Shifts/Year	No. Drums Per Shift	No. of Moves of Particular (Code)	Total No. of Drum Moves (Shift)	Drum Spec. (Code)	Length Per Drum (km)	No. of Drums Per Order	Drums Per Shift	No. of Moves of particular Drum (Code)	Total Moves/Shift	Grand Total Moves/Shift
FA	0606 PLW/CELL	5	0.5	1300	7	59	185.714	690	0.269	3	0.807	58	7	185.714	0.269	2	0.538	1.345
FA	0550 PLW/CELL	50	0.5	900	7	61	128.571	690	0.186	4	0.744							0.744
FA	0600 PLW/CELL	100	0.5	595	3 & 4	61	170	690	0.246	3	0.739	60	3 & 4	170	0.246	2	0.492	1.231
FA	7010 AL/CELL	10	0.5	400	12	59	33.333	690	0.048	3	0.144	62	12	33.333	0.048	2	0.096	0.24
FA	7020 AL/CELL	20	0.5	350	2 × 6	59	58.333	690	0.085	3	0.255	62	2 × 6	58.333	0.085	2	0.0170	0.425
FC	3450 PLW/CELL	50	0.5	80	7	63	11.429	690	0.016	4	0.064	61	7	11.429	0.016	2	0.032	0.096
FC	7100 AL/CELL	100	0.5	15	2 moves at 2 × 6 (4 × 6)	61	2.5	690	0.004	4	0.024							0.024
FB	0550 PLW/CELL	50	0.5	100	7	61	14.286	690	0.021	4	0.084	60 & 61	3, 4 & 7	60: 14.286, 61: 14.286	60: 0.021, 6: 0.021	60: 3, 6: 2	0.105	0.189
FB	0600 PLW/CELL	100	0.5	125	3 & 4	61	35.714	690	0.052	3	0.156	60	3 & 4	35.714	2 moves at 0.052	Effective No. 4	0.26	0.416
FB	7100 AL/CELL	100	0.5	75	2 × 6 (4 × 3)	61 (63)	12.5 & (25)	690	0.018 & (0.036)	3 & 2	0.126	61 & 60	4 × 3	25	2 moves at 0.036	2 & 2	0.144	0.270
FC	3420 PLW/CELL	20	0.5	25	7	58	3.571	690	0.005	3	0.015	61	7	3.571	0.005	2	0.010	0.025
FD	1953 PLW/CELL	10	0.5	150	7	59	21.429	690	0.031	2	0.062	59	2 & 1	85.716	0.124	2	0.248	0.310
FD	1958 PLW/CELL	75	0.5	60	7	61	8.571	690	0.012	3	0.036	63 & 58	2 & 1	34.284	0.05	2	0.100	0.136
FD	1959 PLW/CELL	100	0.5	50	4 & 3	61 & 62	14.286	690	0.020	3	0.060	62 & 63	2 & 1	28.572	0.041	2	0.082	0.142
FD	2115 PLW/CELL	15	0.5	125	7	58	17.857	690	0.026	3	0.078	59 & 62	2 & 1	71.428	0.104	4	0.416	0.494
FD	2150 PLW/CELL	50	0.5	50	7	63	7.143	690	0.010	3	0.030	62 & 59	2 & 1	28.572	0.0414	6	0.248	0.278
FD	2200 PLW/CELL	100	0.5	30	4 & 3	61 & 62	8.572	690	0.012	3	0.036	62 & 63	2 & 1	17.144	0.025	2	0.05	0.086
FA	1550 PLW/CELL	50	0.9	100	2	63	50	690	0.073	3	0.219	61	2	50	0.073	2	0.146	0.365
FA	7820 AL/CELL	20	0.7	150	2 × 3	59	50	690	0.073	3	0.219	62	2 × 3	50	0.073	2	0.146	0.365
FA	7650 AL/CELL	50	0.7	60	6	61	10	690	0.015	3	0.045	60	6	10	0.015	2	0.030	0.075
FC	3620 PLW/CELL	20	0.63	125	4	58	31.25	690	0.045	3	0.135	63	4	31.25	0.045	2	0.090	0.225
FC	3610 PLW/CELL	10	0.9	500	2	59	250	690	0.362	3	1.086	62	2	250	0.362	2	0.724	1.81
FB	1550 PLW/CELL	50	0.9	20	2	63	10	690	0.015	3	0.045	61 & 60	2	10	0.015	3 & 2	0.075	0.12
FB	1630 PLW/CELL	30	0.9	333	2	62	16.5	690	0.024	3	0.072	63 & 61	2	16.5	0.024	2 & 3	0.120	0.192
FA	6820 PLW/CELL	20	0.9	125	2	58	62.5	690	0.091	3	0.273	62	2	62.5	0.091	2	0.182	0.455
FD	3700 TLW/PVC	100	0.63	25	2 × 2	62	12.5	690	0.018	3	0.054	60	2	12.5	0.018	2	0.036	0.090
FA	0600 PLW/CELL	100	0.5	22.5	3 & 4	61	6.429	690	0.009	3	0.026	60	3 & 4	6.429	0.009	2	0.018	0.045

FIG. 6

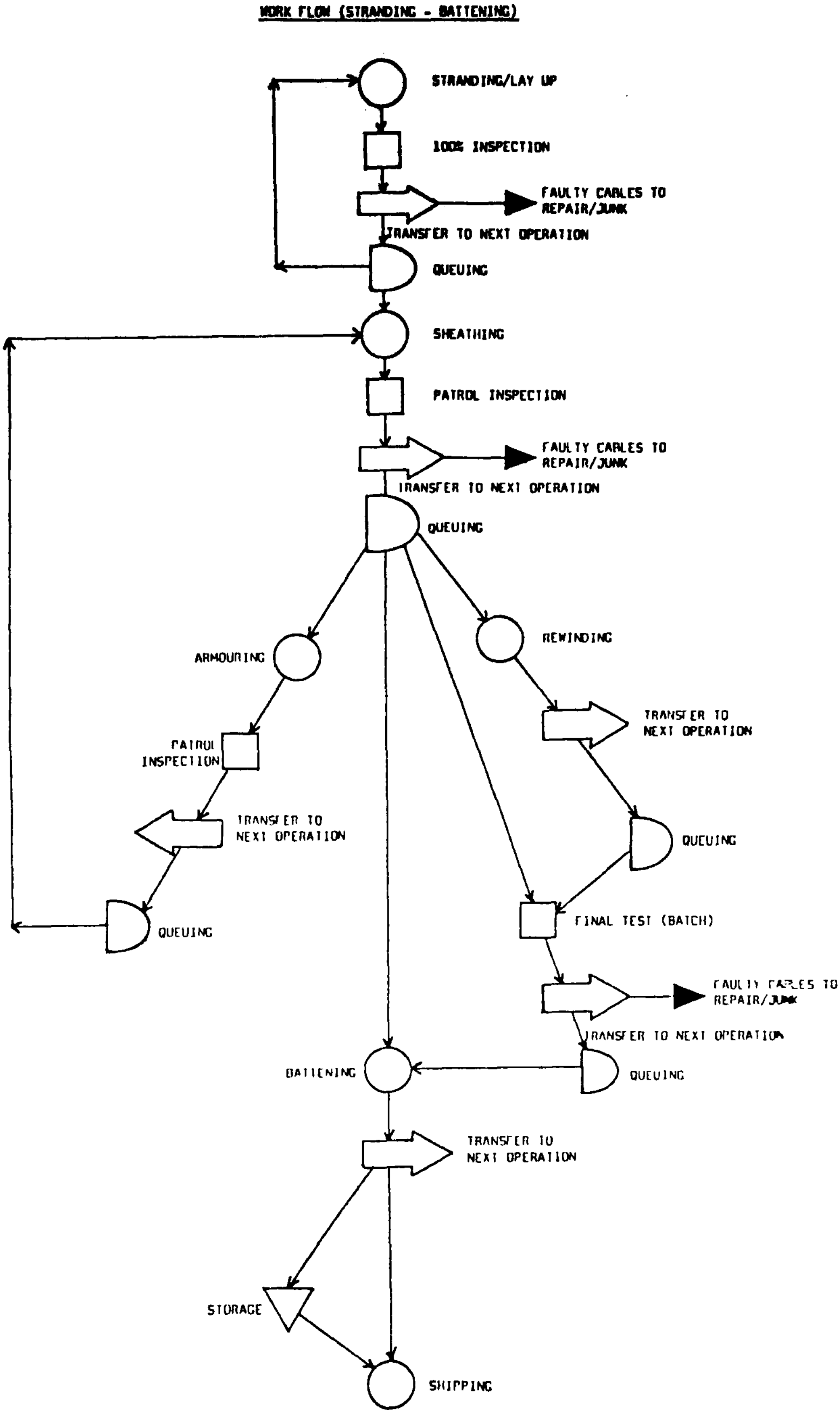

WORK FLOW (STRANDING - BATTENING)
STRANDING/LAY UP
100% INSPECTION
FAULTY CABLES TO REPAIR/JUNK
TRANSFER TO NEXT OPERATION
QUEUING
SHEATHING
PATROL INSPECTION
FAULTY CABLES TO REPAIR/JUNK
TRANSFER TO NEXT OPERATION
QUEUING
ARMOURING
REWINDING
TRANSFER TO NEXT OPERATION
PATROL INSPECTION
TRANSFER TO NEXT OPERATION
QUEUING
QUEUING
FINAL TEST (BATCH)
FAULTY CABLES TO REPAIR/JUNK
TRANSFER TO NEXT OPERATION
BATTENING
QUEUING
TRANSFER TO NEXT OPERATION
STORAGE
SHIPPING

TABLE 8

STRANDING (THROUGHPUT)

(SUMMARY SHEET)

(RESULTS TAKEN FROM MACHINE LOG BOOKS OVER A TWO MONTH REPRESENTATIVE SAMPLE OF THE YEAR'S PRODUCTION.)

MACHINE NUMBER	DRUMS/DAY	SHIFTS/DAY	DRUMS/SHIFT
0 4 D T (7' CORTINOVIS)	3	1	3
0 3 S T (6 BAY CONCENTRIC)	3	3	1
1 2 S T (126 BOBBIN CONCENTRIC)	3	3	1
0 3 D T (POURTIER)	4.4	3	1.5
0 1 D T (4' CORTINOVIS)	15.7	3	5.2
1 2 S T (12/24 BOBBIN CONCENTRIC)	3.8	3	1.3
0 4 S T (3 BAY CONCENTRIC)	4.8	2	2.4
0 2 D T (5' CORTINOVIS)	-	-	-
T O T A L S	37.7 DRUMS/DAY	18 M/C SHIFTS/DAY	15.4 DRUMS/SHIFT

Note: S.T. - Strander
D.T. - Drum Twister

4.2.3 FINAL OPERATIONS

Final operations encompassed material movement inside and outside the factory for marshalling and storage and drum and case shop activities. This analysis was taken from historical records, with Production Control drafting documents used to obtain the actual number of finished cables transported out of the factory. The drum size and weight was recorded for later use. Also analysed were tri-wall containers which were used for packing short coils of cable and connectors. All the movement of finished goods is again carried out by F.L.T., and the results were:

102 movements per day.

The time taken was calculated by taking an average circuit distance of 800 feet. The total distance travelled was 81,600 feet per day. Straight travel time took 3.06 hours.
Stop/starts, 90° turns, and lift/lower added a further 2.74 hrs., making a total time of 5.8 hrs/day. This was then increased to include loading and unloading lorries:

8 hrs.per day.

4.2.3.1 Drum and Case Shop

Drum and case shop activities being an integral part of final operations were analysed as follows:

Empty shipping drums are transported into the factory from the drum and case shop storage area. Log book entries were studied for this purpose and the results calculated as follows:

Storage to extruders	14 trips/day.
Storage to redrumming	10 trips/day.
Storage to redrum and extruders	6 trips/day.
Storage to extruder (Hydrospace)	2 trips/day.
Total:	32 trips/day.

This result is however, only the movement of empty drums into the factory. Within the drum and case shop materials handling daily routine are e.g. drums to spray booth for painting and stenciling; old drums to scrap; drum parts to drum and case shop for drum assembly; housekeeping etc.

Grand Total: 104 trips/day.

Distances were measured and calculated as circuit lengths, times were calculated using the F.L.T. operational data sheets. The different circuits with their varying number of turns, stop starts etc. were totalled and resulted in the following:

Straight travel time	2.3 hours.
90° turns	0.67 hours
Lift/lower, etc.	1.4 hours.
Storage and internal housekeeping	2.0 hours.
Total time taken	6.4 hours/day.

4.2.4 SCRAP COLLECTION

A one week study was undertaken to monitor the number of trips, type of work and collection areas in handling scrap from around the factory. A small department outside the main factory building handled and accounted for all the scrap collected, and all the scrap was handled by fork lift trucks.

The results of this one week study were as follows:- Ref.Table 9. Page 43.
The total number of separate journeys made from junk store to collection areas within the factory and back was calculated and averaged over the five days. The result rounded up, was:

21 trips/day.

Additional to the above work is the following:

Scrap wire coiled for junking in the main shop, Average movement: 12 trips/day.

Total circuits are therefore: 33 trips/day.

Approximately 3 lorries were loaded with scrap each week and each loading operation took 2 hours. Internal scrap store work, i.e. marshalling, feeding coiling and bailing machines, weighing etc. took: 2.1 hrs/day.

This gives an additional fork lift truck work time of: 3.3 hrs/day.

The results summarised are:

Wire basket scrap collection	1.5 hours/day.
Coils of scrap from Hydrospace	1.2 hours/day.
Lorry loading work	1.2 hours/day.
Internal marshalling and weighing	2.1 hours/day.
Total time:	6.0 hours/day.

4.3 SUMMARISING

Within the above analyses, the total movement of work and the time taken has been accounted for. The results so far have been expressed as either the number of trips or journeys made per day or, the amount of material moved per day or shift, the distances moved and the time spent on each handling activity.

For the purposes of analyses and justification of further materials handling projects, the above data base is now sufficient. Work flow routing; procedures; volume; and time taken have been covered.

TABLE 9

SCRAP COLLECTION MATERIAL MOVEMENT

(SUMMARY SHEET)

DAILY AVERAGE OF WEEKLY TOTALS

MATERIAL TYPE	COLLECTION AREA BY CODE REF.	NO. OF TRIPS	WEIGHT ALL LESS THAN 1500 KG
Insulation and twin scrap	O - M	14	"
Bunched cores	I - M	1	"
Cable and test ends	G - M	2	"
Fine wire	J - M	1	"
Armour wire (galv steel)	B - M	3	"

The circuit distances were calculated by pedometer and, using the operational data the time taken was achieved. Below is an example:

Circuit M-I-M Distance	1088
Average number of trips/day	14
Total time taken (includes straight travel 90° turns stop starts etc.)	50 mins
Circuit M-G-M Distance	2240
Average number of trips/day	2
Total time taken	12.70 mins

CHAPTER 5

INTERNAL TRANSPORT RATIONALISATION OPERATIONAL ANALYSIS

5.1 INTRODUCTION

Internal transport within Cable Products Division is solely carried out by fork lift trucks of various shapes and sizes, and, as mentioned in the previous chapter, is the most economical and flexible method of materials handling. However, the fork lift - truck fleet suffered the following problems:

(1) Excessive age and poor condition of the majority of trucks (average age 10 years, oldest trucks 24 years).

(2) The fleet capacity mix did not reflect current or predicted production requirements (insufficient heavy lift capacity trucks).

The consequences of the above problems were:

(A) Safety hazards were unavoidable.

(B) High downtime and maintenance costs (£62.5K in 1980).

(C) Too many trucks to provide a cost effective service. (42 trucks in total with an average downtime for the major portion of almost 15%)

It was felt that the above situation was sufficiently bad that all immediate efforts would be concentrated on the rationalisation of the above fleet making recommendations to provide the most economical and effective solution in view of pending product changes and possible dedicated handling systems. A Project Appropriation Request (P.A.R.) was drawn up to justify and recommend the course of action required.

This PAR is included in its entirety in Appendix (7) Page 120. The remainder of this thesis will endeavour to explain and quantify the statements, analyses, and conclusions, arrived at in the P.A.R. document.

Below is a summary of the methods used for The Operational Analysis.

1 Number and Capacity Mix of Fork Lift Trucks

A Data already available in Chapter 4.0 transformed into minimum number of trucks required and their capacities by adding job weight information.

B Extensive discussions with operating/supervisory personnel.

C Forward projections to ensure adequate cover over the following planned period using 1980-84 objectives.

2 Simulation Exercises

A Computer simulation for internal counterbalanced truck utilisation (heavier range).

B Computer simulation for truck downtime predictions used to estimate additional cover required.

3 Mode of Operation

A Running costs for the three types of fuel. (gas, electric and diesel)

B Capital cost of the relevant trucks.

C Ancilliary equipment required.

D Additional factors - (environmental considerations, level of maintenance, standardisation and manoeuvrability).

4 Organisation and Control

A Assess patrolling around circuit as used in computer simulation.

B Assess 2 way radio - communications.

C Assess manning situation.

5.2 SIZE AND CAPACITY MIX OF FLEET

To analyse F.L.T. movements, and their cost relationships, various methods were assessed. Linear programming was not in this case applicable, i.e. (Assignment, and transportation methods) due to the wide range of start and finish points, routes, loads, and outside influences such as blocked gangways and breakdowns etc. Simulation and basic work measurement techniques such as time and motion study and analytical estimating were applicable and were used as described herein.

The following information was extracted from the Base Data Study Chapter 4.

DEPARTMENT	HANDLING TIME TAKEN BY F.L.T.'s PER DAY.	TIME TAKEN INCLUDING RELAXATION ALLOWANCE AND OBSTACLES, DIVERSIONS, ETC. (30%).
Receiving	2.2 hrs	2.86 hrs
Stores	2.5 hrs	3.25 hrs
Wire Drawing	1.3 hrs	1.69 hrs
Insulation-Stranding	2.05 hrs	2.67 hrs * (plus additional marshalling)
Stranding - Battening	13.0 hrs	16.90 hrs
Final Operations	8 hrs	10.40 hrs
Drum and Case Shop	6.4 hrs	8.32 hrs
Scrap Collection	6 hrs	7.80 hrs

Two areas which were not covered in the Base Data Study (Chapter 4) were: The temporary (inflatable) building, used as a rewinding and storage house, and the outside marshalling, storage and retrieval of drums. The following data was built up for these Departments by analytical estimating and discussion with operating and supervisory personnel:

Air Building	1.1 hrs	1.43 hrs
Outside Operations	4.6 hrs	5.98 hrs
Total F.L.T. Handling Time		61.30 hrs

This theoretical figure for the handling time per day, must now be put into context with the practical constraints imposed by the operating logistics, capacity limitations, cover for breakdowns and margin for safety. The 30% allowance made above differs from the 50% stated in the Cranfield paper page 114 because the S.T.C.trucks are not turret trucks. Also, in consultation with the Industrial Engineering Dept., 30% was a more practical figure based upon work-study activity sampling within C.P.D., Newport.

* From analytical estimating the additional marshalling content was proposed at 1.3 hrs/day.

To complement the available data above, job weight calculations were made, detailed analysis sheets are included in appendix A of the P.A.R. document ref. Appendix 7 and also in Table 12, Page 51. Further investigations were made, to point out the number of smaller trucks within Departments which were used for internal marshalling and operational aids. To take account of: the distance separating various departments; control and organisation; cover for maintenance; shift patterns etc., the resultant number and capacity mix was as follows:- Tables 10 & 11, Pages 49 & 50.

TABLE 10

NUMBER AND CAPACITY MIX OF TRUCKS WITH ASSOCIATED AREAS (HEAVY RANGE).

ASSIGNED AREA	NO. OF TRUCKS	CAPACITY	TYPE
Receiving			
Wire Drawing	1	10,000 lbs.	C/B
Stores			
Insulation Lines	1	6,000 lbs.	C/B
Terminating			
Maintenance	1	4,500 lbs.	C/B
Junk Stores			
Stranding			
Sheathing	1	10,000 lbs.	C/B
Armouring			
Test and Repair			
Final Inspection	* 1	6,000 lbs.	C/B
Redrumming			
Battening	* 1	8,000 lbs.	C/B
Shipping			
Drum and Case Shop	1	6,000 lbs.	C/B
Hydrospace	1	15,000 lbs.	C/B
General Site	1	6,000 lbs.	C/B
Outside Operation	1	8,000 lbs.	C/B
Air Building	1	5,500 lbs.	C/B
Spare	1	8,000 lbs.	C/B
Total Large Capacity Trucks	12		

* Required to work double shift.

Note: C/B is counterbalanced.

TABLE 11

NUMBER AND CAPACITY MIX OF TRUCKS WITH ASSOCIATED AREAS (LIGHT AND MISCELLANEOUS RANGE)

ASSIGNED AREA	NO. OF TRUCKS	CAPACITY	TYPE
General Store	1	2,240 lbs.	Reach
Stranding, Test and Repair	2	3,000 lbs.	Stacker
Compound Store	1	3,000 lbs.	Reach
Insulation Lines, Twinning/quadding	1	3,000 lbs.	Reach
Junk Stores	1	3,000 lbs.	Reach
Wire Drawing	1	3,000 lbs.	Stacker
Terminating	1	2,240 lbs.	Pedestrian
	1	600 lbs.	Trucks
Garage	1	3,000 lbs.	Pallet(Flat Bed)
Admiralty	1	150 lbs	Hook
	1	2,240 lbs.	Trucks
Outside Operations	1	13,200 lbs.	Crane
Receiving	1	4,500 lbs.	Flat Bed
General and Maintenance	1	205 lbs.	Hook Truck
Spare	1	3,000 lbs.	Stacker
Total Small and Miscellaneous Trucks	16		

Note: Stacker and reach trucks are illustrated and identified in the P.A.R. Document, Appendix (7).

TABLE 12 JOB WEIGHT CALCULATIONS

= I.C.H.
= I - H.
= B - H.
= N - E.
= G.E.F.
= O.C.H.
= G - F
= G - B.
= I.C.I.
= I - I

JOURNEY DESCRIPTION	DRUMS PER SHIFT	K.G. TOTAL WEIGHT.
I.C.H.	0.269	353
	0.048	458
	0.085	442
	0.005	967
	0.031	525
	0.026	752
	0.073	434
	0.045	868
	0.362	459
	0.091	872
	0.127	716
	0.289	422
	0.024	522
	0.030	524
	0.007	488
	0.289	292
	0.182	4090
	0.114	4180
	0.117	3880
	0.023	2233
	0.006	1960
	0.002	2231 & 1216
	0.270	2007
	0.207	243
	0.115	435
	0.127	613
	0.007	2720
	0.001	4022
	0.009	3602
	0.059	3602
	0.047	3601
	0.016	1107
	0.009	1107
O.	0.447	420
	0.461	855
	0.024	663
	0.333	1461
	0.065	1758
	0.183	519
	0.041	1739
	0.044	899
	0.097	519
	0.048	1290
	0.004	1361
	0.012	1452
	0.052	1130
	0.030	757
	0.019	899
	0.016	1180
	0.022	1738
	0.120	3482 & 2468
P - D	0.005	434
I.C.E.	0.030	505

JOURNEY DESCRIPTION	DRUMS PER SHIFT	K.G. TOTAL WEIGHT
G.C.H.	0.186	2163
	0.246	1935 & 2453
	0.016	2147
	0.004	1850
	0.021	2162
	0.052	1928 & 2443
	0.018	1850
	0.012	3104
	0.020	2441 & 1746
	0.010	2145
	0.012	2443 & 1747
	0.073	1937
	0.015	1886
	0.015	1955
	0.024	1182
	0.015	1935 & 2453
	0.017	2140
	0.004	2331
G - H	0.725	1322
B - H	0.073	854
	0.051	3695
	0.289	1192
	0.034	2791
	0,024	1282
	0.004	1655
	0.017	2125
	0.007	3590
I - N	0.048	429
I - N	0.048	575
I.C.N.	0.073	326
N.C.E.	0.476	389
N - E	0.048	557
	0.211	400
	0.362	338
	0.096	438
	0.121	303
	0.015	400
O.C.O.	0.009	3729
O.C.O.	0.003	5019
O.C.N.	0.015	300
G - I	0.289	200
G.C.B.	0.017	1967
G.C.B.	0.007	1055
C - B	0.012	550

JOURNEY DESCRIPTION	DRUMS PER SHIFT	TOTAL WEIGHT
G.E.F.	0.807	569
	0.186	2590
	0.246	2270 & 2880
	0.048	809
	0.085	727
	0.016	7107
	0.008	2936
	0.005	1683
	0.124	315 & 223
	0.048	1322 & 686
	0.040	1607 & 844
	0.073	2243
	0.073	652
	0.015	2457
	0.045	1740
	0.362	905
	0.091	1075
	0.447	609
	0.015	2270 & 2880
	0.024	1740
	0.936	540
	0.072	364
	0.999	700
	0.195	812
	0.183	705
	0.041	2211
	0.088	658
	0.097	628
	0.144	530
	0.127	922
	0.060	574
	0.038	658
	0.032	754
	0.066	801
	0.073	1083
	0.051	4177
	0.289	1410
	0.034	3278
	0.024	1533
	0.004	1731
	0.007	4025
	0.036	669
	0.017	2700
	0.104	1185
	0.068	3033
	0.009	1300
	0.207	587
	0.115	1350
	0.127	1468
	0.024	411 & 318
	0.004	5832
	0.120	317
	0.036	3450
	0.004	2095
	0.019	2000

JOURNEY DESCRIPTION	DRUMS PER SHIFT	TOTAL WEIGHT
G - F	0.018	1000
	0.039	700
	0.042	900
	0.147	1000
	0.121	1100
	0.060	400
	0.097	1500
	0.145	1700
	0.144	1000
	0.335	500
	0.007	700
	0.725	1400
	0.009	3750
	0.018	1650
	0.578	250
	0.182	4650
	0.114	4700
	0.117	4900
	0.046	1500
	0.012	2100
	0.003	3300
G - B	0.021	2653
	0.052	2262 & 2869
	0.036	1284
	0.104	396 & 263
	0.040	902 & 481
	0.025	1609 & 845
	0.015	2249
	0.024	1424
	0.051	2099
	0.289	423
	0.034	1415
	0.024	705
	0.004	960
	0.207	269
	0.115	543
G - F	0.015	5800
	0.005	687
	0.018	2100
	0.059	2200
	0.094	2100
	0.016	1300
	0.007	4400
	0.003	4450 & 2100
G - A	0.127	776
G - A	0.004	2914
G - A	0.002	2995 & 1475
B.C.D.	0.012	561

JOURNEY DESCRIPTION	DRUMS PER SHIFT	TOTAL WEIGHT.
O.C.H.	0.018	911
	0.024	1370
	0.051	1666
	0.034	1177
	0.007	3387
	0.004	719
	0.725	1200
	0.013	1545
	0.014	1763
	0.147	770
	0.121	1298
	0.036	3217
	0.097	1707
	0.145	1905
	0.047	2524
	0.067	1946
I.C.I.	0.546	637
	0.912	637
	0.702	390
	0.138	1958
	0.059	956
	0.240	384 & 257
	0.026	1685
E - D	0.120	200
D. C. H.	0.120	300
I - I	0.004	3028
	0.077	409
	0.494	3875 & 1844
	0.006	3028
	0.006	407
	0.047	1073
	0.016	509
	0.009	509
	0.018	610
	0.014	369
	0.054	809
	0.059	2502
	0.282	2653
	0.096	902
	0.054	962
D - H	0.005	573
D - H	0.012	599
A - H	0.127	1106
A - H	0.004	5314
A - H	0.002	3045 & 1497

Discussions with Operating/Supervisory Personnel and Foreward Projections.

Communications with Operating Personnel took the form of extensive discussions with and logging of the various comments made by any and every fork lift truck driver, the battery attendant, and those fitters and electricians involved with the fleet. (6)(8)&(14)

Some of the more relevant comments were:

(a) Truck capacities in certain areas were insufficient.

(b) Safety hazards due to above.

1. Operators as well as the truck driver sitting on the back of trucks to add to counterbalanced weight with the truck bouncing up and down while in motion.

2. Excess wear and tear on all working parts due to operation over the rated capacity.

(c) Safety hazards due to lack of truck maintenance and reluctance by shop supervision to release trucks as:

1. Inefficient maintenance resulted in long periods of truck downtime.

2. Inability to manage without the use of a truck for which there was no replacement.

(d) Poor visibility and manoeuverability of certain makes and models.

(e) Trucks being used until their batteries were flat, instead of the recommended number of working hours per day. Other trucks being used for double shifts with only a short fast charge in between.

(f) Insufficient operational trucks to maintain handling continuity especially the heavy lift capacity trucks.

(g) In some areas, the truck was either not sufficiently equipped to tackle the job being undertaken, or the wrong truck type was in use.

All the above points were discussed with Supervisory Personel; both truck supervision and supervision within the departments being serviced, so as to separate the moans and groans from the legitimate points. A number of the above points reappeared during the analysis of choice of supplier in the following sections.

All these points contributed to the final number, capacity mix, operating area and optional extras required to undertake awkward or special operations effectively. A close look at the product mix and level of business in future years (illustrated below) from the 1980-84 Business Plan, provided the finishing touches to the planned total fleet characteristics. However, standardisation on capacity mix and the analysis of rent or buy, yet to be carried out, were also major factors in recommending the fleet size to cope with current and predicted workloads.

YEAR	B.P.O. *(MCM's)	% Increase/ Decrease	Total *(MCM's)	% Increase/ Decrease
1980	872	1.5	1757	2.4
1981	885	-1.0	1799	0.9
1982	876	0	1815	2.1
1983	876	0	1853	1.4
1984	876		1879	
Total	4385		9103	
Av. = 877/yr 0.6% increase in second year only			Av. 1820.6/ yr 3.6% increase in second year only	

* (MCM's) = million conductor metres.
B.P.O. = British Post Office.

5.3 SIMULATION EXERCISES

"The primary purpose of conducting simulation studies is to learn the most about the behaviour of the system being simulated for the lowest possible cost. To do so, we must plan and design carefully not only the model but also how it is to be run or used". Shannon R.E. (2).

The two main reasons for conducting the simulation exercise were:

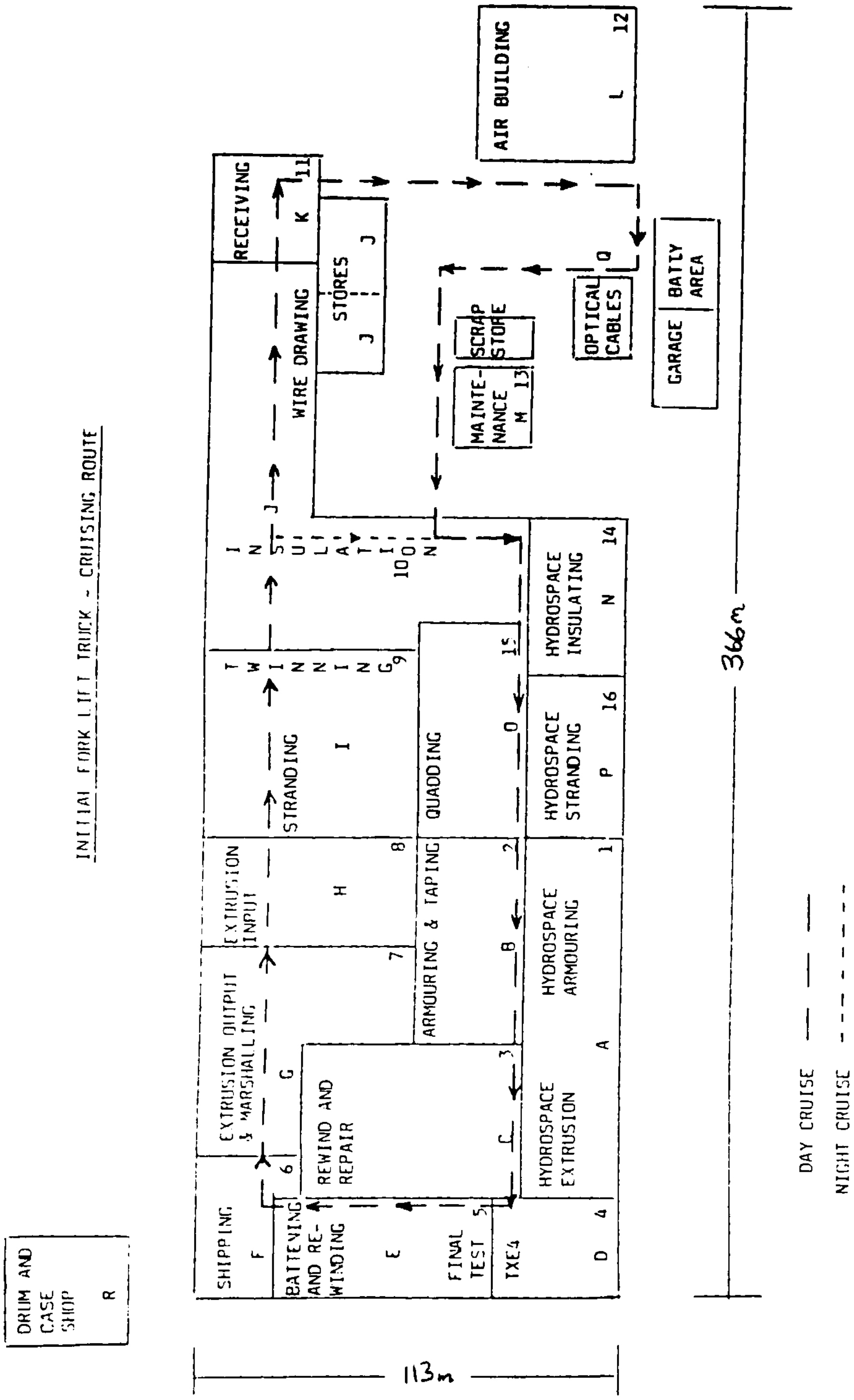
1. To provide a comparison for the previously calculated number of trucks required. (Counterbalanced trucks only).

2. To explore rapidly the effects of various system options.

To begin, the simulation model must be designed with realistic operating rules. In consultation with work study, it was found that a simulation model was being written in order to provide a fork lift truck driver bonus scheme. Analysing the design and operating rules for this simulation model illustrated that with some modification it could be used adequately to propose the number and capacity mix of all internally operated trucks. Therefore, one starts with a simple model and attempts to move in an evolutionary fashion towards a more elaborate model that reflects the complex situation more clearly.

One of the main operating rules did not simulate current conditions; however, it was necessary, in order to run the simulation at the cost and in the time required. This was the circuit, illustrated in Fig. 7. page 55. The following pages illustrate and explain the simulation programme and its results as they existed prior to modification which then included stores work and job weights for truck capacity simulation. A flow diagram was produced for the main truck simulation and is illustrated in Fig. 8, Page 61.

FIG. 7


INITIAL FORK LIFT TRUCK - CRUISING ROUTE
AIR BUILDING L 12
RECEIVING K 11
STORES J J
WIRE DRAWING
SCRAP STORE
MAINTE-NANCE M 13
OPTICAL CABLES Q
GARAGE
BATTY AREA
INSULATION 10
TWINNING 9
STRANDING I
HYDROSPACE INSULATING N 14
QUADDING O 15
HYDROSPACE STRANDING P 16
EXTRUSION INPUT H 8
ARMOURING & TAPING B 2
HYDROSPACE ARMOURING A 1
EXTRUSION OUTPUT & MARSHALLING G 7
REWIND AND REPAIR C 3
HYDROSPACE EXTRUSION
SHIPPING F 6
BATTENING AND RE-WINDING E
FINAL TEST 5
TXE4 D 4
DRUM AND CASE SHOP R
366m
113m
DAY CRUISE
NIGHT CRUISE

A study was made of the shop floor fork truck activity, recording the number of trips witnessed from one section to another; along with the dwell time at each section for each type of trip (26)(27) (28) & (31). Studies were also made of truck speeds in the factory.

From the above studies, the following information was derived:

1. The probability of a job needing to be transported from one section to another.

2. The associated dwell time of any such trip.

3. The truck running speed and hence journey time between locations.

4. From information on machine shift working, probability tables for afternoon and night shift working were derived.

Given the above information, the first requirement for simulations (i.e. historical data) is met. The requirement for random numbers can be met by the computer. This leaves the sole requirement of operating rules.

These were fairly simple to formulate, after the basic assumption that any truck which is empty will take any job available on the section it is passing, i.e. an empty truck will pick up a job, and after the associated journey and dwell time have elapsed will become available for a further job in the destination section. The disadvantages of the circuit principle were that all trucks when unloaded looking for a job would patrol the circuit which would require every operator to be familiar with the whole site and all jobs, their identification and destination. Also, the capacity of trucks must be suited to the job weight, and, the sending of all trucks around areas of heavy and light jobs would create a less efficient service than concentrating trucks in their suited areas.

However, - "Any set of rules for developing models has limited usefulness at best and can only serve as a suggested framework or approach". Shannon R.E. (2)

The above programme was now modified to include the job weights previously calculated by splitting them up into specific bands relating to the mix of trucks required. At this point the standardisation of truck capacities had to be considered. Once the bands had been decided, the probabilities of the various weights were calculated. These probabilities were then added to the simulation programme at the point of job generation. Stores work was also added to the simulation using base data job frequencies and the weight calculations as above.

Numerous simulations were run to achieve an optimum capacity mix of trucks with high sensitivity (low number of jobs waiting at any time). A sample printout is illustrated in Figs. 9 and 10, Pages 62 and 63, with the format and representation explained thereafter.

The remaining problem was, how an empty truck in an empty section would find work. For the purposes of the simulation, it was decided that empty trucks would cruise the factory according to a fixed route "looking" for work. ref. Fig. 7, Page 55.

So according to the above rules a programme was written to simulate fork truck activity from 6 a.m. until 6 a.m., reductions were made for start up, close down, and tea breaks (30 mins. per shift) giving a total run time of 1350 minutes.

Example of Result Formats

Number of Trucks	6	6	6	6	6	6	5
Truck Occupations (%)	86	79	80	88	85	84	91
Total Jobs	715	714	697	719	712	707	679
Average number of jobs waiting per run	11	5	6	9	9	9	27
Jobs left at completion	1	1	2	4	4	2	10

It can be seen from the above results that with 6 trucks working on the circuit principle there is always 1 or more jobs left at the close of simulation. Also, the average number of jobs waiting per run increases quickly if less than 6 trucks are used.

Print Out (ref. Fig's. 9 &10, Pages 62 & 63)

Columns 1-16 (A-P) represent the identified sections within the factory. (See below and fig. 7)
The next columns (1-6) show information regarding truck activity. A number in the column shows that the truck is loaded, and the number itself is the destination of the job being carried. A pair of letters, indicate unloaded, and show the area of the factory the truck is cruising in.
The final column is printed as a graphical representation of the number of jobs waiting. The integer being the number of minutes into the simulation (from 6.00 a.m.) and the mantissa, the number of jobs generated during the previous 15 minutes.

Section Identification

Designation	Main Machine or Activity
1 (A)	Francis Shaw Extruder
2 (B)	Armourers
3 (C)	H.V. Test
4 (D)	TXE4/Braiding
5 (E)	Redrum/Battening
6 (F)	Shipping
7 (G)	Extruder Take Up
8 (H)	Extruder Supply
9 (I)	Drum Twisting
10 (J)	Insulation Lines/Wire Drawing and Stores
11 (K)	Receiving
12 (L)	Air Building
13 (M)	Junk Store
14 (N)	Hydro Extrusion/Maillefers
15 (O)	8 Bay Strander
16 (P)	18/12 Strander
(Q)	Hydrospace Terminating. (Inserted in cruise pattern due to excessive distance between air building and junk store)

The numbers under sections 1-16 represent jobs generated:

Units	=	Jobs of 0-4,000 lbs.
Tens	=	Jobs of 4-6,000 lbs.
Hundreds	=	Jobs of 6-8,000 lbs.
Thousands	=	Jobs of 8-15,000 lbs.

The column of numbers in brackets represents the number of jobs waiting in that minute and is a total of all the 16 sections. The rows of numbers at the bottom of the results represent in turn:

1. The number of jobs in each different weight band generated in the corresponding sections, and the totals. (These weight bands i.e. job weights are 0-2000 lbs; 2-4000 lbs; 4-6000 lbs; 6-8000 lbs; 8-10000 lbs; and 10-15000 lbs).

2. The total number of jobs generated in each section.

3. The average waiting time for jobs in that section.

4. The longest waiting job in that section.

FIG. 8

SIMULATION MODEL FOR FORK LIFT TRUCKS
(FLOW DIAGRAM)
INITIAL CONDITIONS

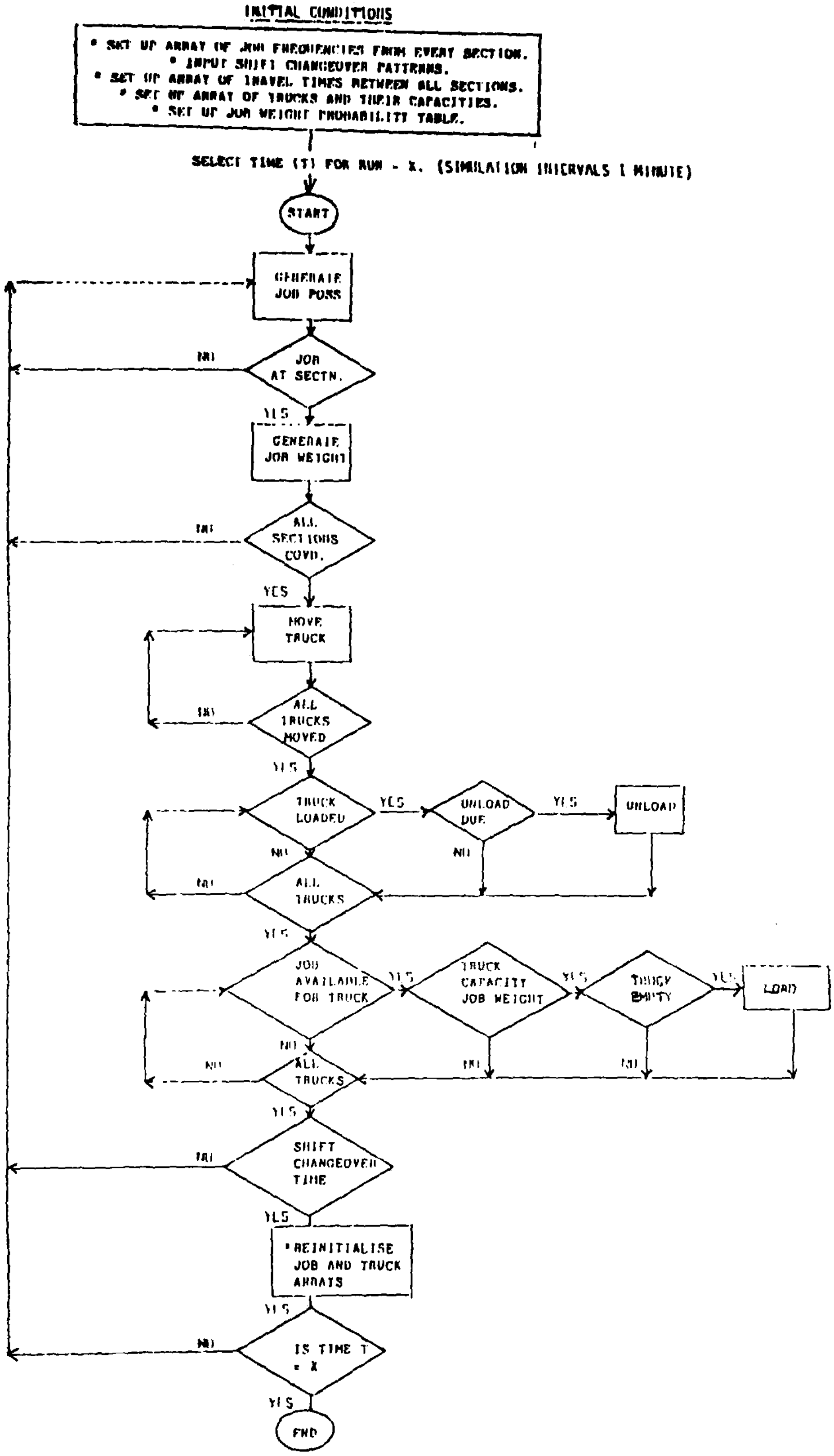


FIG.9

```
ROUTE S005T011 S032T023
LINE 230
ON AT 16:05    11/02/81  WEDNESDAY  UK2
WELCOME TO THE IBM CALL SERVICE.
USER NUMBER,PASSWORD--VUA501,ANYTHING
READY

LOAD FTSINEIL
READY

RUN

FTSINEIL    16:06    11/02/81  WEDNESDAY  UK2

INTERVAL IN MINS THAT PRINT IS REQ
? 15
```

6:00 AM TO 6:00 AM
6:00 AM TO 10:00 PM
ONE SHIFT (DAYS)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P		15	4 6	8	4	4	4	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		1	2	3	4	5	6	
1													1			(2)	10	FG					15.07
	1			1			1	101	2							(7)	5	1					30.11
	2					2	1	101								(7)	5	10					45.07
	1			11			1	100								(5)	NQ	5					60.03
				4		10	2	102	2							(12)	5	7					75.13
				4		21		102	3					1		(14)	5	5					90.07
1				2		21	1	102	4					1		(15)	10	5					105.05
1									2	3	1	2			2	(11)	2	2	6	11	3	HI	120.17
	1	2				10				4	3	1			4	(16)	5	5	8	11	JJ	14	135.21
	1	13		2		4	1			3	4				3	(22)	11	13	15	11	11	15	150.21
	2	3	1	2	1	3	1	1	2	3	3			2	2	(26)	3	12	5	11	11	5	165.19
1	3	1	1	1		35	1	1	2	1	2			3	4	(29)	15	10	10	16	12	12	180.19
2	2	2	3	11		36				1			1	4	2	(28)	3	11	13	10	15	15	195.19
2	1002		2	16	1	36						1		2	4	(31)	6	8	16	10	13	13	210.18
2	1		1	7	1	34		11	1	1		1			4	(28)	8	12	5	16	10	5	225.16
2				3	1000	24		2	1	5		2	1		5	(28)	9	11	5	10	14	8	240.17
2		1		1	1001	14			2	3	1	2			5	(24)	8	11	11	11	13	11	255.13
2	1	4	1		1003	3		2	3	2	2	1		1	5	(31)	3	11	11	5	15	11	270.15
2	2	3		101	1003	2		2	4	2	2				4	(29)	4	16	7	6	15	7	285.18
2	2	2			3			1	6	3	1			2	3	(25)	6	14	6	6	10	7	300.13
2	2	2			1000			2	4	4		1		2	3	(23)	8	11	7	12	8	11	315.16
2	2	3			1000				1	5					2	(16)	15	13	2	12	11	11	330.09
1	1	1			1010				3	4				1	2	(15)	13	6	12	11	11	11	345.12
1	2	4			1000	1			5	1			1		2	(18)	3	10	6	2	11	10	360.17
1	3	4		1	2000	1	1								3	(16)	13	15	6	3	5	5	375.18
1	4	4			2000				1		1			1	3	(17)	13	10	2	1	12	7	390.16
	3	7			2000								1		3	(16)	15	FG	6	FG	12	11	405.12
1	4	9		2	1000		2									(19)	6	6	6	13	JJ	12	420.15
	3	12					1		3					1		(20)	6	5	FG	8	5	1	435.11
	3	14	1	2	1001	1									1	(24)	8	6	14	5	12	13	450.19
	2	14		12	1001	1	1						2		1	(26)	KL	6	12	15	7	6	465.20

FIG.10

E	G	H	I	J	N	O			
	6		1000			1	(8)	1	945.02
	3	1	1000	1	1	1	(8)	5	960.03
	2	1	1000	1	1	1	(7)	10	975.02
	2				1	1	(4)	7	990.02
					1	1	(2)	HI	1005.01
				1			(1)	HI	1020.02
	1			1			(2)	DE	1035.02
	1						(1)	PA	1050.02
							(0)	3	1065.01
							(0)	DE	1080.02
							(0)	10	1095.03
	1						(1)	PA	1110.02
							(0)	BC	1125.01
							(0)	NO	1140.01
							(0)	JJ	1155.02
							(0)	10	1170.03
1	1						(2)	BC	1185.04
							(0)	JJ	1200.02
2			1				(3)	BC	1215.04
		1	1		1		(3)	5	1230.03
				2	1		(3)	11	1245.03
1							(1)	5	1260.02
1		1					(2)	10	1275.03
	1	1		2			(4)	5	1290.04
		1					(1)	BC	1305.00
							(0)	NO	1320.00

SECTIONS.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	TOTAL	JOB WEIGHTS (lbs)
	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	10-15,000
	0	1	0	0	1	3	1	0	1	0	0	0	0	0	0	0	7	8-10,000
	0	1	1	0	2	0	2	0	2	0	1	0	0	0	1	0	10	6-8,000
	0	0	4	0	5	7	17	0	1	0	0	0	0	0	2	0	36	4-6,000
	5	5	2	0	5	15	21	0	1	0	8	0	0	0	6	0	68	2-4,000
	14	27	47	13	99	8	63	37	33	116	39	27	22	19	27	27	618	0-2,000
TOTAL JOBS	19	34	54	13	112	35	104	37	38	116	48	27	22	19	56	27		
AV WAITING TIME	54	73	79	24	13	14	25	14	25	17	20	17	13	27	42	39		
LONGEST JOB WAITING	193	243	285	86	69	114	119	72	91	114	103	68	105	104	143	101(	16)	

TRUCK UTILISATION.

15 8/4 6 4 4 4

85 94 94 94 93 92% UTILIZED

```
NUMBER OF TRUCKS      =      6   ACTUALLY = 7.
TRUCK OCCUPATION (%)=        91
TOTAL JOBS            =      741
AVE NO WAITING / MIN=        16
JOBS LEFT             =      0
  M/C UTILISATION & WORK STUDY DEPT      TEACHING COMPANY SCHEME

PROCESSING   151 UNITS

OFF
OFF AT 16:22
PROCESSING...  151 UNITS;  TERM. TIME...   17 MIN.
```

The conclusions drawn from the simulation runs were as follows:

All jobs were handled adequately with 7 trucks of the following capacity mix:

1 x 15,000 lb	)	
1 x 8,000 lb	)	All internal operation
1 x 6,000 lb	)	
4 x 4,000 lb	)	

Trucks not covered by the simulation runs, within the counterbalanced category, and required from the base data calculations were:

1 x 8,000 lb	Outside operations
1 x 6,000 lb	Drum and case shop
1 x 5,500 lb	Air building (internal)

Due to the nature of the 15,000 lb capacity truck, (i.e. specially adapted and originally bought with the intention of operating solely within the Hydrospace Area and for very heavy lifts, equipment etc.) this truck was deleted from the analysis and replaced by an additional 10,000 lb. capacity standard truck.

Thus the end result of the simulation exercise in number and capacity mix of counterbalanced trucks was 11 trucks in total excluding any spares for maintenance and of the capacity mix above. Without going into depth on the requirement for maintenance cover which is covered in the following sections, to allow 1 spare - counterbalanced truck as has been done in the previous calculations gives the same total of 12 trucks.

The capacity mix is different, however, because no allowances have yet been made for standardisation and future job weight predictions. The previous calculations pages 49 & 50, do take this into account and are the results of combining information already available with the information gathered from 1 & 2 below:

1. Extensive discussions with operating/supervisory personnel.

2. Forward projections to ensure adequate cover over the planned period using 1980-84 objectives.

COMPUTER SIMULATION FOR TRUCK DOWNTIME

The initial objective of truck downtime calculations was to superimpose a programme into the original simulation programme. The expected operation being: a simulation programme which would generate jobs and their weights in the various shop sectors; draw from a pool of suggested trucks in order to maximise handling efficiency while including the generation of fork lift downtime, according to the calculated probabilities.(27)(31) However, due to the constraints mentioned previously: cost and time, and the smaller reach and stacker trucks not having been included in the original simulation, it was decided to approach the Computer Department at the Polytechnic of Wales. It was agreed that a member of the Computer Department would write a separate programme to simulate the occurrences of all fork lift truck breakdowns, and subsequently the length of downtime. The shift patterns and operating hours used in the main simulation programme would be used but, instead of simulating downtime against a truck working to the pattern and efficiency dictated by the main programme; this exercise would simulate downtime against continual operation within the shift patterns.

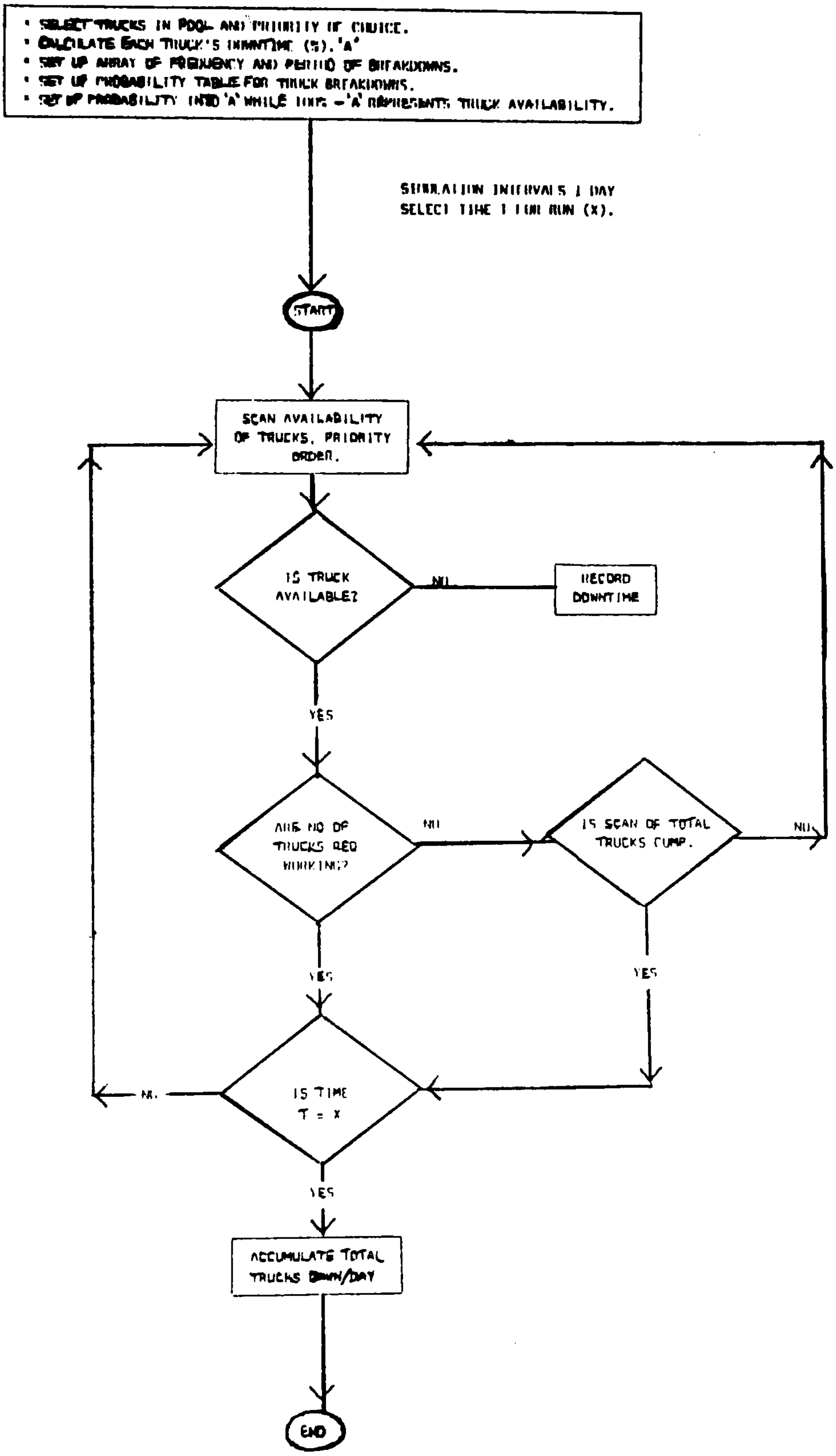
Shown in Fig. 11, Page 66 is a flow diagram, drawn to aid the programming of truck breakdowns and downtime simulation.

FIG. 11

SIMULATION MODEL FOR FORK LIFT TRUCK DOWNTIME.

(FLOW DIAGRAM)

INITIAL CONDITIONS



OPERATING RULES

A fleet of trucks would be specified to act as a pool, the capacity mix and exact number required being those suggested within the previous sections. Added to this would be two or three spare trucks, either new or the best of the existing fleet trucks.

Simulating daily time periods would then illustrate the need for, and number of, extra trucks required over and above the previously suggested fleet size. The need here, represented the experimenter's analysis of the number of occasions and duration, extra trucks were required; thereby assessing the alternative of not replacing a spare truck when a main fleet truck was brokendown for short periods. This illustrates the fact that:

"Simulation models are incapable of generating a solution on their own in the sense of analytical models; they can only serve as a tool for the analysis of the behaviour of a system under conditions specified by the experimenter". Shannon R.E. (2).

Data Collection

The following data was required for the simulation programme to be written:

1. Historical maintenance figures for 1980 analysed to produce each trucks percentage downtime for that year.

2. Analysis in depth to identify each separate occasion per truck and the length of time out of service.

3. Probability tables for each truck depicting initially the likelihood of a breakdown, i.e. the number of separate occasions broken down as a percentage of the total number of working days. ref. Table 13, Page 70.

4. From the above percentages, further tables are built up illustrating the probability (when broken down) of a certain period of downtime. ref. Table 14, Page 71.

5. With the above probabilities calculated, the cumulative probabilities will enable the data to be simulated using random number generation by the computer. Detailed analysis sheets are shown in Appendix 8.

We now have the data in the form required to produce a simulation model. The following is an explanation of the detailed sheets illustrated below.

Given that the probability of a truck being down was calculated to be 30% and the following table represents the probability of different downtime periods:

Downtime (days)	1	5	10
Actual Probability	.2	.6	.2
Cumulative Probability	.19	.79	.99

The above cumulative probabilities represented only the 30% downtime as 0 - .30 was the proportion broken down while .30 - .99 was the proportion working. Therefore if we required the simulation to work quickly and easily one random number generation would be sufficient to stipulate truck up or down, and if down for how long. The above probabilities were therefore converted as follows:

.99 refers to 30% likewise .79 becomes $\frac{.79}{.99} \times .3 = 0.24$

and similarly .19 becomes $\frac{.19}{.99} \times .3 = 0.6$

Thus the complete probability or random number table would be as shown:

	Downtime			Uptime		
Downtime (Days)	1	5	10	0	0	0
Random Number	006	024	030	100	100	100

Various simulations were carried out to:
(a) Identify the best suited old trucks to retain in the main fleet and:
(b) To simulate the continual operation of this fleet by drawing from a pool of the remaining best trucks/or new trucks.

This exercize indicated the total number of trucks making up the recommended fleet. The higher the percentage of old trucks retained in the fleet the higher the number of spare trucks required, and vice versa. The final number and capacity mix was chosen with suitability, maintainability, reliability, standardisation and cost as the main concerns. The results indicated that 1 new spare counterbalanced truck and 1 old spare reach truck would adequately cover for predicted maintenance levels while keeping the total fleet running costs to a minimum. An example of the computer runs is illustrated below. ref. Fig's. 12 and 13, Pages 72 & 73.

N.B. New trucks were simulated by using the maintenance history of the most efficient truck on site.

TABLE 13

CALCULATION OF FORK LIFT TRUCK DOWNTIME PROBABILITIES

* LT 109 4,000 lb.

1	3	4	9	55
1	3	1	1	1
.14	.43	.14	.15	.14
13	56	70	85	99

* LT 118 4,000 lb.

1	2	3	5
17	5	2	4
.61	.17	.07	.14
60	78	85	99

* LT 119 4,000 lb.

1	2	3	4	17
11	3	2	1	1
.61	.17	.11	.05	.06
60	77	88	93	99

* LT 135 4,000 lb.

1	2	3	4	6	7	86	PERIOD DOWN.
7	2	2	1	1	1	1	NO. OF OCCASIONS.
.47	.13	.13	.07	.07	.07	.06	ACTUAL PROBABILITIES.
46	59	72	79	86	93	99	CUMULATIVE PROBABILITIES.

* LT 136 8,000 lb.

1	2	4	6	24
21	4	2	1	1
.73	.14	.07	.03	.03
72	86	93	96	99

LT 137 (4,000 lb.)

1	2	3
9	4	2
0.6	0.27	0.13
59	86	99

LT 138 (4,000 lb.)

1	2	6
4	1	1
0.67	0.17	0.16
66	83	99

LT 140 (4,000 lb.)

1	2	4	5
12	4	1	1
0.67	0.22	0.6	0.5
66	88	94	99

LT 164 (6,000 lb.)

1	2	6
4	3	1
0.5	0.38	0.12
49	87	99

* LT 169 6,000 lb.

1	2	5	24
6	1	1	1
0.67	0.11	0.11	0.11
66	77	88	99

* LT 216
15,000 lb.

1	2
11	1
0.92	0.08
91	99

LT 161
(6,000 lb.)

1	2
16	6
.73	.27
72	99

LT 196 (4,500 lb.)

1	2	8	16	24	96
1	3	4	1	2	1
.08	.25	.33	.08	.17	.08
8	33	66	74	91	99

LT 142 (7,000 lb.)

2	5	16	24	32	72	200	400
15	11	2	3	1	1	2	1
.4	.31	.06	.08	.03	.03	.06	.03
39	70	76	84	87	90	96	99

LT 138 (4,000 lb.)

8	16	24
2	1	2
.4	.2	.4
39	59	99

* Current fleet trucks used in simn. (taking worst trucks first).

TABLE 14

CALCULATION OF INTEGER NO'S FOR USE ON TRUCK DOWNTIME SIMULATION WHEN GENERATING RANDOM NO'S

PRIORITY	F.L.T. NO. LT...	WEIGHT (X 1000 LB)	BREAK DOWN	WORK DAYS	PROB. X 1000	PROBABILITY OUT OF 1000 OF A TRUCK BEING DOWN AND IF DOWN THE NO OF DAYS.							
8	109	4	7	221	32	1 4	3 18	4 23	9 27	55 32	0 1000	0 1000	0 1000
12	118	4	28	265	107	1 65	2 84	3 92	5 107	0 1000	0 1000	0 1000	0 1000
10	119	4	18	267	67	1 41	2 52	3 60	4 63	17 67	0 1000	0 1000	0 1000
11	135	4	15	187	80	1 37	2 48	3 58	4 64	6 69	7 75	85 80	0 1000
6	136	8	29	241	120	1 86	2 103	4 112	6 115	24 120	0 1000	0 1000	0 1000
4	137	4	15	287	52	1 31	2 45	3 52	0 1000	0 1000	0 1000	0 1000	0 1000
7	138	4	6	294	20	1 13	2 17	6 20	0 1000	0 1000	0 1000	0 1000	0 1000
9	140	4	12	287	63	1 42	2 56	4 60	5 63	0 1000	0 1000	0 1000	0 1000
5	161	6	22	289	76	1 55	2 99	0 1000	0 1000	0 1000	0 1000	0 1000	0 1000
2	164	6	8	291	27	1 13	2 24	6 27	0 1000	0 1000	0 1000	0 1000	0 1000
3	159	6	9	259	33	1 22	2 26	5 29	24 33	0 1000	0 1000	0 1000	0 1000
1	216	15	12	295	41	1 38	2 41	0 1000	0 1000	0 1000	0 1000	0 1000	0 1000
SPARE	139	4	5	290	17	8 7	16 10	24 17	0 1000	0 1000	0 1000	0 1000	0 1000
	195	4.5	12	275	44	1 4	2 15	8 30	15 34	24 40	56 44	0 1000	0 1000
	142	7	30	193	187	2 78	5 135	15 145	24 161	72 171	200 181	400 187	0 1000

FIG. 12

How many periods to be simulated ? 365

There are 12 trucks in the pool, how many do you wish to use ? 12

How many trucks needed for work ? 9

Do you wish to use the same random no. for each truck ? N

Period 1	Trucks used	216 , 15	300 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	161 , 6	196 , 4.5	1
	Trucks down	166 , 10 , 1									
Period 2	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	161 , 6	0
	Trucks down										
Period 3	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	161 , 6	0
	Trucks down										
Period 4	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	161 , 6	0
	Trucks down										
Period 5	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 5	169 , 6	161 , 6	0
	Trucks down										
Period 6	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 5	169 , 6	161 , 6	0
	Trucks down										
Period 7	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 5	169 , 6	161 , 6	0
	Trucks down										
Period 8	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	161 , 6	0
	Trucks down										
Period 9	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	161 , 6	0
	Trucks down										
Period 10	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	161 , 6	0
	Trucks down										
Period 11	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 5	169 , 6	161 , 6	0
	Trucks down										
Period 12	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	161 , 6	0
	Trucks down										
Period 13	Trucks used	216 , 15	300 , 10	166 , 10	400 , 8	142 , 7	500 , 6	164 , 6	169 , 6	196 , 4.5	1
	Trucks down	161 , 6 , 1									

FIG. 13

Period	251	252	253	254	255	256	257	258	259	280
Down	2	1	1	1	1	1	2	1	1	1
Period	261	262	263	264	265	266	267	268	269	270
Down	1	1	2	1	1	2	1	2	1	0
Period	271	272	273	274	275	276	277	278	279	280
Down	1	1	2	1	0	0	0	1	0	1
Period	281	282	283	284	285	286	287	288	289	290
Down	2	0	3	1	3	3	1	1	1	0
Period	291	292	293	294	295	296	297	298	299	300
Down	2	1	1	1	1	2	2	1	1	1
Period	301	302	303	304	305	306	307	308	309	310
Down	0	0	0	0	0	0	1	1	1	1
Period	311	312	313	314	315	316	317	318	319	320
Down	1	2	2	1	2	2	1	2	0	0
Period	321	322	323	324	325	326	327	328	329	330
Down	0	1	1	0	2	2	2	1	2	1
Period	331	332	333	334	335	336	337	338	339	340
Down	1	2	2	2	1	2	1	1	1	1
Period	341	342	343	344	345	346	347	348	349	350
Down	1	2	2	1	1	2	1	1	1	1
Period	351	352	353	354	355	356	357	358	359	360
Down	1	1	2	2	2	1	1	1	4	2
Period	361	362	363	364	365	366	367	368	369	370
Down	1	1	1	1	1	0	0	0	0	0

Maximum trucks down at any one period was 4

END OF SIMULATION

READY
SYS
@POP
[Recording terminated at 09:18:32]

5.4 MODE OF OPERATION

Analysis of the motive power options was undertaken for the following two reasons:

(A) To recommend the optimum choice of gas, diesel or electric for the S.T.C. situation (to include cost and suitability). (11)(12)(13)(22) & (24)

(B) To estimate the fuel (and any additional) costs for each option in the detailed discounted cash flow (D.C.F.) calculations. ref. P.A.R. Appendix 7.

Considering (A), an annual comparison was made between the Gas, Diesel and Electric options for the total new truck compliment. For ease of calculations, all the trucks were assumed to be of 8000 lbs capacity and, as an initial D.C.F. calculation (ref. Table 17, Page 94) indicated advantages for the rental option, rental rates were used in this comparison. The following calculations were made:

1. Rental rates (inclusive of maintenance) for the trucks.

2. Rental rates for the additional equipment (i.e. bulk storage tanks for gas/diesel and a pump) with spare batteries for the electric option.

3. Estimates based upon actual costs currently incurred by S.T.C. on the three fuel types, (from Purchasing) leaflets available from the Electric Vehicle Association and, information gathered on attendance at a Seminar relating to electricity costs and the future of electricity held at the South Wales Electricity Board.

Considering (B), the detailed cost comparison is, as mentioned above, illustrated in the P.A.R. Document (Appendix 7), but a brief description of the calculations which made up the fuel costs and the final result including additional factors considered are shown below.

Fuel Calculations and Assumptions

A. Gas

Gas Refill	£7.50
Average use per day - 12 refills	£90.00
Assuming a 6 day week, 46 week year, annual cost is:	£24,840.00

B. Diesel (Gas/Oil)

The formula for the consumption of diesel per working day was: (0.4 lb per brake horse power per hour, multiplied by the horse power of the engine, multiplied by the hours per day) divided by the average usage, divided by 8 lbs of fuel per gallon. This gives a result of:

8 gallons per day.

The present cost of diesel - 15.3p per litre or 70p per gallon, therefore, the cost per truck per day is:

	£5.60
* Total cost per day:	£56.00
Annual cost (based on previous assumptions)	£15,456

C. Electric

The formula for power calculation was:

[The number of cells in the battery multiplied by ampere hour capacity of battery multiplied by discharge level and efficiency factor, divided by 1000 W giving Kilowatt hours (KWH)]. Assuming an 80% discharge, the factor to be used was 3.2, i.e.

$$\frac{36 \times 486 \times 3.2}{1000} = 56 \text{ KWH}$$

* Includes 2 trucks on 2 shift operation.

(1 KWH = 1 unit of electricity) at 3.1 p per unit, 56 KWH = £1.74 per truck per day therefore:

* Total cost per day	£17.40
Annual Cost (Based on above assumptions)	£4,802

With reference to Chapter 7 in the P.A.R. Document, Appendix 7, the total annual cost for each option (points 1,2 & 3 Page 74) was:

Gas	£65,608
Diesel	£56,224
Electricity	£55,474

The additional factors for consideration are compared in a table within the P.A.R. Document, Appendix 7, but the considerations themselves were:

Manoeuverability
Toxic Fumes
Downtime for maintenance
Noise level
General acceptability

Thus the overall conclusion based upon cost and additional factors was electric trucks for internal operation and diesel for outdoor operation.

Considering (B) again, the above formulae were now applied to all those trucks proposed within the options compared in the discounted cash flow calculations. Thus, instead of the 8 x 8000 lb example, the actual number and capacity mix of new and old trucks in each option was estimated for fuel usage and cost. This was based upon all electic trucks with the exception of the one 15,000 lb capacity old truck to be retained which was gas and the one new diesel truck recommended for outdoor operation, from the previous conclusions. These figures are illustrated within the main D.C.F. calculations in the P.A.R. Document, Appendix 7.

* Includes 2 trucks on 2 shift operation.

5.5 ORGANISATION AND CONTROL

The circuit principle used in the simulation exercise was studied in detail but, for the reasons stated previously, (operator familiarity with a very large variety of jobs and duties, and the inefficiencies associated with sending trucks of varying capacities around areas of varying capacities and job generation frequencies) this would prohibit an effective service. Benefits were to be gained in truck utilisation, however, "High utilisation of trucks would not necessarily be an optimum solution to minimising costs of materials handling; but sub-optimal, due to the increase in W.I.P. and possible production delays". Sims E.R. (1).

Various methods of control of fork lift truck activities were assessed, (30) these being explained in the P.A.R. Document, Appendix 7, relating to:

(a) Radio communication systems ('Inductive loop' and 'Free - radiation').

(b) Light system by key locations.

(c) Shop floor work marshallers.

(d) Current system of shop floor despatchers and supervision.

The outcome was that the present system should remain, with more effective supervision. To change too many variables simultaneously would be dangerous. Further to the implementation of the rationalised fleet and the changes in maintenance; manning; and people becoming accustomed to these changes, the options above would be re-evaluated.

It is pointed out in the P.A.R. Document that the proposed F.L.T. rationalisation does not require any reduction in the number of fork lift drivers. Previous to this project, during 1979-80, the fork truck manning level had been reduced by 23%, however, a future possibility would be the integration of overhead gantry drivers into the fork truck driver pool, at least on a part time basis. This will also be investigated at a later date.

Table 15, Page 79 is a copy of the fork lift truck supvervisor's organisation plans for counterbalanced trucks. The smaller reach and stacker trucks are organised by each supervisor in their respective Departments.

Within the reorganisation, certain trucks and their chargers were re-positioned to enhance a more efficient service. The distances from the working areas were reduced, but not to such a degree that this caused decentralisation from the purpose built charging house. With safety always a prime concern, the proposed two new stacker trucks would be housed and charged in an annexe off the insulation line area, together with LT 211, the oldest of the retained trucks. These would be the trucks most susceptible to damage from daily travelling between their work areas and the battery house, where the road surface was very poor and too rough for small trucks. All the new trucks proposed, other than the above two, would be charged within the battery house. Of the older trucks retained, all would be charged in the battery house with the following changes: LT 162, (retained for operation within the wire drawing area and charged there), to be charged in the battery house; LT 179 (retained for operation in the junk store), to be charged in the junk store and LT 180 (retained for operation within the terminating area), to be charged in the terminating area.

TABLE 15 **TRUCK DESIGNATIONS**

Area 1	Truck Capacity	Manning
Receiving		
Wire Drawing		
Stores	1 x 10,000 lbs	3 x dayshift
Tandem Lines	1 x 6,000 lbs	
Terminating	1 x 4,500 lbs	
Maintenance		
Junk Store		
Area 2		
Stranding		
Extrusion	1 x 10,000 lbs	
Armouring		
Test Repair	* 1 x 6,000 lbs	2 x morning/ nights
Inspection		
Redrumming		3 x double dayshift
Lagging		3 x dayshift
Shipping	* 1 x 8,000 lbs	
Drum and Case	1 x 6,000 lbs	
Composite Cables	1 x 15,000 lbs	
General/Site	1 x 6,000 lbs	

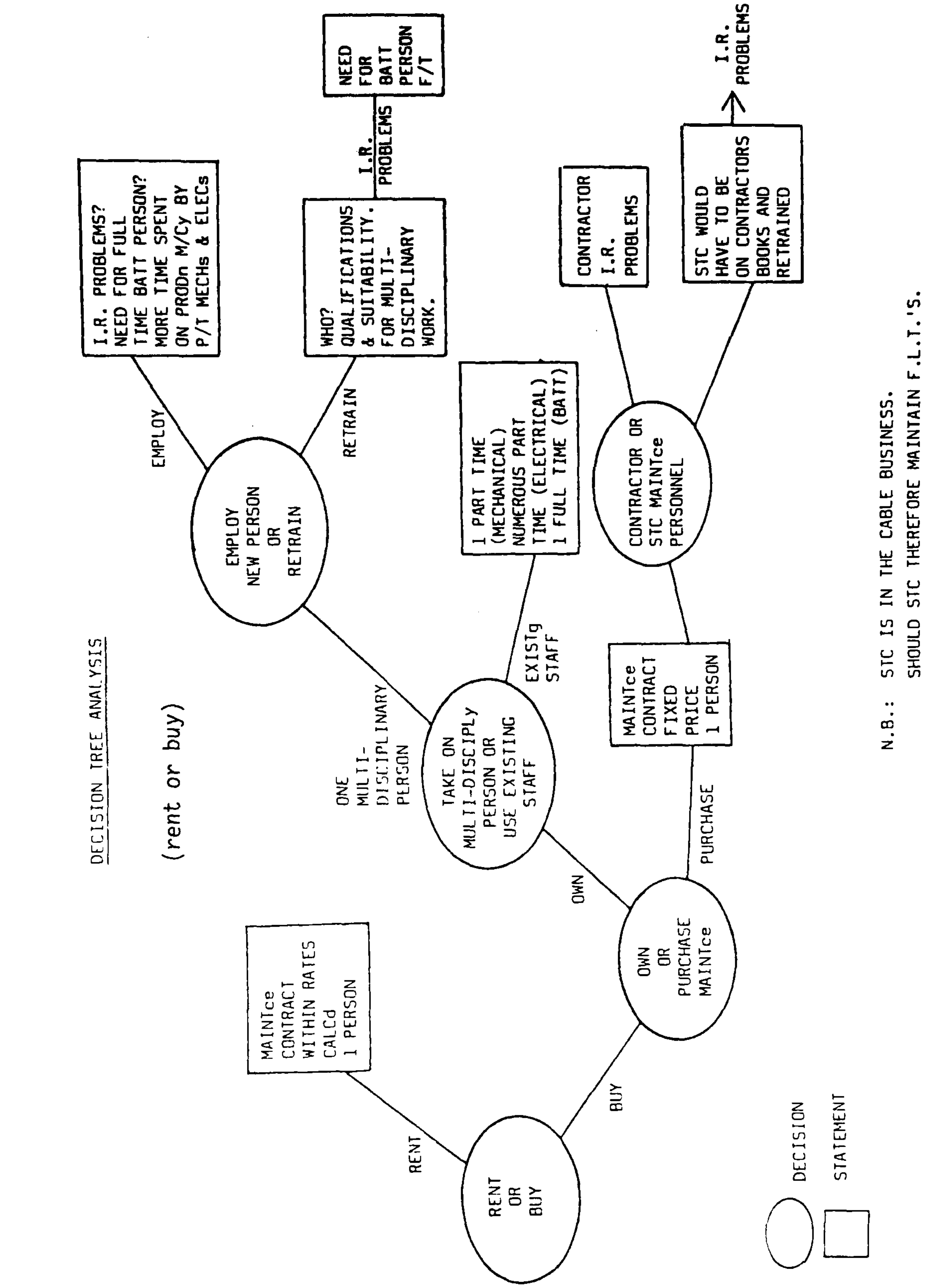
The above excludes: 1 x 8,000 lbs diesel for outside operations.
1 x 5,500 lbs for the air building.

* Battery changes daily 1 x 1,000 lbs
1 x 6,000 lbs

The question of maintenance remained an industrial relations (I.R.) problem as there were talks outstanding between the Union and Management regarding working arrangements and future Management plans (fears of redundancies). The conclusions to date had reflected the need for a rental agreement inferring that the maintenance would be taken up by the proposed supplier. In fact, the likely recommendations would include the maintenance of the total fleet, new and old trucks within the maintenance contract. However, due to the above I.R. situation, the chances of acceptance by Cable Products Division (C.P.D.) Management regarding this proposal within the recommendations were slim. Decision Tree Analysis (7) was used to illustrate the options open with the probable pitfalls/benefits shown in Fig. 14, Page 81.
An additional part of the organisation for the rationalised F.L.T. fleet was a plan of action for future years. This would ensure that of the older trucks kept in the fleet, none were used after their economic / useful lives and that any business changes and/or changes in methods of handling were accommodated. To this end a replacement plan was suggested, illustrated on Page 82, primarily to continually update the older trucks retained.

The method of acquisition of the replacement trucks need not be by that proposed in the main P.A.R., but subject to review, considering all options and their merits at the time of replacement.

FIG. 14


DECISION TREE ANALYSIS
(rent or buy)
RENT OR BUY
RENT
BUY
MAINTce CONTRACT WITHIN RATES CALCd 1 PERSON
OWN OR PURCHASE MAINTce
OWN
PURCHASE
MAINTce CONTRACT FIXED PRICE 1 PERSON
TAKE ON MULTI-DISCIPLy PERSON OR USE EXISTING STAFF
ONE MULTI-DISCIPLINARY PERSON
EXISTg STAFF
1 PART TIME (MECHANICAL) NUMEROUS PART TIME (ELECTRICAL) 1 FULL TIME (BATT)
EMPLOY NEW PERSON OR RETRAIN
EMPLOY
RETRAIN
I.R. PROBLEMS? NEED FOR FULL TIME BATT PERSON? MORE TIME SPENT ON PRODn M/Cy BY P/T MECHs & ELECs
WHO? QUALIFICATIONS & SUITABILITY. FOR MULTI-DISCIPLINARY WORK.
I.R. PROBLEMS
NEED FOR BATT PERSON F/T
CONTRACTOR OR STC MAINTce PERSONNEL
CONTRACTOR I.R. PROBLEMS
STC WOULD HAVE TO BE ON CONTRACTORS BOOKS AND RETRAINED
I.R. PROBLEMS
N.B.: STC IS IN THE CABLE BUSINESS. SHOULD STC THEREFORE MAINTAIN F.L.T.'S.
DECISION
STATEMENT

The following is a list of the old trucks to be kept (requiring gradual replacement) illustrating their age and condition.

I.D.	Type	Counter-balanced or Reach/ Stacker	Capacity lb	Date of Purchase	Condition
LT 213	Electric	Reach	2,240	1979	Good
LT 216	Gas	C/B	15,000	1979	Good
LT 161	Electric	C/B	6,000	1974	Fair
LT 196	Electric	C/B	4,500	1976	Good
LT 179	Electric	Reach	3,000	1972	Fair
LT 211	Electric	Reach	3,000	1972	Fair
LT 143	Electric	Reach	3,000	1973	Fair
LT 162	Electric	Reach	3,000	1974	Fair
LT 178	Electric	Pallet	3,000	1977	Good
Ark - Royal (Receiving Dept.)	Electric	Flat Bed			Fair
Ark - Royal (Cleaning Dept.)	Electric	Flat Bed			Fair
	Diesel	Coles Crane	13,200 lb		Fair

From the knowledge of the above trucks ages and conditions, the most practical option for replacement would be 3 trucks per annum to commence March/April 1983 and to continue until the end of the proposed project on the new trucks from the P.A.R. (i.e. March/ April 1986). At this time, the fleet as a whole will require review for future business plans. The choice of trucks for replacement each year, should be based upon the age and condition of that truck reflected in the maintenance histories and predictions.

The budgetted costs for the replacement of 3 trucks/year would be: £90K p.a.

CHAPTER 6

INTERNAL TRANSPORT RATIONALISATION COMMERCIAL ANALYSIS

6.1 INTRODUCTION

A commercial analysis was undertaken to complement the operational analysis for the presentation of a complete project. i.e. recommendations on operational and financial criteria. The commercial analysis encompassed the choice of supplier and the method of aquisition of trucks, including a discounted cash flow analysis based upon a 4 year planned period. (9)(10) & (23)

Below is a summary of the methods used for commercial analysis.

1. Choice of Supplier

    A. Truck suitability and cost.
    B. Degree of standardisation.
    C. Service provided and guarantees.

2. Method of Aquisition

    A. Suppliers' quotes for the various options and also, sale of redundant trucks.
    B. Maintenance costs from historic records for retained old trucks.

3. Financial Comparisons

    A. Discounted cash flow calculations over the comparison period.

6.2 CHOICE OF SUPPLIER

The prejudgement of supplier in the D.C.F. Section was covered by the author as a matter of convenience but the real test was to obtain demonstrations and give the fork lift truck drivers the chance to try and comment on each truck type and supplier. (5)

Some of the factors considered in the analysis were:

(a) Truck suitability for its intended job.
(b) Flexibility for use in other areas suited to its capacity.
(c) Price
(d) The after sales service, maintenance contract and expected downtime.
(e) Number of engineers in the immediate vicinity, location of nearest spares and service depot.
(f) British or foreign manufacture of trucks; supplier security.
(g) Standardisation on total fleet.
(h) Operator acceptance.

(a), (b) and (h) were covered during the demonstrations and are summarised in two tables, one within the P.A.R. Document, Appendix 7, the other below Table 16, page 85 summarising the author's and truck drivers' opinions. There were 6 major suppliers in the demonstrations received, these are stated in the P.A.R.

For the cost comparison, all suppliers were asked to quote for a standard 6000 lb capacity electric fork lift truck and these are also illustrated in the P.A.R., Appendix 7.
It should be noted that the choice of supplier was not analysed solely within this exercise, but throughout the project. While analysing the rental/lease options, it was noted that Lansing Bagnall showed the most willingness to suit S.T.C. requirements.

TABLE 16

FACTORS FOR CONSIDERATION	ROLLATRUC LIGHT	ROLLATRUC HEAVY	HYSTER LIGHT	HYSTER HEAVY	LANSING LIGHT	LANSING HEAVY	YALE LIGHT	YALE HEAVY	CLARK LIGHT	CLARK HEAVY	CLIMAX LIGHT	CLIMAX HEAVY	ATLET LIGHT	ATLET HEAVY
JOB SUITABILITY	O			O	O	O		O	O	O		O	OO	
COST	O			OO	OO	O		O	O	O		OO	O	
OPERATOR ACCEPTANCE	OO			OO	OO	OO		OO	OO	OO		O	OO	
AFTER SALES SERVICE	OO			OO	OO	OO		OO	O	O		O	OO	
STANDARDISATION ON TOTAL FLEET				O	OO	OO		O	O	OO		O		
	6		8		17		7		13		6		7	

SUPPLIERS

MEASURE OF ACCEPTIBILITY:- O - FAIR - 1
OO - GOOD - 2

6.3 METHOD OF ACQUISITION

The choice between capital purchase, rental, lease and the variations within these main three categories had to be evaluated over the planned period of 4 years. (Chosen because 4 years was covered by the Business Plan and Electric Truck Battery warranty. It was also a suitable period for depreciation calculations, and a standard period for rental/lease agreements.) (3) & (55)

Although choice of supplier plays a leading role in the calculation of method of acquisition, it was decided that initially, one suitable supplier would be chosen purely to receive comparative quotes on the same equipment specification for the main choices above (i.e. rent, purchase and lease, although calculations were also made on deferred capital purchase as a separate option.

It was apparent that a strong justification would have to be provided, for either rental or lease due to the preference for capital purchase by S.T.C. Financial Directors in Headquarters at that time. Because of this, the list of suppliers was briefly analysed for all factors relating to the project in order to provide the most favourable rates. Consequently, the figures for the method of acquisition which proved most economical, and was approved, would hold true on submission of the final recommendations.

The method of analysis for this comparison over the 4 year period was discounted cash flow. All the contributing factors (e.g.- capital cost; rental/leasing rates; maintenance options and costs; tax and tax relief; sale of old trucks etc.) had to be calculated. Other factors which had to be taken into account were flexibility for business and method changes. This is mentioned here because, whichever was the optimum choice; rent or lease was proposed for the smaller reach and stacker trucks. This was due to the pending project entitled "Automated Bobbin Storage and Retrieval" which, if implemented, would eliminate the need for a major portion of these smaller trucks.

Supplier's Quotes for the Various Options and also Sale of Redundant Old Trucks

Quotes were received from many suppliers who could supply the truck specifications required. The main 5 suppliers' quotes [illustrated in the P.A.R. Document (Appendix 7)] provided a cost comparison on an equivalent 6000 lb. capacity counterbalanced truck. This illustrated Lansing Bagnall as the cheapest option. However, quotes had to be received for the complete range of trucks which could be required. The results of these quotes also pointed towards Lansing Bagnall as the cheapest option, being able to supply all the truck specifications required, which aided the standardisation plans. The two leading suppliers Lansing Bagnall and Coventry Climax were also asked to submit comparison quotes illustrating lease and rental options over a 4 year period. Again Lansing Bagnall's rental option appeared the cheapest and the most flexible for STC in terms of pending business and method changes. Also illustrated in Appendix (7) are the two comparative quotes from the above suppliers; Coventry Climax proposing a 4 year lease agreement, with benefits to be gained from the options open at the end of the lease. Lansing Bagnall, proposing a rental contract, (the main difference being compulsory maintenance by Lansing) again 4 years and also with benefits for further years rental. The quotes received were used as input to the discounted cash flow calculations as was the estimate of revenue to be realised from the sale of redundant trucks.

It has been mentioned, that before this project there were 42 trucks in the fleet, the intended number in the rationalised fleet is 28. Included in the 28 are 12 new trucks currently proposed which results in 26 trucks to be disposed of. The disposal list (with book values) is illustrated in the P.A.R. Document (Appendix 7) alongside the Recommended Disposal Plan.

Within the deferred purchase option, the disposal plan was altered to suit the requirement for additional trucks and cover for maintenance while the total compliment of new trucks was being aquired. Within the rental or lease agreements, the Disposal Plan was for sale of all trucks as soon as possible, from day one.

Maintenance Costs from Historic Records for Retained Old Trucks

The maintenance cost breakdown served two purposes for this project.

1. To substantiate the justification for a new and rationalised fleet.
2. To substantiate the need for contract maintenance as opposed to own maintenance.

As mentioned at the beginning of this Chapter, 1980 maintenance costs at 1981 prices taking 15% average inflation was £62,500. To illustrate the cost of maintenance over past years and to project the maintenance costs forward for the "do nothing" situation, a graph is provided, Fig. 15, Page 91.

Also illustrated is the cost per truck actual and predicted, such that proportions of the data can be used for partial fleet retention. On page 89 is an example of the method of data collection for the figures in the graph, where the maintenance costs for fork lift trucks were extracted from each years accounts ledgers.

Detailed analysis was undertaken to identify the actual trucks and their periods of downtime which occurred during 1980. The results being that only 28 out of the 42 trucks were major contributors to the maintenance costs. This was due to the number of smaller and simpler trucks included in the fleet which required no maintenance.

Maintenance Costs Estimate for F.L.T.'s 1980

(Obtained from actual figures available on 1980 ledger under the following sections):

Manufacturing (Lines 513 and 773 on 510 Prime A/C)

Own	- £4,113)	Shop Service Trucks
Purchased	- £3,210)	

Shipping (Lines 513 and 773 on 550 Prime A/C)

Own	- £15,199)	Main F.L.T. Fleet of
Purchased	- £ 5,557)	counterbalanced trucks

Internal Transport (Lines 513 and 773 on 550 Prime A/C)

Own	- £ 4,492)	F.L.T.'s of all kinds
Purchased	- £20,916)	around C.P.D. Site

Total Maintenance for fork lift trucks 1980

Own	£23,804)	
Purchased	£29,683)	(Labour, Burden plus materials)
Combined	£53,487)	

Maintenance records for work carried out in 1980 indicate that 28 machines carried almost all the cost. The following layout suggests the probable split:

Counterbalanced Fork Lift Trucks 4,000 lbs Plus
(Labour, Burden and Materials included)

£37,997 for 1980

Number of Trucks in Count = 19

Average maintenance cost/truck for 1980 is: £2,000/truck/year.

Shop Service Trucks (Reach and Stacker Trucks)

£15,490 for 1980

Number of Trucks in Count = 9

Average maintenance cost/truck for 1980 is: £1,720/truck/year.

Counterbalanced Trucks

Average age of fleet of 19 = 9 years

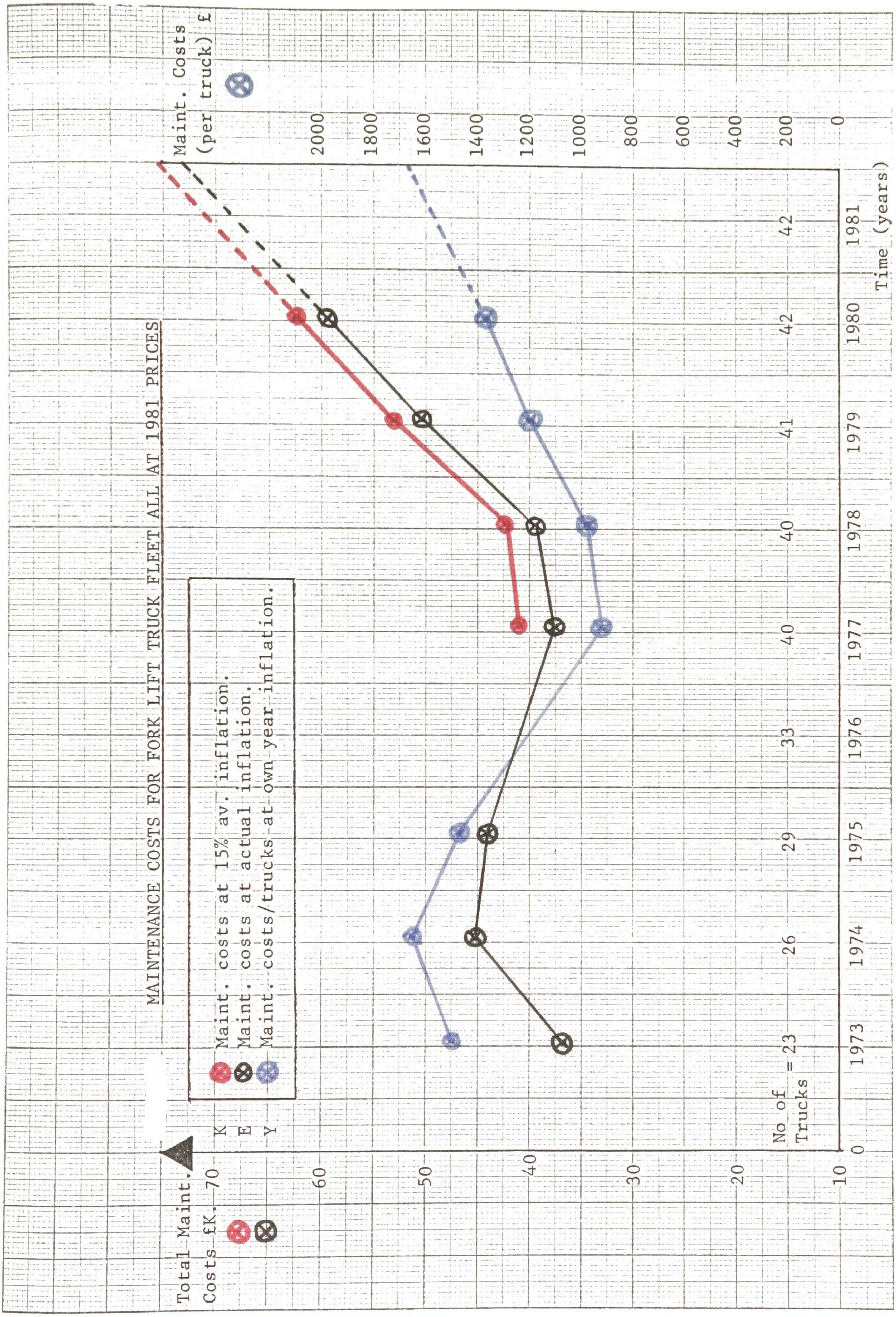
Shop Service Trucks

Average age of those causing trouble (9 trucks) = 9 years.

N.B. In general the present fleet of F.L.T.'s has not had any major overhaul or refurbishment, thus the cost of maintenance per truck is symptomatic of the age of that truck, within the C.P.D. environment.

From the above results, maintenance costs for the options covered in the discounted cash flow calculations were forecast. The analysis also provided supporting information for the proposed mix of trucks to be retained within the rationalised fleet.

FIG. 15



MAINTENANCE COSTS FOR FORK LIFT TRUCK FLEET ALL AT 1981 PRICES
Total Maint. Costs £K.
70
60
50
40
30
20
10
0
KEY
Maint. costs at 15% av. inflation.
Maint. costs at actual inflation.
Maint. costs/trucks at own year inflation.
Maint. Costs (per truck) £
2000
1800
1600
1400
1200
1000
800
600
400
200
0
No of Trucks = 23
26
29
33
40
40
41
42
42
1973
1974
1975
1976
1977
1978
1979
1980
1981
Time (years)

6.4 FINANCIAL COMPARISSONS

Discounted Cash Flow Calculations over Comparison Period

An initial discounted cash flow comparison was undertaken as a trial pending detailed quotes for the new truck compliment. This calculation was based upon 1 off - 6000lb and 1 off 8000lb capacity counterbalanced trucks and included many of the factors anticipated in the main calculations except those of motive power costs, phased capital purchase and annual inflation. The result, illustrated in Table 17, Page 94 was a clear advantage in favour of the rental option.

The main calculations are detailed in the P.A.R. Document (Appendix 7). They include rental; lease with own and purchased maintenance; capital purchase (Year 1) with own and purchased maintenance; phased capital purchase (over a 4 year period) with own and purchased maintenance; and finally the "do nothing" option which is made up solely of own maintenance costs and casual hire predictions.

The following rules and conditions were applied as a basis for the analysis:

1. Discounted cash flow over the 4 year analysis period with the rates indicated below to bring all calculations back to net present value (NPV). (9)

2. All options on a like for like comparison which included sale of purchased trucks after the 4 year period to be comparable with the rental and lease options.

3. STC 53.5% Corporation Tax where applicable. 12% average inflation per annum. 16% discount factor.

4. Book value for sale of the newer trucks with estimates made for fully depreciated trucks.

5. To reap the benefits of the lease contract, trucks would be sold after the 4 year period and the estimated income deducted from the contract price at the outset, giving less expensive annual rates. (As most companies depreciate fork lift trucks over a 5 year period, the estimate was taken as 20% capital cost.)

6. Because the new truck compliment was in the order of 10 plus, one spare truck would be provided free of charge (to be kept on site for preventive, planned and breakdown maintenance) within the rental agreement, thereby reducing the overall number of new trucks required on the rental option by one.

7. Motive power costs were also added as, depending upon the option/number of trucks, the fuelling costs fluctuated.

8. Manning costs (i.e. fork lift drivers) did not change throughout the range of options and therefore was not included in the discounted cash flow calculations. However, maintenance personnel servicing the trucks could change dependant upon the option recommended and is illustrated in the form of a decision tree analysis, Fig. 14, Page 81. This was also not included in the D.C.F. calculations, and was a controversial point due to the industrial relations situation at the time.

The major considerations which include the cost of each option for the preliminary D.C.F. are illustrated below Table 18, Page 95 and support the overall recommendation for a rental agreement. A copy of the discount factors from which the 16% rate was extracted is Appended (7) in the P.A.R. document. The results of the comparison were therefore a cost saving in respect of the rental option. Over the 4 year period, the gross expenditure for the rental option was - £399,000.

TABLE 17

PURCHASE - LEASE - RENT OPTION FOR 1 OFF 6,000 LBS AND 8,000 LBS ELECTRIC F.L.T.'S

YEAR	1	2	3	4	5	6	N.P.V.		
PURCHASE									
CAPITAL	-43,031				+4303				
MAINTENANCE (12%)		-4500	-4500	-4500	-4500				
TAX SAVING									
CAPITAL		+23022				-2152			
MAINTENANCE (53.5%)			+2407	+2407	+2407	+2407			
CASH FLOW	-43,031	+18522	-2093	-2093	+2210	+255			
DISCOUNT FACTOR	1	0.8621	0.7432	0.6407	0.5523	0.4761			
NPV AT 16%	-43,031	+15968	-1556	-1341	+1220	+121	27063	=	100%
LEASE									
LEASE RATE	-10,173	-8138	-8138	-8138	-6103				
MAINTENANCE (12%)	-	-4500	-4500	-4500	-4500				
TAX SAVING									
LEASE RATE	-	+5443	+4354	+4354	+4354	+3265			
MAINTENANCE (53.5%)	-	-	+2407	+2407	+2407	+2407			
CASH FLOW	-10,173	-7195	-5877	-5877	-5877	+5672			
DISCOUNT FACTOR	1	0.8621	0.7432	0.6407	0.5523	0.4761			
N.P.V. AT 16%	-10,173	-6203	-4368	-3765	-3246	+2700	25055	=	93%
RENT									
RENT RATE	-8827	-8827	-8827	-8827	-8827				
TAX SAVING									
RENT RATE (53.5%)	-	+4722	+4722	+4722	+4722	+4722			
CASH FLOW	-8827	-4105	-4105	-4105	-4105	+4722			
DISCOUNT FACTOR	1	0.8621	0.7432	0.6407	0.5523	0.4761			
N.P.V. AT 16%	-8827	-3539	-3051	-2630	-2267	+2248	18066	=	67%

TABLE 18

PURCHASE RENT OR LEASE

FACTORS FOR CONSIDERATION	PURCHASE	RENT	LEASE
TOTAL COST OF FLEET (D.C.F. 4 YEARS)	£162,971	£157,688	£195,206
FLEXIBILITY FOR BUSINESS AND METHOD CHANGES	NONE	TOTAL	NONE
CONTROL OF COSTS	NO	YES	YES/NO
DOWNTIME FOR MAINTENANCE	DEPENDANT ON PARTS AND LABOUR AVAIL-ABILITY	GUARANTEED LESS THAN TWENTY-FOUR HOURS	DEPENDANT ON PURCHASE OR OWN MAINTENANCE
SITUATION AFTER FOUR YEARS	CONTINUING PURCHASE TO KEEP UP AVERAGE AGE OF TRUCKS	CONTINUING RENTAL BUT WITH NEW TRUCKS	CONTINUING LEASE EITHER WITH NEW TRUCKS OR WITH ORIGINAL TRUCKS AT A REDUCED RATE
ADDITIONAL PERSONNEL REQUIRED NOT ACCOUNTED FOR IN THE TOTAL COST ABOVE	YES	NO	YES/NO

CHAPTER 7

RECOMMENDATIONS

7.1 SUMMARY

Below is a list of the recommendations resulting from careful consideration of all previous points and analyses.

1. Reduce the size of the fleet from 42 trucks to 27 trucks with a capacity mix as shown below in Table 19, Page 97.

2. Acquisition by rental with full maintenance contract.

3. Standardise on electric trucks for indoor use and diesel trucks for outdoors.

4. Standardise on Lansing Bagnall trucks.

5. Control trucks by present methods, with some fine tuning, (each truck to its specific function/area.)

6. Prepare ground for future improvement and replacement truck plan.

7. Dispose of redundant trucks by sale of either medium or large lots, as soon as possible after receipt of new trucks.

The above recommendations will provide the most efficient and cost effective service to manufacturing for a 4 year plan period. After this time, each option should be reviewed in the light of changing business, market place, and methods of handling. Price ratios between options may also fluctuate.

TABLE 19

PROPOSED SIZE AND CAPACITY MIX OF FLEET
results(including air building)

Number	Capacity (lbs)	Type
1	15,000	Counterbalanced
2	10,000	Counterbalanced
2	8,000	Counterbalanced
4	6,000	Counterbalanced
1	4,500	Counterbalanced
1	5,500	Counterbalanced
Total of 11 trucks		
3	3,500	Stacker
1	2,240	Stacker
3	2,500	Reach
1	1,760	Reach
1	3,000	Reach
Total of 9 trucks		
1	13,200	Coles Crane
1	4,500	Ark Royal
1	600	Stacker
1	3,000	Flat Bed
1	2,240	Hook Lift
2	205	Hook Lift
Total of 7 trucks		
1 Spare (free of charge on the rental option)	8,000	Counterbalanced
Combined Total of 28 Trucks.		

7.2 DISCUSSION

A reduction from 42 to 27 trucks was achievable, with a more efficiently run truck system, less downtime and spare batteries for double shift working, instead of multiple trucks. Truck supervision were consulted throughout and agreed to the recommendations.

The rental contract was proposed, being the cheapest and most flexible option of all those analysed. However, the recommendation for a maintenance contract was taken, as, in the author's opinion, this was fundamental to the success of the whole project; even though the issue was a very sensitive one. It was not thought at this stage that S.T.C. local management would adopt this part of the recommendations.

Electric trucks were recommended for indoor use for the reasons of truck compactness and manoeuvreability, cost of fueling, and environmental conditions. Out of the three different options, electric, gas, and diesel, the diesel truck was the outdoor recommendation for job suitability, cost, and reliability. All trucks were recommended to be purchased from Lansing Bagnall, because:

(A) as a company they were secure, British, reliable and could offer the cheapest price, and the most flexible deal in terms of trucks and service/maintenance options.

(B) to standardise the total fleet of trucks on site, the major portion of old trucks to be retained being Lansing Bagnall trucks. Maintaining a comprehensive spare parts inventory would also be cheaper and manageable under present organisation and control.

It was recommended that the organisation and control of the new fleet remain unchanged; this was the most suitable option under a time of considerable change in respect of the above recommendations. Once the new fleet and its operation had become routine, then the methods of organisation and control mentioned in the text, would be reassessed. It was felt that the current methods of organisation and control were satisfactory and would become more efficient, given a more efficient and reliable fleet of trucks.

Within the recommendations, a replacement plan was proposed, over and above the previously stated costs, designed to update the fleet annually, or earlier if trucks became unfit for use. The plan covered approximately three trucks per year to be renewed, amounting to approximately £90,000 p.a. This would gradually renew all old trucks within the overall 4 year rationalisation plan. The recommendation for disposal of old and redundant trucks was by medium or large lots either in auction or to suitable customers for residual book value or more. In this way the poor or worthless equipment would be paired off with reasonable or saleable equipment such that S.T.C. would not be left unable to sell the former. Prior to implementation, careful attention would have to be paid to all departments and users affected. It was recommended that a presentation should be made to those concerned, detailing the final (approved) reorganisation/rationalisation. In particular the section heads of each department covered by the materials handling service, illustrating clearly the new set up, method of implementation and the replacement plans, timing, and finally to summarise the reasons and benefits of all decisions.

7.3 APPROVALS

All work involved in the preparation of the recommendations above and the P.A.R. document itself were completed, but, local approval of the P.A.R. took some time due to:

A) The uncertain position relating to the maintenance contract - (the maintenance union and management remained in discussion over other unsettled issues.)
B) Preparation of the official company financial sheets for inclusion in the P.A.R. document before submission to Headquarters was possible.

After approximately one month, the P.A.R. was submitted for headquarters approval. However, the question of maintenance remained unresolved, consequently the official financial sheets had been included in the P.A.R. recommending the lease option. This was presented to achieve the benefits already explained for rental/ lease over purchase and to leave the maintenance options open until final approval was granted.

Provisional approval was indicated approximately one month later with further alterations required, and, to be incorporated as quickly as possible for resubmission to gain full approval.
The alterations were:

1. The official financial sheets be resubmitted to include the 5th year lease option at a rate of 1% of original equipment capital cost.
2. The choice of supplier be changed from Lansing Bagnall to Coventry Climax where possible.

During the project, on an occasional basis, progress was reported to the Industrial Engineering and Management Directorate (I.E.& M) when methods and conclusions were assessed.
Lansing Bagnall were recommended prior to final project completion and agreed by local and headquarters' staff. However, in the time taken for the P.A.R. document to be completed, submitted for approval and updated; the I.E. & M. Directorate had initiated a fork lift truck supplier survey, with the intention of negotiating a group discount deal. Because this study had been initiated, the P.A.R. document was further delayed pending the results. The result was Coventry Climax trucks initially on cost and secondly because an adequate range of trucks could be offered for most S.T.C. group requirements. Although Lansing Bagnall were preffered to Coventry Climax, due to operator acceptance, performance, and service back up, this was not sufficient reason to deviate from the group discount deal. However, Sims E.R. sums up this general situation, indicating in the author's opinion the correct solution for S.T.C., in the following extract:

"When competitive equipment items develop similar economies from the point of view of operating savings, and their comparable design features are both suitable to the job application and supported by competent service organisations, the selection should be made on the basis of price. If, however, any of these factors or criteria are lacking in one or other of the products, price should become a secondary factor and operating characteristics, serviceability, and life expectancy of the product should be the primary basis for selection." Sims E.R. (8)

Thus the major (heavy range) portion of trucks had to be changed to Coventry Climax with new quotes included. The minor (light range) portion remained Lansing Bagnall, (justified on application and job suitability) but purchased via. Coventry Climax, so that all new trucks were leased from one supplier. The P.A.R. document was received fully approved including the above ammendments 2-3 weeks later. All the information and approvals were now available for C.P.D. management to make the final decision and place the order.

The maintenance position remained unchanged and of a delicate nature, and as such, the final decision was taken to adopt the 5 year lease agreement with C.P.D. maintenance:- The purchasing, maintenance and site services manager Mr. E.R. Bryant giving his verbal assurance that properly organised, the fork lift truck maintenance would be adequately covered in house.

CHAPTER 8

CONCLUSIONS

8.1 GENERAL

Materials handling methods have been discussed in the text. At the outset of the project when the base data study was in its infancy, it was envisaged that fork lift trucks would be very difficult to replace due to the existing organisation and variation of work encountered. During the project, various different methods of handling were assessed, for example, pneumatic handling of compounds; conveyors (floor and overhead); marshalling and storage systems using dedicated automated devices; and automatic guided vehicles. Each of these at first appeared to have advantages in isolation for specific areas, but with a little further thought and investigation, each one was ruled out on cost and flexibility, particularly when considering the system as a whole. (Ref. - The Project Objective Page 8.)

Now, at the end of the project, the conclusions reached early in the project, (referring to methods of handling, that is the fork lift truck) remain correct for the circumstances within S.T.C.. It is thought however, that continued advances in automated guided vehicles make this a topic for further assessment, with good labour saving benefits. It is also felt that pneumatic handling of compounds would greatly improve housekeeping, minimise product contamination and reduce materials handling costs. Automated storage and retrieval, although not covered in this thesis was analysed but found to be unsuitable at the present time, due to the very large capital investment required, space which was not available and the uncertain future for the standard copper cables market.

Within the system, manual handling activities were of minimum significance for short-term potential gains. The major percentage of manual handling was accomplished by machine operators as inside cycle time.

The information collected within the base data study, however, will be relevant to any future attempts to eliminate manual handling and introduce an automated storage and handling system, whether a fully integrated or a small dedicated system. The major areas for short term potential savings, other than those already being investigated (i.e. elimination of the rewinding of finished cable) were in the minimisation of inter-process drum and bobbin transportation by mechanical handling and the reduction in costs of undertaking this necessary movement.

The major conclusion drawn from the base data study was the alarming difference (27%) between the theoretical materials handling statistics calculated from the company business plan and production control documents, and those actually taken from shop floor historical records. However, as pointed out previously, the lack of emphasis placed on materials handling by S.T.C., is the sole reason for this large differential. It must be pointed out that this differential has a direct effect upon accounting figures and tendering estimates, the only method of reducing this variance is a higher level of control of shop floor proceedures aimed at reproducing more closely what is specified on the production edit or routing layout. For the project, however, the 27% increase over budget was used as the true materials handling statistic.

As mentioned above, the fork lift truck was the most economical and flexible method of materials handling at Newport under conditions at the time. That is, a condition of many different handling interfaces, material shapes and sizes, and factory layout. But it would also lend itself to change if a fully automated and integrated system were adopted. The recommendation then, of a rental contract including maintenance gave a gross saving of:

£85,000 over the lease option.
£63,000 over the purchase (year 1).
£154,000 over the phased purchase.
and £116,000 over the do nothing option.

With the changes to the recommendations identified in Chapter 7, these savings would vary, but in the author's opinion, due to the in-house maintenance option, (instead of contract maintenance) the truck conditions would deteriorate rapidly from new along an exponential curve to the condition of the 'do nothing' option above. In other words, the materials handling system at Newport would not continue to run at the most cost effective operating level but quickly change into a high maintenance cost operation. The simulation exercise, (both on the number and capacity mix of trucks and the spare trucks required for maintenance) provided a comparison for the manual methods used to initially determine the results. The comparison was very close but because of time restrictions, only a portion of the fleet was simulated. In the author's opinion, simulation built up from sound statistics and operating rules, is a very powerful tool; and if time/money had permitted, all trucks and the maintenance simulation, would have been included in one total simulation programme. It would then have been possible to plan/predict and continually update operational logistics and the maintenance service quickly and easily. The actual decisions taken by C.P.D. local management and S.T.C. Directorate had now changed the project significantly. Below are the actual options chosen:

1. Reduce the size of the fleet from 42 to 28 trucks (changed)
2. Acquisition by lease with in house maintenance (")
3. Standardise on electric trucks for indoor use and diesel trucks for outdoors. (same)
4. Coventry Climax chosen as supplier, limited standardisation. (changed)
5. Control trucks by present methods with some fine tuning. (same)

During project approval, and more so at this point, strong criticism of the deviations from the options recommended was voiced. It was felt that the major reason for the exceptionally poor condition of the fleet and its high maintenance costs was the lack of effective maintenance. These opinions were noted, but no changes resulted in the actions taken. The order was placed and all trucks were delivered to site by the end of April 1982.

8.2 IMPLEMENTATION

Presentations were given to operators and supervision in all relevant departments to illustrate the details of the approved new fleet on order. An indication was given of the implementation plan, which was to coincide with the disposal plan for the old trucks; it was pointed out at the time, that the accuracy of the plan was reliant upon a customer or customers being found for the old trucks and supplier delivery dates being met. The redundant F.L.T. disposal plan was soon fulfilled, with one customer taking almost all the trucks to be disposed of. A transfer date was arranged being the last delivery date of all new trucks.

Problems occured when delivery of the small trucks from Lansing Bagnall (manufactured in Germany) fell behind schedule. Supervision within C.P.D. would not release their old trucks to fulfill C.P.D.'s committment to the customer until such time as Lansing Bagnall had fulfilled its committment to C.P.D.. C.P.D. purchasing therefore had to arrange a special agreement with the customer. One truck had to be retained on site at a hire purchase rate, paid to the customer. Calculations were made by the author to evaluate the economics of this situation; the conclusion, and the action taken, was to buy back the truck, at a higher price than its sale price.

The resultant number of fork lift trucks in the fleet was 29 - one extra small truck bought back (above) and one for spare which was previously free of charge in the rental contract. Final implementation was attained at the end of April, 1982.

8.3 PROGRESS & FINDINGS

The 2 year teaching company associate appointment was completed in June 1982 when the author took up the appointment of senior development engineer (optical cable design). Therefore, the results of the recommendations and decisions taken, from implementation to the time of writing completion, are stated below and are the author's observations and opinions:

The rationalised fleet of 29 trucks coped with the work load adequately. The Coventry Climax trucks, although not as suitable to the job or driver as Lansing Bagnall, were nevertheless good workhorses and covered the jobs required, although, a higher than expected level of teething troubles were encountered. The lease contract in comparison with the rental contract was not as flexible for future changes in either, the number of trucks, or, changes to truck capacities/details. However, due to the group discount deal, the overall cost including the fifth year lease at only 1% of the equivalent capital cost, worked out cheaper.

The maintenance cover was organised in the same fashion as prior to the project, i.e. - 1 Fitter whose workload covered Boilers and compressors, F.L.T.'s and other duties while the pool of Electricians covering all electrical work on site would be allocated to trucks if and when necessary. (No dedicated personel) There was also 1 battery attendant who covered all battery maintenance and charging on site.

Because In-House maintenance was chosen combined with non-standardisation of truck make, spare parts stock-holding was difficult. The maintenance levels, after the initial period, dropped to an acceptible level whereby the organisation of the fleet and total number of trucks continued to cover the workload. The situation now after 2 years is somewhat different. The maintenance level has now increased for the same reasons as originally identified:-

Casual (short term) hire has become necessary on numerous occasions due to several trucks being off the road simultaneously. This is typical (a repeat performance) of the lack of maintenance effort on trucks; truck repairs taking second place to production machinery problems, and waiting time, which also plays a part.

In general, the recommendations made a significant improvement to the materials handling situation at C.P.D. Newport. The one major downfall, preventing the continuation of this improvement, being the failure to include contract maintenance, which as explained above, has a detremental effect on the service provided. It has been stated within the text that C.P.D. are in the business of cable manufacture and not fork lift truck maintenance. This statement is still upheld by the author and the failure by C.P.D. to implement this policy with respect to maintenance was, and is again, the major reason for the current situation.

A contributing factor to the high maintenance costs now being experienced, is the failure of C.P.D. management to fulfil the replacement plan. The finance approved for annual truck replacement (three trucks per year for 1983,84 & 85) was transferred to other higher priority projects. To date no old trucks have been replaced. It can be pointed out once more that this is partly because there remains no one person or department with direct responsibility for materials handling and no change has taken place in the method of accounting for it.

In the author's opinion, well in advance of the end of the lease agreement (1987), major actions will have to be taken to maintain the materials handling service to manufacturing at an acceptible cost. The easiest course of action will be to replace those trucks giving most problems during 1985 and 1986.

APPENDICES 1-10

(PAGES 108-187)

APPENDIX 1

APPENDIX 1

SAMPLE PAGE FROM THE S.T.C. 1984 BUSINESS PLAN.

Cu £910 ; Al £760

Cu £910 ; Al £760

	BPO Sample				1979 Prices	1980 BUDGET								
						Standard Cost ([illegible])								
UNIT TWIN CU	SP per km	No of km	No of mcm	mcm Value	Total Sales	(Metals	materials	L & B	Total)	Freight	Packing	Costs	Margin	
	£			£K	£K	£K	£K	£K	£K	£K	£K	£K	£K	%
EP0025 600 pair 0.4mm	3025	125	150	2.52	378.1	171.8	71.3	154.5	397.6	-	4.2	401.8	(23.7)	(6.3%)
EP0029 1600 pair 0.4mm	7866	34.7	111	2.46	273.0	120.8	44.2	109.1	282.1	-	2.9	285.0	(12.0)	(4.4%)
EP0046 600 pair 0.5mm	3897	80.8	97	3.25	314.9	172.8	63.5	105.2	341.5	-	3.6	345.1	(30.2)	(9.6%)
EP0000 100 pair 0.63mm	1428	165	33	7.14	235.6	93.1	43.5	72.8	209.4	-	2.2	211.6	24.0	10.2%
			391	3.07	1201.6	566.5	222.5	441.6	1230.6	-	12.9	1243.5	(41.9)	(3.5%)
UNIT TWIN AL														
EP0091 100 pair 0.5mm	810	10	2	4.05	8.1	1.0	2.2	2.4	5.6	-	0.1	5.7	2.4	29.6%
EP0096 600 pair 0.5mm	2025	31.7	38	1.69	64.2	18.8	30.3	47.6	96.7	-	1.0	97.7	(33.5)	(52.2%)
EP0097 800 pair 0.5mm	3043	1.9	3	1.93	5.8	1.5	2.3	3.8	7.6	-	0.1	7.7	(1.9)	32.8%)
EP0099 1200 pair 0.5mm	4171	3.3	8	1.74	13.9	3.9	5.8	9.7	19.4	-	0.2	19.6	(5.7)	(41.0%)
			51	1.8	92.0	25.2	40.6	63.5	129.3	-	1.4	130.7	(38.7)	(42.1%)
POLY TWIN DIST. CU														
FA0505 5 pair 0.5mm	108	1300	13	10.8	140.4	23.7	30.7	44.1	98.5	-	1.0	99.5	40.9	29.1%
FA0550 50 pair 0.5mm	412	900	90	4.12	370.8	155.6	89.3	119.8	364.7	-	3.8	368.5	2.3	0.6%
FA0600 100 pair 0.5mm	748	595	119	3.74	445.1	205.8	106.0	118.3	430.1	-	4.5	434.6	10.5	2.4%
FA1550 50 pair 0.9mm	984	100	10	9.84	98.4	56.8	24.4	19.7	100.9	-	1.1	102.0	(3.6)	(3.7%)
			232	4.55	1054.7	441.9	250.4	301.9	994.2	-	10.4	1004.6	50.1	4.8%
POLY TWIN DIST AL														
FA7010 10 pair 0.5mm	112	400	8	5.6	44.8	4.6	11.9	20.9	37.4	-	0.4	37.8	7.0	15.6%
FA7020 20 pair 0.5mm	149	350	14	3.73	52.2	6.7	18.8	25.3	50.8	-	0.5	51.3	0.9	1.7%
FA7620 20 pair 0.7mm	192	150	6	4.8	28.8	5.6	12.0	12.0	29.6	-	0.3	29.9	(1.1)	(3.8%)
FA7650 50 pair 0.7mm	404	60	6	4.04	24.2	5.7	9.5	7.9	23.1	-	0.3	23.4	0.8	3.3%
			34	4.41	150.0	22.6	52.2	66.1	140.9	-	1.5	142.4	7.6	5.1%
ASSC Cu														
FC3450 50 pair 0.5mm	567	80	8	5.67	45.4	13.8	15.8	10.2	39.8	-	0.4	40.2	5.2	11.5%
FC3520 20 pair 0.63mm	436	125	5	10.9	54.5	13.7	17.8	10.8	42.3	-	0.4	42.7	11.8	21.7%
FC 3610 10 pair 0.9mm	431	500	10	21.55	215.5	59.2	81.5	40.0	180.7	-	1.9	102.6	32.9	15.3%
			23	13.71	315.4	86.7	115.1	61.0	262.8	-	2.7	265.5	49.9	15.8%
ASSC AL														
FC7100 100 pair 0.5mm	607	15.0	3	3.03	9.1	1.5	4.3	3.4	9.2	-	0.1	9.3	(0.2)	(2%)
POLY NO 3														
FB0550 50 pair 0.5mm Cu	769	100	10	7.69	76.9	17.3	34.0	19.6	70.9	-	0.7	71.6	5.3	6.9%
FB0600 100 pair 0.5mm Cu	1211	125	25	6.06	151.4	44.4	65.0	33.9	143.3	-	1.5	144.8	6.6	4.4%
FB1550 50 pair 0.9mm Cu	1695	20	2	16.95	33.9	11.5	13.9	6.3	31.7	-	0.3	32.0	1.9	5.6%
FB7100 100 pair 0.5mm AL	906	75	15	4.53	68.0	7.4	35.6	23.4	66.4	-	0.7	67.1	0.9	1.3%
			52	6.35	330.2	80.6	148.5	83.2	312.3	-	3.2	315.5	14.7	4.5%
TOTAL SUBSCRIBER			786		3153	1225	833.6	1020.7	3079.3	-	32.2	3111.5	41.5	1.3%

APPENDIX 2

ESTIMATED TIMES FOR CABLE PRODUCTION AND HANDLING (S. M. V.'s)

SPEC. I.D.	RECEIVING	TRANSPORT TO DRAWING MACHINE	INITIAL DRAW	TRANSPORT TO RE-DRAW &/OR TINNING	REDRAW &/ OR TINNING	TRANSPORT TO T.L. OR MARSHALLING	23 ML M/C RUN TIME / 1000 mts	TOTAL M/C RUN TIME	SET UP TIME	LOAD/UN-LOAD TIME	TRANSPORT TIME	SET UP TIME	TWINNING TIME /1000m	TOTAL TW M/C RUN TIME	LOAD UNLOAD TIME	TRANSPORT TIME
FF 0209 5 TCW 6000 mts	2 / 15 PACK	1.36	10.00	0.07	TIN - 139.8 REDRAW 120.0 259.8	0.33	1.49	365.05	15	3.00	0.9	4.4	1.11	135.98	25.6	1.7
	SET UP TIME 13.0	LAY UP TIME/100mts 1.12	TOTAL LAY-UP TIME 67.2	LOAD/ UNLOAD TIME (6.00 + 17.5 Drum)	TRANSPORT TIME 2.0	SET UP TIME 14.3	OUTER SHTH RUN/100mts 1.96	TOTAL SHTH TIME 58.8	LOAD / UN-LOAD TIME 12.50	TRANSPORT TIME 0.8 + 1.0	FINAL INSPECTION 360	REDRUM RUN 96.00	HANDLING 30.00	TOTAL TIME TAKEN 1502.29	TOTAL HAND-LING TIME 198.76	% HANDLING TIME 13.23%
EP 0042 0.5 PCW 4000 mts	RECEIVING 1pack	TRANS TO D/M 10.15	INITIAL DRAW 90.00	TRANS TO REDRAW &/OR TINNING	REDRAW &/OR TINNING	TRANS TO TL OR MARSH 2.20	12TL M/C RUN TIME 1.16	TOTAL M/C RUN TIME 3786	SET UP TIME 15.00	LOAD/UN-LOAD TIME 15.00	TRANSPORT TIME 2.0	SET UP TIME 5	TWINNING TIME/1000m 0.90	TOTAL TW M/C RUN TIME 14.68	LEAD/UN-LOAD TIME 256	TRANSPORT TIME 2.5
	SET UP TIME 70	GROUP BUNCH/100 mts 1.61	TOTAL RUN TIME 65	LOAD/UNLOAD TIME (37 + 12.99 Drum)	TRANSPORT TIME 2.0 + 0.6	SET UP TIME (incl. in previous set up)	UNIT BUNCH /100 mts 1.61	TOTAL RUN TIME 65	LOAD/UN-LOAD TIME (78 Drms)	TRANSPORT TIME 3.6	SET UP TIME 10	LAY UP /100 mts 7.42	TOTAL RUN TIME 296.8	LOAD UN-LOAD TIME (2.659 + 2.56)	TRANSPORT TIME 2.0	SET UP TIME 10
	OUTER SHTH /100 mts 6.39	TOTAL RUN TIME 255.6	LOAD/UN-LOAD TIME 13.4	TRANSPORT TIME 0.8 + 1.0	FINAL INSPECTION 790									TOTAL TIME TAKEN 7393.89	TOTAL HAND TIME 467.49	% HANDLING (TIME) 6.32%
FC 7100 0.5 ALUM 12000 mts	RECEIVING 12 Reels ≃ 127 kilos	TRANS TO D/M 15.00	INITIAL DRAW -	TRANS TO REDRAW &/OR TIN -	REDRAW &/OR TIN -	TRANSPORT TO T.L. OR MARSH 5.00	M/C RUN TIME/1000m 09 TL 1.55	TOTAL M/C RUN TIME 3784	SET UP TIME 15	LOAD/UN-LOAD TIME 15.00	TRANSPORT TIME 1.0	SET UP TIME 5	TWINNING TIME/1000m 0.70	TOTAL TW m/c RUN TIME 854	LOAD/UN-LOAD TIME 128	TRANSPORT TIME 3.0 + 3.5
	SET UP TIME 70	LAY UP TIME /100 mts 9.21	TOTAL M/C RUN TIME 1114	LOAD UNLOAD TIME 33 + 18	TRANSPORT TIME 4.0	SET UP TIME 5.0	OUTER SHTH / 100 mts 1.87	TOTAL M/C RUN TIME 224.4	LOAD/UN - LOAD TIME 12.30	TRANSPORT TIME 1.6 + 2.0	SET UP TIME 510	SET UP TIME 192	TWINNING TIME/1000m 30	TOTAL RUN TIME 7006.8	LOAD/UNLOAD TIME 425.4	TRANSPORT TIME 6.07%
ZZ 0589 0.8 PCW 2200 mts	RECEIVING 3/5 pack	TRANS TO D/M 6.09	INITIAL DRAW -	TRANS TO REDRAW &/OR TIN 0.12	REDRAW &/OR TIN -	TRANS TO TL OR MARSH 0.6	M/C RUNTIME /1000 mts 24ML 2.74	TOTAL M/C TIME 1269.7	LOAD/ UN-LOAD TIME 15.00	TRANSPORT TIME 2.0	SET UP TIME 15.00	SET UP TIME 5	TWINNING TIME /100m 0.98	TOTAL RUN TIME 227	LOAD/UN-LOAD TIME 128	TRANSPORT TIME 2.5
	SET UP TIME 70	UNIT BUNCH TIME/100mts 1.61	TOTAL RUN TIME 182.6	LOAD/UNLOAD TIME (30 + 17.5)	TRANSPORT TIME 2.0	SET UP TIME 70	LAY UP TIME/100mts 7.42	TOTAL RUN TIME 163.24	LOAD/UN-TIME 37.00	TRANSPORT TIME 2.0	SET UP TIME 9.2	INNER SHTH TIME/100m 9.58	TOTAL RUN TIME 210.8	LOAD UN-LOAD TIME 13.4	TRANSPORT TIME 1.0	SET UP TIME 65
	S.T.A. TIME/100mts 41.2	TOTAL RUN TIME 906.4	LOAD/UNLOAD TIME 30.00	TRANSPORT TIME 0.8	SET UP TIME 9.2	OUTER SHTH TIME/100mts 16.4	TOTAL M/C RUN TIME 360.8	LOAD/UN-TIME 13.4	TRANSPORT TIME 3.0	FINAL INSPECTION 63				TOTAL TIME TAKEN 3931.35	TOTAL HAND TIME 304.41	% HANDLING (TIME) 7.74%

SPEC I.D.	RECEIVING	TRANSPORT TO D/M	INITIAL DRAW	TRANSPORT TO REDRAW &/OR TINNING	REDRAW &/ OR TINNING	TRANSPORT TO TL OR MARSHALLING	M/C RUN TIME/1000m	TOTAL M/C RUN TIME	SET UP TIME	LOAD UNLOAD TIME	TRANSPORT TIME	SET UP TIME	QUAD TIME /100 mts	TOTAL M/C RUN TIME	LOAD UNLOAD TIME	TRANSPORT TIME
EF 3506 0.9 PCW 1000m	1 Pack	10.15	-	-	-	2.20	1.44	700	15	22.8	3.5	30	3.00	3625	1012	4.0
	SET UP TIME	1st LAY UP TIME/100m	TOTAL M/C RUN TIME	LOAD/UN-LOAD TIME	TRANSPORT TIME	SET UP TIME	OUTER SHTH TIME/100m									
	180	13.00	138	118	2.0	9.2	15.4	169.4	13.4	3.2	108			6165.85	1191.25	19.32%

ASSUMPTIONS

ALL TRANSPORT TIMES ARE ESTIMATED TAKING INTO ACCOUNT POSSIBLE INTERFERENCES.

THE REDRUMMING OPERATION IS TAKEN TO BE MATERIALS HANDLING BUT SETTING UP IS CLASSED AS A PRODUCTION TIME.

SUMMARY OF RESULTS -

SPEC. No.	(Materials Handling as a percentage of total production time)
FF 0209	13.23%
EP 0042	6.32%
FC 7100	6.07%
ZZ 0589	7.74%
EF 3506	19.32%
Average =	10.54%

APPENDIX 3

Lifting Cycle Times for Counterbalanced and Reach Trucks

(see additional sheet for allowances which must be added to basic cycle times).

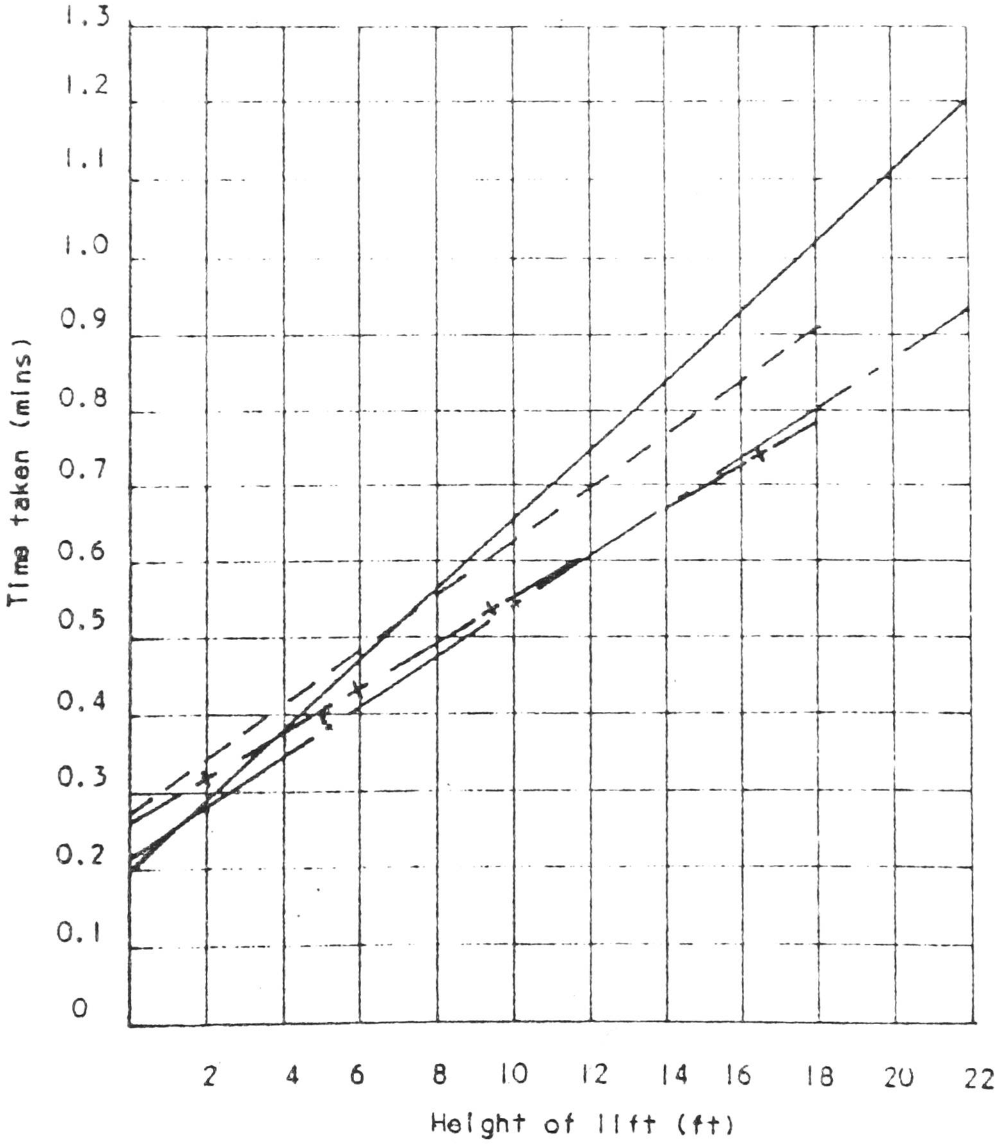
— — — — Counterbalanced truck - lifting laden, lowering unladen.

— + — + — Counterbalanced truck - lifting unladen. lowering laden.

———— Reach truck - lifting laden, lowering unladen.

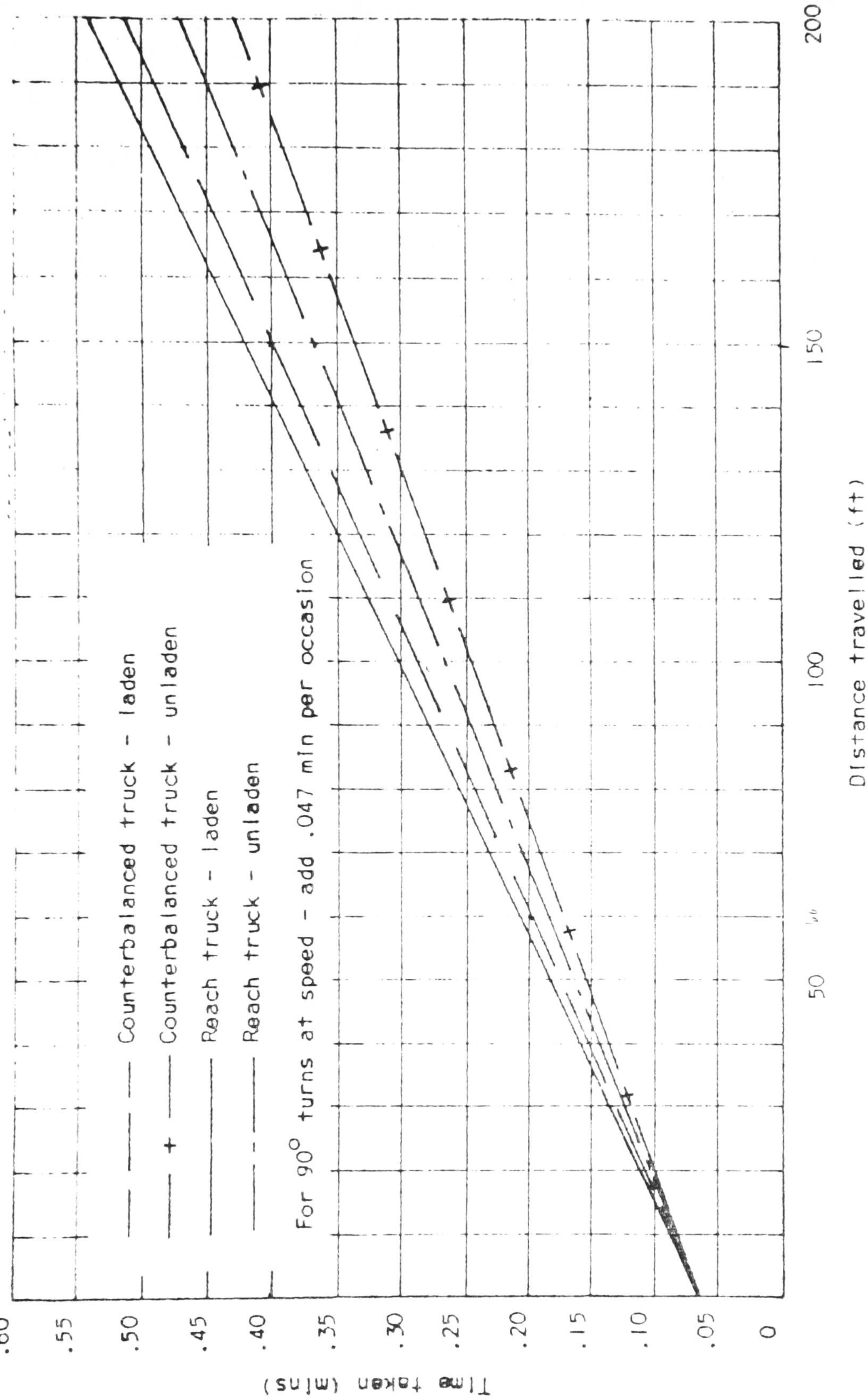
—— - ——— Reach truck - lifting unladen, lowering laden.

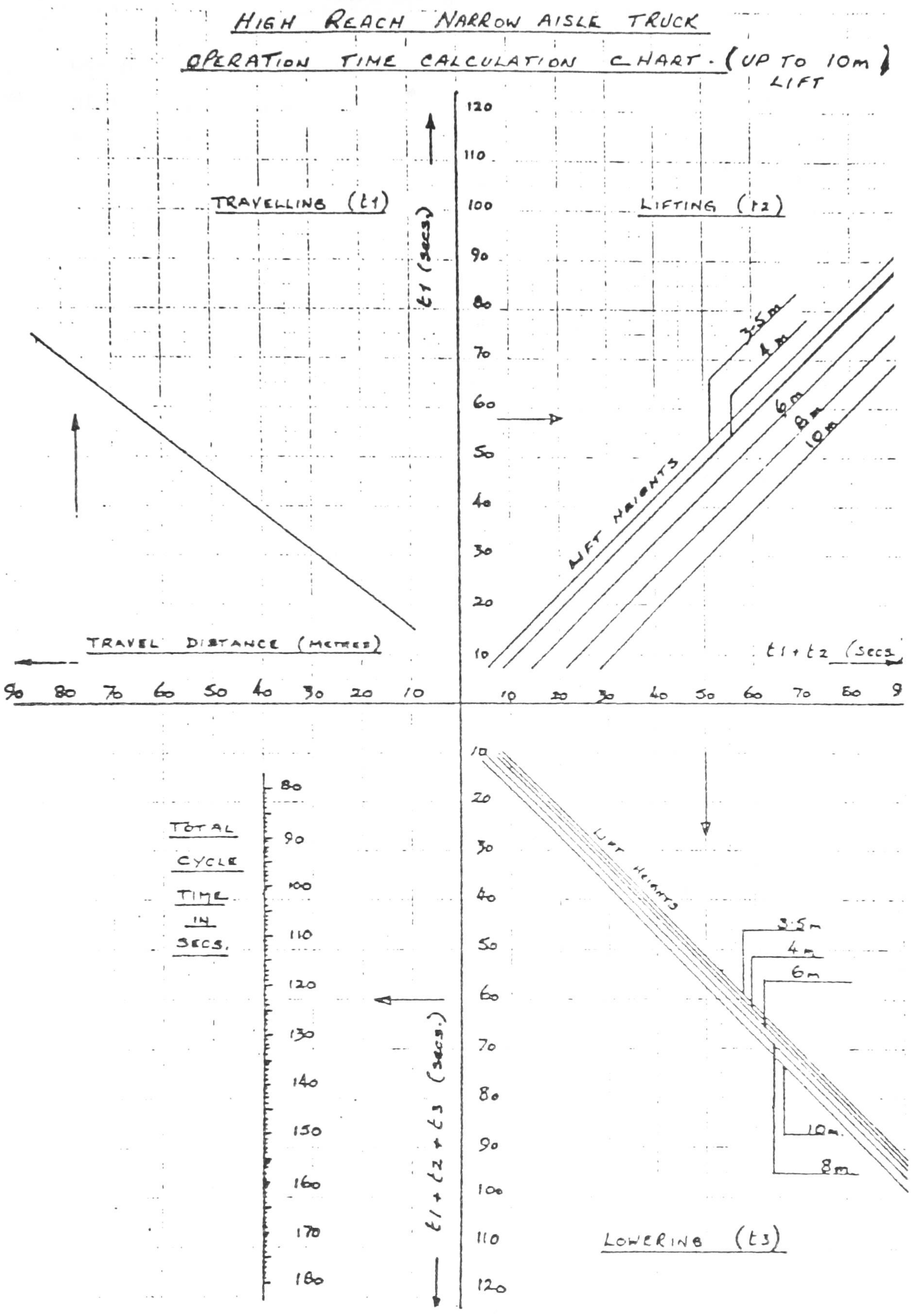
NOTE: Times include running forks into pallets to running out and turning through 90° ready for travel with pallet (or vice versa).



Travelling Times for Counterbalanced and Reach Trucks

(See additional sheet for allowances which must be added to basic cycle times).




HIGH REACH NARROW AISLE TRUCK
OPERATION TIME CALCULATION CHART. (UP TO 10m LIFT)
TRAVELLING (t1)
t1 (secs)
LIFTING (t2)
LIFT HEIGHTS
3.5m
4m
6m
8m
10m
TRAVEL DISTANCE (METRES)
t1 + t2 (secs)
90 80 70 60 50 40 30 20 10
10 20 30 40 50 60 70 80
120 110 100 90 80 70 60 50 40 30 20 10
TOTAL CYCLE TIME IN SECS.
80 90 100 110 120 130 140 150 160 170 180
t1 + t2 + t3 (secs.)
LOWERING (t3)

Work Cycle Times for Turret Truck

Use of Diagram The left hand arm of the 'x' axis is the scale for travel distance. The upper part of the 'y' axis is the scale for travel time(t_1) taking return journeys into account. The right hand arm of the 'x' axis shows the sum of travelling time (t_1) and lifting time (t_2). The scale in the lower part is that for the accumulated travel, lifting and lowering time i.e. ($t_1 + t_2 + t_3$). In the bottom left hand section there appears the total cycle time scale. This scale takes into account additional time elements involved in picking up and depositing the loads operational time for the load pick-up device etc.

To determine the average time for one working cycle from the diagram then 2/3 of the racking aisle length and 2/3 of the maximum lift height should be used as mean values.

To use the diagram start from the travel distance scale and project a vertical line from appropriate point on the travel distance scale to its point of intersection on the travel time co-ordinate line. From this point extend the line parallel to the 'x' axis until it intersects the appropriate lifting time co-ordinate line. Continue the line downwards to the lowering time co-ordinate line. Extend the line parallel to the 'x' axis through to the total cycle time scale. The accumulative time elements can be read direct from the diagram, proceeding in a clockwise direction.

The Total Cycle Time scale is based on the assumption that the truck is operating in one stacking aisle only, and that the pallets are standing ready at the P & D station.

Add a 50% allowance to the total cycle time to allow for idle time, truck transfer from one aisle to another, drivers personal allowances etc.

APPENDIX 3 cont.

Operating Data for Handling Equipment

Equipment Type	Minimum Operating Gangway Width Required (ft)
1 ton Reach Truck	8'-0"
1¼ ton Reach Truck	8'-0"
1½ ton Reach Truck	8'-6"
2 ton Reach Truck	9'-0"
1 ton Counterbalance F.L.T.	10'-0"
2 ton Counterbalance F.L.T.	12'-0"
1 ton Turret Truck	5'-7"

APPENDIX 4

APPENDIX 4

ACTUAL AND PREDICTED BUSINESS CHANGES

A. Most telephone cable is of unit twin construction (i.e. one single core wrapped around another). The required size of cable is made up of any number of these pairs, from one to 4,800. Frequent use of copper and aluminium as conductor material is made, however, copper is fast eliminating the aluminium market.

B. On distribution cables a switch to 10 pair unit construction is expected, which if made on the normal twinning machines will require a further 10 pair construction machine before being bunched. But if the twinning machines are replaced by a 10 pair unit machine, this will relieve the present twinning capacity constraint and the need for concentric stranding machines in the long term.

C. Another fast developing change is from trunk quad cables to transverse screened cables. This change is more rapid than the above and the result will inevitably be elimination of the quadding machines and one dedicated concentric stranding machine.

D. A fourth major business change is of course Optical Cable Production. Although this will, in the long term, replace conventional copper and aluminium cables completely, in the short - medium term, while optical cable develops, the two types will co-exist and there are no fears of a major shortfall in conventional cable orders in the next decade.

The Company Business Plan predicts a steady rise in volume and value of sales of conventional cable by 5-6% over the next 4 years.

APPENDIX 5

APPENDIX 5

WIRE DRAWING CAPACITY AND THROUGHPUT

1 Supply Pack (8.00) mm Dia. Rod Breakdown m/c's 2.1/2 internal packs (2.540) mm Dia.	1 Supply Pack Rod Breakdown m/c's 2.1/2 internal packs (2.030) mm Dia.
1 Pack (2.540) mm Dia. Tinning m/c's 3 reels	1 Pack (2.030) mm Dia. Secondary Drawing m/c's 9 - 10 reels
1 reel Secondary Drawing m/c's 3 reels	
Output from Secondary Drawing is:- 9 reels/internal pack.	

APPENDIX 6

A P P E N D I X 6

CONFIDENCE LIMITS

The area for which doubt arose in the use of the 1980 budget was mainly stranding to shipping. The following analysis was therefore undertaken in order to establish confidence limits, which could then be extrapolated over future years business plan predictions. Actual results were taken from each m/c's log book entries over a period of two months (25.9.80 - 26.11.80) this being a representative sample of production throughout the year. The results were calculated as an average throughput in drums per shift and compared with the theoretical results to produce the following:

Actual results (taken from m/c log book entries).
15.4 drums/shift across all stranders.

Theoretical results (taken from 1980 budget).
11.23 drums/shift across all stranders.

It can be seen that the difference, 4.17 drums/shift is 27% of the actual two month sample result for 1980. This difference can be accounted for in the following ways:

(1) Cable is cut at stranding producing multiple lengths on multiple drums when the process layouts show one length - one drum. The reasons for this are:

(a) Snaps or short lengths during production.
(b) Shortage of the correct size drum.
(c) Different m/c used to that stated on the process layout (possibly due to breakdown or capacity/throughput mix problems) necessitating the use of different size drums.

(2) Rework for faulty cable either at stranding or on any post-stranding operation. This results in a doubling of the predicted work and therefore work movement.

The Marketing Department annually correlate actual production with previous years predictions in order to predict more accurately the following years budget. However, no allowances would be made for materials handling procedures such as those mentioned above. A higher scrap allowance for (2) would be the only likely outcome. Thus for future projects on materials handling which requires the use of the base data results herein, the following assumptions and allowances will be made.

(a) Assumptions

The procedure of cutting cable at stranding will be looked into with respect to the wrong drum sizes being used.

Normal cost reduction projects undertaken to increase quality and reduce production costs, will gradually decrease the current level of scrap and rework.

(b) Allowances

Where equipment specifications or new methods rely upon these base data results, the difference of 27% on 1980 calculations will be revised annually and used to assess the actual level of materials handling on future years business plan predictions.

APPENDIX 7

APPENDIX 7

PAR NO. 81-2032

INTERNAL TRANSPORT FLEET RATIONALISATION

MATERIALS HANDLING

Standard Telephones & Cables Ltd.,
Cable Products Division,
Newport, Gwent.

MATERIALS HANDLING

(INTERNAL TRANSPORT) P.A.R. No. 81-2032

INDEX

MATERIALS HANDLING

(INTERNAL TRANSPORT) P.A.R. No. 81-2032

APPENDIX

A. TRUCK REQUIREMENT ANALYSES (SAMPLE)

B. DISPOSAL PLAN FOR OLD TRUCKS (S. CZYRKO)

C. ORGANISATION AND MANNING

D. TABLE OF DISCOUNT FACTORS

LEASE EQUIPMENT DETAIL (US $000) $ @ 2.39 / £.

ITEM NO.	DESCRIPTION OF ITEM	3 UNIT COST	4 QUANTITY REQUIRED	5 TOTAL CAPITAL EXPENDITURE AVOIDED	6 ANNUAL DEPRECIATION LOST	7 ANNUAL LEASE EXPENSE	8 ESTIMATED ANNUAL EXPENSE AVOIDED	9 NET ANNUAL LEASE EXPENSE	10 TERM OF LEASE (YEARS)	
1	Pallet Stacker 1.6 tonne. Electric.	22,4	3	67,2	13,44	12,10			5	
2	Counterbalanced 5.0 tonne. Electric truck.	41.60	2	83.2	16.72	15.40			5	
3	Counterbalanced 4.0 tonne. Electric truck.	58.54	1	58.54	11.70	10.50			5	
4	Counterbalanced 3.0 tonne. Electric truck.	40.3	3	103.9	20.78	18.60			5	
5	Reach truck 1.0 tonne. Electric	32.8	1	32.8	6.56	6.00			5	
6	Counterbalanced 4.0 tonne Diesel truck.	40.4	1	40.4	8.08	7.30			5	
7	Counterbalanced 4.0 tonne Electric truck.	39.7	1	39.7	7.94	7.10			5	
	Total		12	425.5	85.1	77.0	105	8.1	5	40.5

STC–GE. 45 Fixed Asset Control Manual Section 12

SECTION 1 - SHEET 3

COST SUMMARY OWNED / RENTAL $K @ 2.39 / £

	Annual Cost		Total Cost	
	Leased	Owned	Leased	Owned
ASSETS.				
Capital purchase cost £178.03 = $ K 425,5		85,1		425,5
Total lease cost (exc. maint) = £161.00 = $ 385				
Ave. annual lease = $ 77.0 Total = $77,0 x 3.60478 discount @ 12%	77,0		278,0	
COSTS.				
Maintenance.				
Annual inflated cost discounted @ 12% to 1981 value = Total $ 388,4. Annual cost = 388,4 / 5		77,7		388,4
Annual inflated cost discounted @ 12% to 1981 value = Total 388,4. Annual cost = 388,4 / 5	77,7		388,4	
Fuel				
Annual inflated cost discounted to 1981 value = Total $ 158.0 for owned and leased plant.	31,6	31,6	158,0	158,0
Interest				
Total interest on owned asset calculated @ 5% of annual net plant value.		8,5		42,6
Development Grant				
Calculated @ 15% of Capital cost.		(12,8)		(64,0)
TOTAL	186,3	190,1	824,5	950,5

COSTS AT OWN YEAR VALUES £K

	1982	1983	1984	1985	1986
Rental Option					
Rental (including maintenance)	56.17	60.39	65.12	70.42	76.36
Maintenance (owned trucks)	16.0	17.92	20.07	22.48	25.18
Fuel Costs	14.78	16.55	18.54	20.76	23.25
Total Rental Costs	86.95	94.86	103.73	113.66	124.79
Purchase Option					
Depreciation	35.6	35.6	35.6	35.6	35.6
Interest	7.12	5.34	3.56	1.78	-
Maintenance	40.00	41.92	44.07	46.48	57.18
Fuel Costs	14.78	16.55	18.54	20.76	23.25
Development Grant	5.36	5.36	5.36	5.36	5.36
Total Purchase Costs	102.86	104.77	107.13	109.98	121.39
Without the Project (current situation)					
Maintenance	84.0	95.76	109.17	124.45	139.38
Short Term Hire Costs	2.0	2.28	2.60	2.96	3.32
Fuel Costs	19.08	21.37	23.93	26.80	30.02
Total Costs	105.08	119.41	135.70	154.21	172.72

STC SL 4678 (10/79)

PROJECT APPROPRIATION REQUEST TO LEASE CAPITAL ASSETS (US $000).

BUDGETED (✓)	NON-BUDGETED (✓)	PROJECT NO.
	✓	81-2032

COMPANY, DIVISION OR PLANT & GROUP: CABLE PRODUCTS DIVISION
LOCATION: NEWPORT
DATE: 9.12.81

CAPITAL LEASE ☐ / OPERATING LEASE ☐	INITIAL LEASE ☑ / RENEWAL LEASE ☐	LOCAL CURR.	RATE (1 L.C. UNIT=$)	NAME AND LOCATION OF LESSOR
		£ Sterling	$ 2.39	CABLE PRODUCTS DIVISION, NEWPORT

DESCRIPTION OF ASSETS TO BE LEASED: Quantity 12 Lift Trucks of various specification

MAC CODES	051			
%	100			

1. COST SUMMARY

	DESCRIPTION	ANNUAL COST LEASED (TERM 5 YRS)	ANNUAL COST OWNED (LIFE 5 YRS)	TOTAL COST LEASED	TOTAL COST OWNED
A. ASSETS	1. Yrs 1 - 4	95.0		265.8	
	2. Yr 5	2.4		2.4	
	3. Owned		85.1		425.5
	4.				
	SUB-TOTAL	97.4	85.1	268.2	425.5
B. ANNUAL COST OF SERVICES	1. Taxes				
	2. Insurance	As Buy	As Lease	As Buy	As Lease
	3. Maintenance	Yr.1-4 57.4	57.4	160.6	160.6
		Yr. 5 40.0	40.0	40.0	40.0
	4. Other Fuel	As Buy	As Lease	As Buy	
	Grant	Inc.in Lease	(12.8)	Inc.in Lease	(64.0)
	SUB-TOTAL	97.4	84.6	200.6	136.6
C.	TOTAL (A + B)	194.8	169.7	468.8	562.1
D. DETERMINATION OF NET COST	Salvage/RESIDUAL VALUE			–	(20.2)
	NET (C-RESIDUAL VALUE)			468.8	541.9

EVALUATION CRITERIA

IF OWNED

1. R.O.I. 23.5 %
2. Payback in Years 1.9 Yrs
3. Is interest included in determination of R.O.I.? Yes
4. Other R.O.A. 29.4%

IF LEASED

1. Discount Rate Used 16 %
2. Other

TERMS OF LEASE (Summarize options to renew and cancel plus any other unusual terms). This is a lease project with a 5 year term. The 5th year is a secondary lease at 1% Capital Cost plus maintenance.

JUSTIFICATION OF PROPOSED LEASE: Offers the most flexible alternative with virtually new equipment always available.

APPROVALS

(Names to be typed, or clearly printed, under signatures)

PLANT/DIV./PROD. LINE	DATE	STC HEADQUARTERS	DATE	ITTE HEADQUARTERS	DATE	WORLD HEADQUARTERS	DATE
COMPT.		DIR. TECH.				P.L.M.	
MTG. MGR.		DIR. ADMIN.				DIR. R.E.	
PLANT MGR.		DIR. I. E. & M. [signature]	12/81			DIR. I.R.	
DIV. MGR.		TREAS. [signature]	10/12/81			DIR. QUAL.	
PROD. LINE DIRECTOR [signature]		DIR. FIN. CONTROLS [signature]	16/12/81			DIR. STAFF. OPS.	
		DIR. TELECOMMS.				COMPT.	
M.A.C.	DATE					TREAS.	
CHAIRMAN ETC. [signature] 10-12-81		CHAIRMAN/MAN. DIR.		GROUP EXEC.		DIR. I.E. & M.	
						DIR. CAP. ASSETS & E.C.	

ITT HEADQUARTERS – FINAL APPROVALS

DIRECTOR–OPERATIONS STAFF	DATE	OFFICE OF THE CHIEF EXECUTIVE	DATE	PRESIDENT AND CHIEF EXECUTIVE	DATE

Detail Attached

6 JAN 1982

921/WB/JLE

MALLINSON HOUSE

DATE: 24th December, 1981

TO: MR. C. ROBINSON

FROM: W.E.C. BOWD
- pp. C.A.C. SECRETARY

CC: MR. R. BASSETT
MR. C. LEWIS

SUBJECT: PAR 81-2032L LIFT TRUCKS

AMOUNT APPROVED	CAPITAL	EXPENSE	(SALVAGE)
97.4 p.a. for 5 years.			

$000's @ 2.39

The Subject Appropriation Request has been approved by STC Headquarters for expenditure

A copy of the approved request is attached for your records.

All requisitions for outside purchases to be actioned through purchasing, and full trade discounts obtained where possible.

VARIATIONS/RESTRICTIONS TO AMOUNT REQUESTED

CABLE PRODUCTS DIVISION NEWPORT

PROJECT APPROPRIATION REQUEST (RENTAL)

TITLE: INTERNAL TRANSPORT RATIONALISATION NO. 81-2032

2.0 MANAGEMENT SUMMARY

2.1 Project Objective

To provide a cost effective internal transport service to meet the future needs of the Cable Products Division overcoming current problems and reducing operating costs by £115.2 K over a four year period at 1981 prices.

2.2 Problem

The internal transport situation at CPD Newport is unsatisfactory and rapidly worsening due to the inadequacy of the existing fork lift truck fleet.

The causes of this problem are:-

a. The fleet capacity mix does not reflect current and planned production requirements - e.g. a shortage of trucks for heavy lifts (3 trucks in excess of 8,000 lb capacity are required, only 1 truck is currently in operation).

b. Excessive age and poor condition of the majority of existing trucks. (Average age 10 years, oldest trucks 24 years)

At any time, 5 to 10 trucks are out of service, necessitating expediency action. Service to manufacturing is only maintained by good day-to-day fleet management. Trucks are inevitably loaded above their rated safe capacity with a resultant increase in truck downtime for maintenance.

In addition, operating costs are excessive for the following reasons:-

c. The fleet is too large (42 trucks)

d. Maintenance costs are excessive for the reasons stated above - a and b. (£K62.5 in 1980).

If these problems are not resolved promptly, manufacturing performance will be seriously impeded by poor internal transport service.

2.3 Proposals

Following an 11 month study of the internal transport requirements at CPD Newport we recommend and propose:-

a. That the total fleet is reduced from 42 trucks to 28 trucks.

b. That of the 28 trucks, 12 are hired on a rental agreement with full maintenance cover. The rental committment being £K52 NETT per annum.

c. That the balance of 16 trucks required are the best trucks of the correct capacity mix from the existing fleet.

2.4 Key Financial Data (£K)

Gross Expenditure (Excluding manning) over 4 years	399.2
Cross Savings over 4 years	115.2
Pay Back	1.9yrs
R.O.I.	23.5%
R.O.A.	29.4%
Date of implementation	December, 1981.

3.0 BACKGROUND / CURRENT SITUATION.

3.1 BACKGROUND

Materials Handling is a vital part of C.P.D. Newport's operation and has been long overdue for critical review with regard to minimising costs and increasing efficiency.

One of the major considerations within the materials handling system is internal transport primarily fork lift trucks. This project covers the rationalisation and updating of this equipment to provide a cost effective service to manufacturing.

Detailed analyses of the internal transport fleet began early October, 1980, studies were carried out on the viability of alternative modes of material movement but the fork lift truck was considered to be the optimum choice, being the flexible base of the handling system.

This project forms the first part of a 2 year project entitled "Materials Handling". Following the fork lift truck rationalisation, bulk storage of sheathing compounds will be investigated together with the possible automation of bobbin transfer from insulating lines to twinning to marshalling to laying up and return of empties. The above projects are being covered as part of the authors appointment as an Associate for the Standard Telephones and Cables/ Polytechnic of Wales Teaching Company programme.

3.2 CURRENT SITUATION

There are currently 42 trucks of various ages, capacities and makes at C.P.D. Newport which are listed below.

These trucks have been acquired over many years, a proportion of the fleet being transferred from Woolwich between 1976-77. Consequently there is no overall standardisation on make or capacity of truck, which, combined with the wide range of ages, makes a suitable parts stockholding impractical. This situation causes high downtime not least from the age and poor condition of the fleet but from parts which are difficult to obtain and have long lead times.

Trucks in operation include some reach and stacker trucks 24 years old and the average age of the total fleet is 10 years. During the last 10 years, product mix changes have occured such that the basic 4,000 lb capacity truck of which there are 9 is no longer capable of meeting weight demands put upon it.

There are four trucks of 7,000 lb capacity and above, of these only one 8,000 lb electric truck is continuously available for use throughout the factory and this particular truck has recently suffered a bent mast through its generally poor condition. The requirement is for 5 trucks of 8,000 lb capacity and above, all fully available for work throughout the factory.

The situation due to this shortfall of large capacity trucks is critical. During the normal working day, the 15,000lb truck originally intended for the composite area has to be fitted with forks for heavy drum lifts; fitted with fork extensions for copper and occasional unloading of wood deliveries; and refitted with hook and boom for composite work, all of which can only be carried out by maintenance personnel who have their own priority lists which results in excessive waiting time.

Coupled with the above problems are the problems associated with the 15,000 lb truck breaking down. In such circumstances, copper deliveries are held up and have resulted in stoppages at the rod breakdown machines, heavy drum lifts both inside and outside the factory are delayed causing hold ups on production machines and in shipping.

The smaller base capacity trucks of 5,000 lb and below, of which there are 10 are in very poor condition being continually overloaded due to the lack of load indication on the truck and heavier drum weights than were originally envisaged. The trucks ages are past the economic life and in most cases past the useful life expectancy. These factors render the fleet service unpredictable, costly and inefficient.

The maintenance costs were £62,5K in 1980 and although every effort is being made to reduce this cost in 1981, the second half of the year is showing significant increases in the number of truck breakdowns. Recent daily statistics indicate occurrences of 10 major counterbalanced trucks inoperative simultaneously ignoring the number of reach, stacker and miscellaneous trucks.

Summarising:-

> The average downtime during 1980 was 15 truck days per week, service only being maintained by expediency action, good day to day fleet management and costly short term hire. The level of service in such a situation is very poor and impedes manufacturing performance.

The causes are:- Incorrect capacity mix and poor electrical and mechanical condition.

> High downtime exists due to the above factors and is accelerated by continual overloading. Running costs are far in excess of an efficient cost effective service due to the high number of trucks (42) needed to maintain the present level of service.

3.3 CONCLUSIONS

In order to attain a cost effective and fully operational materials handling service and to continue this service to manufacturing in future years, the present fleet of fork lift trucks must be rationalised. The major part of the fleet, consisting of old and worn out equipment, must be updated and replaced by fewer trucks but of the correct capacity mix consistent with present and predicted business demands.

CURRENT FLEET OF COUNTERBALANCED F.L.T.'s

CAPACITY (lb)	MAKE	POWER	YEAR OF MANUFACTURE	CONDITION
15,000	HYSTER	GAS	1979	GOOD
10,000	CLARK	GAS	1975	INOPERATIVE
8,000	CLARK	ELECTRIC	1970	POOR
7,000	CLARK	GAS	1973	FAIR
6,000	CLARK	ELECTRIC	1975	POOR
6,000	CLARK	ELECTRIC	1975	FAIR
6,000	CLARK	ELECTRIC	1974	FAIR
5,000	CLARK	ELECTRIC	1972	POOR
5,500	LANSING BAGNALL	ELECTRIC	HIRED	GOOD
4,500	LANSING BAGNALL	ELECTRIC	EX. N.W.	GOOD
4,000	YALE	ELECTRIC	1962	POOR
4,000	CLARK	ELECTRIC	1965	INOPERATIVE
4,000	CLARK	ELECTRIC	1965	POOR
4,000	CLARK	ELECTRIC	1970	POOR
,000	CLARK	ELECTRIC	1971	POOR
4,000	CLARK	ELECTRIC	1971	POOR
4,000	CLARK	ELECTRIC	1972	POOR
2950	CLARK	ELECTRIC	1975	POOR

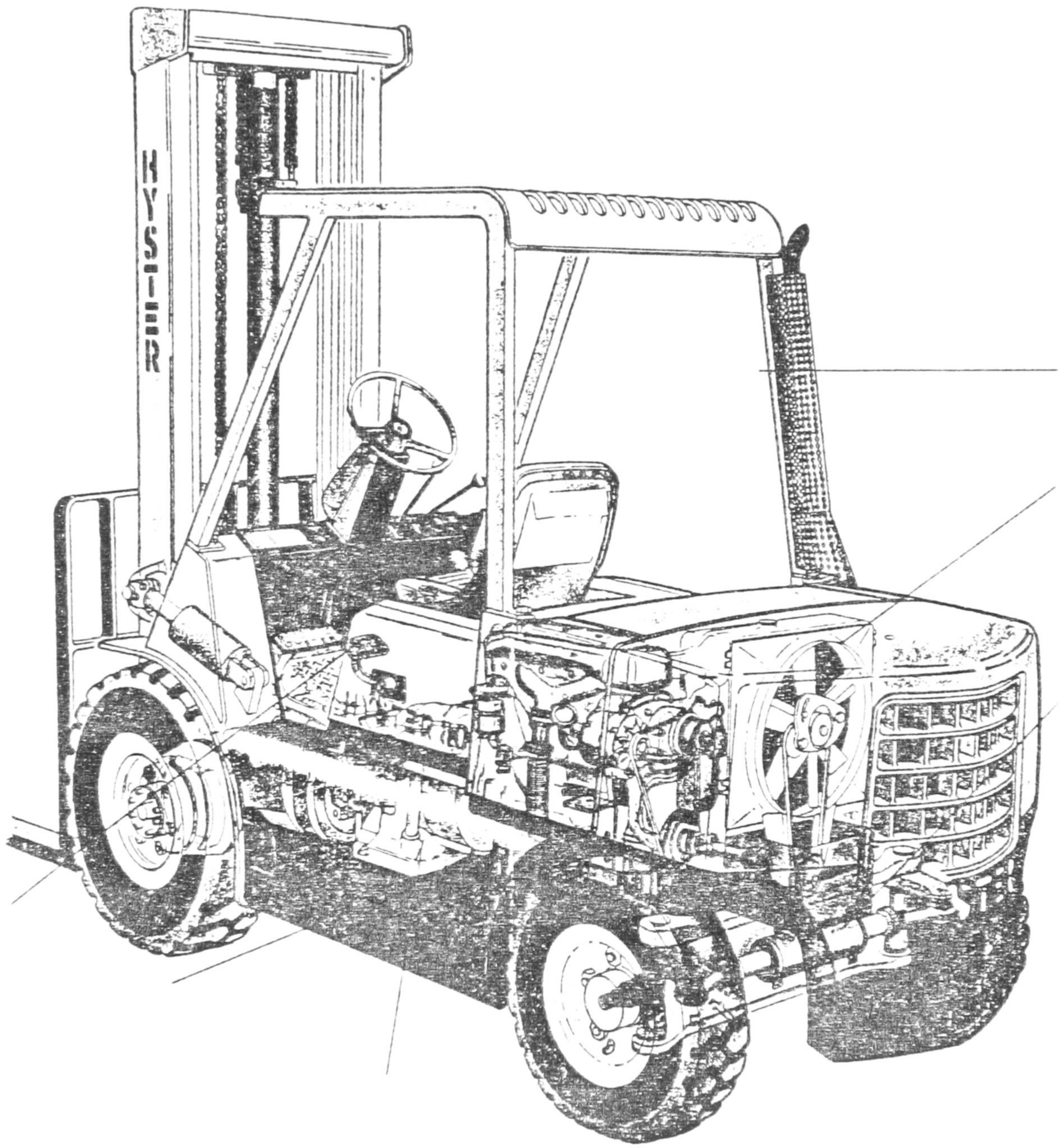
CURRENT FLEET OF REACH AND STACKER TRUCKS

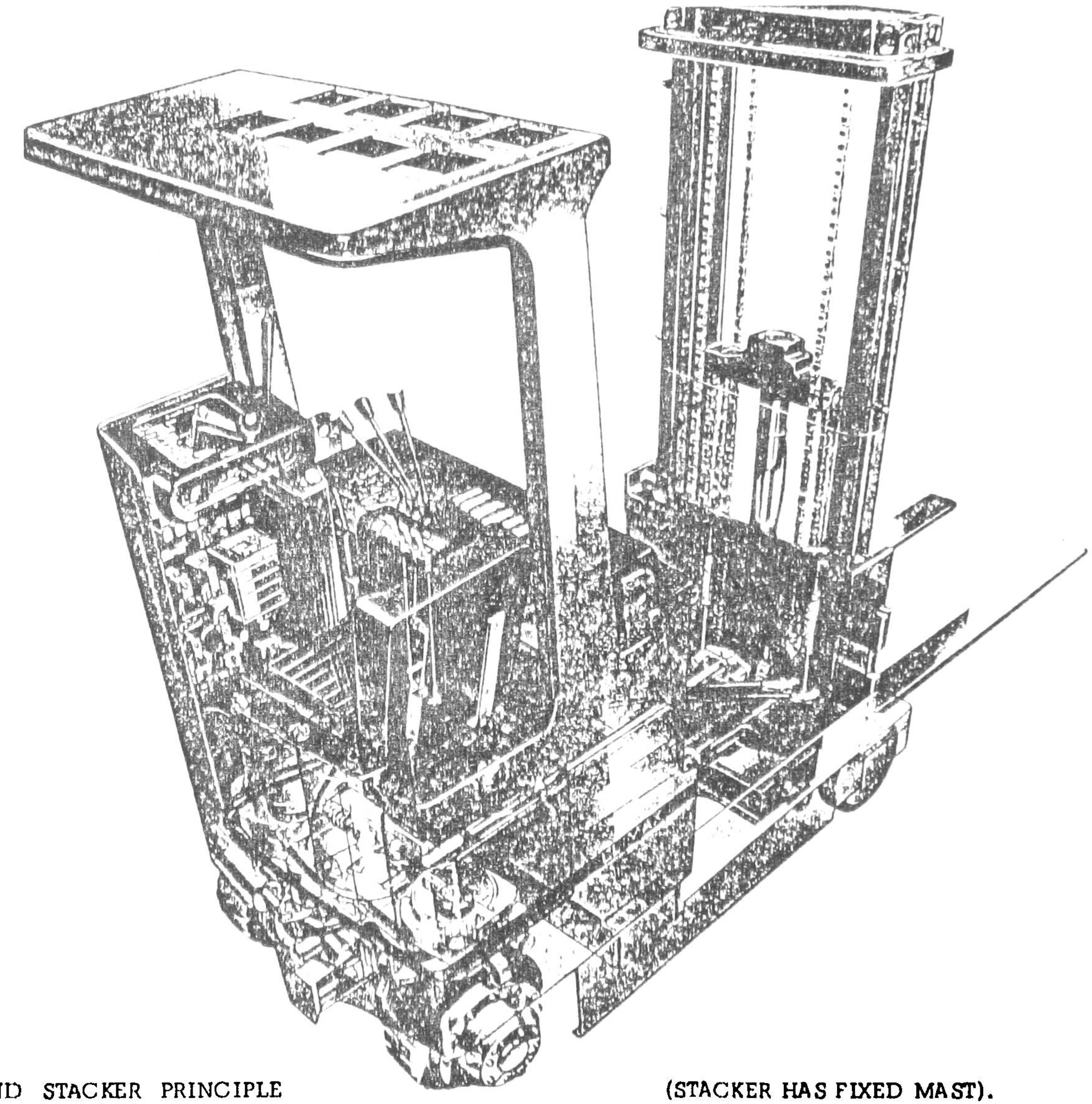
CAPACITY (lb)	M A K E	POWER	YEAR OF MANUFACTURE	CONDITION
2500	LANSING BAGNALL	ELECTRIC	1957	POOR
2900	YALE	ELECTRIC	1957	POOR
2200	B. T. ROLLATRUC	ELECTRIC	1961	POOR
2900	YALE	ELECTRIC	1969	POOR
3000	CLARK	ELECTRIC	1973	FAIR
3000	CLARK	ELECTRIC	1974	POOR
2200	B. T. ROLLATRUC	ELECTRIC	1974	POOR
2500	LANSING BAGNALL	ELECTRIC	1976	FAIR
2240	LANSING BAGNALL	ELECTRIC	1979	FAIR
3300	LANSING BAGNALL	ELECTRIC	EX. N. W.	POOR
1760	LANSING BAGNALL	ELECTRIC	EX. N. W.	FAIR
2200	LANSING BAGNALL	ELECTRIC	1979	GOOD

CURRENT FLEET OF MISCELLANEOUS TRUCKS

CAPACITY (lb)	M A K E	POWER	YEAR OF MANUFACTURE	CONDITION
13,200	COLES CRANE	DIESEL	EX. N. W.	GOOD
FLAT BED	B. E. V. (ARK ROYAL)	ELECTRIC	EX. N. W.	FAIR
DRUM WAGON	AMIESE	ELECTRIC	1966 ?	FAIR
600	TITAN	MANUAL/HYD	1973	GOOD
1500	CROWN	MANUAL/HYD	EX. N. W.	GOOD
1500	CROWN	MANUAL/HYD	EX. N. W.	GOOD
3000	LANSING BAGNALL	ELECTRIC	EX. N. W.	FAIR
3000	LANSING BAGNALL	ELECTRIC	EX. N. W.	GOOD
205	LLOYDS BRITISH	MAN/HYD	HOOK TRUCK	FAIR
2240	ECCLES	MAN/HYD	BOOM TRUCK	GOOD
1100	LINK	MAN/HYD	HOOK TRUCK	GOOD
560	MINILIFT	MAN/HYD	HOOK TRUCK	GOOD

A COUNTERBALANCED (C/B) TRUCK





THE REACH AND STACKER PRINCIPLE (STACKER HAS FIXED MAST).

4.0 TRUCK REQUIREMENTS

4.1 Analyses

Recommendations are based on a combination of four major analyses:-

Theoretical analysis based on the cable sample from the 1980 Business Plan extrapolated over the next five years using the 1980-85 objectives (W.I.P. movements).

Material movement per department, using historical records combined with extensive discussions with operating and supervisory personnel. (Non W.I.P. movements, e.g. Raw Materials).

Computer based simulation of truck utilisation, carried out jointly with the Work Study Department (counterbalanced indoor trucks only).

Computer based simulation of truck downtime for planned and breakdown maintenance (carried out jointly with the Polytechnic of Wales computer staff).

4.2 Major Findings

The major proportion of the current fleet of 42 trucks are of the wrong capacity mix and in very poor condition.

Service to manufacturing could be maintained by 28 trucks of the correct capacity mix and condition.

Acquisition of 12 new trucks of a higher lifting capacity is essential to complement the 16 best trucks in the present fleet to provide a cost effective service.

Within the reduction from 42 - 28 trucks manning levels are not affected for the following reasons :-

a) Trucks are not dedicated to specific personnel.

b) Shop service personnel draw from a number of trucks set aside for their use but driving the trucks is only a small part of their normal work in the present situation.

c) Multiple trucks are used for multiple shift working whereas in the proposed situation one truck with a spare battery to increase truck utilisation will be used thereby decreasing the number of trucks and cost.

d) At any one time there are over 5 trucks not in use for various reasons.

A combination of the above analyses and findings resulted in the following recommendations for the size and capacity mix of the internal transport fleet at CPD, Newport:- 4.3

4.3 EXPLANATION OF ANALYSES

Brief details of the analyses carried out to determine the number and capacity mix of trucks is attached.

From a breakdown of the 1980 Business Plan - cable sample, each cable specification and its length was extracted; the size, weight and number of bobbins and drums at each operation was determined from the process layouts and cable design specifications.

Assuming all orders are equally distributed over the year, the total number of bobbins and drums moved throughout the factory was calculated as an average figure. Fluctuations in load demand in different sections was covered using practical production information.

Inter process distance measurements together with fork lift truck operating data was used to determine the time taken to move the material and therefore the number of trucks required, in each capacity range.

The above procedure was used for Work in Progress (W.I.P.) movement through the telephone facility at C.P.D. Newport. Non W.I.P. movement and raw materials, machinery etc. was calculated from practical historic information in each department knowing the amount of material per load transferred.

All material movement using mechanical means in C.P.D. Newport was then analysed in set weight categories to determine the number of each different type of fork lift truck required. Maintenance records were also analysed to predict present and proposed levels of downtime and cost in order to obtain the most cost effective, efficient method of acquisition and cover for maintenance downtime.

For the indoor operations of F.L.T.'s, the number and capacity mix requirements were checked using a computer aided simulation programme devised by Mr. O.G. Erasmus (Work Study Department) C.P.D. Newport, added to by the author, to include raw materials, job weights and truck capacities. For the additional trucks required to cover downtime for maintenance the number and capacity mix requirements were checked using a computer aided simulation programme produced by the Polytechnic of Wales computer staff in conjunction with the author.

4.4 PROPOSED SIZE AND CAPACITY MIX OF TRUCKS

COUNTERBALANCED

NO.	CAPACITY (lbs.)	TYPE
1	15,000	GAS
2	10,000	ELECTRIC
1	8,000 + Spare Battery	ELECTRIC
1	8,000	DIESEL
4	6,000 + 1 Spare Battery	ELECTRIC
1	4,500	ELECTRIC
1	5,500	ELECTRIC
	TOTAL OF 11 TRUCKS	

POWERED REACH AND STACKER TRUCKS

3	3,500	ELECTRIC (STACKER)
1	2,240	ELECTRIC (STACKER)
3	2,500	ELECTRIC (REACH)
1	1,760	ELECTRIC (REACH)
1	3,000	ELECTRIC (REACH)
	TOTAL OF 9 TRUCKS	

MISCELLANEOUS TRUCKS

1	13,200	DIESEL (COLES CRANE)
1	4,500	ELECTRIC (ARK ROYAL)
1	3,000	ELECTRIC (FLAT BED)
1	2,240	ELECTRIC (HOOK LIFT)
1	600	MANUAL (STACKER)
2	205	MANUAL (HOOK LIFT)
	TOTAL OF 7 TRUCKS	

COMBINED TOTAL OF 27 TRUCKS + 1 FREE ON SITE AS A SPARE WITH THE RENTAL CONTRACT.

5.0 CHOICE OF SUPPLIER

Analyses were concentrated on the following areas:-

a) Truck suitability for its intended job.

b) Flexibility for use in other areas suited to its capacity.

c) Price (quotes attached).

d) The after sales service, maintenance contract and expected downtime.

e) Number of engineers in the immediate vicinity, location of nearest spares and service depot.

f) British or foreign manufacture of trucks, supplier security.

(a) and (b) above were analysed by means of demonstrations and trials from various suppliers listed below.

Demonstration given

1. ROLLATRUC
2. LANSING BAGNALL
3. EATON YALE
4. COVENTRY CLIMAX
5. ALTET
6. HYSTER

Factors considered

	Can Manufacturer supply all trucks to C.P.D. Specification	Strength & Construction	All-round vision	Comfort	Ergonomic Design
1.	Small trucks only	Good	Good	Good	Good
2.	All trucks	Very good	Good	Very good	Very good
3.	* C/B only	Good	Good	Good	Fair
4.	* C/B only	Good	Good	Fair	Fair
5.	Small trucks only	Good	Good	Very good	Very good
6.	* C/B only	Very good	Good	Good	Good

* C/B = Counterbalanced.

Based upon the results of the above trials and factors considered, the optimum supplier is Lansing Bagnall

EATON YALE TRUCKS

EDDISSON PLANT

6,ooo lbs lift capacity Fork Lift Truck - ERC 6o

£15,95o   inclusive of discount.

(confirmation to follow.)

REGARDS   EATON YALE - EDDISSON PLANT.

CATERPILLAR TRUCKS

337548 BOWLIF G

SUE 3.05 5/10/81

ATTN: MR N J PERRY - PRODUCTION CONTROL

CONFIRMING MY CONVERSATION WITH YOU REGADING A PRICE OF CATERPILLAR FORK LIFT TRUCK MODEL M-60B (72 VOLT) 6,000 LBS CAPACITY, COMPLETE WITH 500 AHC BATTERY AND 12 HOUR CHARGER.

TOTAL PRICE £17,810.00 + V A T

+++

REGARDS
BRIAN CHESTER
LIFT TRUCK SALESMAN

337548 BOWLIF G

LANSING BAGNALL TRUCKS

498366 STC NP G
498597 LBBRGD G

OR THE ATTENTION OF :
MR NIEL PERRY

2.10.81

THE BUDGET CAPITAL COST
FOR STANDARD SPECIFICATION FOER 9 3.0

THE PURCHASE PRI CE WOULD BE £15,730
PER TRUCK. THIS TO INCLUDE YOUR S.T.C.
DISCOUNTS.

REGARDS
ROGER TOWNEND
FORK TRUCK RENTALS.

498597 LBBRGD G
498366 STC NP G

CLIMAX TRUCKS

(Lease with maintenance - five year period.)

ITEM NO.	MODEL AND NO. OFF	NETT PURCHASE PRICE	LEASE RATE PER WEEK	MAINTENANCE COST PER WEEK			TOTAL PER WEEK COST YRS. 1-3	TOTAL COST PER WEEK YR. 4	TOTAL COST PER WEEK YR. 5	TOTAL OUTLAY
				YR.1-3	4	5				
1	100EC	18,873.60	53.96	27.39	33.92	39.00	81.35	87.88	92.96	13,633.88
2	-----	18,840.00	53.87	27.39	33.92	39.00	81.26	87.79	92.89	13,620.88
3	80EC	26,015.00	74.38	27.39	34.23	39.36	101.77	108.61	113.74	16,854.24
4	80DA	16,217.50	46.37	33.57	41.96	48.25	79.94	88.33	94.62	13,670.28
5	1 x 60EC	18,408.00	52.63	40.96	51.20	58.88	93.59	103.83	111.51	16,064.36
6	1 x 60EC	15,908.00	45.48	27.39	34.23	39.36	72.87	79.71	84.84	12,345.84
7	4 x 60EC	60,704.00	173.57	109.56	136.92	157.44	283.13	310.49	331.01	48,080.76
8	3 x S/ Stacker	30,601.00	87.50	45.00	45.00	56.25	132.50	132.50	143.75	21,255.00
9	1 x Reach Truck (Atlet)	11,407.00	32.62	14.50	14.50	15.50	47.12	47.12	48.12	
			620.38	353.15	525.88	493.04	973.53	1046.26	1113.44	162,927.96

NOTES

Items 1, 2, 5, 6, and 7 include for 60" long chamfered forks.
Item 1 includes for spotlight fitted on mast.
Items 3 and 4 include for SMC fork positioners type C16 fitted with 60" chamfered forks.
Items 3, 5, and 8 include for a spare battery
Item 6 includes for a spotlight fitted to the mast and a metal cab.

15% regional development grant is included in all lease figures.

CLARK TRUCKS

493363 STC NP G
497998 CLARKW G   TLX NO C1874   GA   5.10.81
10.40

FROM : CLARKLIFT CARDIFF
========================

ATTN MR NEIL PERRY
==================

RE: TELEPHONED REQUEST

STANDARD 6000 LBS ELECTRIC TRUCK
MODEL EC500 60
130'' STD MAST
18 THF 27 BATTERY
SP 18/115 CHARGER

PRICE DELIVERED= £19,730

REGARDS,
BILL PERSSE

497998 CLARKW G
493363 STC NP G

6.0 ALTERNATIVES

6.1 Take no action

Cable production has become as cost competitive as the consumer market and as such demands the most efficient and cost effective service.

To take no action would result in an increase in fork lift truck downtime due to the age and condition of the fleet. This would necessitate expensive casual hire to meet service and capacity shortfalls, and consequently an increase in maintenance and associated costs. This is the most expensive option £515K over 4 years. Minimising the number of trucks would not be possible and would not result in a cost effective efficient service to manufacturing. To take no action is not therefore a practical alternative and is rejected.

6.2 Acquire new trucks by Capital Purchase (Year 1)

Use the minor portion of the existing fleet (16 trucks) supplemented by the capital purchase of 12 trucks in Year 1. This would provide the required service but not at the least cost. Flexibility would be very limited and if in house maintenance is adopted would depend upon the availability of spares and labour. Capital expenditure would be £158K in Year 1, not including running costs, manning costs or maintenance labour. The gross expenditure (excluding manning) over the 4 year plan period would be £458K. For reasons of cost and flexibility this option is not recommended.

6.3 Acquire new trucks by Phased Capital Purchase

Use the major portion of the existing fleet, supplemented by phased purchase of 12 critical trucks over the 4 year plan period.

This is not the lowest cost option and does not provide the required service until the end of the 4 year period. In years 1, 2 and 3 the current fleet would be gradually replaced which would neither minimise the number of trucks required to effectively maintain the required service, nor minimise the associated operating costs. Gross expenditure over the 4 year period (excluding manning) of £553K.

For the above reasons this option is not recommended.

6.4 <u>Acquire new trucks by leasing</u>

Use the minor portion of the existing fleet (17 trucks) supplemented by a leased fleet of 11 major trucks. This again is not the cheapest option and would not provide the flexibility required for business and method changes.(i.e at a later stage when further reductions or changes in fork lift truck specifications are achieved by possible dedicated handling systems the leased trucks would have to be sold and trucks of different specifications acquired). The financial analyses illustrate a gross expenditure of £484K over the 4 year planning period (neglecting manning costs).

For the reasons above this option is not recommended.

6.5 <u>Acquire new trucks by Rental</u>

Use the minor portion of the existing fleet (16 trucks) supplemented by a rental fleet of 12 major trucks acquired in Year 1.

This option is the cheapest option and will provide sufficient flexibility for business and method changes at no extra cost (i.e. within the rental option truck specification changes within limits required due to method changes are acceptable at no extra cost. The number of trucks is at a minimum with this option and the total expenditure (excluding manning) over the 4 year plan period is £415K.

For these reasons, this option is recommended, to provide the optimum service at minimum cost.

6.6 FINANCIAL ANALYSIS (D.C.F.)

The following sheets illustrate each option on a like for like comparison, based upon a 4 year contract period due to the uncertainty of further predictions.

The options are calculated on a discounted cash flow basis using S.T.C. 53.5% corp. tax where applicable. Book value for re-sale of the newer trucks and estimations of value for fully depreciated trucks is covered. 12% inflation per year is used as an average future estimate.

NOTE·

1. On the purchase options, trucks are sold after the four year period to compare with the rental option.

   On the lease option, trucks are sold after four years by the leasing company and the residual value expected is apportioned to each years lease cost, reducing the nominal rate. In both the above cases, the depressed state of the secondhand truck market forces the residual value of the trucks to reflect book value which is 20% of capital cost, the trucks being depereciated over five years.

2. Explanation of Maintenance Costs.

   a) Rental

      Purchase maintenance is included in the rental rate for the 12 new trucks. £1000/truck p.a. is used for the old trucks kept. (Based on historical accounting records).

   b) Lease.

      As a) above except that 17 old trucks would be kept because, with rental one spare truck is provided free of charge.

   c) Capital Purchase year 1.

      Maintenance is based on historical figures for the old trucks; new trucks are under guarantee for the first year, and only incur routine maintenace costs. Thereafter contract maintenance is included for the new trucks only.

   d) Phased Capital Purchase.

      As above c) but with more trucks present in the fleet until full cover is attained after total acquisition at the end of the four years.

   e) Do nothing.

      All maintenance based on an extrapolation of historical accountancy figures.

   Manning costs are not included as there is no reduction in headcount as a result of the project thus the labour content is the same for every option.

   Fuel has been included as this affects the total costs depending upon the option.

* See Appendix C Section 2.

R E N T A L

YEAR	1982 1.	1983 2.	1984 3.	1985 4.	1986 5.
RENTAL RATES (including additional equipment)	- 56,165	- 60,390	- 65,122	- 70,422	
TAX RELIEF AT 53,5%		+ 30,048	+ 32,309	+ 34,840	+ 37,676
MAINTENANCE	- 16,000	- 17,920	- 20,070	- 22,479	
TAX RELIEF AT 53,5%		+ 8,560	+ 9,587	+ 10,738	+ 12,026
OLD TRUCK INCOME	+ 26,000				
TAX ON INCOME 53,5%		- 13,910			
FUEL USED	- 14,776	- 16,549	- 18,535	- 20,759	
TAX RELIEF ON FUEL 53,5%		+ 7,905	+ 8,854	+ 9,916	+ 11,106
CASH FLOW	- 60,941	- 62,256	- 52,977	- 58,166	+ 60,808
DISCOUNT FACTOR 16%	-	0,8621	0,7432	0,6407	0,5523
N.P.V. 12% INFL. 16% DISCOUNT FACTOR	- 60,941	- 53,671	- 39,373	- 37,267	+ 33,584

TOTAL COST AFTER CONTRACT (4 years) (£157,668) *EXCLUDING MANNING COSTS.

LEASE

YEAR	1982 1.	1983 2.	1984 3.	1985 4.	1986 5.
LEASE RATES (including addit'l equip.)	- 76,842	- 80,847	- 84,814	- 89,034	
TAX RELIEF AT 53,5%		+ 41,110	+ 43,253	+ 45,375	+ 47,633
MAINTENANCE	- 17,000	- 19,040	- 21,325	- 23,884	
TAX RELIEF AT 53,5%		+ 9,095	+ 10,186	+ 11,409	+ 12,778
OLD TRUCK INCOME	+ 25,000				
TAX ON INCOME 53,5%		- 13,375			
FUEL COSTS	- 14,776	- 16,549	- 18,535	- 20,759	
TAX RELIEF ON FUEL 53,5%		+ 7,905	+ 8,854	+ 9,916	+ 11,106
CASH FLOW	- 83,618	- 71,701	- 62,381	- 66,977	+ 71,517
DISCOUNT FACTOR 16%	1	0,8621	0,7432	0,6407	0,5523
N.P.V. 12% INFL. P.A 16% DISCOUNT FACTOR	- 83,618	- 61,813	- 46,362	- 42,912	+ 39,499

TOTAL COST AFTER CONTRACT (4 year) (5 years incl. tax) (£195,206) Excluding manning costs

CAPITAL PURCHASE YEAR 1

YEAR	1982 1.	1983 2.	1984 3.	1985 4.	1986 5.
CAPITAL (Inc.Development Grant of 15%	- 195,400 + 29,300				
TAX RELIEF AT 53,5%		+ 104,539			
MAINTENANCE	- 25,333	- 50,540	- 56,605	- 63,397	
TAX RELIEF AT 53,5%		+ 13,553	+ 27,039	+ 30,284	+ 33,917
OLD TRUCK INCOME	+ 26,000			+ 31,600	
TAX ON INCOME 53,5%		- 13,910			- 16,906
FUEL COSTS	- 14,776	- 16,549	- 18,535	- 20,759	
TAX RELIEF ON FUEL 53.5%		+ 7,905	+ 8,854	+ 9,916	+ 11,106
CASH FLOW	- 180,209	+ 44,998	- 39,247	- 12,356	+ 28,117
DISCOUNT FACTOR 16%	1	0,8621	0,7432	0,6407	0,5523
N.P.V. 12% INFL. P.A. 16% DISCOUNT FACTOR (INCLUDES ADDITIONAL EQUIPMENT £32,653)	- 180,209	+ 38,793	- 29,168	- 7,916	+ 15,529

→ TOTAL COST AFTER 4 years (5 years incl. tax)

(£162,971) *Excluding manning costs.

PHASED CAPITAL PURCHASE

YEAR	1982 1.	1983 2.	1984 3.	1985 4.	1986 5.
CAPITAL PURCHASE	- 55,287	- 49,252	- 34,136	- 39,235	-
TAX RELIEF AT 53,5%		+ 29,579	+ 23,526	+ 18,263	+ 20,991
MAINTENANCE COSTS	- 68,000	- 65,720	- 66,211	- 61,387	
TAX RELIEF AT 53,5%		+ 36,380	+ 35,160	+ 35,423	+ 31,569
OLD TRUCK INCOME	+ 7,000	+ 6,000	+ 4,000	+ 85,128	
TAX ON INCOME 53,5%		- 3,745	- 3,210	- 2,140	- 45,543
FUEL COSTS	- 17,910	- 19,748	- 20,737	- 22,797	
TAX RELIEF ON FUEL 53.5%		+ 9,582	+ 10,565	+ 11,094	+ 12,196
CASH FLOW	- 73,258	- 56,924	- 51,043	+ 24,349	+ 19,213
DISCOUNT FACTOR 16%	1	0,8621	0,7432	0,6407	0,5523
N.P.V. 12% INFL P.A.	- 73,258	- 49,074	- 37,935	+ 15,600	+ 10,611

16% Discount factor (includes additional equipment, £32,653) →

TOTAL COST AFTER CONTRACT (4 year) (5 years incl. tax)

(£166,709) *Excludes manning costs

DO NOTHING

YEAR	1982 1.	1983 2.	1984 3.	1985 4.	1986 5.
MAINTENANCE	- 84,000	- 95,760	- 109,166	- 124,450	
TAX RELIEF AT 53,5%		+ 44,940	+ 51,232	+ 58,404	+ 66,581
CASUAL HIRE PREDICTIONS	- 2,000	- 2,280	- 2,599	- 2,963	
TAX RELIEF AT 53,5%		+ 1,070	+ 1,220	+ 1,390	+ 1,585
FUEL COSTS	- 19,076	- 21,365	- 23,929	- 26,800	
TAX RELIEF AT 53.5%		+ 10,206	+ 11,430	+ 12,820	+ 14,338
CASH FLOW	- 105,076	- 63,189	- 71,812	- 81,599	+ 82,504
DISCOUNT FACTOR AT 16%	1	0,8621	0,7432	0,6407	0,5523
N.P.V. 12% INFL P.A. 16% DISCOUNT FACTOR	- 105,076	- 54,475	- 53,371	- 52,280	+ 45,567

TOTAL COST AFTER 4 years (5 years including Tax)

(£219,635) *Excluding manning costs

7.0 MOTIVE POWER OPTIONS

7.1 Gas

From the comparison of running costs below, the gas option is not the cheapest option. If all trucks are gas, the noise and fume emission indoors would be unacceptable and not conducive to a healthy and clean environment. The internal combustion engine truck is not as manoeuvrable in the restricted gangways and confined spaces between machines as its electric equivalent.

For these reasons Gas motive power is not recommended.

7.2 Diesel

Again, this is not the cheapest option and it is unacceptable for all trucks to be diesel fuelled working indoors for health and safety reasons. As above its manoeuvrability is limited in the restricted gangways therefore this option is not recommended for indoor trucks. There is a requirement for 1 truck continually working outdoors and this option is recommended for that truck.

7.3 Electric

Electric motive power is the cheapest form of operation over a period as shown below; electric trucks do not emit fumes and operate with minimum noise emission.
Where multiple shift working is required, spare batteries are used which provide continuous truck service with only brief interruptions for battery change-over.
8 hr chargers would then be used to replace the 12 hr charger used for a single shift system.
Manoeuvrability is better than both the diesel and gas operated trucks. Electric is easier to operate and maintain especially in continuous stop-start operation such as exists at C.P.D. Newport.

For these reasons, electric motive power is recommended for indoor use.

7.4 COST COMPARISON

The proposal is for 8 counterbalanced trucks which have the option of using gas diesel or electric propulsion. For ease of calculations and comparisons, all 8,000lb capacity trucks will be assumed, costed over one year.

SET UP COSTS	Gas	Diesel	Electric
Rental of bulk storage tanks and spare batteries (2 off) for required shift working.	256	256	2,000
OPERATING COSTS			
Rental rates (inclusive of maint.)	40,512	40,512	48,672
Fuel used	24,840	15,456	4,802
Annual Total	65,608	56,224	55,474

ASSUMPTION:-

Fuel for truck usage of 6 days/wk

46 wks / yr.

Two trucks are required to work 2 shifts.
This is taken into account in the calculations.

Single batteries and chargers are included in the rental rates.

Additional factors to be considered:-

	Gas	Diesel	Electric
Manoeuvrability	Fair	Fair	Good
Toxic Fumes	High	Medium	None * 1
Downtime for maintenance	High	High	Low * 2
Noise level	High	High	Low
General acceptability	Low	Low	High * 3

* 1 Electric trucks emit no toxic fumes in operation. Charging is carried out in a separate specially ventilated building.

* 2 Electric motors are more reliable than the internal combustion engine, with less moving parts prone to wear and failure.

* 3 General acceptability here, refers to operating and manufacturing personnel's attitudes and feelings toward having a particular type of truck operating within their working environment.

Overall conclusion based on cost and additional factors is that electric trucks are preferred for indoor use and diesel for outdoors.

Ref. Appendix D.

8.0 RECOMMENDATIONS

The recommendations are:-

Reduce the size of the fleet from 42 trucks to 28.

Acquisition by rental with a full maintenance contract.

Standardise on electric trucks for indoor use and 1 diesel truck for outdoors.

Standardise on Lansing Bagnall.

* Control trucks by present methods (each truck to its specific function)

On a 4 year basis, the gross expenditure for the rental option is - £399K

This is a saving of:-	-	£85K over lease
	-	£63K over Purchase Year 1
	-	£154K over Phased Purchase
	-	£116K over the "Do nothing" situation

The above recommendations will provide the most efficient and cost effective service to manufacturing for a 4 year plan period after which each option should be reviewed in the light of a changing business, market place and methods of handling. Price ratios between options may also fluctuate.

* See Appendix C Section 1

9.0 IMPLEMENTATION PLAN

9.1	P.A.R. Approval	30.9.81.
9.2	Plan and Evaluation for disposal of redundant trucks (Purchasing Department)	14.8.81.
9.3	Solutions to maintenance I.R. problems associated with the rental agreement maintenance contract (Mr.E.R. Bryant)	21.8.81.
9.4	Prepare truck specifications (L. Hooper/N.J. Perry)	21.8.81.
9.5	Financial Justification (Accounts Dept/N.J. Perry)	28.8.81.
9.6	Raise Rental Requisition and Place Order (S. Czyrko/L. Hooper/N.J. Perry)	14.10.81.
9.7	Install chargers and commission new trucks (A.E. Hall/N.J. Perry/L. Hooper)	14.12.81.
9.8.	Disposal Plan Implementation (Purchasing Dept.)	14.12.81.
9.9	Continual assessment and refinement of logistics and operating procedures (K. Lovell/N.J. Perry)	

SL 4528

PLANT PROJECT PROPOSAL DETAIL: REPLACEMENT ITEMS

Project No. 81-2032 Project Internal Transport Rationalisation Prepared by N.J.Perry Date 27.8.81

EQUIPMENT PROPOSED				EQUIPMENT TO BE REPLACED						REASON FOR REPLACING
Item	Quantity	Make and Description	Cost (Total) £	Make	Qty.	Purch. Year	Cost £	Net Value £	Salv. Value £	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)	(l)
1		PROPOSED RENTED TRUCKS	-	Clark 10,000 lb	1	1975	8449	-	2	Poor physical condition
2	2	Lansing 5 Tonne F.L.T.	-	Clark 8,000 lb	1	1970	4266	-	2	" " "
3	3	Lansing 4 Tonne F.L.T.	-	Clark 7,000 lb	1	1973	5966	-	2	" " "
4	3	Lansing 3 Tonne F.L.T.	-	Clark 6,000 lb	1	1975	7855	-	2	" " "
5				Clark 4,000 lb	2	1965	4789	-	1	" " "
6				"	1	1970	2846	-	1	" " "
7				Yale 4,000 lb	1	1962	2175	-	1	" " "
8				Clark 4,000 lb	2	1972	6689	-	2	" " "
9				"	1	1972	3763	-	1	" " "
10				"	1	1975	6788	-	1	" " "
11	3	Lansing Bagnall 1.6 Tonne Stacker	-	Lansing 2,500 lb	1	1957	1817	-	1	" " "
12				Yale 2,900 lb	1	1957	1000	-	1	" " "
13				Roolatruc 2,200 lb	1	1961	396	-	0.5	Technical Obsolescence
14				Yale 2,800 lb	1	1969	650	-	1	Poor physical condition
15				Clark 3,000 lb	1	1969	1500	-	1	" " "
16	1	Lansing Bagnall 1.0 Tonne Reach		Lansing 3,300 lb	1	1971	2233	-	1	" " "
17		Truck		Rollatruc 2,200 lb	1	1974	2583	-	1	" " "
18				Lansing 3,000 lb	1	1966	885	-	1	" " "
19				Crown	2	1976	2000	-	1	Technical Obsolescence
20				Link 1,100 lb	1	1977	745	141	0.5	Technical Obsolescence
	12			Clark 6,000lb	1	1974	6500	-	1	
		P.T.O.		Clark 5,000 lb	1	1972	4553	-	1	(TOTAL SALV.VALUE = £26K)

The disposal list is composed of 25 trucks, the 26th truck is the Amiese Drum Wagon (1966) which is virtually obsolete. It has no re-sale value only scrap metal value and consequently it will be temporarily stored until its sole use which is one particularly wide drum, used approximately once or twice a year has been replaced as part of the drum rationalisation, currently taking place.

Following the replacement of this drum, the Amiese Wagon will be scrapped.

10. FINANCE.

COSTS AT OWN YEAR VALUES. £ K.

Rental Option.	1982	1983	1984	1985	1986
Rental (exc maintenance)	31.97	36.19	40.92	46.22	52.16
Maintenance (total)	40.20	42.12	44.27	46.68	49.38
Fuel Costs	14.78	16.55	18.54	20.76	23.25
Total Rental Costs. £ K	86.95	94.86	103.73	113.66	124.79

Purchase Option.					
Depreciation. Total £195.4	39.1	39.1	39.1	39.1	39.1
Interest	7.8	5.9	3.9	2.0	-
Maintenance.	25.33	50.54	56.61	63.40	71.00
Fuel Costs.	14.78	16.55	18.54	20.76	23.25
Development Grant.	5.86	5.86	5.86	5.86	5.86
Total Purchase Costs £ K	92.87	117.95	124.01	131.12	139.21

Without the Project (current situation)					
Maintenance.	84.0	95.76	109.17	124.45	139.38
Short term hire costs.	2.0	2.28	2.60	2.96	3.32
Fuel Costs.	19.08	21.37	23.93	26.80	30.02
Total Costs.	105.08	119.41	135.70	154.21	172.72

ANALYSIS AND JUSTIFICATION (US $...) | 8/81 | $2.39/£ | 81/2032

COMPANY, DIVISION OR PLANT, AND LOCATION: CABLE PRODUCTS, NEWPORT

PROJECT TITLE: INTERNAL TRANSPORT RATIONALISATION

Line No.	ITEMS OF COST	SL 4674 Line No.	Current Annual Sales % Without Project	Before Proj. is Oper'l Year 2	Before Proj. is Oper'l Year 1	After Project is Operational Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	TOTAL PROJECT
				19	1981	1982	1983	1984	1985	1986	19	19	19	19	19	19	19	19	19	19	
1	TOTAL SALES	21																			
2	Total Material Costs	22																			
3	a. Direct Labour + A.L.B.																				
	b. Indirect Labour + A.L.B.																				
	c. Other Manufacturing Costs					(120.2)	(145.6)	(174.7)	(207.9)	(220.6)											(869.0)
	d. Contract Engineering																				
	e. Installation Costs																				
	f. Freight & Packing																				
4	a. Variances—Manufacturing																				
	b. " —Other (Specify)																				
5	a. R & D Assessment																				
	b. R & D Local																				
6	Inventory Adjustments																				
7	Other Costs (Specify)																				
8	Total Other Operating Costs	24				(120.2)	(145.6)	(174.7)	(207.9)	(220.6)											(869.0)
9	Depreciation	23				85.1	85.1	85.1	85.1	85.1											425.5
10	TOTAL COST OF SALES					(35.1)	(60.5)	(89.6)	(122.8)	(135.5)											443.5
11	(Commission Income) (Royalty & Other)																				
12	NY Gross Earnings																				
13	a. Marketing Expense—Fixed					35.1	60.5	89.6	122.8	135.5											443.5
	b. Marketing Expense—Variable																				
14	Admin. & General Expense																				
15	Contract Service Charge																				
16	Interest	37				17.0	12.8	8.5	4.3	-											42.6
17	Total Marketing + A & G	25				17.0	12.8	8.5	4.3	-											42.6
18	Net Income before Tax					18.1	47.7	81.1	118.5	135.5											400.9
19	a. Tax	25a				9.7	25.5	43.4	63.3	72.5											214.4
	b. Government/Other Grants	21a				12.8	12.8	12.8	12.8	12.8											64.0
20	NET INCOME AFTER TAX	26				21.2	35.0	50.5	67.8	75.8											250.3
21	Increase (Decrease) in number of employees due to Project																				
	a. Direct Personnel																				
	b. Indirect Personnel																				

STC INVESTMENT ANALYSIS – CALCULATION OF TAX (US $000)

81/2032		$ 2.39/£	8/81

COMPANY, DIVISION OR PLANT, AND LOCATION: CABLE PRODUCTS, NEWPORT

PROJECT TITLE: INTERNAL TRANSPORT RATIONALISATION

Line No.		BEFORE PROJECT IS OPERATIONAL Year 2	Year 1	AFTER PROJECT IS OPERATIONAL Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	TOTAL PROJECT
		19	1981	1982	1983	1984	1985	1986	19	19	19	19	19	19	19	19	19	19	
1	Written-down value at 1st Jan.																		
2	Gross Additions:																		
	a. Plant (exc. private cars)		425.5																425.5
	b. Private Cars																		
	c. Industrial Buildings and Leasehold Improvements of Structural Nature																		
	d. Insulation of existing Industrial Buildings																		
3	Total Costs		425.5																425.5
4	(Salvage)		(62.1)																(62.1)
5	Total Nett Costs		363.4																363.4
6	(Allowances)																		
	1st Year:																		
	a. Plant (exc. private cars) (100%)		(425.5)																(425.5)
	b. Private Cars (25%)																		
	c. Insulation of existing Industrial Buildings (100%)																		
	d. Scientific Research (100%)																		
7	Initial: New Industrial Blds. (50%)																		
8	Annual:																		
	a. Private Cars (diminishing (25%) from 2nd year after purchase)																		
	b. New Industrial Buildings (Straight Line) (4%)																		
9	Payback on Salvage (Line 4) (100%)		(62.1)																(62.1)
10	(Total Nett Allowances)		(363.4)																(363.4)
11	Written-down value at 31st Dec. (Line 5 less Line 10)																		
	Taxable Profits																		
12	Nett Profit before Depreciation		–	103.2	132.8	166.2	203.6	220.6											826.4
13	(Total Nett Allowances) (Line 10)		(363.4)	–	–	–	–	–											(363.4)
14	Taxable Profit/(Loss)		(363.4)	103.2	132.8	166.2	203.6	220.6											463.0
15	Tax Rebate/ (Payment) @ 53.5 %		194.4	(55.2)	(71.0)	(88.9)	(100.8)	(118.0)											(247.5)

COMPANY, DIVISION OR PLANT, & LOCATION: PURCHASE OPTION

[illegible]ABL[illegible] [illegible]ROL[illegible]TS, [illegible]WP[illegible]

LOCAL CURR. | RATE (1 L.C. UNIT =) [illegible] | PROJECT TITLE: [illegible]RNA[illegible] [illegible]RA[illegible]ORT [illegible]TIO[illegible]ISA[illegible]ON

	Line No.	SALES AND RELATED AMOUNTS ARE FOR	Before Proj. is Operational Year 2 (19)	Before Proj. is Operational Year 1 (1981)	Year 1 (1982)	Year 2 (1983)	Year 3 (1984)	Year 4 (1985)	Year 5 (1986)	Year 6 (19)	Year 7 (19)	Year 8 (19)	Year 9 (19)	Year 10 (19)	Year 11 (19)	Year 12 (19)	Year 13 (19)	Year 14 (19)	Year 15 (19)	TOTAL PROJECT	AVERAGE YEAR (_ YRS)
WITH THE PROJECT	1	Sales																			
	2	Material Costs																			
	3	Depreciation & Amortization																			
	4	Other Operation Costs																			
	5	Marketing & A&G Expenses																			
	6	Net Income After Taxes																			
	7	Working Capital																			
	8	Net Cash Surplus (Requirements)																			
	9	Return on Assets %																			
	10	Return on Sales %																			
WITHOUT THE PROJECT	11	Sales																			
	12	Material Costs																			
	13	Depreciation & Amortization																			
	14	Other Operating Costs																			
	15	Marketing & A&G Expenses																			
	16	Net Income After Taxes																			
	17	Working Capital																			
	18	Net Cash Surplus (Requirements)																			
	19	Return on Assets %																			
	20	Return on Sales %																			
DUE TO THE PROJECT	21	Sales																			
	21a	Government/Other Grants			12.8	12.8	12.8	12.8	12.8											64.0	[illegible]
	22	Material Costs																			
	23	Depreciation & Amortization			85.1	85.1	85.1	85.1	85.1											425.5	[illegible]
	24	Other Operating Costs			(120.2)	(145.6)	(174.7)	(207.9)	(220.6)											(869.0)	[illegible]
	25	Marketing & A&G Expenses			17.0	12.8	8.5	4.3	-											42.[illegible]	
	25a	Tax			9.7	25.5	43.4	63.3	72.5											214.[illegible]	
	26	Net Income After Taxes			21.2	35.0	50.5	67.8	75.8											250.3	[illegible]
	27	Capital Project Expenditures		425.5																425.5	[illegible]
	28	Assets Transferred to Project																			
	29	Working Capital			(255.3)	(212.8)	(172.4)	(131.0)	(84.9)	33.1										(165.3)	[illegible]
	30	TOTAL CAPITAL INVESTMENT																			[illegible]
	31	Net Cash Surplus (Requirements)		(425.5)	3616	77.6	95.2	114.5	111.8	(118.0)											
	32	Cumulative Cash Surplus (Reqmts.)		(425.5)	(63.9)	13.7	108.9	223.4	335.2	217.2											
	33	Return on Assets %		-	6.2	13.7	29.7	79.7	-	-											[illegible]
	34	Return on Sales %																			
	35	Payback Period—Years																			
	36	Return on Investment %																			
	37	Interest Included in Line 25																		1.9	
	38	Related Expenses Included in Line 27																		[illegible]	

PURCHASE OPTION

SL 4678 (10/79)

STC INVESTMENT ANALYSIS SUMMARY – PART II – CASH REQUIREMENTS AND PROPOSED FINANCING (US $000)

LOCAL CURR	RATE (1 L.C. Unit =)	DATE	PROJECT No.
£ Sterling	$ 2.39/£	8/81	81/2032

COMPANY, DIVISION OR PLANT, AND LOCATION: CABLE PRODUCTS, NEWPORT

PROJECT TITLE: INTERNAL TRANSPORT RATIONALISATION

Pt.II

LINE No.		Before Proj. is operational: Year 2	Before Proj. is operational: Year 1	After project is operational: Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	TOTAL PROJECT	Average Year (5 Yrs)
		19	1981	1982	1983	1984	1985	1986	1987	19	19	19	19	19	19	19	19	19		
	DUE TO PROJECT																			
1	Net Income After Taxes			21.2	35.0	50.5	67.8	75.8											250.3	50.1
2	Depreciation and Amortization			85.1	85.1	85.1	85.1	85.1											425.5	85.1
3	Total Funds Provided			106.3	120.1	135.6	152.9	160.9											675.8	135.2
	FUNDS APPLIED TO PROJECT																			
4	Gross Additions		425.5																425.5	85.1
5	Current Receivables – Incr. (Decr.)																			
6	Inventories – Incr. (Decr.)																			
7	Other Current Assets – Incr. (Decr.)																			
8a	Trade Payables – Decr. (Incr.)																			
8b	Other Current Liabilities – Decr. (Incr.)																			
9a	P. & L. Tax Contra – Rebate (Payment)			(9.7)	(25.5)	(43.4)	(63.3)	(72.5)											(214.4)	(42.9)
9b	Tax Deferred – Payment (Rebate)			194.4	55.2	71.0	88.9	108.8	118.0										247.5	49.5
9c	Government Grants-Amortization (Receipts)			(51.2)	12.8	12.8	12.8	12.8											-	-
10	Total Funds Applied		425.5	(255.3)	42.5	40.1	38.4	49.1	118.0										458.6	91.7
11	NET CASH SURPLUS (REQUIREMENTS)		425.5	361.6	77.6	95.2	114.5	111.8	(118.0)										217.2	43.4
	PROPOSED FINANCING																			
12	(Internal Financing)																			
13	(System Finance Companies)																			
14	(Headquarters Financing)																			
	(Outside Financing–																			
15	Bank Borrowing – Short Term																			
16	– Long Term)																			
17	(Other Outside Financing-Identify)																			
18	Repayment Of Notes and Advances																			
19	TOTAL REPAYMENT (BORROWINGS)																			

COMPANY, DIVISION OR PLANT AND LOCATION	PROJECT TITLE
CABLE PRODUCTS, NEWPORT	INTERNAL TRANSPORT RATIONALISATION

WORKING CAPITAL

Line No.	DUE TO THE PROJECT	Current Average Usage in Weeks	Before proj is operational: Year 2 19	Before proj is operational: Year 1 1981	After project is operational: Year 1 1982	Year 2 1983	Year 3 1984	Year 4 1985	Year 5 1986	Year 6 1987	Year 7 19	Year 8 19	Year 9 19	Year 10 19	Year 11 19	Year 12 19	Year 13 19	Year 14 19	Year 15 19	TOTAL PROJECT	Aver. Yea (5 Yr.)
1	Receivables																				
2	Inventory																				
	a. Raw Materials																				
	b. Fecepart and Components – Bought																				
	c. Fecoparts – Inled																				
	d. Work In Process																				
	e. Finished Goods																				
	Total Inventory																				
	Other Current Assets																				
	Total																				
	Payables																				
	a. Tax				204.1	174.4	146.8	121.2	84.9	(33.1)										698.3	139.7
	b. Other Current Liabilities				51.2	38.4	25.6	12.8	-	-										128.0	25.[illegible]
	c. Development Grants																				
	Total				255.3	212.8	172.4	134.0	84.9	(33.1)										826.3	165.3
	NET WORKING CAPITAL				(255.3)	(212.8)	(172.4)	(134.0)	(84.9)	33.1										(826.3)	(165.3)

RETURN ON ASSETS

Total Current Assets																				
Net Plant				340.4	255.3	170.2	85.1	-	-										851.0	170.2
Total Assets				340.4	255.3	170.2	85.1	-	-										851.0	170.2
Net Income after Tax				21.2	35.0	50.5	67.8	75.8	-										250.3	50.1
% RETURN ON ASSETS				6.2	13.7	29.7	79.7	-	-										29.4	29.4

P.A.R. - APPENDIX A

ASSUMPTIONS: ALL ORDERS ARE EQUALLY DISTRIBUTED OVER THE YEAR
46 WEEKS/YEAR: 15 SHIFTS/WEEK
TOTAL BOBBINS MOVED PER SHIFT IS AN AVERAGE FIGURE

CORE BOBBIN MOVES PER SHIFT (INS^G TO STRAND^G & BACK)

		X			A	B	AB	C	ABC	2X.A B.D.	D	(Pairs) (2) X.A. B.C.D.		Pairs x 4 Moves Av (8) X.A. B.C.D.
Spec	I.D.	No. of Pairs	Core Diam. (mm)	Max Length Per Bobbin (km)	Order Length (Per 1980 budget) (km)	Average Set Length (m) km	No. of Set Lengths per order (Not whole sets)	Shifts/ Year	No. of Sets Per Shift	No. of Bobbins Per Order	No. of Sets Lengths per Bobbin	No. of Core Bobbins/Shift (Ins-Twin)	Total No. of Bobbin Moves (Mechanical)	Total Bobbins Moves/Shift
FA	0505 PLW/CELL	5	0.5	14	1300	7000 - 7	185.714	690	0.269	929	2	1.346	4	5.393
FA	0550 PLW/CELL	50	0.5	14	900	7	128.571	690	0.186	6429	2	9.317	4	37.267
FA	0600 PLW/CELL	100	0.5	14	595	7	85	690	0.123	8500	2	12.319	4	49.275
FA	7010 A1/CELL	10	0.5	24	400	12000 12	33.333	690	0.048	334	2	0.483	4	1.932
FA	7020 A1/CELL	20	0.5	24	350	12	29.167	690	0.042	584	2	0.846	4	3.382
FC	3450 PLW/CELL	50	0.5	14	80	7	11.429	690	0.016	572	2	0.828	4	3.313
FC	7100 A1/CELL	100	0.5	24	15	12	1.25	690	0.002	125	2	0.181	4	0.725 a
FB	0550 PLW/CELL	50	0.5	14	100	7	14.286	690	0.021	715	2	1.035	4	4.141
FB	0600 PLW/CELL	100	0.5	14	125	7	17.857	690	0.026	1786	2	2.588	4	10.349
FB	7100 A1/CELL	100	0.5	24	75	12	6.25	690	0.009	625	2	0.906	4	3.623
FC	3420 PLW/CELL	20	0.5	14	25	7	3.571	690	0.005	72	2	0.104	4	0.414
FD	1953 PLW/CELL	10	0.5	14	150	7	21.429	690	0.031	429	2	0.311	4	1.242
*ZZ	0693 PLW/CELL	50	0.5	14	80	7	11.429	690	0.017	572	2	0.828	4	3.313
FD	1958 PLW/CELL	75	0.5	14	60	7	8.571	690	0.012	643	2	0.932	4	3.727
FD	1959 PLW/CELL	100	0.5	14	50	7	7.143	690	0.010	715	2	1.035	4	4.141
ZZ	0614 PLW/POLY	50	0.5	14	80	7	11.429	690	0.017	572	2	00.828	4	3.313
FD	2115 PLW/CELL	15	0.5	14	125	7	17.857	690	0.026	268	2	0.388	4	1.553
FD	2150 PLW/CELL	50	0.5	14	50	7	7.143	690	0.010	358	2	0.515	4	2.07
*FD	2200 PLW/CELL	100	0.5	14	30	7	4.286	690	0.006	429	2	0.621	4	2.486
FA	1550 PLW/CELL	50	0.9	4	100	2000 2	50.00	690	0.073	2500	2	3.623	4	14.493
FA	7620 A1/CELL	20	0.7	12	150	6000 6	25.00	690	0.036	500	2	0.725	4	2.899
FA	76 0 A1/CELL	50	0.7	12	60	6	10.00	690	0.015	500	2	0.725	4	2.899
FA	3620 PLW/CELL	20	0.63	8	125	4000 4	31.25	690	0.045	625	2	0.906	4	3.623
FC	3610 PLW/CELL	10	0.9	4	500	2000 2	250.00	690	0.362	2500	2	3.623	4	14.493
FB	1550 PLW/CELL	50	0.9	4	20	2	10	690	0.015	500	2	0.725	4	2.899
FB	1530 PLW/CELL	30	0.9	4	33	2	16.5	690	0.024	495	2	0.717	4	2.87
AF	00271 TLW/PVC	Single	0.4	25	23000	25000 25	920	690	1.333	920		1.333	2	2.666

CABLE DRUM MOVES PER SHIFT (STRANDING ON TO REDRUM)
(SHIPPING DRUMS NOT INCLUDED)

Spec	I.D.	No. of Pairs	Core Diam. (mm)	Order Length (km)	Length Per Drum (km)	Drum Spec. (Code)	No. of Drums Per Order	Shifts/Year	No Drums Per Shift	No. of Moves of Particular (Code)	Total No. of Drum Moves (Shift)	Drum Spec. (Code)	Length Per Drum (km)	No. of Drums Per Order	Drums Per Shift	No. of Moves of particular Drum (Code)	Total Moves/Shift	Grand Total Moves/Shift
FA	0506 PLW/CELL	5	0.5	1300	7	59	185.714	690	0.269	3	0.807	58	7	185.714	0.269	2	0.538	1.345
FA	0550 PLW/CELL	50	0.5	900	7	61	128.571	690	0.186	4	0.744							0.744
FA	0600 PLW/CELL	100	0.5	595	3 & 4	61	170	690	0.246	3	0.739	60	3 & 4	170	0.246	2	0.492	1.231
FA	7010 AL/CELL	10	0.5	400	12	59	33.333	690	0.048	3	0.144	62	12	33.333	0.048	2	0.096	0.24
FA	7020 AL/CELL	20	0.5	350	2 x 6	59	58.333	690	0.085	3	0.255	62	2 x 6	58.333	0.085	2	0.0170	0.425
FC	3450 PLW/CELL	50	0.5	80	7	63	11.429	690	0.016	4	0.064	61	7	11.429	0.016	2	0.032	0.096
FC	7100 AL/CELL	100	0.5	15	2 moves at 2 x 6 (4 x 6)	61	2.5	690	0.004	4	0.024							0.024
FB	0550 PLW/CELL	50	0.5	100	7	61	14.286	690	0.021	4	0.084	60 & 61	3, 4 & 7	60: 14.286 61: 14.286	60: 0.021 61: 0.021	60: 3 61: 2	0.105	0.189
FB	0600 PLW/CELL	100	0.5	125	3 & 4	61	35.714	690	0.052	3	0.156	60	3 & 4	35.714	2 moves at 0.052	Effective No. 4	0.26	0.416
FB	7100 AL/CELL	100	0.5	75	2 x 6 (4 x 3)	61 (63)	12.5 & (25)	690	0.018 & (0.036)	3 & 2	0.126	61 & 60	4 x 3	25	2 moves at 0.036	2 & 2	0.144	0.270
FC	3420 PLW/CELL	20	0.5	25	7	58	3.571	690	0.005	3	0.015	61	7	3.571	0.005	2	0.010	0.025
FD	1953 PLW/CELL	10	0.5	150	7	59	21.429	690	0.031	2	0.062	59	2 & 1	85.716	0.124	2	0.248	0.310
FD	1958 PLW/CELL	75	0.5	60	7	61	8.571	690	0.012	3	0.036	63 & 58	2 & 1	34.284	0.05	2	0.100	0.136
FD	1959 PLW/CELL	100	0.5	50	4 & 3	61 & 62	14.286	690	0.020	3	0.060	62 & 63	2 & 1	28.572	0.041	2	0.082	0.142
FD	2115 PLW/CELL	15	0.5	125	7	58	17.857	690	0.026	3	0.078	59 & 62	2 & 1	71.428	0.104	4	0.416	0.494
FD	2150 PLW/CELL	50	0.5	50	7	63	7.143	690	0.010	3	0.030	62 & 59	2 & 1	28.572	0.0414	6	0.248	0.278
• FD	2200 PLW/CELL	100	0.5	30	4 & 3	61 & 62	8.572	690	0.012	3	0.036	62 & 63	2 & 1	17.144	0.025	2	0.05	0.086
FA	1550 PLW/CELL	50	0.9	100	2	63	50	690	0.073	3	0.219	61	2	50	0.073	2	0.146	0.365
FA	7620 AL/CELL	20	0.7	150	2 x 3	59	50	690	0.073	3	0.219	62	2 x 3	50	0.073	2	0.146	0.365
FA	7650 AL/CELL	50	0.7	60	6	61	10	690	0.015	3	0.045	60	6	10	0.015	2	0.030	0.075
FC	3620 PLW/CELL	20	0.63	125	4	58	31.25	690	0.045	3	0.135	63	4	31.25	0.045	2	0.090	0.225
FC	3610 PLW/CELL	10	0.9	500	2	59	250	690	0.362	3	1.086	62	2	250	0.362	2	0.724	1.81
FB	1550 PLW/CELL	50	0.9	20	2	63	10	690	0.015	3	0.045	61 & 60	2	10	0.015	3 & 2	0.075	0.12
FB	1530 PLW/CELL	30	0.9	333	2	62	16.5	690	0.024	3	0.072	63 & 61	2	16.5	0.024	2 & 3	0.120	0.192
FA	6820 PLW/CELL	20	0.9	125	2	58	62.5	690	0.091	3	0.273	62	2	62.5	0.091	2	0.182	0.455
FD	3700 TLW/PVC	100	0.63	25	2 x 2	62	12.5	690	0.018	3	0.054	60	2	12.5	0.018	2	0.036	0.090
FA	0600 PLW/CELL	100	0.5	22.5	3 & 4	61	6.429	690	0.009	3	0.028	60	3 & 4	6.429	0.009	2	0.018	0.046

ASSUMPTIONS: EMPTY DRUMS MOVED BY A COUNTERBALANCED F.L.T. ARE: ALL DRUMS (METAL) FROM REDRUMMING AND ALL DRUMS 6' FLANGE DIAM. & ABOVE. (60, 61, 66, 67) – CODE Nos.

CALCULATION OF DRUM AND CABLE WEIGHTS

N.B. WHERE LENGTH PER DRUM IS SPLIT INTO TWO, NO. OF DRUMS PER SHIFT MUST BE HALVED.

Key		Key	
I–H	● (red)	G–E	■ (blue)
O–H	● (blue)	G–B	■ (green)
I–I	● (green)	B–H	■ (red)
O–I	● (black)		

Spec. I.D.	Drums Per Shift	Length Per Drum km	Type of Drum (Code No.)	Total Weight/Drum kg		Machine From-To Info	Drums Per Shift	Length Per Drum km	Type of Drum	Total Weight/Drum kg		Machine From-To Info	Drums Per Shift	Length Per Drum km	Type of Drum	Total Weight kg		Machine From-To Info
FA 0505	0.269	7	59	222.5 353	● I–H	I.R.I. 05ST–02EX	0.807	7	58	384 569	■ G–E	02EX REDRUM						
FA 0550	0.186	7	61	17 & 2.5 2163	C G-H	I.R.I. 02ST–02EX	0.186	7	61	2209.5 2590	■ G–E	02EX REDRUM						
FA 0600	0.246	1x3 & 1x4	61 x 2	1555 & 2073 1935 & 2453	C G-H	I.R.I. 02ST–03EX	0.246	1x3 & 1x4	60 x 2	1830 & 2440 2270 & 2880	■ G–E	03EX REDRUM						
FA 7010	0.048	12	59	328 458	● I–H	I.R.I. 11ST–02EX	0.048	12	62	609 809	■ G–E	02EX REDRUM						
FA 7020	0.085	6	59	312 442	● I–H	I.R.I. 11ST–02EX	0.085	6	62	527 727	■ G–E	02EX REDRUM						
FA 3450	0.016	7	63	1827 2147	C G-H	I.R.I. 02ST–01EX	0.016	7	61	6727 7107	■ G–E	01EX REDRUM						
FC 7100	0.004	6	61	1470 1850	C G-H	I.R.I. 02ST–01EX	0.008	2 x 3km	61 x 2	2556 2936	■ G–E	01EX REDRUM						
FB 0550	0.021	7	61	1782 2162	C G-H	I.R.I. 02ST–02EX	0.021	7	60	2212.5 2653	■ G–B	02EX 01AR	0.042	4 & 3	60 & 61	3251.5 & 2439 3692 & 2819	■ B–H	01AR–05EX
FB 0600	0.052	3 & 4	61 x 2	1548 & 2063 1928 & 2443	C G-H	I.R.I. 02ST–03EX	0.052	3 & 4	60 x 2	1821.5 & 2428.5 2262 & 2869	■ G–B	03EX 01AR	0.052	4 & 3	60 x 2	5098.5 & 3824 5539 & 4264	■ B–H	01AR–05EX
FB 7100	0.018	2 x 6	61 x 2	1470 1850	C G-H	I.R.I. 02ST–03EX	0.036	4 x 3km	63 x 4	964 1284	■ G–B	03EX 01AR	0.036	4 x 3km	61 x 4	2781 3161	■ B–H	01AR–05EX
FC 3420	0.005	7	58	7815 967	● I–H	I.R.I. 11ST–02EX	0.005	7	61	1303 1683	■ G–E	02EX REDRUM						
FD 1953	0.031	7	59	395 525	● I–H	I.R.I. 11ST–03EX	0.124	3 x 2km & 1 x 1km	59	185 & 92.5 315 & 223	■ G–E	03EX REDRUM						
FD 1958	0.012	7	61	2724 3104	C G-H	I.R.I. 02ST–03EX	0.048	3 x 2km & 1 x 1km	63 x 3 & 58 x 1	1002 & 501 1322 & 686	■ G–E	03EX REDRUM						
FD 1959	0.020	1 x 4km & 1 x 3km	61 & 62	2061 & 1546 2441 & 1746	C G-H	I.R.I. 02ST–03EX	0.040	3 x 2km & 1 x 1km	63 x 2 & 62 x 1	1287 & 643.5 1607 & 844	■ G–E	03EX REDRUM						
FD 2115	0.026	7	58	556.5 742	● I–H	I.R.I. 11ST–03EX	0.104	3 x 2km & 1 x 1km	59	265.5 & 132.8 396 & 263	■ G–B	03EX 01AR	0.104	3 x 2km & 1 x 1km	59	659 & 3296 789 & 460	■ B–H	01AR–07EX
FD 2150	0.010	7	63	1824.5 2145	C G-H	I.R.I. 02ST–03EX	0.040	3 x 2km & 1 x 1km	62 & 59	701.5 & 351 902 & 481	■ G–B	03EX & 01AR	0.040	3 x 2km & 1 x 1km	61 & 58	1788 & 894 2168 & 1079	■ B–H	01AR–05EX
FD 2200	0.012	1 x 4km & 1 x 3km	61 & 62	2062.5 1547 2443 & 1747	C G-H	I.R.I. 02ST–03EX	0.025	3 x 2km & 1 x 1km	63 x 2 & 62 x 1	1289 & 644.5 1609 & 845	■ G–B	03EX 01AR	0.025	3 x 2km & 1 x 1km	63 x 2 & 62 x 1	2686.5 & 1343.5 3007 & 1544	■ B–H	01AR–05EX
FA 1550	0.073	2	63	1616.5 1937	C G-H	I.R.I. 02ST–03EX	0.073	2	61	1862.5 2243	■ G–E	03EX REDRUM						
FA 7620	0.073	3 x 3km	59	608/2 434	● I–H	I.R.I. 11ST–02EX	0.073	2 x 3km	62	903.5/2 652	■ G–E	02EX REDRUM						
FA 7650	0.015	6	61	1506 1886	C G-H	I.R.I. 02ST–03EX	0.015	6	60	2017 2457	■ G–E	03EX REDRUM						
FC 3520	0.045	4	58	682.5 868	● I–H	I.R.I. 11ST–01EX	0.045	4	63	1420 1740	■ G–E	01EX REDRUM						
FC 3610	0.362	2	59	329 459	● I–H	I.R.I. 11ST–01EX	0.362	2	62	705 906	■ G–E	01EX REDRUM						
FB 1550	0.015	2	63	1634.5 1955	C G-H	I.R.I. 02ST–03EX	0.015	2	61	1868.5 2249	■ G–B	03EX 01AR	0.015	2	61	3858.5 4239	■ B–H	01AR–05EX
FB 1530	0.024	2	62	981.5 1182	C G-H	I.R.I. 02ST–03EX	0.024	2	63	1153.5 1474	■ G–B	03EX 01AR	0.024	2	61	2491.5 2872	■ B–H	01AR–05EX
FA 6820	0.091	2	58	686.5 872	● I–H	I.R.I. 11ST–03EX	0.091	2	62	874.5 1075	■ G–E	03EX REDRUM						
FA 3700	0.018	1	62	711 911	● O–I	I.R.I. 03ST–01EX	0.018	1	M	915 1000	■ G–E	01EX BATT						
FA 0600	0.015	3 & 4	61 x 2	1555 & 2073 1935 & 2453	C G-H	I.R.I. 02ST–03EX	0.015	1 x 3 & 1 x 4	60 x 2	1830 & 2440 2270 & 2880	■ G–E	03EX REDRUM						

P.A.R. - APPENDIX B

DISPOSAL PLAN FOR REDUNDANT TRUCKS

OPTIONS FOR DISPOSAL

(1) Interested dealers circulated with full details of all redundant trucks, and asked for forward offers for trucks in one lot. If the trucks were to be sold on a "one off" basis, then the sale would take an unacceptable length of time and the company would, in all probability, be left with the worst of the trucks.

(2) An advertisement could be placed in a suitable trade magazine, inviting interested parties to send for further details.

(3) Sale by auction. Central Motor Auctions, of Dursley, who currently handle auction of some Company vehicles, have offered to dispose of the trucks by auction. They hold sales of surplus plant once a month, and suggest that because of the depressed state of the market we release a small number of trucks (say six) each month to secure higher bids. One extra advantage of this method would be to aid the smooth introduction of the new Fork Truck fleet, since we could hold back some trucks to back up the new fleet during commissioning.

Option (1) is already in motion, and when all replies have been received, a decision can be made on options (2) and (3).

P.A.R. - APPENDIX C

ORGANISATION AND MANNING

(1) Alternative methods of Fork Lift Truck Control and Logistics were analysed as follows:-

1.1 A complete factory circuit.

On this circuit the major counterbalanced trucks from all departments except outside operations, would travel around a one directional circuit throughout the factory when looking for a job.

Initially this appeared to provide higher truck utilisation but only if additional supporting systems (such as those described below) were added. However, careful analysis proved this method complex and not practically feasible for the following reasons:-

(a) A very large work in progress inventory would be required to increase truck utilisation and possibly decrease the number of trucks.

(b) Driver recognition of work identity and destination would be very difficult due to the variety of jobs and procedures throughout the factory.

(c) If the circuit principle was initiated, the trucks would split up into smaller circuits centred around areas of highest work activity, leaving areas of low activity with long waiting times.

1.2 Two-way radio with a central control unit to receive and transmit all requests for job movement.

This method of control was envisaged in use with either the present method of control or the above circuit. However, the circuit principle would still require job identification to enable the driver to recognise a job on arrival.

1.3 Light system

Easily visible lights positioned at each station where jobs await transportation, again, the concept would be used in conjunction with the present method of control or the circuit principle.

1.4 Shop Floor Marshallers

Marshallers would present jobs in their correct priority and weight groups for pick up by a F.L.T. driver giving him the necessary routing information and further work to be done at his destination. This possibility was considered too labour intensive and would not be cost effective in the light of the other options available.

The present method of fork lift truck control:-

each truck to a specific function, allows areas of high work movement to be supplied with more trucks than areas of low work movement.

In each case the trucks work on a circuit principle, but on mini-circuits centred around areas of high activity. This enables speedy driver familiarisation with pending work and routing information which is conducive to an efficient and cost effective service.

Areas of low truck utilisation are serviced by a truck from another area as a matter of routine or by special request to the F.L.T. foreman, whereby any available truck of sufficient capacity is temporarily transferred.

Major consideration was given to the cost effectiveness, advantages and disadvantages of each option with special attention to the problems associated with implementation of too many changes at one time.

The results illustrated that, the present method:- each truck to its specific function should be maintained with continual appraisal and improvement in operating logistics. Upon successful implementation of the proposed project, the two-way radio and light system should be analysed together with a revised circuit principle pending further progress on dedicated handling systems.

2.0 MANNING

The proposed reduction in internal transport from 42 to 28 F.L.T.'s can be attained without reduction in manning levels for the following reasons:-

1. One truck with spare batteries is able to work multiple shifts, instead of a number of trucks for different shifts, as is the case at present.
2. Redundant and inoperative trucks which exist can be sold and not replaced.
3. Reach, Stacker and miscellaneous trucks have no set drivers. Shop Service personnel use these trucks when necessary, but have other duties which take up most of their time. Therefore a reduction in the number of trucks does not necessitate a reduction in the number of shop service personnel.

PRESENT WORTH FACTORS

Present Value of 1 Unit

$(1 + r)^{-n}$

n	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%
1	0.9901	0.9804	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259	0.9174	0.9091	0.9009	0.8929
2	0.9803	0.9612	0.9426	0.9246	0.9070	0.8900	0.8734	0.8573	0.8417	0.8264	0.8116	0.7972
3	0.9706	0.9423	0.9151	0.8890	0.8638	0.8396	0.8163	0.7938	0.7722	0.7513	0.7312	0.7118
4	0.9610	0.9238	0.8885	0.8548	0.8227	0.7921	0.7629	0.7350	0.7084	0.6830	0.6587	0.6355
5	0.9515	0.9057	0.8626	0.8219	0.7835	0.7473	0.7130	0.6806	0.6499	0.6209	0.5935	0.5674
6	0.9420	0.8880	0.8375	0.7903	0.7462	0.7050	0.6663	0.6302	0.5963	0.5645	0.5346	0.5066
7	0.9327	0.8706	0.8131	0.7599	0.7107	0.6651	0.6227	0.5835	0.5470	0.5132	0.4817	0.4523
8	0.9235	0.8535	0.7894	0.7307	0.6768	0.6274	0.5820	0.5403	0.5019	0.4665	0.4339	0.4039
9	0.9143	0.8368	0.7664	0.7026	0.6446	0.5919	0.5439	0.5002	0.4604	0.4241	0.3909	0.3606
10	0.9053	0.8203	0.7441	0.6756	0.6139	0.5584	0.5083	0.4632	0.4224	0.3855	0.3522	0.3220
11	0.8963	0.8043	0.7224	0.6496	0.5847	0.5268	0.4751	0.4289	0.3875	0.3505	0.3173	0.2875
12	0.8874	0.7885	0.7014	0.6246	0.5568	0.4970	0.4440	0.3971	0.3555	0.3186	0.2858	0.2567
13	0.8787	0.7730	0.6810	0.6006	0.5303	0.4688	0.4150	0.3677	0.3262	0.2897	0.2575	0.2292
14	0.8700	0.7579	0.6611	0.5775	0.5051	0.4423	0.3878	0.3405	0.2992	0.2633	0.2320	0.2046
15	0.8613	0.7430	0.6419	0.5553	0.4810	0.4173	0.3624	0.3152	0.2745	0.2394	0.2090	0.1827

n	13%	14%	15%	16%	17%	18%	19%	20%	21%	22%	23%	24%
1	0.8850	0.8772	0.8696	0.8621	0.8547	0.8475	0.8403	0.8333	0.8264	0.8197	0.8130	0.806
2	0.7831	0.7695	0.7561	0.7432	0.7305	0.7182	0.7062	0.6944	0.6830	0.6719	0.6610	0.650
3	0.6931	0.6750	0.6575	0.6407	0.6244	0.6086	0.5934	0.5787	0.5645	0.5507	0.5374	0.524
4	0.6133	0.5921	0.5718	0.5523	0.5337	0.5158	0.4987	0.4823	0.4665	0.4514	0.4369	0.423
5	0.5428	0.5194	0.4972	0.4761	0.4561	0.4371	0.4190	0.4019	0.3855	0.3700	0.3552	0.341
6	0.4803	0.4556	0.4323	0.4104	0.3898	0.3704	0.3521	0.3349	0.3186	0.3033	0.2888	0.2751
7	0.4251	0.3996	0.3759	0.3538	0.3332	0.3139	0.2959	0.2791	0.2633	0.2486	0.2348	0.2218
8	0.3762	0.3506	0.3269	0.3050	0.2848	0.2660	0.2487	0.2326	0.2176	0.2038	0.1909	0.1789
9	0.3329	0.3075	0.2843	0.2630	0.2434	0.2255	0.2090	0.1938	0.1799	0.1670	0.1552	0.1443
10	0.2946	0.2697	0.2472	0.2267	0.2080	0.1911	0.1756	0.1615	0.1486	0.1369	0.1262	0.1164
11	0.2607	0.2366	0.2149	0.1954	0.1778	0.1619	0.1476	0.1346	0.1228	0.1122	0.1026	0.0938
12	0.2307	0.2076	0.1869	0.1685	0.1520	0.1372	0.1240	0.1122	0.1015	0.0920	0.0834	0.0757
13	0.2042	0.1821	0.1625	0.1452	0.1299	0.1163	0.1042	0.0935	0.0839	0.0754	0.0678	0.0610
14	0.1807	0.1597	0.1413	0.1252	0.1110	0.0985	0.0876	0.0779	0.0693	0.0618	0.0551	0.0492
15	0.1599	0.1401	0.1229	0.1079	0.0949	0.0835	0.0736	0.0649	0.0573	0.0507	0.0448	0.0397

n	25%	26%	27%	28%	29%	30%	31%	32%	33%	34%	35%	36%
1	0.8000	0.7937	0.7874	0.7813	0.7752	0.7692	0.7634	0.7576	0.7519	0.7463	0.7407	0.7353
2	0.6400	0.6299	0.6200	0.6104	0.6009	0.5917	0.5827	0.5739	0.5653	0.5569	0.5487	0.5407
3	0.5120	0.4999	0.4882	0.4768	0.4658	0.4552	0.4448	0.4348	0.4251	0.4156	0.4064	0.3975
4	0.4096	0.3968	0.3844	0.3725	0.3611	0.3501	0.3396	0.3294	0.3196	0.3102	0.3011	0.2923
5	0.3277	0.3149	0.3027	0.2910	0.2799	0.2693	0.2592	0.2495	0.2403	0.2315	0.2230	0.2149
6	0.2621	0.2499	0.2383	0.2274	0.2170	0.2072	0.1979	0.1890	0.1807	0.1727	0.1652	0.1580
7	0.2097	0.1983	0.1877	0.1776	0.1682	0.1594	0.1510	0.1432	0.1358	0.1289	0.1224	0.1162
8	0.1678	0.1574	0.1478	0.1388	0.1304	0.1226	0.1153	0.1085	0.1021	0.0962	0.0906	0.0854
9	0.1342	0.1249	0.1164	0.1084	0.1011	0.0943	0.0880	0.0822	0.0768	0.0718	0.0671	0.0628
10	0.1074	0.0992	0.0916	0.0847	0.0784	0.0725	0.0672	0.0623	0.0577	0.0536	0.0497	0.0462
11	0.0859	0.0787	0.0721	0.0662	0.0607	0.0558	0.0513	0.0472	0.0434	0.0400	0.0368	0.0340
12	0.0687	0.0625	0.0568	0.0517	0.0471	0.0429	0.0392	0.0357	0.0326	0.0298	0.0273	0.0250
13	0.0550	0.0496	0.0447	0.0404	0.0365	0.0330	0.0299	0.0271	0.0245	0.0223	0.0202	0.0184
14	0.0440	0.0393	0.0352	0.0316	0.0283	0.0253	0.0228	0.0205	0.0185	0.0166	0.0150	0.0135
15	0.0352	0.0312	0.0277	0.0247	0.0219	0.0195	0.0174	0.0155	0.0139	0.0124	0.0111	0.0099

n	37%	38%	39%	40%	41%	42%	43%	44%	45%	46%	47%	48%
1	0.7299	0.7246	0.7194	0.7143	0.7092	0.7042	0.6993	0.6944	0.6897	0.6849	0.6803	0.6757
2	0.5328	0.5251	0.5176	0.5102	0.5030	0.4959	0.4890	0.4823	0.4756	0.4691	0.4628	0.4565
3	0.3889	0.3805	0.3724	0.3644	0.3567	0.3492	0.3420	0.3349	0.3280	0.3213	0.3148	0.3085
4	0.2839	0.2757	0.2679	0.2603	0.2530	0.2459	0.2391	0.2326	0.2262	0.2201	0.2142	0.2084
5	0.2072	0.1998	0.1927	0.1859	0.1794	0.1732	0.1672	0.1615	0.1560	0.1507	0.1457	0.1408
6	0.1512	0.1448	0.1386	0.1328	0.1273	0.1220	0.1169	0.1122	0.1076	0.1032	0.0991	0.0952
7	0.1104	0.1049	0.0997	0.0949	0.0903	0.0859	0.0818	0.0779	0.0742	0.0707	0.0674	0.0643
8	0.0806	0.0760	0.0718	0.0678	0.0640	0.0605	0.0572	0.0541	0.0512	0.0484	0.0459	0.0434
9	0.0588	0.0551	0.0516	0.0484	0.0454	0.0426	0.0400	0.0376	0.0353	0.0332	0.0312	0.0294
10	0.0429	0.0399	0.0371	0.0346	0.0322	0.0300	0.0280	0.0261	0.0243	0.0227	0.0212	0.0198
11	0.0313	0.0289	0.0267	0.0247	0.0228	0.0211	0.0196	0.0181	0.0168	0.0156	0.0144	0.0134
12	0.0229	0.0210	0.0192	0.0176	0.0162	0.0149	0.0137	0.0126	0.0116	0.0107	0.0098	0.0091
13	0.0167	0.0152	0.0138	0.0126	0.0115	0.0105	0.0096	0.0087	0.0080	0.0073	0.0067	0.0061
14	0.0122	0.0110	0.0099	0.0090	0.0081	0.0074	0.0067	0.0061	0.0055	0.0050	0.0045	0.0041
15	0.0089	0.0080	0.0072	0.0064	0.0058	0.0052	0.0047	0.0042	0.0038	0.0034	0.0031	0.0028

APPENDIX 8

APPENDIX 8

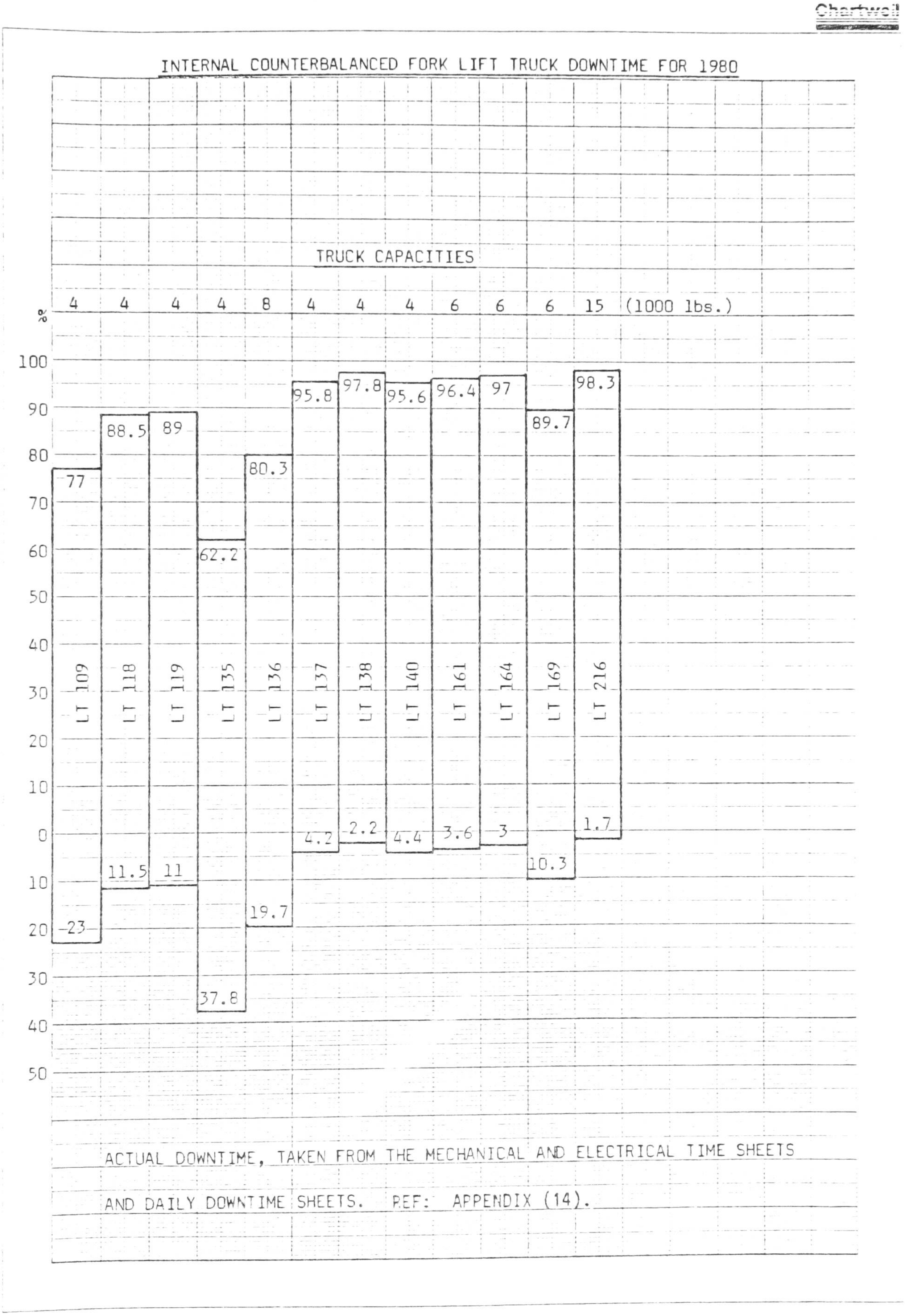
(000 lbs) D = Downtime awaiting repair

TOTAL NO DAYS	4 LT 109			4 LT 118			4 LT 119			4 LT 135			8 LT 136			4 LT 137		
	20			2		4	2.5		2	3		2	2.5		2	8		1
	2			8		3	15		2.5	3.5		2	11.75		3	22.75		5
				4		3	3.75		2.5	8.4		1.5	48		1	2.8		1
				3.5		1	2.33		1.5	24			26		1.5	4.25		
				2.75		1	7.75		2	40			3		1	?		
				32		1	2		2	48			1.75		1.5	12		
				3.5			15			23.5			24		4.75	1.5		
				32						1.75			8		3	1		
				7.5						18.5			8		4	4.5		
				6						15			10		3			
				16						2			1.75		2.5			
				2.33											3			
				37											3.5			
				7.75											1			
				6											2.5			
				5														
				13														
				8														
271 (ELECT.) 'E'	22	528	-	196.33	64	13	48.3	196	12.5	219.15	680	5.5	144.75	280	37.28	38.8	32	7
	E	D	M	E	D	M	E	D	M	E	D	M	E	D	M	E	D	M
208 (MECH.) 'M'																		
TOTAL	22			196.3		17	48.3		16.3	219.15		7.17	144.75		48.53	58.8		9.12
2400 HRS		550			277.3			260.6			906.3			473.3			100	
DOWNTIME %		22.92%			11.55%			10.86%			37.76%			19.72%			4.17%	
WORKING DAYS (1980-300)																		

APPENDIX 8 CONTD.

(000 lbs) D = Downtime awaiting repair

TOTAL NO DAYS	4 LT 138			4 LT 140			6 LT 161			6 LT 164			6 LT 169			15 LT 216		
	.75			35.5			8		1	3		3	1		2.5			2
	1.25			0.5			4.75		2.5	12		1	5		5			3
	.75			28			1		1.5	8		1	32.75					2
	1			2.5			1.66		2	10			9.5					1.5
				4			3		3				1					3
				4.25			7.5		1.5				2					2.5
				1.25			1		3									4
				1			3.25		1.5									3
				1.5					2									1
				3.5					7									1.5
				1														2
				2.75														
				12														
				13.66														
				2														
				1.5														
271 (ELECT.) 'E'	3.75	48	-	88.91	16		22.16	32	25	33	40	5	51.75	184	7.5	-	8	25.5
	E	D	M	E	D	M	E	D	M	E	D	M	E	D	M	E	D	M
208 (MECH.) 'M'																		
TOTAL	3.75		-	88.91		-	22.16		32.6	33		6.5	51.75		9.77			33.22
2400 HRS		51.75			104.9			86.8			72.5			246			41.2	
DOWNTIME %		2.16%			4.37%			3.62%			3.02%			10.25%			1.72%	
WORKING DAYS (1980-300)																		


Chartwell
INTERNAL COUNTERBALANCED FORK LIFT TRUCK DOWNTIME FOR 1980
TRUCK CAPACITIES
4 4 4 4 8 4 4 4 6 6 6 15 (1000 lbs.)
%
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
UPTIME
DOWNTIME
77
88.5
89
62.2
80.3
95.8
97.8
95.6
96.4
97
89.7
98.3
LT 109
LT 118
LT 119
LT 135
LT 136
LT 137
LT 138
LT 140
LT 161
LT 164
LT 169
LT 216
23
11.5
11
37.8
19.7
4.2
2.2
4.4
3.6
3
10.3
1.7
ACTUAL DOWNTIME, TAKEN FROM THE MECHANICAL AND ELECTRICAL TIME SHEETS
AND DAILY DOWNTIME SHEETS. REF: APPENDIX (14).

APPENDIX 9

A P P E N D I X 9

ADDITIONAL IMPROVEMENT PROJECTS

The current procedure of taking up finished cable onto metal process drums is carried out principally because some take up units will not handle wooden shipping drums and cable is made in multiple lengths at sheathing and is cut on rewinding. This is custom and practice, but take up equipment length measurement and sheathing procedures are being improved and changed to allow the finished lengths of cable to be cut and taken up onto shipping drums during the final sheathing operation.

Within the above manual handling time, operators and assistants carry out the m/c loading and unloading, rewinding, final inspection and battening. Shop service personnel are not involved with any manual handling of drums, only mechanical handling by fork lift truck.

APPENDIX 10

PLATE 2.

PRESENT FACTORY LAYOUT

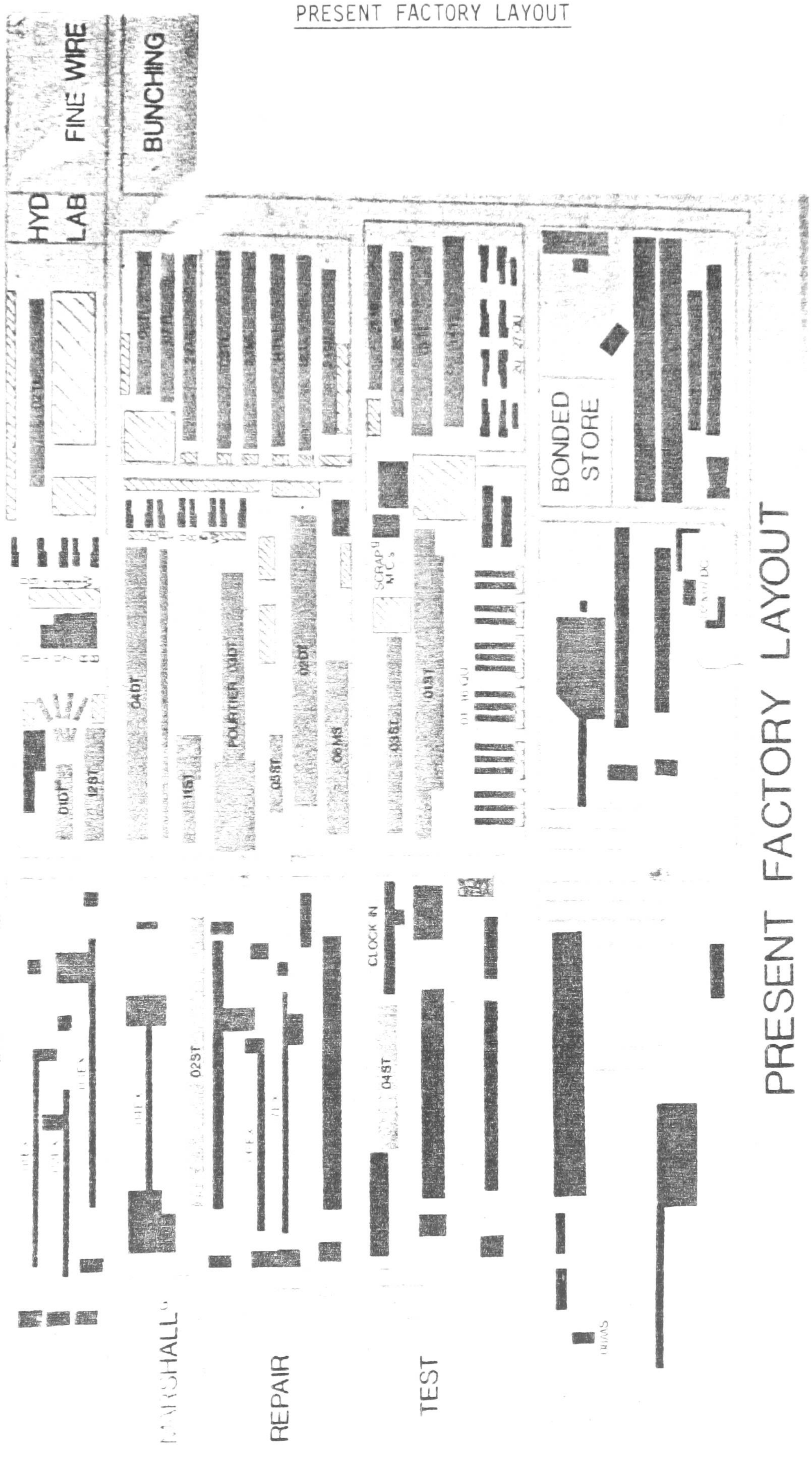


PLATE 3.

POSSIBLE FACTORY LAYOUT (1).

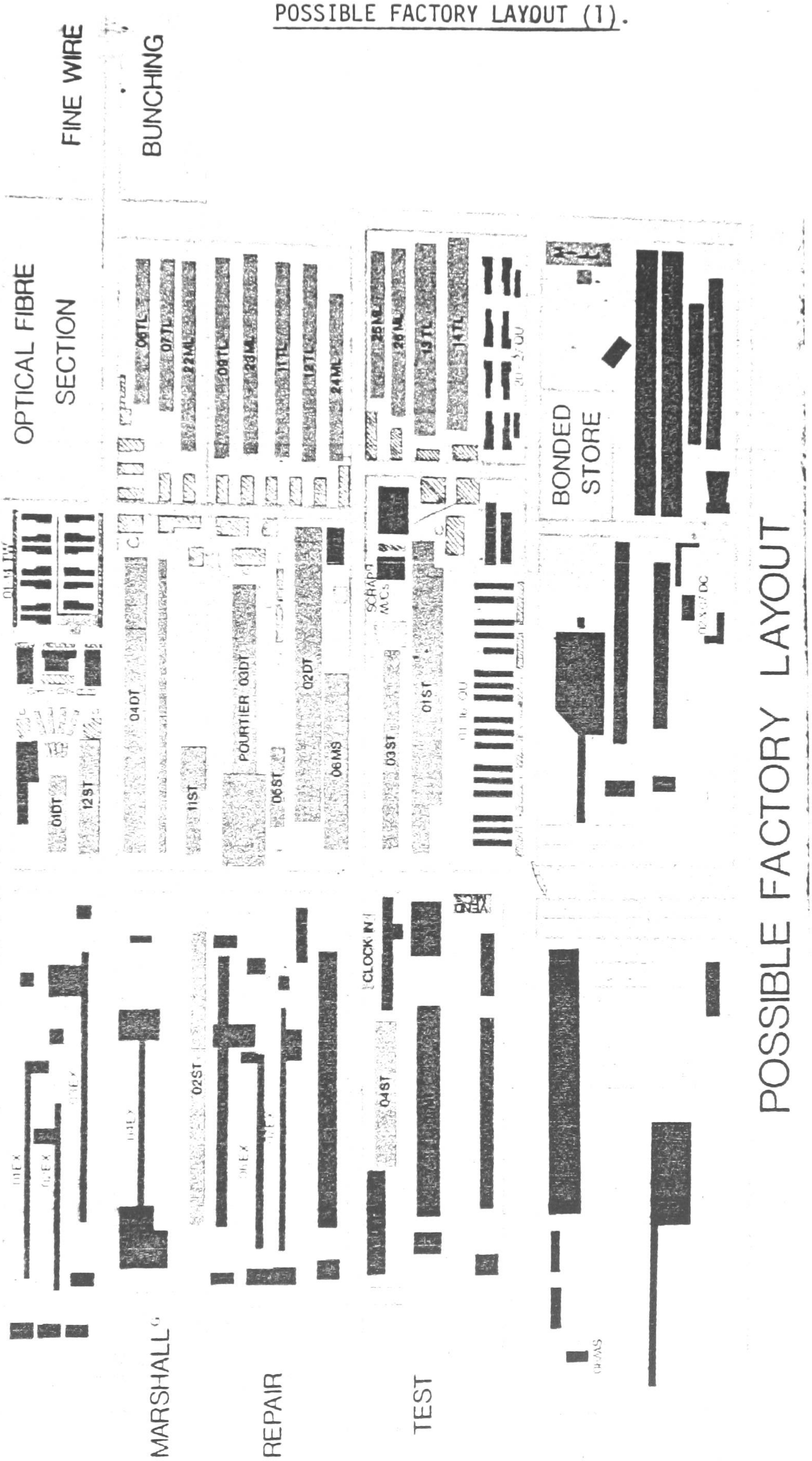
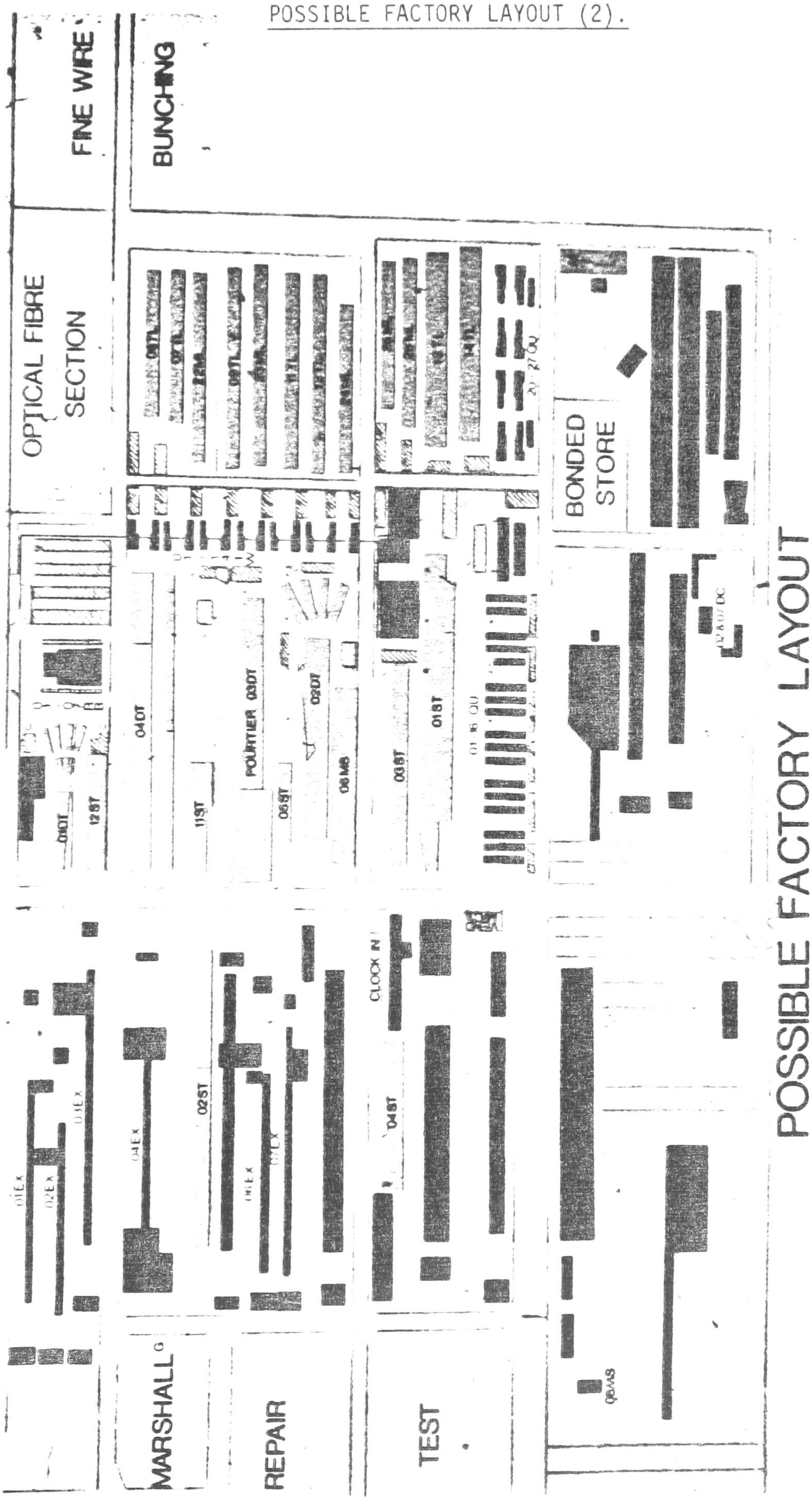


PLATE 4.

POSSIBLE FACTORY LAYOUT (2).



COURSES ATTENDED

The following courses were attended during the two year Teaching Company Appointment to both further the author's development and to provide a background in specific areas where more knowledge was necessary.

1. A Management Orientation Programme (M.O.P.) a one week residential course organised and run by Standard Telephones and Cables at one of their London centres.

2. A Materials Handling Course entitled "Warehouse Layout and Methods", a one week residential course organised and run by The National Materials Handling Centre of Cranfield at a suitable training centre in Peterborough.

3. A Materials Handling course entitled "How to Reduce Your Fork-Lift Truck Costs" a three day residential course organised and run by the National Materials Handling Centre at Cranfield.

4. An Electricity Board Seminar on "Costs and the Future" a one day seminar organised and run by the South Wales Electricity Board at St. Mellons, Cardiff.

B I B L I O G R A P H Y

1. SIMS E.R. — OPERATIONS RESEARCH IN MATERIALS HANDLINGS.

   THE INDUSTRIAL EDUCATION INSTITUTE.

2. SHANNON R.E. — SYSTEMS SIMULATION - THE ART AND SCIENCE.

   PRENTICE HALL INC 1975.

3. NOT KNOWN — MATERIALS HANDLING.

   THE INSTITUTE OF DIRECTORS & DEPARTMENT OF INDUSTRY PUBLICATION.
   72 Pages
   1977 The Sidney Press Ltd.

4. NOT KNOWN — HANDLING & STORAGE IN RANK RADIO INTERNATIONAL.

   RANK RADIO INTERNATIONAL LECTURE AND COURSE MINUTES.

   (Layout and design of integrated storage and handling systems for production) May 1976.

5. NOT KNOWN — AN ALGORITHMIC APPROACH TO MATERIALS HANDLING.

   MANAGEMENT SERVICES PUBLICATION.

   March 1977.

6. VARIOUS — A MANAGEMENT GUIDE FROM CONCEPT TO PRODUCTION CODE OF PRACTICE.

   THE INSTITUTION OF PRODUCTION ENGINEERS PUBLICATIONS 1974

7. THIERAUD R. J.
   KLAKAMP R. C. — DECISION MAKING THROUGH OPERATIONS RESEARCH.

   Wiley International 1975.
   Second Edition.
   Section 2, p.p. 33 - 56.
   Section 14, p.p. 449 - 493.
   Section 4 p.p. 120 - 156.

8. VARIOUS — DISPLAY SYSTEMS FOR PRODUCTION ENGINEERS & MANAGERS

   THE INSTITUTION OF PRODUCTION ENGINEERS PUBLICATION. 1977.

9. BROMWICH M. — THE ECONOMICS OF CAPITAL BUDGETING. Chapter 5 Page 86 - 111 (internal rate of return versus net present value).

Penguin Books 1977.

10. VARIOUS — THE COST AUDIT.

THE POLYTECHNIC OF WALES PUBLICATION.

11. WIERSMA C. H. — ECONOMIC UTILISATION OF FORK TRUCKS. (INDUSTRIAL ENGINEERING MAGAZINE).

April 1976 p.p. 32 - 35.

12. NOT KNOWN. — STEPS TO STOP LIFT TRUCK ENERGY WASTE.

ALLIS CHALMERS CORP.

Plant Management & Engineering 1979.

13. FINLAYSON T. — CUT DOWN LIFT TRUCK WASTE.

Industrial World. November 1977 p.p. 17 - 19.

14. TOMPKINS D.D. — INDUSTRIAL DESIGN, HUMAN FACTORS AND MATERIALS HANDLING EQUIPMENT.

Chartered Mechanical Engineer September 1976 p.p. 116 - 118.

15. NOT KNOWN — FORK TRUCK DESIGN.

Engineering Materials & Design Magazine. April 1979 p.p. 43 - 47.

16. FRÖHLICH C., SIMRIT F. — GRIPPERS AND CLAMPING ELEMENTS - MODULAR ELEMENTS FOR THE AUTOMATION OF PRODUCTION TECHNOLOGY.

The Industrial Robot. December 1979.

17. STRAKER E. — YOUR GUIDE TO POPULAR TRUCKS - 1.

POPULAR TRUCK SURVEY.

Materials Handling News. May 1977. p.p. 58 - 59, 61, 63 - 65 & 67.

18. STRAKER E. YOUR GUIDE TO POPULAR TRUCKS - 2

POPULAR TRUCK SURVEY.

Materials Handling News.
June 1977 p.p. 35 - 37, 41 & 43.

19. STRAKER E. YOUR GUIDE TO SMALL TRUCKS - PART 1.

SMALL TRUCK SURVEY.

Materials Handling News.
October 1976 p.p. 51 - 53 & 55 - 58.

20. BURTON G. MASTS - CAUSE FOR CONCERN.

Material Handling News.
October 1979 p.p. 93, 95 & 97.

21. STRAKER E. YOUR GUIDE TO SMALL TRUCKS - PART 2.

SMALL TRUCK SURVEY.

Materials Handling News.
November 1976 p.p. 43 - 45,
47 & 50.

22. VARIOUS METHOD OF PROPULSION.

ELECTRIC VEHICLE ASSOCIATION
OF G.B. LTD. PUBLICATION. 1980.

23. CHESTER F.B. THE ECONOMIC LIFE OF FORK LIFT TRUCKS.

Wire Journal April 1979
p.p. 90 - 92.

24. RABEY E. FORK LIFT TRUCKS - WHICH FUEL TO USE?

Maintenance Engineering
May 1978 p.p. 47, 49 & 51.

25. NOT KNOWN DRIVERLESS TRUCK PROGRESS.

MATERIALS HANDLING NEWS
PUBLICATION.

Materials Handling News
April 1980.

26. DAVID R.J.
COLLIER P.I. THE SIMULATION OF A FORK LIFT TRUCK AND CRANE TRANSFER OPERATION.

Department of Mechanical Eng.
and Eng. Production U.W.I.S.T.
Cardiff.

27. NAYLOR T. H.
COMPUTER SIMULATION TECHNIQUES
1968 Wiley J. & Son.

28. DAVID R. J.
LALWANI C.S.
SOME APPLICATIONS OF COMPUTER SIMULATION.
MODELLING IN A PORT SYSTEM.

Department of Maritime Studies
U.W.I.S.T. Cardiff.

29. CROSBY J. R.
FORK FAILURE IT CAN BE AVOIDED.

Industrial Engineering.
June 1979 p.p. 40 - 43.

30. TRUNICK P. A.
WHAT DISTRIBUTION MANAGERS SHOULD KNOW ABOUT HANDLING.

Handling & Shipping Management Journal.
March 1981. Vol. 22 No. 3.
p.p. 40 - 44.

31. ROSS B. T.
SIMULATION STUDY OF A HOSPITAL AUTOMATED MATERIALS HANDLING SYSTEM.

A.I.I.E. Proceedings of Spring Annual Conference.
Spring 1979 p.p. 93 - 101.

32. STUPAK J. Jr.
OPTIMISING PNEUMATIC CONVEYORS.

Machine Design.
May 20th, 1976 p.p. 125 - 127.

33. SCHULTZ G. A.
IN-PLANT HANDLING OF BULK MATERIALS IN PACKAGES AND CONTAINERS.

Chemical Engineering.
Oct. 30th, 1978 p.p. 29 - 38.

34. KRAUS M. N.
GUIDE TO PNEUMATIC CONVEYORS

Chemical Engineering
Oct. 30th, 1978 p.p. 63 - 73.

35. JOHANSON J. R.
KNOW YOUR MATERIAL.
HOW TO PREDICT AND USE THE PROPERTIES OF BULK SOLIDS.

Chemical Engineering.
Oct. 30th, 1978 p.p. 9 - 17.

36. NOT KNOWN

BULK SYSTEM HANDLES ADDITIVES IN S.M.C. PROCESSING PLANTS.

PLASTICS ENGINEERING PUBLICATION.

Plastic Engineering. July 1976 p.p. 31 - 32.

37. NOT KNOWN

IBC's - A MORE FLEXIBLE RANGE OF OPTIONS.

CARGO SYSTEMS PUBLICATION.

Cargo Systems March 1975 p.p. 45, 47 & 49.

38. KLÜPFEL O.

HOW CURVED BELTS CAN CUT COSTS.

Materials Handling News. November 1977 p.p. 112 - 113, 115 & 117.

39. THIELE C. W.

CONVEYING OF P.V.C. POWDER AND COMPOUNDS.

Pactech Conference 1st Annual Proceedings Sept 16 - 18, 1975 p. 107.

40. ARMSTRONG R.
ROBERTS S.

FROM SILOS TO CROSSHEAD CONTROL OF MACHINES AND PROCESS PARAMETERS IS VITAL IN WIRE COATING OPERATION.

Plastic Des. Process Vol. 15 No. 11, Nov. 1975, p.p. 15 - 16.

41. NOT KNOWN

Materials Handling
Bulk Solids
D.O.I. Publication.
1981 Rolibri Press Ltd.

42. KULWIEC R.
SCHULTZ G.A.

CONVEYOR SAFETY TIPS.

Materials Handling News.

43. NOT KNOWN

CONVEYORS.

Production Engineering Publication.

Production Engineering, October 1977 p.p. 50 - 59.

44. MELCHIOR J.

CALCULATING CHAIN PULL FOR OVERHEAD CONVEYORS.

Plant Engineering. Sept. 6th 1979, p.p. 107 - 110.

45. NOT KNOWN

THE BIG BUILD-UP.

Materials Handling News. October 1979 p.p. 59, 61, 63, 65 & 67.

46. BAXTER R.

MOVING IN.

Materials Handling News. February 1980, p.p. 42 - 43.

47. NOT KNOWN

NEW FOR LONG HAULS - A SELF PROPELLED PLATFORM !

Modern Materials Handling. July 1977 p.p. 53 - 55.

48. NOT KNOWN

WHY CONSIDER "COMPUTERS" FOR OVERHEAD CONVEYORS?

Modern Materials Handling. July 1977 p.p. 64 - 70.

49. ELSAYED E. A.
PROCTOR C. L.

ORDERED ENTRY AND RANDOM CHOICE CONVEYORS WITH MULTIPLE POISSON INPUTS.

International Journal of Production Research. 1977 Vol. 15, No. 5 p.p. 439 - 451.

50. THOMSON M.

CONVEYORS AND THE ACT.

Storage Handling Distribution. Nov. 1976 p.p. 48, 49.

51. MAXWELL W. L.
WILSON R. C.

DYNAMIC NETWORK FLOW MODELLING OF FIXED PATH MATERIAL HANDLING SYSTEMS.

Handling Systems A.I.I.E. * Transactions Journal March 81. Vol. No. 13 No. 1 p.p. 12 - 21.

52. CARRIE A. S.
MOORE J. M.
ROCZNIAK M.
SEPPANEN J. J.

GRAPH THEORY AND COMPUTER AIDED FACILITIES DESIGN.

Omega Journal 1978. Vol. 6, No. 4 p.p. 353 - 361.

53. KELLY D. L.

INTEGRATING THE COMPUTER INTO THE MATERIAL FLOW SYSTEM.

A.I.I.E. * Proceedings Fall Annual Conference Fall 1979. p.p. 135 - 140.

54. HEISTERBERG R. J. — NEW TOOLS FOR COMPUTER AIDED FACILITIES PLANNING AND DESIGN

A.I.I.E.* Proceedings
Spring Annual Conference 1978
p. 107 - 120.

55. JONES W. — MATERIALS HANDLING.

Department of Mech. & Production Engineering Poly of Wales Publication.

56. NOT KNOWN — AUTOMATICALLY OPERATED CARS.

Storage Handling & Distribution News.

* A.I.I.E.

American Institute of Industrial Engineers Inc.