THE POLICY AND ORGANISATION FOR DEALING WITH SMALL ORDERS IN AN INDUSTRIAL COMPANY

by

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SUMMARY

The research described in this thesis was undertaken at Dunlop Limited, General Rubber Goods Division, Skelmersdale and concerned automotive braking components supplied to Automotive Products Limited. The majority of the sales revenue was generated by a small number of injection moulded components; the remainder was generated by those components which constitute the majority of the product range and were generally manufactured by compression moulding in small quantities.

The large number of small order products represented an area of uncertainty for the Dunlop management; a major objective of the project was to reduce this uncertainty. The problem was considered under three headings: the marketing, manufacture and costing of small orders.

An investigation was undertaken to identify the significant differences between the high volume and low volume order markets. A survey was made of industrial buyer behaviour literature and hypotheses generated predicting the behaviour of the Automotive Products purchasing organisation. The hypotheses were tested and an assessment made of Dunlop as a supplier. Alternative approaches to product pricing were evaluated and a pricing policy which related product price to the amount of customer tooling investment was developed.

Small order manufacturing efficiency was examined and improvements suggested. A new approach to labour costing was developed and implemented. Subsequent investiations revealed that the existing standard costing system was not appropriate to the costing of small orders; an exercise was undertaken to forecast future demand for small orders and derive standard cost budgets in order to assess the viability of small order manufacture. An interactive cost model of small order manufacture was also developed which enabled expected actual performance to be predicted.

As a result of the investigations the company was recommended to continue small order manufacture on condition that some improvements were made. An attempt was then made to draw some general inferences from the study.

pricing costing buyer behaviour forecasting.

CONTENTS

ACKNOWLEDGEMENTS

Research within the Interdisciplinary Higher Degrees Scheme is a difficult enterprise, for one is obliged to meet both academic and industrial objectives simultaneously. It would represent an impossible task were it not for the co-operation and advice of both the University academic staff and members of the sponsoring organisation.

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At Dunlop Limited, the project was conceived and supervised by Mr. C.J. Shaw, Product Manager (Mill and Moulded Products). Mr. Shaw conducted my induction to industry in a sympathetic and instructive way. Even although we were not always in agreement I could always be sure of a fair hearing. I would also like to thank Dr J.R. Bainbridge for the unique combination of humour and objectivity which he provided at all times. Many thanks also to Lynda Pilkington for undertaking the arduous task of translating the several hundred pages of barely legible scribble into a coherent typed manuscript.

Last, but by no means least, I would like to thank my wife, Jan, for providing encouragement at all times, and not complaining too often about the growing mountain of miscellaneous paper which I managed to collect but not to control.

CHAPTER 1

Introduction

1.1 Historical Background

Many large companies, especially those supplying components to the motor industry, are involved in the manufacture of a large product range, the greater part of which constitutes only a small proportion of the business. The company resources are almost inevitably directed towards the production and selling of these few parts which constitute the greater part of the business; marketing strategies and information systems are designed to facilitate high volume production, leaving operating managers in a state of uncertainty about the profitability and even desirability of the myriad of small orders.

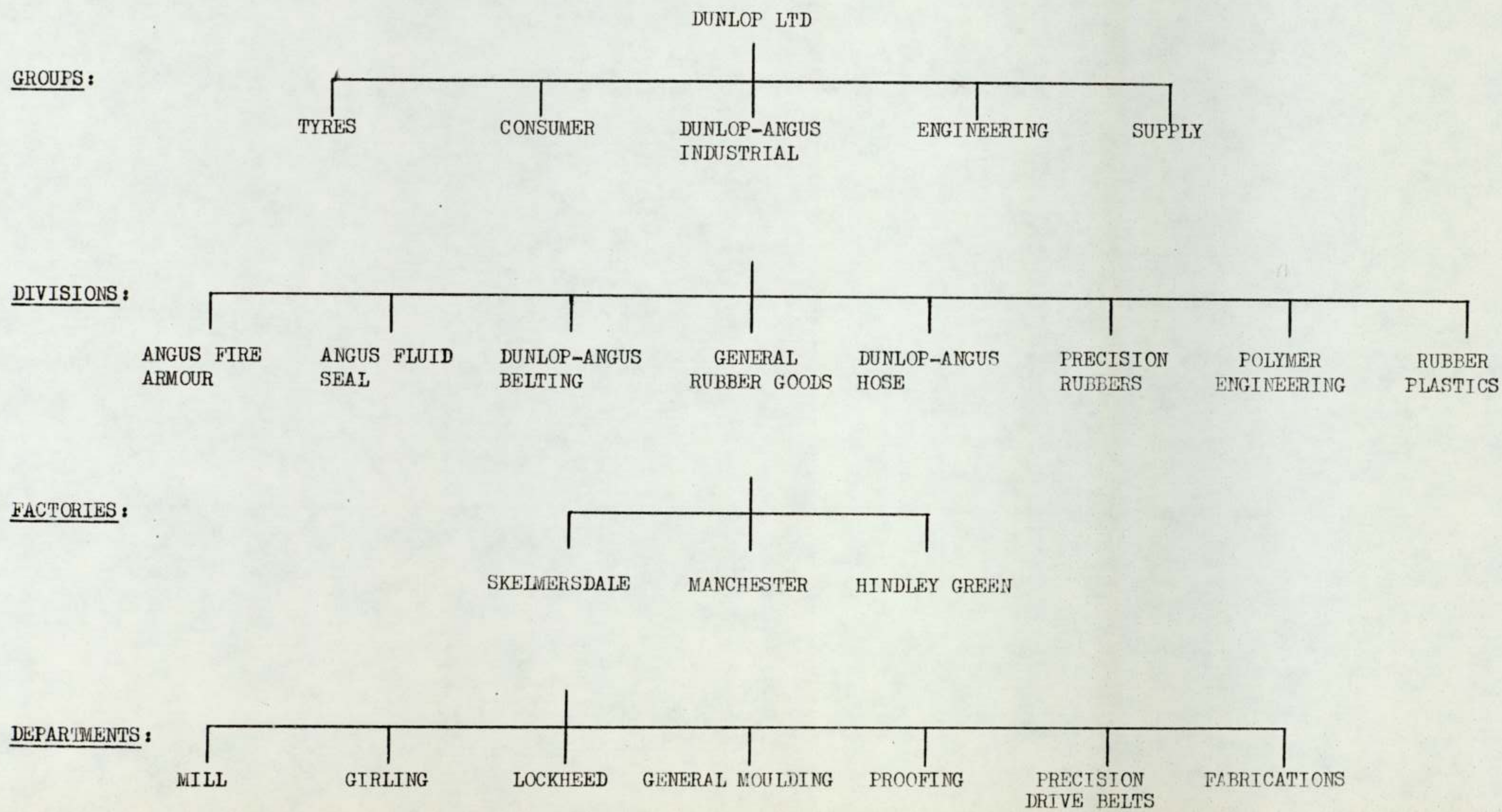
It is this area which has been tackled in the project described herein. The project was based at Dunlop Limited, General Rubber Goods Division and was undertaken during 1974 - 1977. Before describing the research area in detail it would be helpful to outline the history of Dunlop, Skelmersdale since it provides an insight into the problems which arose in the factory since its inception.

The Dunlop Rubber Company was founded in 1900 as a successor to the Pneumatic Tyre and Booth Cycle Agency which had been formed to manufacture and market the first pneumatic tyre of John Boyd Dunlop. By 1975 the company had grown to multinational status, with selling operations in Australia, Canada, France, Germany and South Africa and an annual turnover in excess of £1,000m.

The Company is divided into five main product groups; Tyre Group (which constitutes over 60% of the turnover); Consumer Group; Supply Group; Engineering Group and Dunlop-Angus Industrial Group. The groups are further split into divisions, as shown in Exhibit 1.1. The Skelmersdale factories were incorporated into the General Rubber Goods Division. The products manufactured in the factories reflected the diversity of markets served by the Division; there were departments which manufactured precision drive belts, offset litho blankets, low pressure marine fenders, general automotive mouldings and precision rubber mouldings for automotive braking systems.

The factories were constructed speculatively by Dunlop, with considerable encouragement from the government in the form of development grants under the Skelmersdale New Town Development Scheme. It was intended to incorporate facilities to manufacture 'Metalastik' rubber-to-metal bonded products (from Polymer Engineering Division, Leicester) and to take over the work of the main G.R.G. factory in Manchester. The transfer of headquarter factory operations to Skelmersdale, due to take place between 1965 and 1970, was abandoned after capital expenditure of £3½m and cumulative losses exceeding £1m. At the same time Polymer Engineering Division found that additional capacity to manufacture Metalastik products was not required elsewhere.

EXHIBIT 1.1 : LOCKHEED DEPARTMENT IN RELATION TO COMPANY STRUCTURE



Thus the management based at Skelmersdale were left with a new factory but little work to fill it; they were forced to go to the Dunlop-Angus Industrial Group looking for business with which other divisions were willing to part. As a result areas of business were acquired for Skelmersdale which were at the most only marginally profitable in their previous environment.

The business with the Lockheed Brakes Division of Automotive Products Limited was obtained in this way; manufacture of brake seals, dust covers and diaphragms was transferred from Polymer Engineering Division, Leicester to Oil and Marine Division, Grimsby before finally arriving in Skelmersdale in 1970/71. Productivity improved significantly since the introduction at Skelmersdale; production levels which had required 450 shop floor operatives could, by 1974, be achieved with 80-90, albeit after some considerable capital expenditure on new production processes. The Lockheed Department still proved unprofitable however and the Departmental Accounts were characterised by large adverse variances against standard.

It was felt that a large percentage of the variances could be attributed to the lack of control information available to management. The problem was exacerbated by the nature of the business, which was such that a small number of parts constituted most of the output of the department; the remainder of the output consisted of a large number of parts of comparatively low volume. The area to be studied consisted of those parts which made up nearly 80% of the product range but which represented less than 20% of the output (by volume of parts) of the Lockheed Department.

The management at Skelmersdale were working under considerable uncertainty, not only in terms of operational control information but also in terms of the continuation of demand; the purchase by Automotive Products of a precision rubber moulding company (Alfred Roberts Limited) did not bode well for the future of the Lockheed Department at Skelmersdale, which had not been profitable in six years of operation.. Management resources had been directed towards 'fire fighting' high volume production problems, small orders attaining only a relatively low priority.

1.2 Specification of the Problem

The initial project brief was therefore:-

1.2.1 To define what was meant by a small order.

1.2.2 To discover the proportion of the total Lockheed Department business which small orders represented, by volume, turnover and contribution.

1.2.3 To determine the production costs of small orders and hence the profitability.

1.2.4 To develop more objective criteria for accepting or rejecting small orders - it was felt that the decision to accept or reject an order was more a function of the pressure exerted by the customer than objective commercial reasoning on the part of Dunlop management. It was not known the extent to which the refusal of a small order might affect the offering of high volume orders.

1.2.5 To determine whether the requirements of both Automotive Products and Dunlop might be better achieved by the creation of a separate facility to manufacture small orders.

It was apparent that the problem of small orders was more fundamental than the above project brief suggests. The problem was at the interface of the production, marketing and financial policies of the company - to look at any one area in isolation would be very limited. To production management for example, the manufacture of small and large batches simultaneously in the same production area may be seen as an obstacle to efficient production, absorbing resources which they feel could be more fruitfully employed elsewhere. To the marketing function on the other hand small orders may be seen as an essential service provided for the customer in order that more incentive high volume orders may be obtained - 'a sprat to catch a mackerel'.

It was possible that small orders may in themselves have been profitable. However the absolute and relative profitability of small orders can be very difficult to determine, for not only does one encounter the usual problems of defining profitability, but also the costing system in a company orientated towards high volume production may not give sufficiently accurate product costs for small orders.

If the company is aiming for a target return on investment it is possible that small orders viewed in isolation may not reach the threshold level. On the other hand, if the company is aiming for maximum market penetration small orders may be an essential component in a marketing strategy to achieve that aim.

The recommendations made to the company must be seen in the light of what the company's objectives are, what criteria it uses to assess achievement of those objectives and the organisational importance of the different operating functions which are likely to be in conflict over the problem.

The small order problem could be summarised by four questions:

(i) How is a small order defined?

(ii) How should small orders be marketed?

(iii) How should small orders be produced?

(iv) How should small order work be costed?

1.3 Work Undertaken

Since much of the necessary data was not available for analysis it was difficult for Dunlop management to specify exactly what were the problems associated with small orders. It was necessary therefore to structure the problem in a more coherent form and identify the major issues. To this end a questionnaire was administered to key Dunlop managers to determine what were felt to be the major problems associated with the manufacture and distribution of small orders (see Exhibit 1.2 for personnel approached). A more detailed description of the investigation can be found in Appendix A.

From this study it was apparent that three major areas were felt to be crucial. These major areas were subdivided into actions required on the part of the researcher and a network plan of the work to be undertaken constructed, (see Exhibit 1.3). This exercise was extremely valuable, for not only did it provide the researcher with a logical structure to approach the problem, but also could be used to show the company management the direction which the project was to take. The presence of a student in the factory could produce problems, particularly when the staff were uncertain of what was being attempted; there was a temptation to use the researcher as just another resource to analyse day-to-day problems. The network could be used to ensure that the direction of the project was kept and that questions were answered in a logical order.

EXHIBIT 1.2 : MANAGEMENT STRUCTURE AT START OF PROJECT

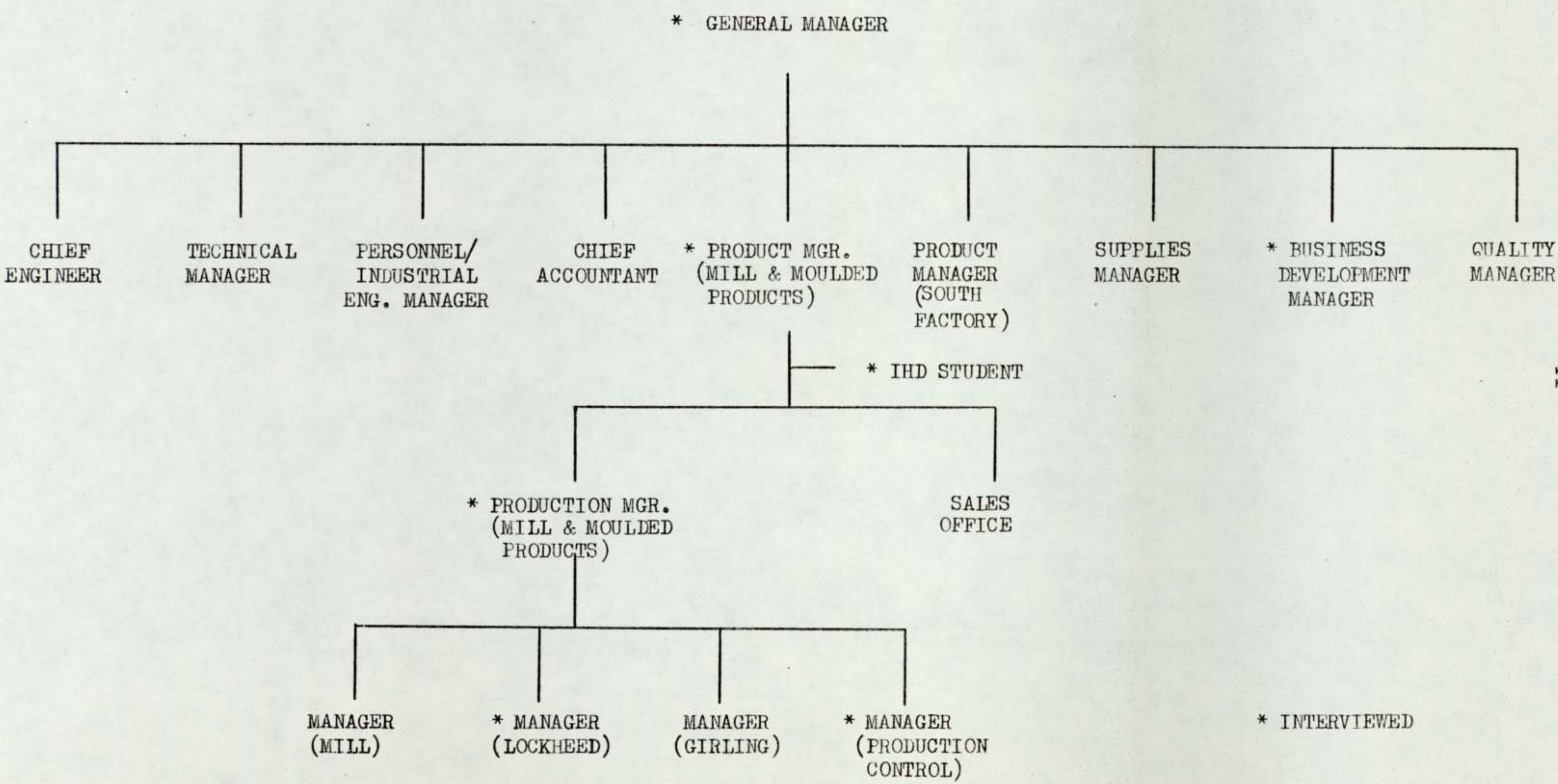
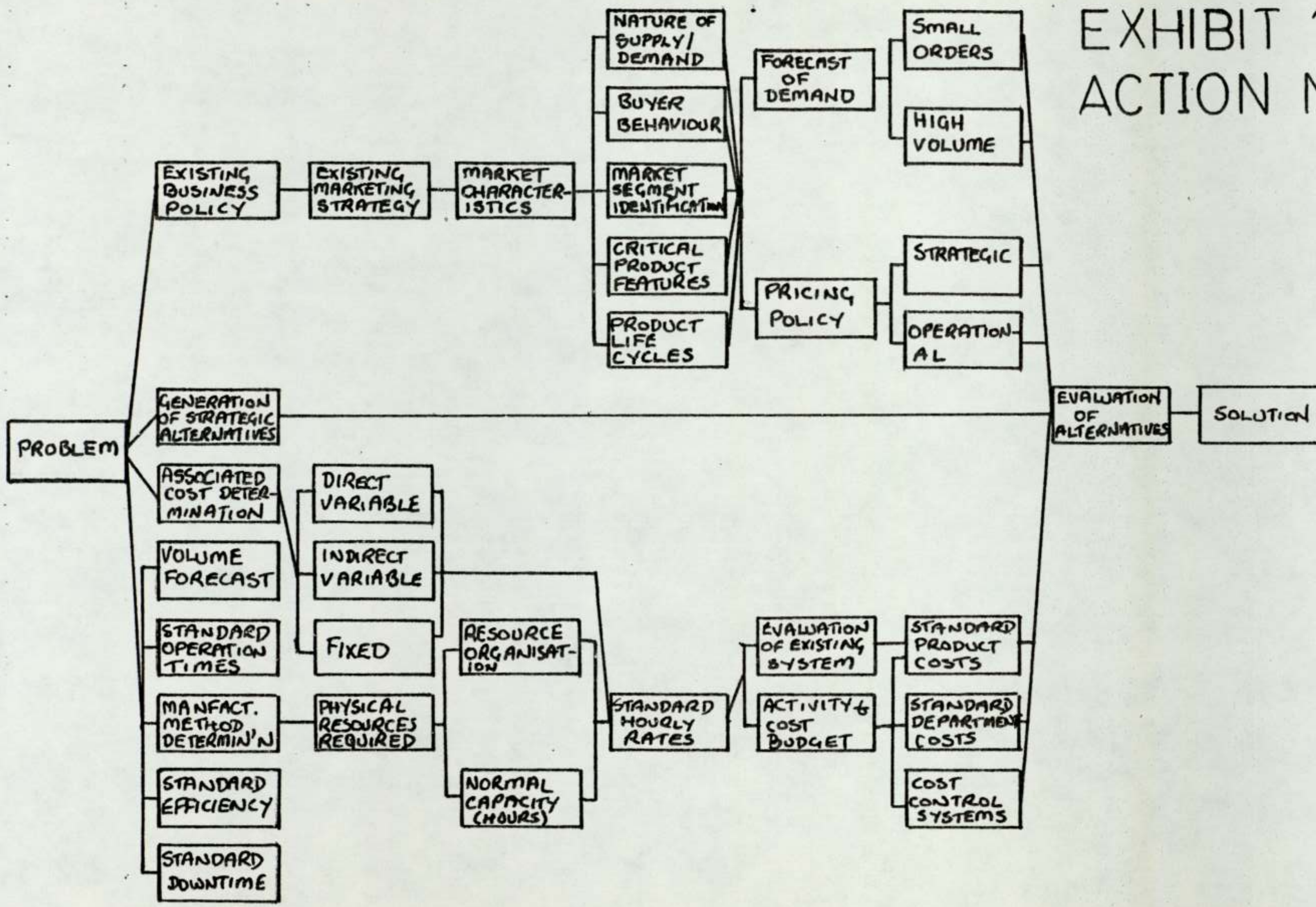


EXHIBIT 1.3. :IHD ACTION NETWORK



Each question was expanded into a series of subsidiary questions to enable an evaluation of the complete problem to be made. Inevitably a large number of questions were raised which could not be answered fully within the time available, but it was felt that the researcher should at the very least be aware of the logical sequence of investigation and make assumptions where full answers could not be obtained with the resources available. The breadth of the approach is inherent in the IHD approach to research; to isolate one limited area for intensive investigation may be a more academically rigorous approach but it does not help to solve the real problem. It is fundamental to IHD philosophy that the research must be directed towards the solution of a practical problem; research which concentrates on one facet whilst ignoring the others could never provide a practical solution no matter how academically respectable. The use of this research paradigm has meant that the answers to some questions are not as academically sophisticated as they might have been had that area been studied in isolation . However for a company where the paucity of information was extreme the attempts which have been made during the life of the project represent a considerable step forward. Where information was not available the methodological approach necessary to obtain it has been outlined.

The main areas of approach were:

1.3.1 Marketing

1.3.1.1 The determination of the existing Dunlop marketing policy towards Automotive Products in relation to the existing market structure and the relationship between the two companies.

1.3.1.2 An investigation of the factors influencing the purchasing behaviour of Automotive Products leading to the development of an effective marketing strategy for small orders.

1.3.1.3 The identification of the major market segments (within the market served by Automotive Products) and a projection of likely future trends in each segment. It was suggested that some estimation of the product form life cycles would be desirable as the majority of small orders in the Lockheed Department were for spares use (approximately 70%) & it could not simply be assumed that as the demand for certain small orders disappeared it would automatically be replaced by parts dropping from the high volume category. This was a particularly moot point in view of the rationalisation programme which Automotive Products had undertaken in the past 3 years; the use of one component for more than one braking application implied that demand fall-off upon cessation of original equipment manufacture for one application would not be so sudden. Thus the average product form life cycle could be expected to lengthen as fewer parts were used to service a greater number of requirements.

1.3.1.4 The development of a pricing policy for small orders which considered the market conditions and company objectives in addition to accurate cost information. It was hoped that the pricing structure should also consider whether the parts were singly or multiply sourced, but investigation showed that this information was not accessible.

At the very least it was felt that a price structure should be developed which was 'rational' in that similar parts should have similar prices (if the demand is also similar). The Product Analysis Pricing approach of Brown and Jaques was tried but found inadequate for the Skelmersdale application(see Chapter 5).

1.3.2 <u>Accountancy</u>

The Lockheed Department was characterised by a large 'shop loss' i.e. departmental cost variance, but it was not actually known what proportion of the shop loss resulted from the manufacture of small orders or even what proportion of the total business small orders constituted (there being no definition of small orders).

A product standard costing system was in operation throughout the department but was apparently inaccurate for the end of year accounts showed an overall adverse variance in excess of 50%. There being only a rudimentary cost control system it was impossible to make a meaningful comparison between the actual costs of production and the standard costs on a part by part (or product group) basis.

The extent to which inefficient operation contributed towards the adverse variances was not known. Similarly it was not possible to determine whether the assumptions and operation of the standard costing system could be contributing to the discrepancy. Therefore the following actions were necessary:

1.3.2.1 The development of activity and cost budgets for the section which manufactures small orders.

1.3.2.2 The design and implementation of an effective cost control system. This would serve two purposes:-

(a) To ensure the accuracy of the assumptions made in establishing the standard costing system.

(b) To enable lower level operating managers to establish more effective control of the small order manufacturing operations since very little information reaches them.

1.3.3 <u>Operations Management</u>

At the beginning of the project it was suggested that a separate section might be set up to manufacture small orders. The author was asked to provide information to the company to enable an assessment to be made of the resources required for the section. A decision to set up the small order moulding section was made before all the necessary areas could be covered to the author's satisfaction. This is a frequently occuring problem when one is trying to satisfy both company and academic demands; the company is often satisfied with a more rapid but less rigorous answer than would be required to meet the standards of research. Furthermore the researcher can sometimes derive a solution to a problem which may have changed quite radically during the analysis, for one is trying to impose a static or semi-dynamic construction on a problem which may be highly dynamic.

Nevertheless a stand must eventually be made or the researcher will be continually updating information or models without achieving a final solution; an attempt must be made to outline a clear methodology such that later revisions to existing models may be achieved with as little extra work as possible. To this end it was decided that the following areas should be investigated to determine the feasibility of setting up a small order section:

1.3.3.1 A determination of the physical resources required to manufacture small orders. This required the following information :

* The total current demand for small orders (and future trends in demand).
* The manufacturing methods used and the standard operation times.
* Standard efficiency and downtime figures for the small order section.

1.3.3.2 A consideration of how the resources could be organised into an effective operative operating unit, or whether an efficiency operation might be achieved with an effective management information and control system only.

1.3.4 Broader Issues

Whilst the specific aim of the project was to identify the major issues of the small order problem at Skelmersdale and indicate solutions, more general issues are raised by the investigation which may have implications for many large companies which market a large product range. It is possible that many of these companies may not even be aware that small orders can constitute a problem, for management information systems which have been developed to control a high volume production process may not be sufficiently sensitive to indicate that a problem exists. It is hoped that the results of this research project may indicate to management of these companies potential problem areas; the solutions suggested, however, are likely to be particular to the Dunlop, Skelmersdale situation.

CHAPTER 2

The Definition of Small Orders

2.1 The Nature of the Problem

At the start of the project it was not clear what were the major problems associated with small orders; the 'project profile' study identified the three major areas of investigation which the Skelmersdale management felt were the most important, namely the marketing, accounting and operations management aspects of the problem. It was not clear however what the Skelmersdale management meant by the term 'small order'.

A number of alternative approaches to the problem of defining small orders for the purposes of analysis were considered. The objective of the exercise was to derive a working definition of small orders which could be used during the life of the project. The alternative approaches considered were:

1. Volume/Revenue Threshold.
2. Running Time/Set-up Time Ratios.
3. Product End User Analysis.
4. Alternative Production Technologies.

2.2 The Alternative Approaches

2.2.1 Volume/Revenue Threshold

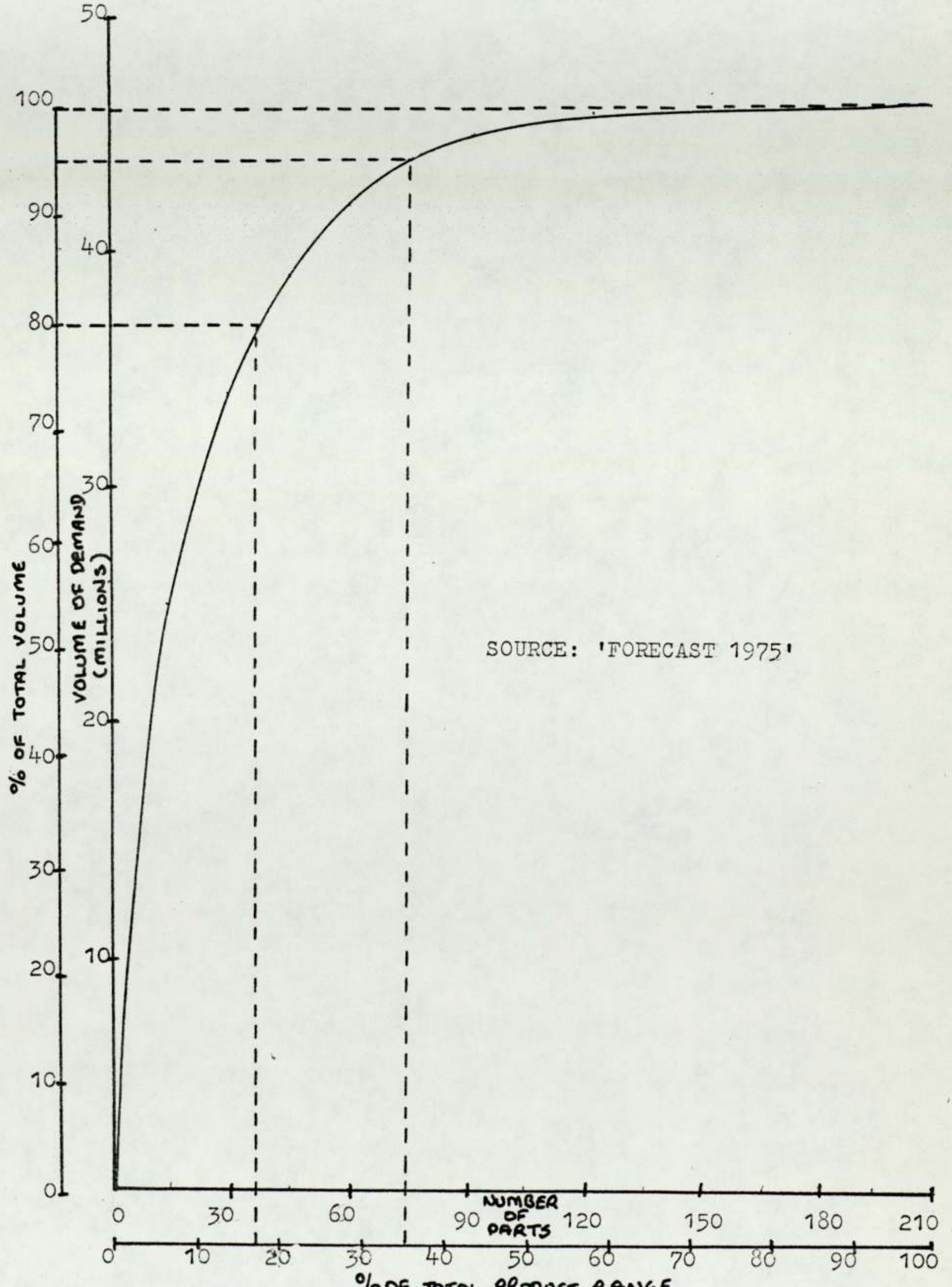
Superficially the simplest way to define a small order would be to determine a level of annual output or demand, below which all products would be classified as small orders. A major problem occurs when an attempt is made to determine the level of the threshold.

During initial discussions it was suggested that the level should be set at 100,000 seals per year and 20,000 dust covers ('boots') per year (for a detailed description of the products and their uses see Chapter 3). Since the overall distribution of volume for the Lockheed Department had not been examined in any depth, a Pareto analysis of the annual demand (in terms of number of parts and revenue) was undertaken. The results of the investigation, illustrated in Exhibit 2.1, indicated the nature of the problem which faced the Skelmersdale management.

It is often found that 80% of the total volume (or revenue) is provided by 20% of the total number of products in the product range. The results for Skelmersdale were consistent with this general rule, the curve being slightly steeper than is normally found, 15% of the total number of parts constituted 80% of the total volume of the Lockheed Department. A similar analysis based on revenue resulted in a slightly shallower Pareto curve, indicating that higher prices were obtained for the lower volume items (18% of the product range provided 80% of the total turnover for the Department).

Using the arbitrary volume threshold suggested, 155 products were classified as small orders, representing 67% of the Lockheed Department product range and constituting 4.5% of the total volume of the Department.

EXHIBIT 2.1. :PARETO ANALYSIS OF LOCKHEED DEPARTMENT DEMAND



All but nine of the parts included in this definition were manufactured by the traditional compression moulding technique rather than the injection moulding process which had been introduced for high volume products (approximately 9 years previously). All items with annual volumes in excess of the threshold levels were manufactured by the injection moulding process.

Although the number of injection moulded products classified as small orders by this definition was limited, it was expected that more injection moulded products would become 'small orders' as the end of each product form life cycle was approached. Whilst the Skelmersdale management admitted that, in the longer term, small volume injection moulded products would constitute a problem, it was felt to be a significant area for investigation at the initial stages of the project. It therefore became clear that the use of the term 'small order' in Skelmersdale was synonomous with compression moulded products.

An additional difficulty in the use of the volume threshold approach was presented by the changes which occurred in the demand for Lockheed Department products; the demand for all brake rubbers began to decline steadily from October 1974, finally reaching a minimum level in June 1975 which was only 50% of the 1974 average monthly demand. The change in demand level, which was due to the general recession which affected the motor industry, made it difficult to establish a volume threshold for small orders which would not alter the number of parts included in the definition from month to month.

The original threshold level had been established by using a volume forecast for 1975; as the year progressed it became clear that the forecast was becoming increasingly unrepresentative of the current demand for Lockheed Department products.

2.2.2 Running Time/Set-up Time

Batch size could also have been used to define small orders since there appears to be a high correlation between annual demand and batch size. It was the practice at Skelmersdale to attempt to manufacture the complete monthly schedule for a product in one production run (usually the monthly schedule was one twelfth of the annual demand) and therefor it was possible to define small orders as those products manufactured in small batches. Since a small batch implies a low running time/set-up time ratio it should have been possible to set a threshold value of this ratio, below which all products would be classified as small orders.

Similar problems to those encountered with the volume threshold approach were found; it was difficult to determine a threshold level of running time/set-up time which was not purely arbitrary. At the very best all that could be achieved was to determine a ratio of running time to set-up time below which the run was uneconomic. (Where uneconomic batches can be defined as batches where the costs of setting up the machines and producing the batches exceed the total benefit to be gained). There was no evidence to suggest that this was what management meant when defining a part as a small order.

There were additional problems associated with this approach; no individual standard set-up times were available for the Department. Actual mould changeover times were available for injection moulds on a weekly basis, which represented the time taken to remove particular named injection moulds and replace them with other moulds. There was a considerable variation in the time taken to effect the same mould change on different occasions (see Exhibit 2.2). A number of possible explanations for the variation were suggested:

1. Different machine setters making the mould changes with varying degrees of experience.
2. Maintenance may have been undertaken during some of the mould changes.
3. The moulding machine may not have been set at the correct temperature to mould the new product when the changeover occurred.

In the standard costs a blanket allowance of 6½% was applied to the standard moulding minute values to allow for mould set-up and cleaning; this represented an average figure provided by the Industrial Engineering Department after a study of one month's production in the injection moulding section.. Whilst this figure may have been useful for the purposes of costing, it was not meaningful as a definition of an acceptable norm; set-up time will remain relatively constant irrespective of the length of the production run and will therefore constitute a large percentage of short production runs.

EXHIBIT 2.2. : TYPICAL INJECTION MOULD CHANGEOVER DATA

INJ. MLD. CHANGES. 1974

WK 10			WK 11			WK 12			WK 13			WK 14		
3812·753 / J16015	P	8.0	— / 102509		1.5	698 / 102509		1.0	81124 / 586	P	2.0	563 / 3875·419	P	1.5
J16013 / 3813·711		3.0	102501 / 3871·735		2.0	102509 / 698		2.25	— / 698		2.0	586 / 3842·626	P	2.0
437 / J8110	P	4.0	— / 102509		1.0	V12368 / 3829·430		4.0	3813·711 / J11187	P	2.0	27867 / J13490		3.0
J8110 / 85422		4.0	3813·713 / V12368		7.0	437 / 85422		2.25	3371·431 / 31118	P	2.0	14562 / 6042	P	2.0
27867 / V12368		5.0	53427 / 29630		3.0	3851·447 / 3871·735	P	3.0	J13491 / 27867	P	2.5	3812·729 / 85422		2.0
V12363 / 27867		2.0	3812·737 / 3877·716	P	3.5	3871·735 / 53427		2.5	V19161 / 563	P	2.5	J13410 / 27867		3.0
3876·415 / 537		2.0	J7553 / 3812·746	P	4.5	85420 / 437		1.0	563 / 3875·419		2.0	27526 / 12046	P	1.5
563 / 3876·415		6.0	12046 / 588		4.0	437 / 85422		3.0	3871·735 / J4025		2.0	12046 / 3375·421		2.0
695 / 3871·735		2.0	J8110 / 3817·715	P	2.5	53427 / 3871·735		3.0	3875·429 / 563		2.0	3842·626 / 3866·423	P	2.5
J14156 / J13470		2.25	39325 / J13491	P	7.5	3312·746 / 53427	P	3.5	J16015 / 3812·783	P	5.0	V12363 / 27630	P	4.0
J13470 / J22718		1.5	583 / 12646		2.0	1377 / 563	P	2.0	3817·715 / V12368	P	2.0	6042 / 3277·718	P	2.0
J530 / J7663	P	2.0	V12365 / 3813·713		5.0	563 / V19161		4.0	V12368 / 3817·715	P	4.0	31118 / 107126	P	2.0
3876·415 / 3877·718		1.0	29630 / 27867		3.5	539 / 14562	P	1.0	J4025 / 3371·735		4.0	10799 / 3371·431	P	2.5
3877·715 / 3876·415		1.0	J13491 / 437		4.0	3323·415 / 109838	P	3.0	85422 / 3812·749	P	2.0	27526 / 12046		4.0
12046 / 31118		2.0	12046 / 10799		1.5	27562 / 27526	P	1.5				12046 / 2762		1.5
J3121·0 / J13491	P	2.25	3312·430 / V13027		1.5	698 / 102509		1.5				2762 / 12046		1.5

For compression moulded products even less information was available; there were no estimates of set-up times and no allowance was made in the standard costs. Individual set-up times were difficult to determine for the compression moulded products; products were moulded in loose cavities (see Chapter 6) and a number of different cavities were usually loaded in each press. Little setting up of the machine was required, the majority of the pre-production time was concerned with the heating of the cavities. Production runs normally lasted at least one week, intermediate changeover times being minimised by placing new moulds in the presses at the end of a shift.

In summary therefore although some information was available for injection moulded products, no comparable data was available for compression moulded products and would have been difficult to obtain.

If running time/set-up time data had been available for both compression and injection moulded products at least two running time to set-up time ratios would have been required, reflecting the different processes involved. A number of other running time/set-up time ratios could have been chosen for the rubber preparation and finishing stages of manufacture, but since there was excess capacity and only limited investment in these areas, it was more sensible to concentrate on the areas with limited capacity and relatively high capital investment, namely the moulding sections. Even with only two running time/set-up time ratios it would have been very difficult to ensure that the two ratios chosen were comparable. It was therefore decided that, in view of the difficulty of obtaining meaningful information, the running time to set-up time approach would not be used to define small orders.

2.2.3 Product End User Analysis

The products of the Lockheed Department could be classified as original equipment parts, original equipment spares (for vehicles still in production) and 'dead' spares (for vehicles no longer in production). It was not possible to separate original equipment products from original equipment spares, since the majority of the higher volume products were supplied to both markets.

'Dead' spares could be readily identified, but such an exercise would have been of only limited value, for it included some of the highest volume parts as well as many of the small volume parts. Therefore there was little value in using the market destinations of the products to define the class of small order parts; the approach had little to offer over which was better than the other possible approaches.

2.2.4 Production Technology

In general it appeared that Dunlop management equated small orders with parts produced by the compression moulding technique and it was felt that the majority of the problems associated with small orders could be identified by an investigation concentrating on compression moulded products.

In the longer term it was likely that injection moulded products would be manufactured in small batches and at such a time must be regarded as small orders. However, at the start of the project use of the production technology definition had considerable advantages:

1. The compression moulding machines could be readily identified in order to determine the costs of production.
2. The cost structure for all products manufactured by this method was the same.
3. Compression moulded parts exhibited many of the characteristics which management believed were the major problem areas with small orders, notably:

   (a) High Reject Rates

   Compression parts had a significantly higher reject rate than injection moulded products. Taking the average reject rates over a one year period, the average compression reject level was 59% (on good production) compared with 14% (on good production) for all injection moulded products. With a sample of 40 compression moulded parts and 83 injection moulded parts the difference in reject levels was found to be significant at the 99% confidence level. Splitting the injection moulded parts into higher and lower volume categories yielded mean reject levels of 14% and 20% respectively. With sample sizes of 20 and 63 the difference in mean reject levels was not significant at the 95% level. Thus the difference in reject levels appears to depend more upon the manufacturing process employed than the volume of production.

(b) Delivery

Interviews conducted with purchasing and engineering personnel employed by Automotive Products revealed that they were generally satisfied with the delivery performance of products which were injection moulded, but were highly dissatisfied with the delivery performance for compression moulded products (see Chapter 4). The dissatisfaction was particularly marked at the Parts and Service Division of Automotive Products, who ordered the greatest proportion of the Skelmersdale compression moulding output.

In support of the criticism of poor delivery performance for compression moulded products it was found that there was a considerable arrears problem with compression parts, whereas injection moulded parts were usually delivered on time in approximately the required quantities.

(c) Annual Demand

Using the volume threshold definition there was a small number of injection moulded parts which were defined as low volume parts. In general however injection moulded products were manufactured in large quantities, whilst compression moulded products were produced in smaller quantities. Indeed this was to be expected since the injection moulding process was inherently much quicker than compression moulding; the standard minute value per part for a typical injection moulding set-up was approximately 0.05 SM/part compared with 0.20 SM/part for a product manufactured by the compression process.

(d) Quality and Quantity of Information

Information suitable for analysis at Skelmersdale was often difficult to obtain; in general there seemed to be the impression that information systems were not required by the competent manager (this statement was made to the author by a senior manager). The informational problems for compression moulded products were particularly acute, for not only was the quantity of information strictly limited, as illustrated by the attempt to obtain set-up data, but also when information was obtained it was of dubious quality and was frequently out of date. Skelmersdale management did not appear to believe that compression moulded parts were of sufficient importance to justify the time and effort required to maintain the records in an up-to-date form . Some examples of the poor quality of the information encountered are given in Exhibit 2.3, together with references to the relevant chapters of the thesis.

EXHIBIT 2.3

	PROBLEMS ENCOUNTERED	REFERENCE
1. PROCESS ENGINEERING		
Specifications	Specifications frequently did not reflect the current process and were often missing.	Chapter 8
Tooling	Tool condition reports not kept for compression mould tooling at the beginning of the project.	Chapter 6
2. INDUSTRIAL ENGINEERING		
Standard Times	No standard times available for 40% of the compression moulded products.	Chapter 7
	Standard moulding times were not updated when process changes were made.	Chapter 7
Incentive Schemes	Incentive scheme not introduced until 6 months after the set up of the Small Order Section.	Chapter 8
3. PRODUCTION MANAGEMENT		
Downtime Analysis	Machine downtime records not kept for compression presses.	Chapter 8
Operator Performance	Records of compression moulding operator performance not kept.	Chapter 10
4. COSTING		
Standard Costs	Not updated when significant process changes made.	Chapter 8, 10
	Changes in indirect labour not incorporated in standard costs.	Chapter 8
	Blanket allowances derived for the Department as a whole were incorporated in the standard costs.	Chapter 10
Cost Control	Actual cost records kept only for the whole Department (thereby reflecting mainly the high volume performance)	Chapter 8

2.3 The Choice of a Definition

The use of the production technology definition offered considerable advantages over the other approaches. In addition the approach was acceptable to the Skelmersdale management, the terms 'compression moulded part' and 'small order part' being used indiscriminately.

Whilst the compression moulding definition was not as theoretically acceptable as the batch size/running time definition, it must be remembered that essentially the same products would be defined as small orders whichever definition were used; the approaches only differ in the number of 'marginal small order' parts which are defined as small orders for the purposes of analysis.

In the following chapters therefore the term 'small order' will mean products which are manufactured by the compression moulding process.

CHAPTER 3

The Products And Their Markets

3.1 The Products

The Lockheed Department manufactured rubber braking components for the Lockheed Brake and Spares and Service Division of Automotive Products Ltd. The products could be split into two broad classes:

3.1.1 Seals

Approximately 70% of the output of the Department consisted of seals which were used in the hydraulic actuating systems of motor vehicles, mainly in the brake and clutch systems. The seals were designed to fit into the master cylinder or slave cylinder bores and acted upon the hydraulic fluid in the system. The seals had to fit the bores closely to prevent fluid seepage and therefore had to be manufactured to close tolerances (within 0.005") and were generally cup-shaped (see Exhibit 3.1 for examples). The formulation of the rubber compound used also had to be precisely specified to suit the hydraulic fluid which was to be employed; the use of an incorrect formulation could cause excessive swelling of the seal in the cylinder bore resulting in brake failure for which Dunlop could be held liable.

3.1.2 Dust Covers ('Boots')

Dust covers, as the name suggests, were used to prevent the ingress of dirt, grease and water into the exposed components of braking and steering systems. The dust covers were manufactured to greater tolerances than seals but were of a more complex structure and were often more difficult to mould (see Exhibit 3.2). The formilation of the rubber compound used, although less critical than for seals, was still important since the dust covers had to remain effective in a variety of operational environments.

3.2 The Market

The activity of the Lockheed Department, Skelmersdale was devoted entirely to the manufacture of rubber braking and steering components for the Lockheed Brakes and Steering and Parts and Services Divisions of Automotive Products Ltd. Parts sent to the Brakes Division were incorporated in brake systems which were then supplied to the vehicle manufacturers; approximately 50% of the total UK brake market was held by Automotive Products, the remaining share being held by the Girling Division of Joseph Lucas Limited.

Components sent to the Spares and Service Division were either incorporated into master or slave cylinders and packaged ready for sale under the Lockheed brand name or were distributed through the motor manufacturers own network for sale under the manufacturers brand name (Unipart, Motorcraft, Mopar). (Exhibit 3.3)

EXHIBIT 3.1 : TYPICAL BRAKE SEALS

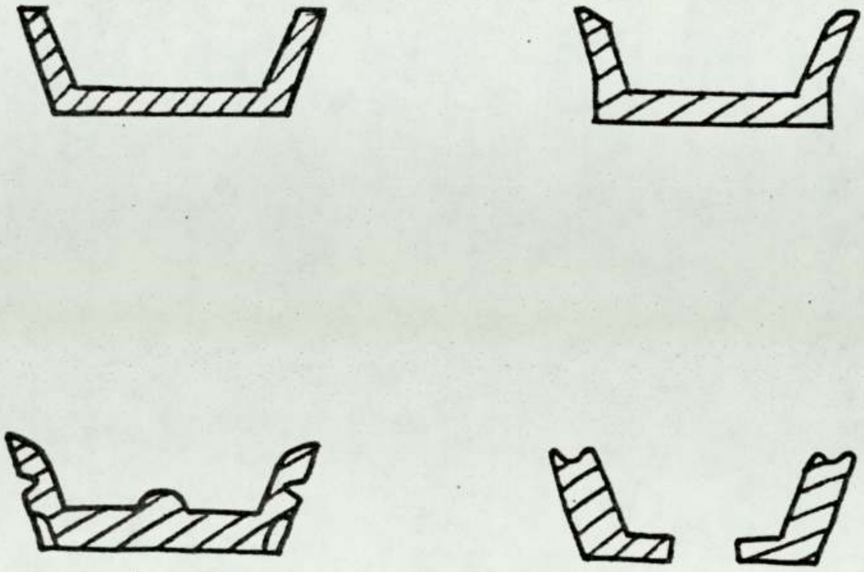


EXHIBIT 3.2 : TYPICAL DUST COVERS

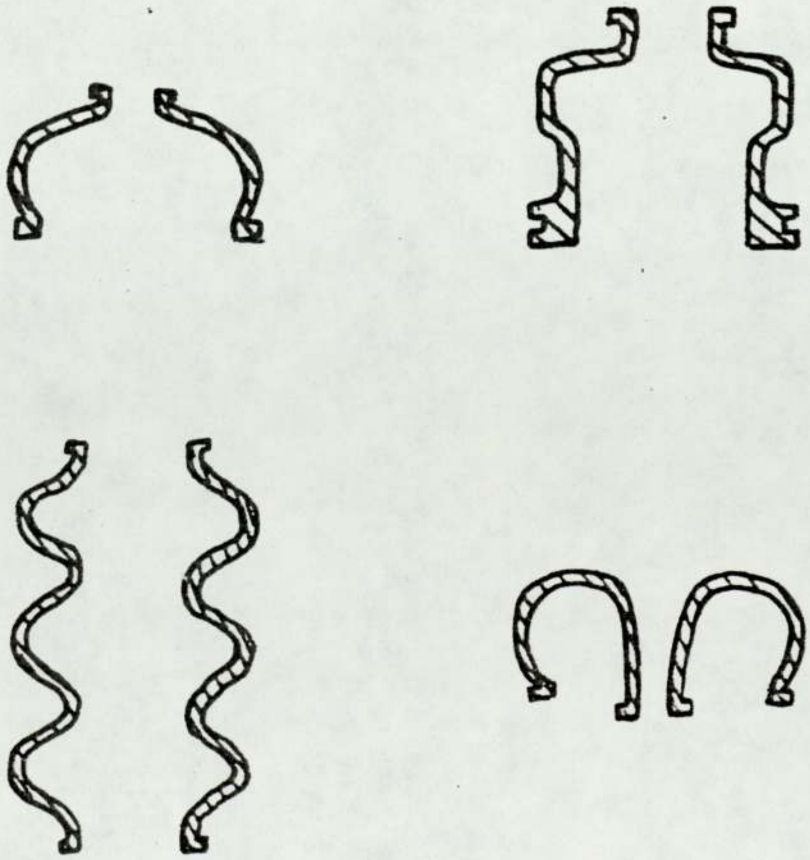
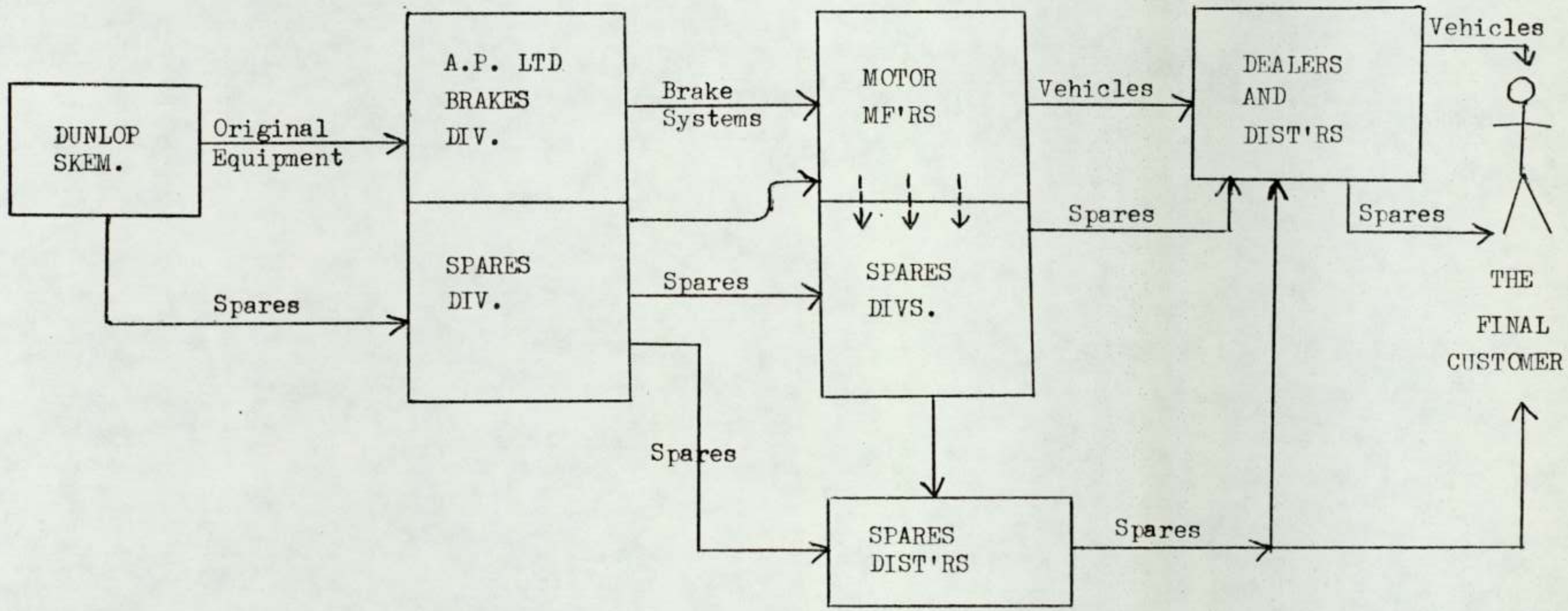


EXHIBIT 3.3 : THE MANUFACTURING/DISTRIBUTION CHAIN



The distribution chain was relatively long and complex, with at least four distribution links before the products of the Lockheed Department reached the final end user. As a result little was known in Skelmersdale about trends in the final market; Dunlop was therefore highly dependant upon Automotive Products for forecasting future demand. In addition the length of the distributive chain and the amount of stock which was held at each stage assumed great significance during the changes which occurred during the project (see Section 3.5).

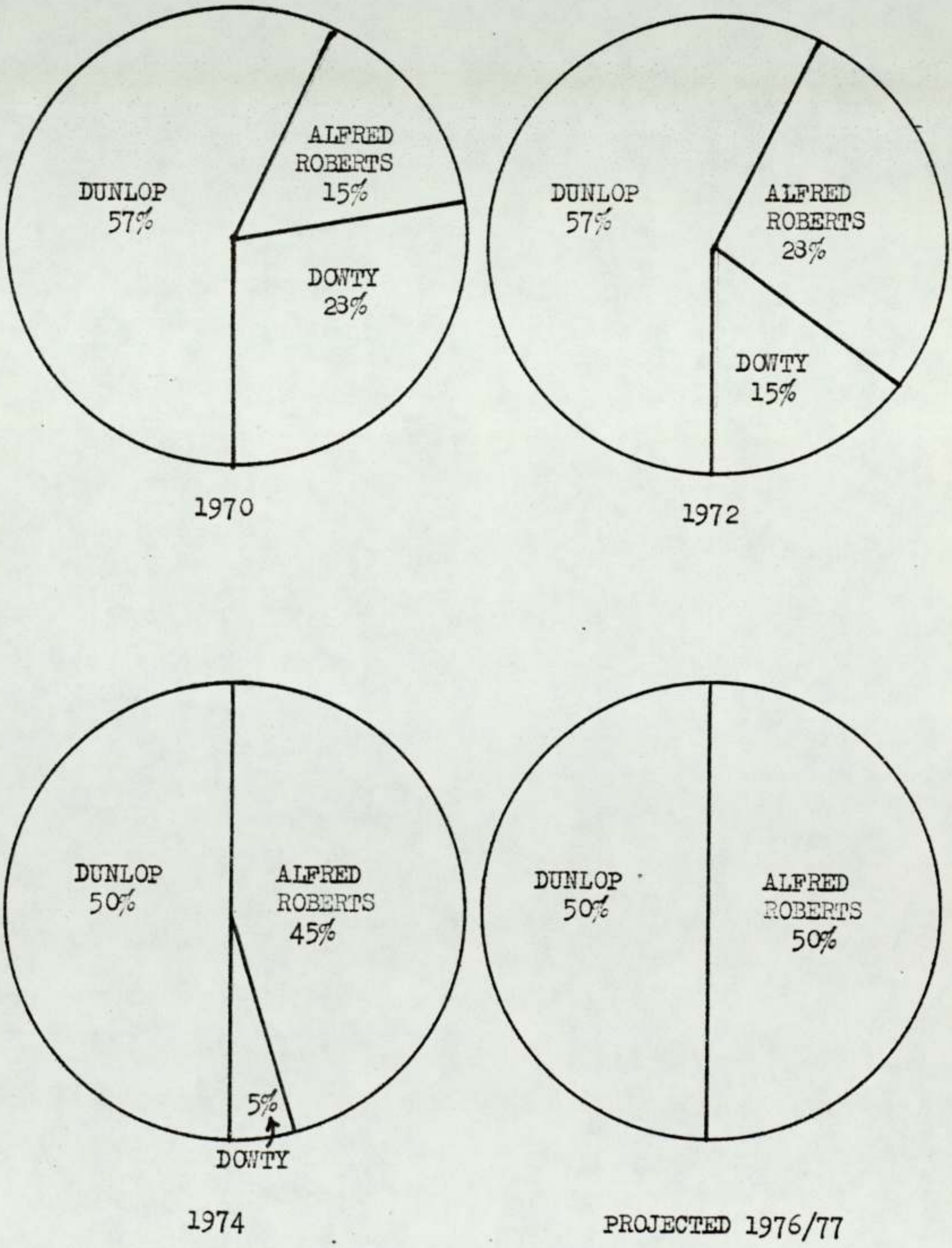
Since Automotive Products was a monopsonist,no sales effort was required by Dunlop; AP provided a firm schedule of requirements for one month ahead with one further months tentative schedule. A six month rolling forward schedule was also provided for certain products, although no firm commitment was given.

Products were purchased by two separate buying organisations within Automotive Products. The Lockheed Brakes Division, based in Leamington Spa, bought parts for use in original equipment, the Parts and Service Division, based in Banbury, purchased parts for vehicles which were no longer in production. Spare parts for vehicles still in production were purchased by the Lockheed Brakes Division and were issued to the Spares Division as required.

3.3 Competition

There were three major supplies of precision moulded brake rubbers during the project: Dunlop Ltd, Dowty Seals and Alfred Roberts Limited (AP Rubber Division). Exhibit 3.4 shows the changes in market share which occurred between 1970 and 1974.

EXHIBIT 3.4. : SHARES OF A.P. BRAKE MARKET (BY TURNOVER)



By 1974 Dunlop Skelmersdale's market share had fallen to 50% of the total Automotive Products requirement and the share held by Dowty Seals had fallen to 5% of the total. This was the direct result of the acquisition of Alfred Roberts Limited by Automotive Products in 1972. The acquisition was made to ensure security of supply for AP (AP's competitors, Girling already possessed a rubber company which supplied some of its brake rubber requirements). The stated policy of Automotive Products was to phase out Dowty Seals, leaving Dunlop and AP Rubber to supply half of the brake rubber demand each.

An agreement was drawn up in 1976 between Automotive Products Limited and Dunlop Limited ensuring that Dunlop, Skelmersdale would supply 50% of the total AP demand for brake rubbers. The agreement did not specify how the market share was to be measured (by revenue or volume) and did not provide for a system which would ensure that the agreement was being observed. Thus the long term future of the Lockheed Department was made uncertain in view of the likely growth of the internal supplier. In the short term no radical change in market share was envisaged; AP Rubber Division had neither the press capacity nor tooling to enable a sudden resourcing move to be undertaken. In addition the cash flow problems which beset Automotive Products during 1974 and 1975 meant that major capital investment was unlikely (see Section 3.5). A further constraint on sudden change was presented by the system of mould purchase; Dunlop was part owner of the moulds which were purchased on the behalf of Automotive Products. Removal of the moulds would not have been possible without the permission of the Skelmersdale management. For some products, especially those included in the small order category, Dunlop was the monopoly supplier, since it possessed the only moulds for the products.

3.4 Analysis of Market Destination

At the start of the project there was a shortage of information about the market for automotive brake components, especially concerning demand in the final market. Attempts were made to determine the vehicles to which the products were fitted and to estimate trends in demand by contacting Automotive Products. Despite considerable efforts by the Dunlop, Skelmersdale management to be allowed access to certain Automotive Products records, permission was eventually refused by AP on the grounds that insufficient manpower was available to obtain the information. (Although this appeared to be an excuse, it has to be admitted that AP were reducing staff at the time of the request).

It was not felt that a full scale market research investigation at a later stage in the distribution chain could reveal meaningful results without initial knowledge of the vehicles to which Dunlop, Skelmersdale products were fitted. In addition, the serious cutbacks in volume which were affecting the Skelmersdale factory at the end of 1974 (see Section 3.5) meant that it was difficult to obtain authorisation for any expenditure beyond that required for normal day-to-day operations. As a result of these problems it was decided to determine what information could be obtained from Skelmersdale records.

3.4.1 Objectives of the Investigation

An investigation was undertaken with the following objectives:

3.4.1.1 To determine the proportion of Lockheed Department production which was destined for spares use and which was destined for original equipment. This was a particularly significant problem area since the motor industry was undergoing a significant downturn at the time of the investigation and it was felt that the spares demand would remain relatively steady (with perhaps some destocking) whilst the original equipment demand would decline in proportion to vehicle manufacture.

3.4.1.2 To determine the end use of the products and, if possible, predict trends in the likely demand for each segment identified.

3.4.1.3 To compare the results for small orders (as defined in Chapter 2) with the results for the whole Lockheed Department and assess the effect which any difference would have on the pattern of demand.

3.4.2 Information Available

Much of the information required could be obtained by analysis of the Automotive Products part coding system and by determination of the department to which the parts were delivered. The following sources of information were used:

3.4.2.1 End Use

All Lockheed Department products were prefixed by a code letter which signified the end uses of the products.

Prefix Letter	Use of Part
A	Heavy Brakes (Commercial and Military Vehicles)
B	Ordinary Wheel Brakes (7" - 11" diameter)
C	Master Cylinders and Servos
D	Disc Brakes
J	Steering Parts

3.4.2.2 Spares/Original Equipment Split

Each part could be classified as original equipment, 'live' spares or 'dead' spares by the determination of the department to which it was delivered in Automotive Products. Where a part was delivered both for original equipment and live spares use it was assumed that the ratio of deliveries (o.e./live spares) made in 1974 would continue to hold in 1975.

Delivery Classification	Description
'Brakes'	Original Equipment
L9	Original Equipment('live') spares i.e. spares for vehicles still in production.
L42	'Dead' spares i.e. spares for vehicles no longer in production.

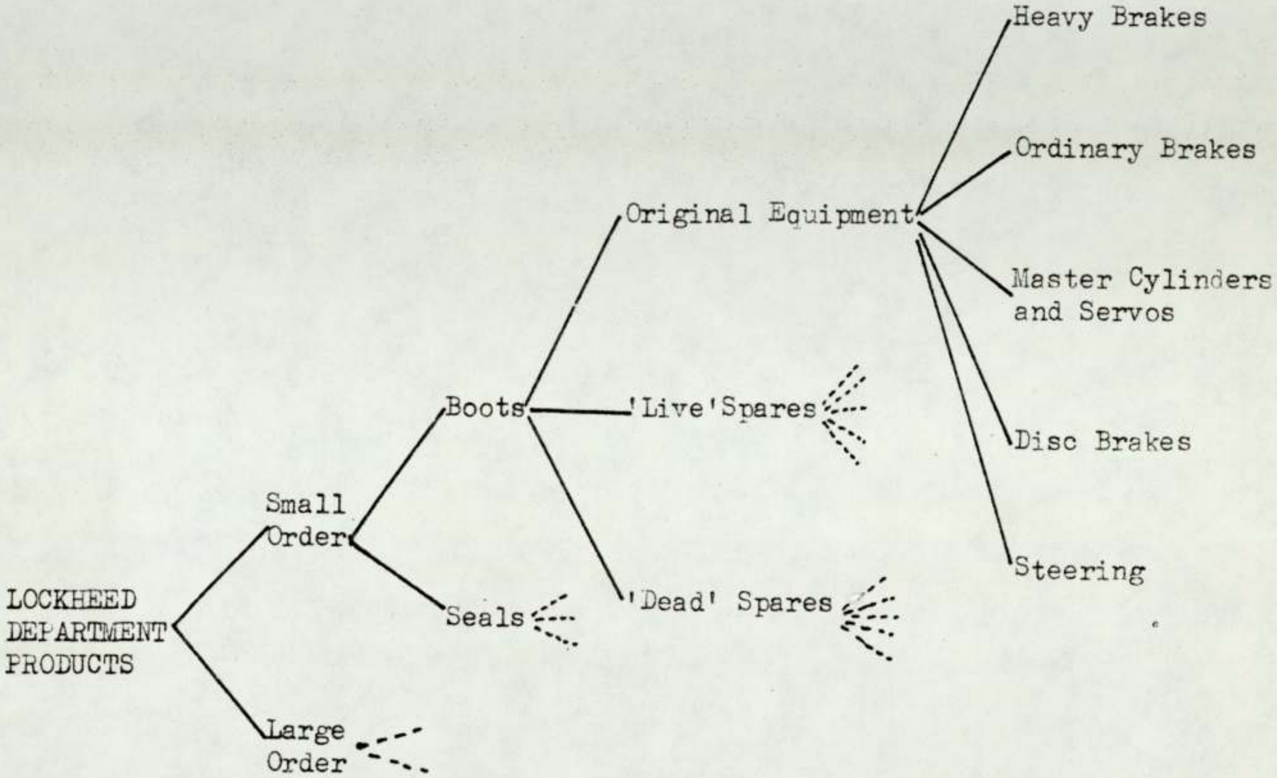
3.4.2.3 Volume Forecast

Automotive Products purchasing department provided an estimated monthly requirement for each product to be manufactured in the Lockheed Department in 1975. The forecast was used to estimate the volume and turnover of parts in each market classification.

3.4.2.4 Summary of Information Available

The output of the Lockheed Department was analysed as shown in Exhibit 3.5.

EXHIBIT 3.5 : ANALYSIS OF MARKET DESTINATION



3.4.3 Results of Investigation

The results of the investigation are shown in Exhibit 3.6., Exhibit 3.7 and 3.8 show the relative distribution for small and large orders. No detailed information concerning the original equipment versus spares split was available for parts which were sent to Steering Division. It was assumed that the o.e./spares ratio would be the same as for the other parts examined in the study.

The major results were as follows:

3.4.3.1 Original Equipment versus Spares

Approximately 45-50% of the high volume business was devoted to original equipment parts, for both seals and boots. The small order business was more concerned with the supply of spare parts; approximately 80% of small order boots and seals were destined for spares use. The majority of the dead spares were small orders - of the 90 parts classified as dead spares, 70 were small order parts. This was to be expected since the dead spares were for vehicles which were no longer in production; the parts thus classified were at the end of the product form life cycle.

The majority of parts destined for incorporation in heavy brake systems (11 out of 13 parts) were also classified as small orders. This was to be expected since the total number of heavy vehicles

EXHIBIT 3.6 : RESULTS OF PRODUCT END USE ANALYSIS

CLASSIFICATION	LARGE ORDERS				SMALL ORDERS			
	ANNUAL VOLUME	% OF ANNUAL VOLUME	ANNUAL TURN-OVER	% OF ANNUAL TURN-OVER	ANNUAL VOLUME	% OF ANNUAL VOLUME	ANNUAL TURN-OVER	% OF ANNUAL TURN-OVER
	(000)		(£000)		(000)		(£000)	
			SEALS					
1. ORIGINAL EQUIPMENT								
A	197	1%	3	-	40	2%	2	2%
B	5749	18%	65	9%	-	-	-	-
C	8924	28%	248	33%	206	13%	14	12%
D	1281	4%	64	8%	72	5%	6	5%
TOTAL O.E.	16151	51%	380	50%	318	20%	22	19%
2. O.E. SPARES								
A	290	3%	16	2%	224	14%	10	9%
B	5362	17%	64	9%	48	3%	1	1%
C	7926	25%	268	35%	528	33%	38	33%
D	-	-	-	-	-	-	-	-
TOTAL O.E. SPARES	14078	45%	348	46%	800	50%	49	43%
3. DEAD SPARES	1216	4%	27	4%	475	30%	43	38%
TOTAL SEALS	31445	100%	755	100%	1593	100%	114	100%

CLASSIFICATION	LARGE ORDERS				SMALL ORDERS			
	ANNUAL VOLUME	% OF ANNUAL VOLUME	ANNUAL TURN-OVER	% OF ANNUAL TURN-OVER	ANNUAL VOLUME	% OF ANNUAL VOLUME	ANNUAL TURN-OVER	% OF ANNUAL TURN-OVER
	(000)		(£000)		(000)		(£000)	
			BOOTS					
1. ORIGINAL EQUIPMENT								
A	230	2%	6	1%	32	7%	14	16%
B	4541	36%	107	26%	30	7%	5	5%
C	1304	10%	71	17%	2	-	-	-
D	-	-	-	-	-	-	-	-
Total O.E.	6075	48%	184	44%	64	14%	19	21%
2. O.E. SPARES								
A	632	5%	18	4%	21	5%	7	9%
B	1689	13%	24	6%	8	2%	6	7%
C	1525	12%	67	16%	42	9%	9	10%
D	-	-	-	-	-	-	-	-
Total O.E. Spares	3846	30%	109	26%	71	16%	23	26%
3. DEAD SPARES	874	7%	54	13%	171	38%	32	36%
4. STEERING	1816	15%	71	17%	143	32%	15	17%
TOTAL BOOTS	12611	100%	418	100%	449	100%	89	100%

EXHIBIT 3.7. :PRODUCT END USE- LOCKHEED DEPARTMENT SEALS (BY VOLUME)

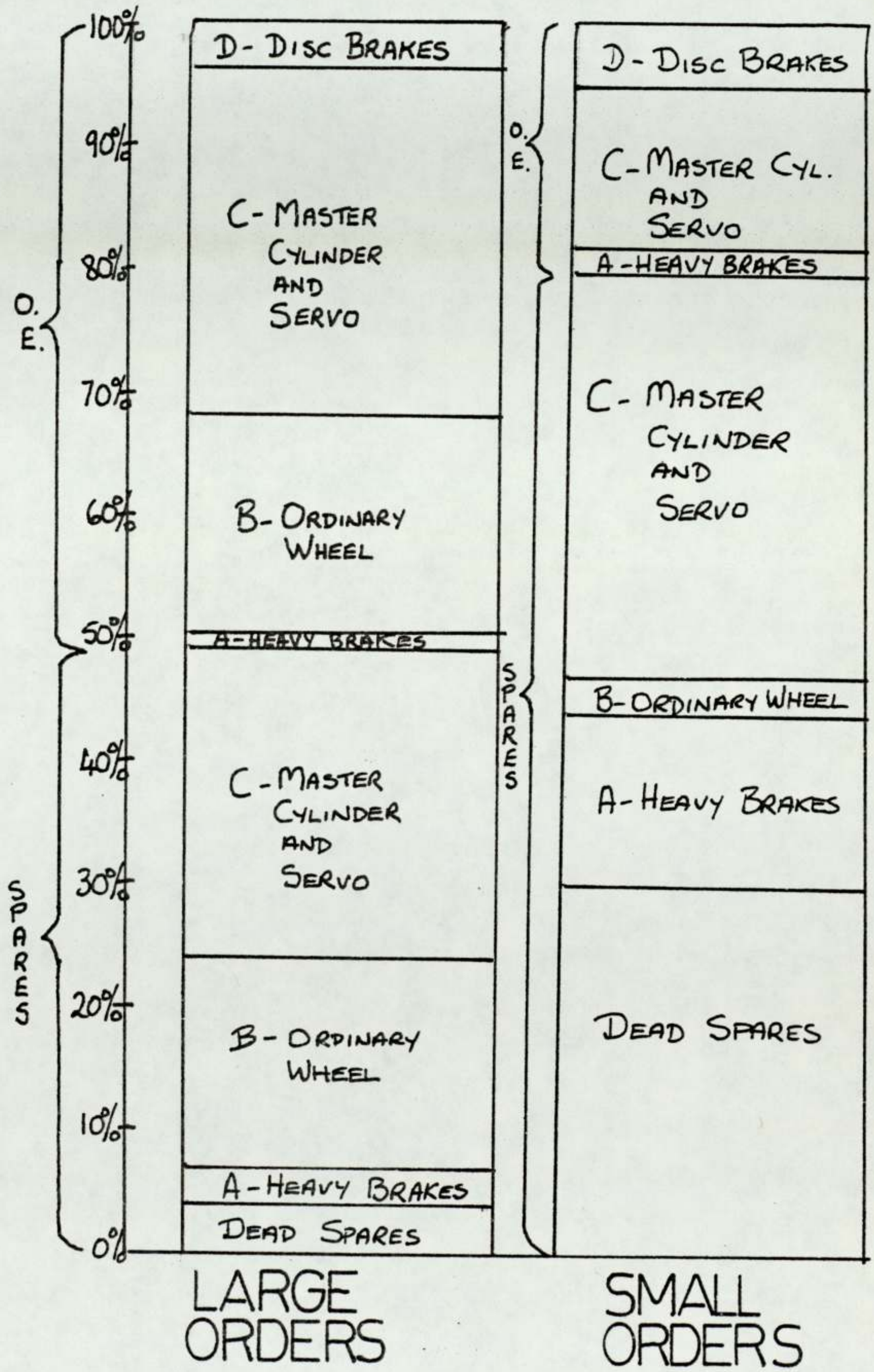
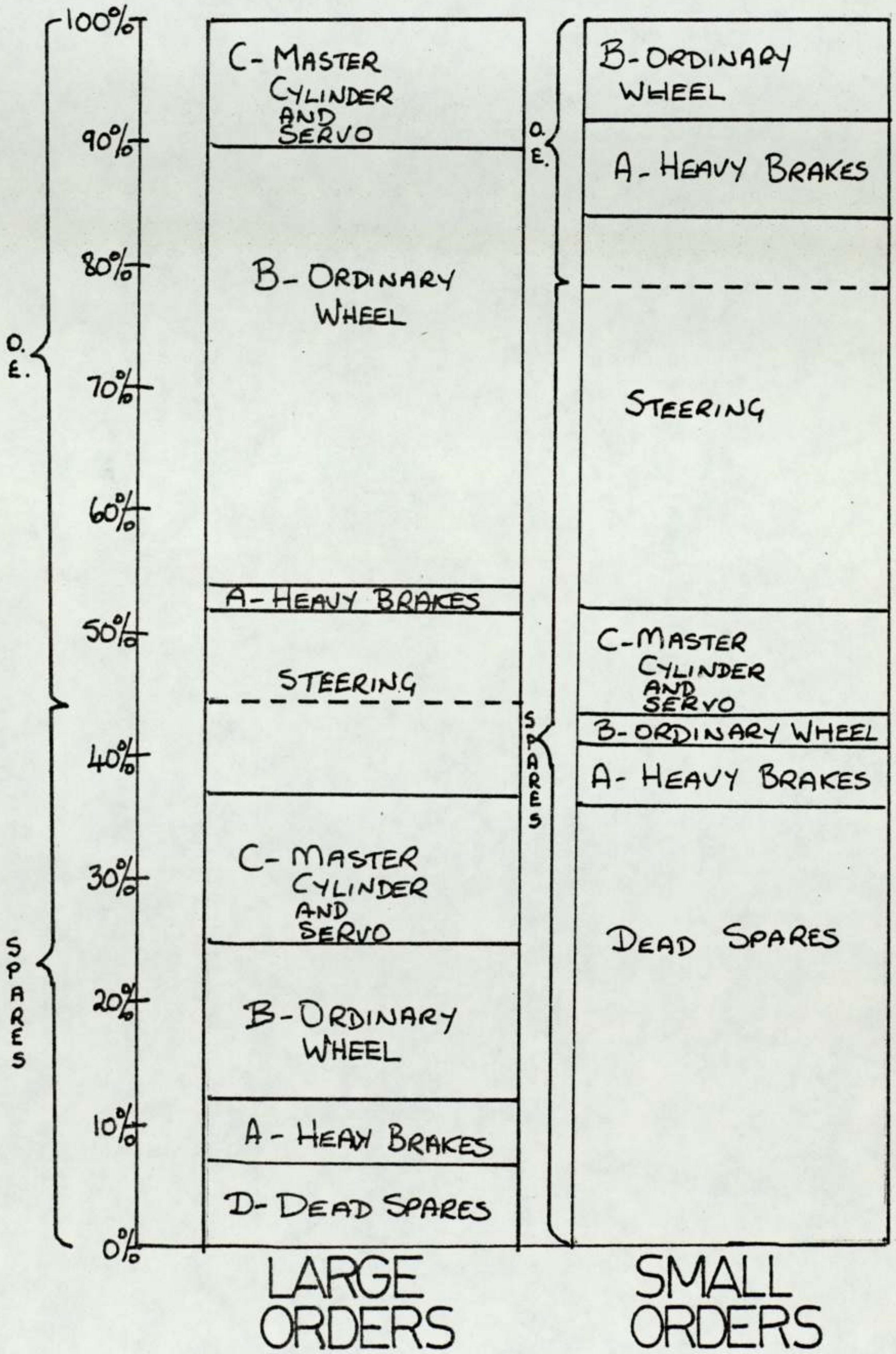


EXHIBIT 3.8. : PRODUCT END USE - LOCKHEED DEPARTMENT BOOTS (BY VOLUME)



produced is much lower than the number of cars and light commercial vehicles produced.

3.4.3.2 Differences of Emphasis

Only a small proportion of small order production was destined for incorporation into ordinary wheel brakes in comparison to the proportion of high volume production which was destined for this use. It is possible that the reason for the difference in emphasis may be found in the fact that parts included in this classification were used in the rear drum brake systems, the design of which had not been changed significantly for 10 years. Additionally there was only a limited number of different rear drum brake designs. Thus the volume required for ordinary wheel brakes was likely to remain relatively static, for as a vehicle ceased production its successor was likely to use a similar rear braking system.

3.4.3.3 Disc Brake Seals

Only a very small proportion of either high or low volume seal production was destined for use in disc brake slave cylinder. (No disc brake boots were made at all since the Lockheed disc brake design did not use boots to protect the mechanism from dirt and water - a seal, known as a wiper seal performed this function).

Dunlop, Skelmersdale had declined to supply disc brake seals in large quantities since it was felt that the method of manufacture required was not compatable with the production facilities at Skelmersdale.

Although there had been an increasing adoption of disc brakes for volume cars in the 1960's and early 1970's it was not expected that the trend would continue (according to senior engineering staff at Automotive Products) since drum brakes were felt to offer the best compromise of braking efficiency and effective hand brake operation for rear brakes. In fact some vehicle manufacturers who had adopted four wheel disc brakes had reverted to a disc/drum set-up on the grounds of cost effectiveness.

Thus there was likely to be a continuing demand for ordinary wheel brakes in the forseeable future.

3.4.3.4 Marketing Strategy

The market end use analysis, in conjunction with an examination of product standard costs, indicated product groups where the selling prices were low and therefore gave a reduced level of contribution to fixed overhead. Product groups were also identified where selling prices were high relative to costs. The Skelmersdale management was therefore provided with an indication of which product groups should be avoided if possible and which product groups Automotive Products should be encouraged to purchase from Skelmersdale.

Although it was the overall level of contribution for the whole Lockheed Department which was important, the identification of product group contribution rates the effects which changes in product mix would have.

	Low Contribution Product Groups	High Contribution Product Groups
1. High Volume	Ordinary wheel brakes (o/e and spares)	Master cylinders and servo (o/e and spares)
	Heavy Brakes(o/e)	Dead Spares
2. Small Order	Steering Boots	Heavy Brakes Boots (o/e and spares)
	Heavy Brake Seals (spares)	Dead Spares Seals

3.5 Changes in Demand During The Project

During 1974 the annual rate of vehicle production dropped from 142,000 units/month (the 1973 average rate of production) to 92,000 units per month, a reduction of 35%. This reflected the general recession which affected all Western European and North American vehicle manufacturers to varying extents. British manufacturers were particularly adversely affected. Foreign vehicle manufacturers began to increase their penetration of the British market; Automotive Products did not supply foreign manufacturers in significant quantities.

The Automotive Products schedules for the Lockheed Department began to decline in the middle of 1974. By July 1975 the demand was only 20% of the 1973 average monthly demand (see Exhibit 3.9). An attempt had been made at the end of 1974 to estimate the extent to which the schedules would be affected by the reduced level of new vehicle production. The following assumptions were made:

1. The demand for original equipment parts would be reduced in proportion to vehicle manufacture (a reduction of 35%).
2. The demand for spares would remain relatively static in the the medium term, since the total number of vehicles requiring parts for spares would not be significantly affected by the recession.

Applying these assumptions to the market end use analysis predicted a total level of business (turnover, volume and total gross contribution levels) of approximately 80% of the 1973 level of business. Subsequent decline in the schedules showed this estimate to be incorrect and the assumptions to be rather naive.

Possible faults in the assumptions were:

1. It was assumed that Automotive Products would retain approximately 50% of the UK brake market. Subsequent information suggests that Automotive Products lost ground to Girling during this period (Girling was the major supplier of brake systems to the Ford Motor Company, who were not so seriously affected as the other UK vehicle manufacturers).

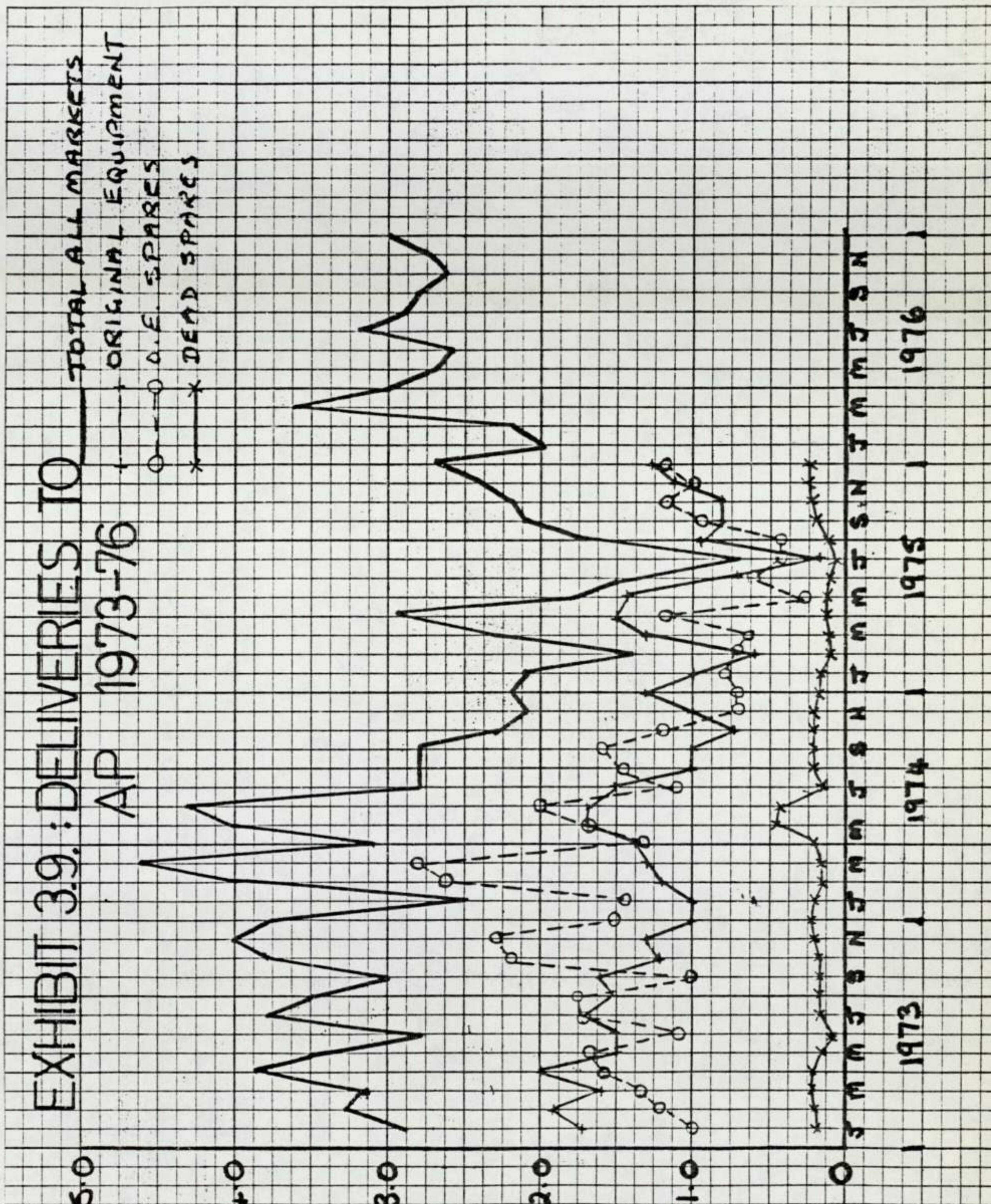


EXHIBIT 3.9: DELIVERIES TO AP 1973-76
TOTAL ALL MARKETS
ORIGINAL EQUIPMENT
O.E. SPARES
DEAD SPARES
DELIVERIES TO AP (MILLIONS)
5.0
4.0
3.0
2.0
1.0
0
J M M J S N J M M J S N J M M J S N J M M J S N
1973
1974
1975
1976

2. The reduction in new vehicle demand produced cash flow problems for companies at all stages in the distribution chain and resulted in considerable reductions in the levels of stock held at each stage. The reduction in short/medium term demand for Lockheed Department products was therefore greater than any changes which were occurring in the final market place.

Automotive Products were particularly adversely affected by the reduction in new vehicle production; an analysis of the company's published results during the period 1964-74 showed that the profits of the company (before interest and tax) closely followed the level of UK vehicle production. As vehicle production was reduced in 1974 Automotive Products suffered a cash flow problem, as shown by a reduction in the ratio of current assets to current liabilities from 1973 to 1974:

	1973	1974
Current Assets/Current Liabilities	1.95	1.57

The cash flow problem initiated a stock reduction programme; inventories were reduced by £7.6m during 1975, equivalent to a reduction of 24%, and many employees were made redundant. (Source : Automotive Products Ltd, Company Report for financial year ended 31.12.75).

3. During the period covered by the forecast the price of petrol increased sharply, resulting in reduced usage by private motorists. It is possible that the reduced mileage would reduce the demand for brakes spares but probably not to a significant extent; the renewal of brake components is more dependant upon component age than the amount of use which the components have suffered.

The effects of the reduction of the schedules were considerable. A redundancy programme was initiated for both shop floor and staff and the Lockheed Department began to incur losses. Volume levels remained depressed until the middle of 1976, by which time the destocking of the distribution chain had ceased. The level of business then continued at approximately 2.8 million parts per month, 80% of the 1973 level of demand, as had been predicted at the end of 1974.

3.6 Econometric Analysis

During 1975 a time series regression study was undertaken to determine the relationship between UK vehicle production and the demand for Lockheed Department products. The objectives of the study were:

1. To provide information which would assist the forecasting of future demand for Lockheed Department products.
2. To indicate the market mechanisms affecting the demand for Automotive Products braking components, with particular reference to stockholding policies and lead times.

Initially it was decided to determine the relationship between original equipment demand and UK vehicle production, leaving the determination of spares demand characteristics to a later date, since the independent variables were likely to be more complex (for example: disposable income, new car purchase prices, patterns of servicing).

3.6.1 Methodology

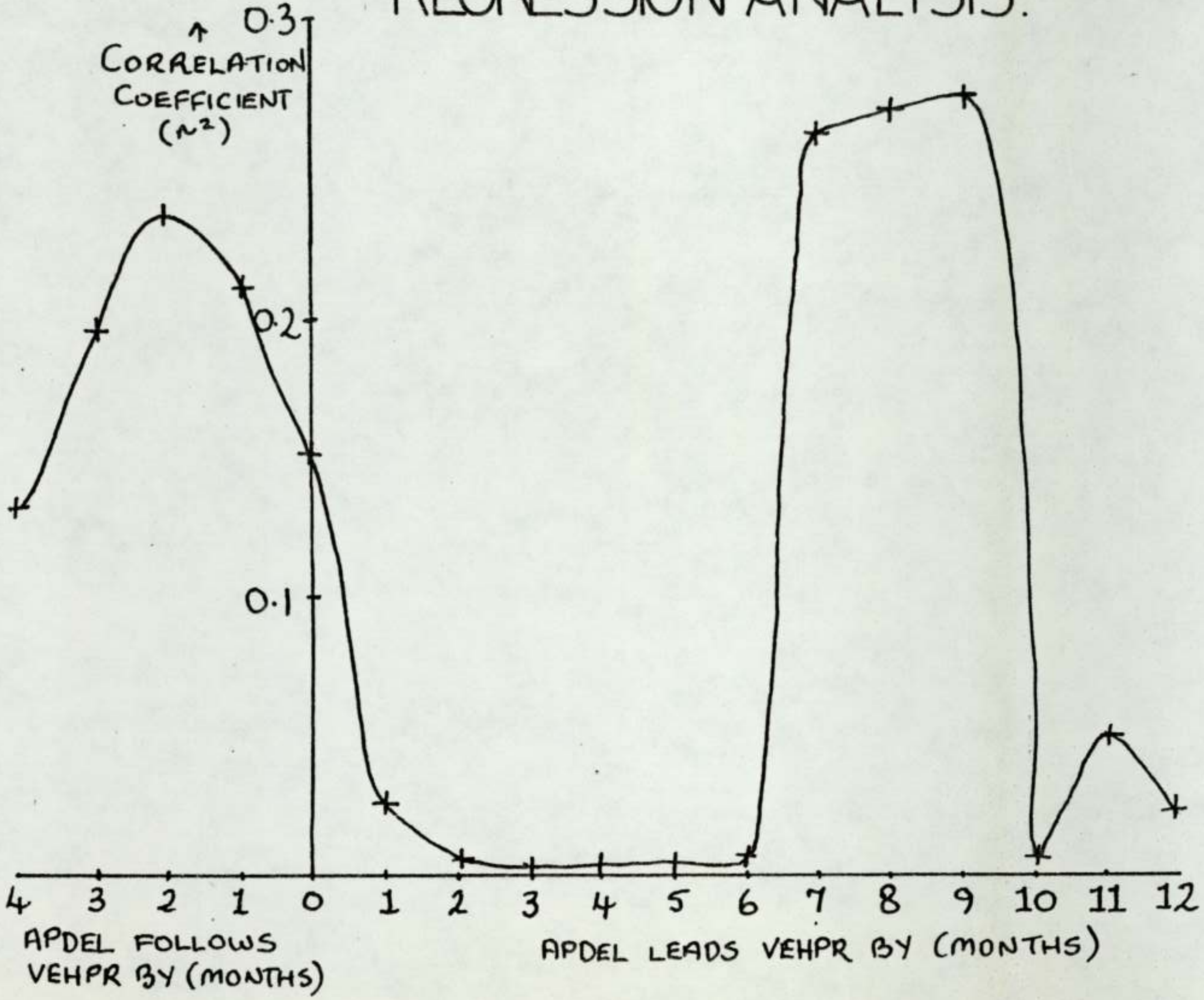
A standard ICL XDS3 Statistical Package was used in conjunction with an ICL 1900 computer. The independent variable used was the monthly total UK vehicle production (VEHPR), obtained from the Society of Motor Manufacturers and Traders for the period September 1972 - December 1975. The dependent variable (APDEL) was the deliveries of parts to the Brakes Division (original equipment) of Automotive Products for the same period.

Since it was unlikely that the requirement for braking components in any one month would be directly related to the vehicle production in the same month (because of the manufacturing lead times and stockholding policies of Automotive Products) the dependent variable (deliveries to AP) was allowed to lead the independent variable (UK vehicle production) by up to 12 months and to follow it by up to 4 months. A separate regression analysis was performed for each of the 17 possible situations.

3.6.2 Results

3.6.2.1 The correlation coefficients (r^2)obtained from the successive regression analysis are shown in Exhibit 3.10. The demand for original equipment components was found to be most strongly correlated (significant at the 95% confidence level) with vehicle production 7-9 months after the parts were required by Automotive Products and also with vehicle production 2 months before the parts were required.

EXHIBIT 3.10: RESULTS OF TIME SERIES REGRESSION ANALYSIS.



It is possible that the correlation with future vehicle production reflected the forward schedules provided to Automotive Products by the vehicle manufacturers and reflected the manufacturing lead time for complete brake assemblies. The correlation with vehicle production two months previously may show the effect of unexpectedly high or low levels of production during that period which affected the stock levels of Automotive Products and/or the vehicle manufacturers; the schedules provided to the Lockheed Department therefore may have reflected the adjustment of stock levels as well as forward demand.

3.6.2.2 The regression analysis yielded a series of equations which related the demand for Lockheed Department original equipment parts, relating to vehicle production 2 months previously and 7-9 months hence. In order that a forecast could be made of future demand for the Lockheed Department products it was necessary to perform a multiple regression between demand for the products and the time lagged vehicle production figures with which it was most highly correlated. Before this exercise could be undertaken however, Automotive Products decided to have all consignments of original equipment and original equipment spares delivered to the same location; it was therefore no longer possible to separate o/e demand from spares demand.

It was therefore decided to postpone any further work to determine the future demand for o.e. components until Automotive Products provided a breakdown of the o.e./spares split. Unfortunately Automotive Products did not provide this information during the remainder of the project and no further progress was made until a separate forecasting exercise was undertaken at the end of 1976 (see Chapter 9).

3.7 Discussion

In a derived demand market situation with a monopsonist customer there is a danger that a passive marketing strategy will be adopted, relying heavily upon the customer to provide marketing information. In the relationship between Dunlop, Skelmersdale and Automotive Products Limited there was little opportunity to indulge in conventional selling; attempts could only be made to increase the share of the Automotive Products brake rubbers market held by Dunlop. Since the only other major 'competitor' was owned by the customer it was unlikely that even this strategy would be successful, since competition was likely to be based not upon price, delivery, quality etc., but rather upon the insurance of security of supply.

There is still a need to undertake an analysis of the market in order to determine the nature of demand. This is particularly necessary where the monopsonist customer is himself in a derived demand situation and where he has only limited market information (or little inclination to use it). The investigations described in this chapter were intended to reduce the uncertainty of the Dunlop, Skelmersdale management about the market and to aid forecasting of market trends. The first objective was met, the second objective (forecasting) being somewhat less successfully achieved. However, the failure of the forecasting illustrated the need for market information, for had the length of the distribution chain been known at the start of the market recession it is possible that the Skelmersdale management would have realised that the drastic reduction in demand for brake rubbers could not have continued. Unfortunately the value of this information was only seen in retrospect.

The market analysis highlighted a major difference between high volume and small orders. Small order parts were mainly destined for spares use. This fact was to have a significant effect on the marketing strategy which was to be adopted for these products, for the spares/original equipment split had several important implications:

(1) The need to deliver exactly to schedule was less critical for small orders since production lines were not likely to be halted if delivery was delayed. Thus the Dunlop management were permitted greater freedom to schedule the production of small orders economically.
(2) It was likely that a more flexible pricing policy could be adopted for small orders since the profit margins of spare parts are generally greater than for original equipment parts (perhaps because the opportunity cost of having a vehicle off the road is much greater than the cost of the spare parts).

Before a marketing strategy could be developed however, there were two areas of uncertainty which required more intensive investigation:

(1) To determine the product and service attributes which Automotive Products felt were critical and determine the performance of Dunlop, Skelmersdale against those criteria. (See Chapter 4).

(2) To examine the pricing policy used for Lockheed Department products, evaluate alternative approaches to pricing and determine the most suitable pricing strategy (see Chapter 5).

CHAPTER 4

An Investigation of Industrial Buyer Behaviour

4.1 Objectives of Study

According to Webster and Wind (1) a study of industrial buyer behaviour should:-

(1) Identify, guide and evaluate the need for market information and suggest factors which are likely to affect behaviour.

(2) Aid the analysis and interpretation of existing information.

(3) Improve the value of predictions about buyer behaviour.

The objectives of the study described in this chapter agreed closely with those of Webster and Wind; the investigation was intended to assist the development of an effective marketing strategy towards Automotive Products by the determination of the major factors influencing the behaviour of the buying group, the criteria which were used by that group to assess supplier performance and the achievement of Dunlop against those criteria.

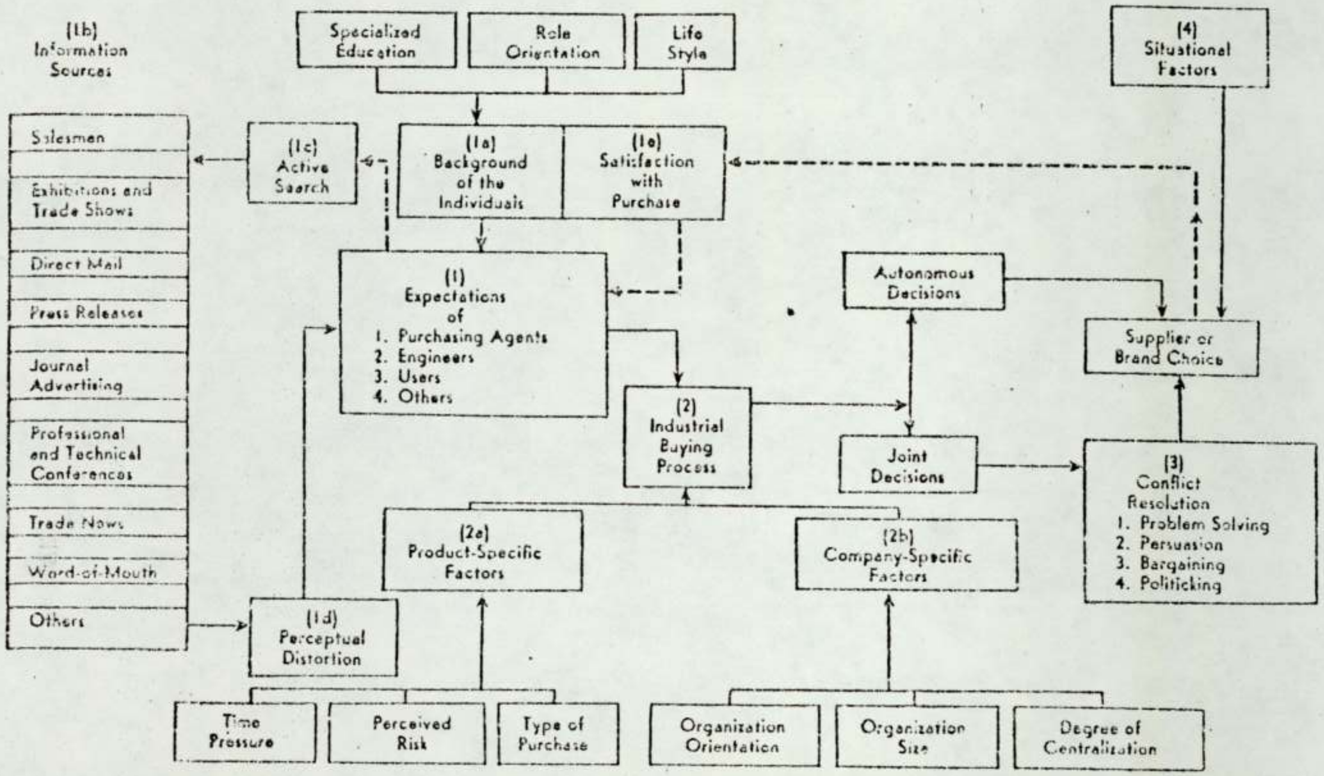
A survey of industrial buyer behaviour literature was undertaken in order to generate hypotheses which could be tested by comparison with the actual behaviour exhibited by those responsible for purchasing in Automotive Products Limited. It was also felt that a survey of previous studies of buyer behaviour would assist the structuring of the research framework for the Automotive Products study.

4.2 Literature Survey

Unfortunately, whilst there has been theorising about industrial buyer behaviour, only a limited amount of field work has been undertaken. Furthermore a closer examination of the models of behaviour proposed reveals that they are not falsifiable in the Popperian sense (2) and are therefore difficult to test; the models make few predictions of behaviour which, when tested, could be used to falsify (refute) or support the model. Even the general models of consumer behaviour of Howard and Sheth (3); Nicosia (4) and Engel, Kollat and Blackwell (5) are deficient in this respect.

The so-called 'black box' models of human behaviour are almost by definition descriptive rather than predictive. A model such as that of Sheth (6) (See Exhibit 4.1) appears to be a fair representation of buyer behaviour until an attempt is made to use it; the connection of variables to processing units is of limited value unless the relationship between the inputs and outputs can be established. i.e. what effects changes in the variables will have on behaviour. At best the models provide a starting point for analysis and do not provide complete answers in themselves. It may well be that the model builders were attempting to achieve an objective which no general psychological or sociological theory has

EXHIBIT 4.1. : THE SHETH INTEGRATIVE MODEL OF INDUSTRIAL BUYER BEHAVIOUR.



yet reached - the prediction of human behaviour in complex situations.

4.2.1 Differences Between The Organisational And Consumer Purchasing Processes

Although both general models of consumer behaviour and specific models of organisational purchasing behaviour have been criticised in the previous section, it is important to note that there are several important differences between the two types of purchasing process which should be emphasised (7):

(1) Organisational buying decisions are made more complex because more people are involved in the decision process at different stages, with each person involved possibly playing a different role.

(2) Industrial products are often of a greater technical complexity; a considerable proportion of the decision process must be spent in the evaluation of technical performance data, frequently requiring considerable technical competence.

(3) Since many industrial products have a high technical content the purchasing decisions are likely to take longer, be made with greater caution and be more difficult to rescind once made than are consumer purchasing decisions.

4.2.2 Generic Model Types

Kotler (8) has identified six generic behavioural models which have been used to translate buying influences into buying responses. In brief they are:

4.2.2.1 Pavlovian Learning Model

Purchasing behaviour is regarded as a repertoire of habit forms initiated by cues and determined by past rewards. This approach, developed from a psychological-physiological investigation of the salivatory responses of dogs has never quite proved adequate to explain behaviour which stems from higher mental processes.

4.2.2.2 Freudian Psychoanalytic Model

The behaviour of the buyer can be explained in terms of deep-seated urges and drives. The Freudian paradigm was developed as an analytical tool used to investigate neurotic behaviour and lacks predictive power. Any number of interpretations can be given for a behaviour pattern.

4.2.2.3 Veblenian Social Psychology Model

The behaviour of the buyer is constrained and influenced by the pressures of the group of which the buyer is a number. Purchasing is thereby a group activity.

4.2.2.4 Hobbesian Organisational Model

Corporate man steers a careful course between satisfying his own needs and those of the organisation to which he belongs and is related to the model described in section 4.2.2.5.

4.2.2.5 Behavioural Model (Cyert and March (9))

The Behavioural Model outlines how the sociopsychological mechanisms of individual behaviour determine organisational functioning. The theory is based upon four relational concepts of behaviour:

1. Quasi-resolution of conflict - latent conflict in the organisation is reduced by attempting to achieve a concensus decision.
2. Uncertainty avoidance - an attempt to reduce the uncertainty of the outcome of a decision by producing a 'regulated environment' of accepted proceedures, tradition etc.
3. Problemistic Search - the direction of search for a solution to a problem moves from the solutions of related familiar problems to those solutions for unfamiliar problems. This tends to inhibit innovation and produces heavy reliance on past experience.
4. Adaptive organisational learning - the behaviour of the whole organisation will be modified as a result of past experience.

Unfortunately, as with other theories of this type, the Behavioural Theory of the Firm lacks predictive power.

4.2.2.6 Marshallian Economic Model

The Economic Model assumes 'rational' behaviour towards the goal of profit maximisation (which requires perfect knowledge), but ignores the more complex behavioural aspects.

Webster and Wind (10) suggest a clear dichotomy between the models of industrial buyer behaviour - 'task' versus 'non-task' orientated models. A 'task' model emphasise the importance of variables specifically related to the problem in hand such as price, delivery etc. 'Non-task' models are concerned principally with variables not specifically related to the task in hand, such as the buyers motives and attitudes. Examples of task and non-task models are:-

Task	Non-Task
Minimum Price Model	Self Aggrandisement Model
Lowest Total Costs Model	Ego-enhancement Model
Rational Buyer Model	Perceived Risk Model (11)
Reciprocal Buying Model	Dyadic Model (12)
Constrained Choice Model	Lateral Relationships Model (13)
Source Loyalty Model	Buying Influences Model(14)

Neither model-type is adequate on its own - in order to fully explain behaviour a model must contain a combination of both task and non-task variables. Buyers are certainly affected by the organisational and social setting in which they operate (15), but they are also individuals with motives and attitudes which must be considered (16).

Using the nomenclature of Webster and Wind, a good model must consider the individual, socail, organisational and environmental influences for both task and non-task variables:

Source of Influence	Task Variables	Non-Task Variables
Individual	Desire to get lowest price	Personal values
Interpersonal (social)	Meeting to set product specifications	Off the job interaction amongst company employees
Organisational	Company policy with respect to product quality	Company policy with respect to community relations
Environmental	Expected trends in business conditions	Political factors in election year

4.2.3 Specific Models of Behaviour

The Decision Process Model of Webster (1965) (18) regards industrial purchasing behaviour as a series of sequential decisions which have to be made before a solution can be reached. The buying process is divided into four phases:

1. Problem Recognition - the creation of a buying situation by a discrepancy between desired goals and actual achievement; this may be due to falling stock levels of a component, design of a new product etc.
2. Assignment of Buying Authority - decisions must be made concerning the make-up and structure of the decision group (both formal and informal).
3. Search Process - a more or less routine procedure of setting objectives, considering alternatives and determining criteria for assessment.
4. Choice Process - the procedure for selecting amongst alternatives.

Unfortunately although this model is complex in that it incorporates both task and non-task variables, it lacks predictive power by virtue of its generality.

The 'BUYGRID' model of the American Marketing Science Institute (19) uses an eight stage decision process approach, but again fails because of lack of predictive power, i.e. it fails to identify any cause-effect relationships. The model introduces the concept that the decision process will be different dependent upon the nature of the purchasing task. Distinctions are drawn between the characteristics of:

New Buy - where there is no previous experience of the product or service to be purchased.

Modified Rebuy - where the buyer has reason to search for a new source of supply because of dissatisfaction with the existing supplier.

Straight Rebuy - characterised by lack of search activity and routinisation of purchasing procedures.

It is clear that whilst considerable attention has been devoted to the development of a conceptional framework for analysis (20, 6, 14), the majority of the models are either simplistic to be of only general use or else they lack predictive power. It is possible that the shortcomings of these models stem from the paucity of empirical investigation to establish the input-output relationships between the variables on one hand and the actual behaviour observed on the other.

These failings become more understandable when one considers the problems of investigation; one can either study purchasing behaviour in the 'real' situation where many variables can change from one purchasing problem to the next, or one can restrict the number of variables in a laboratory situation and run the risk of the subjects exhibiting atypical behaviour.

Empirical studies have been made using both methodologies; the 'laboratory' studies tend to give more definite conclusions than the 'real life' investigations but perhaps lack generality because of the falseness of the laboratory environment.

4.2.4 Empirical Evidence

4.2.4.1 The Decision Making Unit

Industrial purchasing behaviour is characterised by group participation in the decision making process. Studying the buyer alone would therefore be very unwise. Rather one must examine the roles of the individuals in the Decision Making Unit (D.M.U.) and determine how each will react to different purchasing situations (21).

Howard and Moore (22) found that there are commonly at least three departments involved in the purchasing decision: Purchasing (the buyer); Quality Control (the engineers) and Manufacturing (the users). Given the different backgrounds and job functions it is unlikely that all three groups will be fully satisfied with the ultimate decision;

a compromise solution must be reached to fulfil company objectives which can often lead to conflict between the groups (23, 13). Smallbone (24) has suggested that as the turnover of the products and the size of the firm increase the larger will be the size of the decision making unit.

Alexander, Cross and Cunningham (25) in a study of 106 American firms found that 3 or more people influenced the purchasing decision in more than 75% of the firms. In a special study of the British engineering industry it was found that the purchasing decisions in medium-sized firms (400 - 1000 employees) were subject to at least 5 influences, whilst in the larger firms (over 1000 employees) at least 6 influences could be detected (26).

Buckner (27) in an industry-wide British study found that up to three specialist functions could be involved at each stage of the purchasing decision process, with up to 10 functional groups having some involvement. Buckner also found that purchasing tends to be a centralised function in most companies, with over half of the personnel involved in purchasing having company-wide responsibilities. If the findings of Wind(28) can be generalised, it is to be expected that the purchasing agents in the centralised purchasing units would have greater loyalty to the norms and patterns of the buying unit than to those of the user (decentralised purchasing units being much closer in attitude to the users).

Not all the members of the D.M.U. have the same degree of involvement in the purchasing decision; the role played by each member will depend upon the job function, the nature of the buying task and the organisation and the personalities of the group members. Klass (29) has suggested four roles played within the group: contributors, participants, responsibles and directors. Using the same basic concept Webster and Wind (30) communicate the ideas more effectively. The categories which they suggest are:

1. Influencers - organisational members who influence the buying or usage decisions either directly or indirectly. Typically they will provide criteria which constrain the choices or will provide information with which to evaluate purchasing alternatives.
2. Buyers - possess the formal authority to select suppliers and arrange the terms of purchase, but may have their choices severely limited by the influence of others (such as technical personnel).
3. Deciders - possess the power to make the formal selection of suppliers. It may be the buyer, but not necessarily; it may merely be left to the buyer to implement the decision.

4. Gatekeepers - individuals who control the flow of information into the group. Not only the buyer who is in contact with potential suppliers, but also librarians, secretaries and the buying company's own salesmen.

The focus of responsibility will shift within the group depending upon:

(a) The technical complexity of the product.
(b) The essentiality of the product to the business.
(c) The specific technical knowledge of the individuals involved.

Fisher (31) has suggested that the focus of responsibility in the Decision Making Unit is a function of product complexity and the commercial uncertainty of the decision and suggests that the focus of responsibility can be determined by the examination of a number of **bipolar factors** (for example standard products vs differentiated products, small order vs large order etc).

		Product Complexity	
		Low	High
Commercial Uncertainty	Low	Buyer emphasis	Technologist emphasis
	High	Policy maker emphasis	Total involvement

4.2.4.2 Source Loyalty and Search Activity

Industrial buyers are extremely conservative in that they tend to maintain a fixed supplier set; they are not only extremely reluctant to abandon existing suppliers but are also inhibited in the degree to which they will search for new sources of supply.

In a survey of nearly 1000 British firms Buckner (27) found that 1 in 5 firms requested 3 or less quotations. Wind (32), Harding (33) and Kettlewood (34) have all found strong evidence of source loyalty and lack of search activity.

The freight transport industry has come in for particular attention. Bayliss and Edwards (35) found that only 120 out of a total of 361 firms studied were aware of the prices of alternative modes of transport, and of these only 90 could actually quote the alternative prices. Cunningham and Kettlewood (36) found that, on average, the mode of transport had remained unchanged for 11 years; it was also found that non-price factors were considered more important than price, especially once the carrier was established. Kennedy (37) found that less than half of road hauliers and traders asked for more than one quotation when purchasing a heavy goods vehicle chassis.

Luftman (38) studied the stimulus for, and the nature of, the search process in the heavy earth moving and value industries. He found two basic reasons for the buyer to search the market; 'dissatisfaction with the existing supplier' and 'requirement for a new component'. Dissatisfaction was the most important single stimulus to search and in all cases led to the choice of a new supplier. The dissatisfaction (with price/delivery/quality) with the existing supplier normally lasted for 6 months before a decision to discontinue patronage was made. This reflects the conservatism of buyers buying goods designed to their own specifications; they are unwilling to take the risks and stand the costs of duplicating production capacity elsewhere. Search activity caused by the demand for a new component never led to the choice of a supplier outside the existing supplier set.

Luftman also found that the more senior the buyer in the organisation, the more limited was his search (either because of time pressure or greater experience). American-owned companies tended to search the market to a much greater extent than British-owned companies, reflecting the greater importance attributed to the purchasing function in those companies and perhaps the greater sophistication of technique which other research has identified in American-owned companies (39).

Cardozo and Cagley (40) in a simulated buying game, confirmed Luftman's findings that buyers tended to emphasise the importance of firms with which they had experience, rather than those which met the purchase specifications and supply requirements. Another laboratory simulation (41) examined search behaviour and risk taking behaviour with respect to the educational background and experience of the subjects. The more educated buyers searched more but ended up with higher risk decisions. More experienced buyers searched less, but made lower risk decisions. Both highly educated buyers and experienced buyers were less likely to assess suppliers on price differences alone; they also considered the other features of the suppliers, such as technical competence and reliability of supply.

Cunningham and White (42) studied the behaviour of buyers of machine tools in Britain in relation to the size of the firms. The number of bids sought increased with technical complexity and price. The number of bids sought also increased as the size of the firm decreased, which Cunningham and White suggest is due to the increasing proportion of the budget that each order takes and thereby the relative importance of the order. Although an average of three quotations were obtained the true average was likely to be lower since many buyers requested one or more 'dummy' quotations merely to satisfy the requirements of the organisational system (agreeing with the predictions of the Behavioural Theory of the Firm).

4.2.4.3 Component Purchasing in the British Vehicle Industry

Buckner's study of how British industry buys concerned itself not only with industry as a whole but also with important industrial sectors. A comparison of the vehicle and allied industries with industry as a whole reveals several interesting differences:

1. The role of Design and Development Engineering is much more significant in the purchasing of components in the vehicle industry than in the rest of industry. The role of Buying is also emphasised relative to industry as a whole.
2. Operating management participates to a much lesser degree in the purchasing of components in the vehicle industry.
3. Generally the Buying Department decides who should be invited to bid (rather than operating management) whilst Design and Development Engineering specify the product and evaluate the alternatives.

The major involvement of the Buying, Design and Development and Production Engineering functions in the vehicle industry enabled predictions to be made about the important product features for at least three likely members of the Decision Making Unit.

The rankings of the important factors in purchasing for the three functions (all industry) were:

Buying	Design and Development	Production Engineering
Price	Price	Technical Specifications
Delivery	Technical Specifications	Manufacturers Services
Technical Specifications	Delivery	Price
Previous Experience	Previous Experience	Delivery

Despite the apparent emphasis on the price of the product, nearly half of the firms would not change from their existing best supplier to an identical supplier for a price reduction of less than 5%. This figure is an 'all industry' figure however, it is not known whether vehicle manufacturers behave differently.

4.3 Hypothesis Generation

As a result of the literature survey outlined in section 4.2, it was possible to generate a number of hypothesis about the purchasing behaviour exhibited by AP personnel and the factors influencing this behaviour prior to any investigation being undertaken. The empirical investigation could therefore be structured to test the validity of the hypotheses. Seven major hypotheses were formulated:

4.3.1 Purchasing Sophistication

Automotive Products were likely to be relatively unsophisticated in the use of purchasing techniques, making little use of value analysis, optimum order quantities, PERT etc.

4.3.2 Purchasing Influences

At least 6 buying influences should affect the purchasing decision, with different functions having varying degrees of influence at each stage of the decision process.

4.3.3 Behaviour in Different Buying Situations

Purchasing behaviour was likely to be different for 'new buy', 'modified rebuy' and 'straight rebuy' situations.

4.3.4 Search Activity

There should have been a marked reluctance to search the market for alternative suppliers, the company prefering a small set of suppliers of whom they have experience.

4.3.5 Price Sensitivity

Sensitivity to price changes (as exhibited by resourcing actions)should have been relatively low providing that other product characteristics (delivery, quality etc) were satisfactory.

4.3.6 Primacy of the Purchasing and Design Engineering Departments

The influence of the Purchasing and Design and Development functions should have been paramount in the purchasing decision (rather than the influence of operating management or production engineering).

4.3.7 Product Feature Ranking

The study by Buckner (27) suggested that members of the Buying Department concerned with the purchasing of components should have considered the following product features as most important:

Price, Delivery, Technical Specifications.

The Design and Development Engineering Department members on the other hand would be expected to give the product features the following rankings:

Price, Technical Specifications, Delivery.

In addition to testing the above hypotheses the investigation was directed towards a number of other areas which would assist the development of an effective marketing strategy:

4.3.8 Buying Group Structure

1. The identification of members of the Decision Making Unit as influences, deciders, buyers and gatekeepers.
2. The communication and work flow systems (who says what in what channel to whom and with what results).
3. The status and responsibility of the members of the D.M.U.
4. The reward system within which the D.M.U. members operated - how they were judged to be successful, by whom and with what results.

4.3.9 Organisational Environment

1. The determination of company goals and tasks.
2. Constraints placed upon the D.M.U. members by company policy.
3. Automotive Products general policy towards Dunlop, Skelmersdale.
4. Formal and informal communications between the two organisations.

In addition it would have been valuable to have considered individual factors (the educational and work backgrounds, motivation and general personality traits etc) which were likely to affect the behaviour of the members of the D.M.U. However, it was felt that because the researcher was employed by the supplier (Dunlop) an antagonistic reaction would have been provoked by the posing of personal questions to personnel employed by the customer (AP); it was therefore felt to be more expedient to delete this area of research from the investigation. The investigation was therefore prejudiced to some extent by the lack of total independence of the researcher.

4.4 Structuring the Investigation

The investigation had three distinct sequential stages:

1. The identification of the communications channels between AP and Dunlop, Skelmersdale and the personnel involved.
2. The design of a suitable questionnaire which would elicit the answers to the questions raised in section 4.3.
3. The administration of the questionnaire to the personnel identified in stage 1.

4.4.1 Identification of Key Personnel

All staff and management at Skelmersdale who were known to have any contact with Automotive Products were interviewed and were asked to identify the AP personnel with whom they communicated and describe the nature of the communication. As a result of the interviews the following personnel were identified as the most important influencers of the purchasing of rubber components:

Department	Name and Title
Purchasing	D.K. (Chief Buyer - Production) R.S. (Buyer - Rubber and Plastics) J.T. (Senior Buyer - Spares and Service Division) G.S. (Assistant Buyer - Spares and Service Division)
Engineering	N.M. (Development Engineer - Rubber and Plastics)
Material Control	G.S. (Provisions Controller, Rubber, Plastics and Springs, Leamington) R.P. (Senior Progress Controller, Banbury)
Quality Control	G.L. (S.Q.A. Engineer)

The questionnaire was to be administered to all the above personnel.

4.4.2 Questionnaire Design

An open-ended semi-structured design was adopted for the questionnaire which allowed specific points of interest to be followed up as they arose in the interviews. As it was not intended to aggregate the answers to the open-ended questions in an analytical sense it was felt justified to adopt this approach. The overall profile of the questionnaire was such that the interviewee was led from general questions to more specific (and more controversial) questions as the interview proceeded. (A copy of the questionnaire which was administered is included in Appendix B).

Towards the end of the questionnaire two more specific questions were asked which could be subjected to a more rigorous analysis. These questions were designed to fulfil two objectives:

1. To identify the product features which the interviewee felt were most important in three different purchasing situations:

   Initial purchase of a new component

   Repeat purchase of an original equipment component

   Repeat purchase of a spares component

2. Having determined the features which the interviewee considered most important, to assess the performance of Dunlop, Skelmersdale on these features. The interviewee was also asked to rate the performance of his best and his worst supplier on these features in order that the scores could be related to what was realistically achievable rather than what was ideal (for example, if the best supplier achieved 6/10 for delivery and Dunlop achieved 5/10 then performance was probably satisfactory; if the best supplier achieved 9/10 then the performance of Dunlop was not satisfactory). Interviewees were asked to assess the performance of Dunlop only for those product features of which they had personal experience. No specific reference was made to 'small orders' versus 'large orders' since it was not felt that this was a distinction distraction which Automotive Products personnel would normally make. However, as was indicated in Chapter 3 the majority of small order parts were supplied to the Spares Divisions; in terms of part types, purchasing of small orders can be held to be synonomous with purchasing by the Spares Division.

4.5 Results of the Investigation

As there were no major contradictions detectable between the answers given to the open-ended questions by the different interviewees, it is not proposed to detail each answer given. A summary description will be given of the purchasing activities undertaken by Automotive Products personnel, using the specific answers given to elaborate the activities of each member of the D.M.U.

The nature of the activities undertaken and the constitution of the D.M.U. varied with three types of purchasing activity:

1. Initial purchase of a new component (all original equipment since, at the time of the investigation, AP were not marketing spares components for vehicles manufactured outside the United Kingdom).
2. Repeat purchase of an original equipment component (for incorporation in a complete brake assembly which was sold to the vehicle manufacturer).
3. Repeat purchase of a spares component (which would either be packaged by AP and distributed through the spares distribution network or else incorporated in a sub-assembly which in turn would enter the distribution network).

The product feature rankings and performance assessments will be detailed for each member of the D.M.U. since they indicated the differences in emphasis between the different functions involved and highlighted where specific improvements in performance were required.

4.5.1 Initial Purchase of a New Component

All purchasing of new components was undertaken from the Brakes Division of Automotive Products based in Leamington Spa, Warwickshire; all original equipment assembly was undertaken in the Leamington plant. Four major functions were involved in the purchasing and supply of a new braking component:

1. Engineering - who designed the component in conjunction with the Sales Department to meet the customer performance specification (this activity was undertaken by the Advance Engineering Section) and developed the product ready for production (undertaken by the Development Engineering Section, Rubber and Plastics). The Development Engineering Section also specified the potential suppliers who would be acceptable to manufacture the component.
2. Quality Control - specifically the Supplier Quality Assurance (SQA) Section, who visited the potential supplier to assess the suitability of the production equipment and process and quality control systems and who provided a report which reviewed the business policy, financial stability and organisational structure of the company in question. The SQA Section was also responsible for ensuring that the quality standards of existing suppliers were maintained.
3. Purchasing - who negotiated the supply contract with potential suppliers selected from the list of Engineering Department approved suppliers, agreed the purchase price and supply quantities and made the final supplier selection. The Purchasing Department also co-ordinated

the activities of the other service functions involved in the purchase and acted to resolve any major supply or quality problems which arose.

4. Material Control - who placed the delivery schedule on the supplier chosen and ensured that the schedules were in accord with the production department assembly schedules.

Only three companies were generally approved by the Engineering Department to supply brake rubbers to Automotive Products: Dunlop, Skelmersdale, Dowty Seals and Alfred Roberts Ltd (a subsidiary of AP). Although other suppliers might be considered to supply existing components (usually as alternative sources of supply), orders for new components were never placed with new suppliers since the perceived risk was too great.

Suppliers to AP were graded into three categories:

A - suppliers whose supplied goods reject level was less than 2% of total delivery.

B - supplied goods reject levels of 2% - 4%.

C - supplied goods reject levels of 4% - 6%.

No non-graded supplier would be asked to supply Automotive Products; even grade C suppliers could only be used after written authorisation had been given by the Purchasing Manager. Dunlop, Skelmersdale had been granted grade B status at the time of the investigation. Competitive bids were not always sought, especially for small volume components; high volume components usually required three competitive bids and were frequently multiple-sourced.

4.5.1.1 Product Feature Rankings

The product feature rankings provided by the AP personnel most involved with the purchase of a new component are given below. The performance of Dunlop, Skelmersdale on each of the features is given in brackets. Each performance assessment has been adjusted to fit on a 1 to 10 scale (1-poor, 10-excellent) in order that a comparison can be made between each individual's assessment. The adjustment has been effected by making the performance assessment of the worst supplier equal 1 and that of the best supplier equal 10; linearity of subjective assessment has been assumed between these two limits.

EXHIBIT 4.2 : PRODUCT FEATURE RANKINGS (NEW COMPONENT INITIAL PURCHASE)

PRODUCT FEATURE	FUNCTION: PURCHASING		ENGINEERING	MATERIAL CONTROL	QUALITY
	DK	RS	NM	GS	GL
Quality	1.5(5.0)	1(8.3)	1(6.6)		*
Delivery	1.5(5.8)	2(8.0)	7(8.3)	1(8.6)	
Price	3.5(7.5)	3(7.5)	5(-)		
Familiarity with Supplier	3.5(7.8)	7(-)	3(-)		
Access to Research Facilities	5.5(-)	5(-)	2(7.1)		
Flexibility to Specification Changes	5.5(-)	4(10)	4(-)		
Speed of Response to Enquiries	7 (5.0)	6(10)	6(-)	2(10)	

* Subject G.L. refused to complete the product feature rankings and performance assessment without the approval of his immediate superior. Despite several requests to

complete the forms GL never provided the required information.

4.5.2 Repeat Purchase of an Original Equipment Component

The repeat purchase of an original equipment component was more routinized that the initial purchase of the same component. The same functional groups were involved in the repeat purchase but the roles played by each group differed from the initial purchase.

The Material Control Department dominated the repeat purchase procedure. Each month the Material Control Department provided the supplier with a delivery schedule for the following month for each product for which the supplier was approved. A tentative delivery schedule was also provided for the next month. Delivery against the schedule was monitored and progress chasing undertaken as required. Occasional adjustments were made to the schedule between issuing periods by direct contact between the Provisions Controller, Leamington and the Production Control Manager, Skelmersdale.

The Purchasing and Engineering Departments were only involved on an irregular basis, in particular if critical delivery or quality problems were encountered. The Purchasing and Engineering Departments were also involved if replacement or extra moulds were requested by the supplier (for which Automotive Products contributed part cost). A mould purchase request was submitted by the supplier to the Purchasing Department; after an estimation of likely future requirements was made, the Engineering

Department was requested to comment upon the suitability of the proposed additional mould. If the results of the investigation were satisfactory the Purchasing Department would authorise the supplier to order and commission a new mould.

The Quality Control Department's activities were restricted to periodic visits to the suppliers' factory by the SQA Engineer to ensure that standards were being maintained, and to the monitoring of the reject component levels of deliveries to AP.

Multiple sourcing decisions were usually taken only at the initial purchasing stage or when the demand for a component increased to a level where additional tooling capacity was required. In line with the policy of Automotive Products to have only two suppliers of rubber braking components (Dunlop, Skelmersdale and Alfred Roberts Limited - see Chapter 3) new tooling was normally only laid down in the factories of the preferred suppliers.

4.5.2.1 Product Feature Rankings

Since the involvement of the Purchasing and Engineering Departments in the repeat purchase of an original equipment was marginal and infrequent, none of the personnel interviewed in these departments felt that it would be meaningful for them to complete the product feature rankings and performance assessments for this purchasing activity.

Whilst the involvement of the Quality Control Department was still significant in this form of Purchasing activity, the SQA Engineer declined to complete the product feature rankings, as mentioned in section 4.5.1.1.

Therefore product feature rankings and performance assessments were obtained only from the Material Control Department (this being the department with the most significant involvement in repeat purchasing). The Provisions Controller, Leamington (GS) felt that only two product features were relevant in the assessment of supplier performance: delivery and speed of response to enquiries and alterations. The results were as follows:

EXHIBIT 4.3 : REPEAT PURCHASE ORIGINAL EQUIPMENT COMPONENT

PRODUCT FEATURE	FUNCTION MATERIAL CONTROL G.S. RANK	PERFORMANCE
Delivery	1	(8.6)
Speed of Response to Enquiries/Changes	2	(10.0)

4.5.3 Repeat Purchase of a Spares Component

The purchasing of spares was controlled by the Spares and Service Division of Automotive Products, based in Banbury, Oxfordshire. The Division possessed its own purchasing and Material Control Departments (the material control department was known as the Progress Control Department in Banbury) but relied upon the Brakes Division, Leamington to supply engineering and technical services as required. The majority of the spares components supplied by Dunlop, Skelmersdale were despatched directly to Banbury; the remaining parts (those with an original equipment call-off in excess of 50% of the total demand) were despatched to Leamington and were then transferred to Banbury as required.

The departments principally involved in the purchasing of spares components were:

1. Purchasing - who negotiated the supply contract with the supplier and agreed purchase prices and supply quantities. By the time that any component came under the control of the Spares Division, tooling was generally laid down with an approved supplier; the Banbury Purchasing Department usually retained the same supplier unless severe quality problems were encountered.
2. Progress Control - who performed a similar role to that undertaken by Material Control in Leamington by placing the delivery schedule on the supplier and ensured that the schedules were in accord with the Marketing Department forecast sales.
3. Engineering (Leamington) - who were asked to approve the design of any additional or replacement mould requested by a spares supplier. Authorisation for the mould purchase would be given by the Purchasing Department, Spares and Service Division.
4. Quality Control - who monitored the reject levels of deliveries to Banbury (Bought Out Quality Control) and made periodic visits to supplier factories (Supplier Quality Assurance Section, Leamington).

Both the Purchasing and Progress Control Departments performed a similar function in Banbury to that of their counterparts in Leamington. However, the authority of the Spares Division Purchasing Department was considerably less than that of the Brakes Division, for generally it had only limited influence over the choice of the supplier; the supplier who had supplied the original equipment component was usually asked to continue the supply to the Spares Division. The reduced status of the purchasing function in Banbury was reflected in the job titles of the purchasing officers involved in the procurement of rubber components; Senior Buyer and Assistant Buyer in Banbury compared with Chief Buyer and Buyer in Leamington.

Despite the apparently reduced authority of the purchasing function in the Spares Division, the visit to Banbury revealed that the Purchasing Department were considering the transfer of much of the low volume business from Dunlop, G.R.G. Division, Skelmersdale to Dunlop, Precision Rubbers Division, Bagworth. It was claimed that, although the number of parts delivered to Banbury had increased significantly, the mixture of parts delivered did not reflect the needs of the Spares and Service Division.

Discussions with the Senior Progress Controller revealed that 43 parts were classed as 'critical', of the 43 parts there were 16 parts for which AP had orders which could not be met until the relevant components were received from Dunlop. The researcher was shown a list of 10 parts which were earmarked for transfer, together with a comparison between the prices which had been quoted by Precision Rubbers

Division and those currently obtained from G.R.G. Division, Skelmersdale. Of the 10 parts examined, 7 were at unit prices which were $\frac{1}{2}$-$\frac{3}{4}$ of the G.R.G. Division prices, even when tool amortisation cost were included. Of the remaining 3 parts, two were at marginally higher prices and one was considerably higher.

Price was not given as the major stimulus for the resourcing action however, the Assistant Buyer interviewed stated that the Spares and Service Division were not particularly price sensitive. The fact that Precision Rubbers Division had apparently quoted 'realistic' delivery dates was given as the major reason for the proposed change; the lower prices were regarded as an additional bonus. Both the Senior Buyer and Assistant Buyer stated that if the delivery performance could be improved then the resourcing action would not be taken, despite the lower prices which could be obtained elsewhere.

In addition the visit to Banbury revealed that G.R.G. Division usually declined to quote for new compression tooling. The implications of this policy,which prevented the customer from increasing tooling investment and thereby reducing unit price will be discussed fully in Chapter 5.

4.5.3.1 Product Feature Rankings

The product feature rankings and performance assessments were obtained from the Purchasing Department and Progress Control Department personnel involved in the purchasing of rubber braking components.

No results were obtained for the Engineering Department or Quality Control Department personnel; in the former case because the involvement in the purchasing of spares components was minimal, in the latter case because of a refusal to complete the questionnaire without consultation with more senior Quality Control Department management.

The performance results (in brackets) reflected the dissatisfaction which had been expressed about the performance of Dunlop, Skelmersdale. The performance results have again been adjusted to a common 1 to 10 scale (1-poor, 10-excellent).

EXHIBIT 4.4 : REPEAT PURCHASE, SPARES COMPONENT

PRODUCT FEATURE	FUNCTION		
	PURCHASING		PROGRESS CONTROL
	JT	GA	RP
Quality	1 (6.7)	3 (6.0)	1 (-)
Delivery	2.5(4.3)	2 (5.0)	2 (1)
Price	2.5(3.3)	1 (6.0)	3 (-)
Availability of product/ compound research facilities	4 (10)	6 (-)	6 (-)
Response to schedule changes	5 (7.5)	5 (4.3)	4 (10)
Speed of Response to quotation requests	6 (7.1)	4 (6.7)	5 (-)

4.6 Discussion of Results

4.6.1 Hypothesis Testing

The investigation enabled the hypotheses generated in section 4.3 to be tested. The results of the hypothesis tests were as follows:

4.6.1.1 Purchasing Sophistication

As predicted, Automotive Products made little use of many of the techniques of purchasing control; optimum batch sizes, target prices and value analysis were not employed by any of the personnel involved in the purchasing process.

In addition no formal system was employed which could be used to assess buyer performance (the Ford Motor Company for example employs a system which uses the difference between previously set target prices and actual purchase prices to assess the performance of individual buyers).

It must therefore be concluded that the purchasing function in Automotive Products was relatively unsophisticated in technique. This does not imply any criticism of the personnel involved in purchasing at Automotive Products, but does suggest that sophisticated analytical techniques were not available for them to use.

4.6.1.2 Purchasing Influences

In section 4.3.2 it was hypothesised that at least six major influences would be detected in the purchasing process. Although eight individuals were identified as having some involvement, only four major functions appeared to have any influence on the purchasing decision; Purchasing, Design and Development Engineering, Material (Progress) Control and Quality Control.

Up to 5 individuals were involved in the purchasing decision for both original equipment and spares components, with only the engineering and quality control personnel having simultaneous involvement in both types of purchasing activity.

Using the nomenclature of Webster and Wind (30) the Purchasing Department personnel played two major roles: that of deciders (by having the formal authority to select the supplier) and buyers (by carrying out the purchasing decision). The Engineering Department personnel act as influencers (by providing a list of approved suppliers and evaluating the technical competence of potential suppliers). The Quality Control Engineer is an influencer, for he evaluates the quality standards of the potential suppliers and restricts the supplier set to only those suppliers who can achieve the quality levels required. The role of the Material/Progress Control personnel was rather more ambiguous; they did not influence the initial purchasing decision, but rather provided the other members of the D.M.U. with feedback about the wisdom of the choice after the decision had been made. By providing an assessment of supplier delivery performance they can be regarded as influencers of the next purchasing decision.

Thus the importance of each function altered with each stage of the purchasing activity. The Engineering and Quality Control Departments provided a list of alternative suppliers; the Purchasing Department made the formal selection of supplier and the Material/Progress Control Department implemented the decision.

4.6.1.3 Behaviour in Different Buying Situations

Purchasing behaviour and functional emphasis was different in the three purchasing situations, as hypothesised in section 4.3.3.

In the 'new buy' situation (initial purchase of a new component) there was a strong initial technological emphasis as the Engineering Department designed the product and, in conjunction with the Quality Control Department, determined a set of potential suppliers whose technical competence was sufficient to manufacture the product. The emphasis then shifted to the Purchasing Department, who selected the supplier, and the Material Control Department, who carried out the purchasing decision.

The straight rebuy (repeat purchase of an original equipment or spares component) was characterised by a lack of search activity and routinisation of purchasing procedures; the Material/Progress Control Department undertook the routine monthly scheduling without consultation with other members of the D.M.U. (unless problems were encountered).

The 'modified rebuy' situation was illustrated by the critical supply situation discovered at the Spares Division. The Purchasing and Progress Control Departments were paramount in the initiation of the search activity to locate an alternative supplier. It is indicative of the essential conservatism of the purchasing functions in Automotive Products that the potential alternative supplier chosen was a sister division of the existing supplier (although with a safety critical component the adoption of a conservative policy was not necessarily irrational).

The validity of conclusions drawn from the 'modified rebuy' situation must, however, remain questionable. It is possible that the Spares Division personnel were using the opportunity of a visit by a representative of Dunlop to apply pressure to improve the supply situation. This again highlights the weakness of the position for a researcher who is an employee of one of the involved companies; the results of the investigation must always be examined to determine whether they have been subject to manipulation.

4.6.1.4 Search Activity

are there any more?

The purchasing process in Automotive Products was characterised by a marked reluctance to search the market for alternative suppliers. At the time of the investigation there were only three approved major suppliers of rubber braking components and it was the stated policy of AP to reduce this number of two as soon as possible. (The threatened resourcing action by the Spares Division was contrary to this policy. However, as was stated in section 4.6.1.3, the threat to resource must be regarded with some scepticism, for no resourcing action had been taken by the end of the project, nine months after the statement of intent).

4.6.1.5 Price Sensitivity

It was difficult to be conclusive about the price sensitivity of Automotive Products. There were two items of circumstantial evidence which suggested that price sensitivity was relatively low:

1. In all cases where price was ranked as a significant product feature it was listed as less important then quality and delivery.
2. Subject GA (Assistant Buyer, Spares Division) stated that, although Precision Rubbers Division prices were generally 50-75% of Skelmersdale prices, resourcing would not be initiated if the delivery situation could be improved.

4.6.1.6 Primacy of the Purchasing and Design Engineering Departments

The empirical evidence from the Buckner (27) study suggested that the purchasing and design engineering functions should have been paramount in the purchasing decision (rather than the influence of operating management or production engineering).

The investigation into Automotive Products purchasing behaviour confirmed this hypothesis for the initial purchase of a new component. For repeat purchases on the other hand the requirements of operating management (as expressed by the Material/ Progress Control Departments) were more significant. The hypothesis can therefore only be said to hold true for initial purchases in this situation.

4.6.1.7 Product Feature Rankings

The Buckner (27) study suggested that the members of the Purchasing Department should have considered the following product features as most important:

Price, Delivery, Technical Specification (in descending order of importance).

Of the four purchasing personnel interviewed, 3 gave the following product feature ranking:

Quality, Delivery, Price.

Only one interviewee gave the predicted ranking.. (Quality can be equated with technical specification in this case, since it reflected the extent to which customer-determined technical specifications were achieved by the supplier). This result illustrates the importance which was attributed to quality by the Automotive Products personnel, an understandable view when the safety critical nature of the product is considered. With the exception of subject GA (Purchasing, Banbury) all interviewees who included quality in their rankings rated it as the most important single feature.

The results also indicated that Automotive Products were not as price sensitive as other companies who purchase components within the motor industry. The placing of both quality and delivery ahead of price suggested that, whilst the components performed a necessary and critical role in the braking system, the cost of the rubber brake components was not significant when compared with the cost of the complete system.

The Buckner study also found that the Design and Development Engineering function ranked the product features (in descending order) as follows:

Price, Technical Specifications, Delivery.

The interviewee NM (Development Engineer) gave the following product features as most important:

Quality, Access to Research Facilities, Familiarity with Supplier.

Although it would have been dangerous to draw any general conclusions from the result of one product feature ranking, the result indicated the conservatism of the Engineering function in Automotive Products. The importance of a familiar supplier, whose technical competence was known, was stressed relative to the price or delivery performance of that supplier.

There was an apparent divergance between the rankings given by the Material/Progress Control Department personnel in Leamington and Banbury (Leamington - Delivery, Response to Changes; Banbury - Quality, Delivery, Price). However, it must be remembered that the interviewees were asked only to rank those product features with which they were familiar; the Leamington interviewee only considered two product features whereas the Banbury interviewee ranked all six product features. When this is considered, it can be seen that in both cases delivery was ranked as more important than response to changes.

4.6.2 Performance Assessments

The assessments of the performance of Dunlop, Skelmersdale made by the Automotive Products personnel differed between the two locations supplied:

4.6.2.1 Original Equipment (Leamington)

The performance ratings given to Dunlop by the Brakes Division personnel can be regarded as satisfactory; average to good ratings were given for all product features which were considered important. Particularly high marks were awarded for flexibility of response to schedule changes and enquiries; there appeared to be a good working relationship between the two companies.

The majority of the high volume products were destined for the Brakes Division; it may be concluded that the high volume performance of Dunlop, Skelmersdale was considered satisfactory by the personnel most involved in the purchasing of brake components in Automotive Products Ltd.

4.6.2.2 Spares Components (Banbury)

The performance of Dunlop, Skelmersdale as a supplier of rubber components was seen as rather less than satisfactory by the Spares Division personnel. Although satisfactory/good ratings were given for quality, price and flexibility of response to schedule changes, very poor ratings were given for delivery performance; subject RP (Progress Control) summarised the situation by saying that, whilst Dunlop would accept virtually all schedule changes, no change would be made to the deliveries.

The majority of the problem was encountered with low volume, compression moulded products; the delivery performance for the small number of high volume, injection moulded products was considered satisfactory. In fact it was claimed that the satisfactory delivery of the high volume products tended to distort the overall delivery performance when volume was used as a criterion; the total volume of deliveries was usually near to the figure required by the schedule. The non-delivery of small volume parts did not significantly affect the total volume of parts supplied; a superficial inspection of the number of parts delivered would therefore not reveal the problem.

The poor performance rating given to Dunlop, Skelmersdale was supported by the resourcing action which was being considered; the situation had reached a critical stage.

4.7 Marketing Strategy Implications

4.7.1 Brakes Division (Original Equipment)

A contribution of the existing marketing strategy towards the Brakes Division was suggested by the results of the investigation. It was suggested that the links between the Design and Development Engineering Department (Automotive Products) and the Process Engineering Department (Dunlop) should be strengthened to ensure that more prototype development was undertaken at Skelmersdale, for it was indicated that the supplier who undertook the prototype production usually received the order for the production part (no prototype development was then in progress at Skelmersdale).

4.7.2 Spares Division

An improvement in delivery performance was indicated if the Spares Division business (mainly small orders) was to be retained. The Progress Control Department was requested to supply a list of the most critical part numbers to Skelmersdale, in order that special efforts could be made to improve the delivery. No such list was ever provided, suggesting that the delivery situation was not quite as critical as had been suggested during the interviews. Nevertheless a programme was initiated at Skelmersdale to improve the output of the Small Order Section, with particular reference to those products which had high (internal) reject levels; improvements were just being achieved at the end of the project in 1977.

Dunlop, Precision Rubbers Division, was contacted to discuss the potential resourcing actions. It was agreed that a limited number of parts could be supplied by Precision Rubbers Division, albeit at prices more consistent with those obtained by G.R.G. Division, Skelmersdale. The extent of any resourcing moves could be controlled by the Skelmersdale management, for Precision Rubbers Division were not approved by Automotive Products to mix the compound for the products; supplies of compound would therefore have to come from Skelmersdale (which was approved). By the end of the project however, no transfer of any of the Skelmersdale products had taken place.

The investigation also highlighted an inconsistency in the policy of the Skelmersdale management towards Automotive Products. A pricing policy had been agreed (see Chapter 5) which charged the customer a product price which was related to the degree of investment which he had in tooling (the more moulds which were held, the lower the product unit price). The customer was not being allowed to increase the number of moulds (and thereby reducing the unit price) because all requests to increase tooling on compression moulded products were being refused (in order to allow Process Engineering resources to be directed towards the improvement of high volume, injection moulded production). A recommendation was therefore made to the Skelmersdale management that requests for new compression tooling should be considered more seriously, rather than being rejected out of hand. A commitment to this effect was given by the senior Skelmersdale management, but it is not known whether any changes were made.

Finally it was suggested that more frequent contacts should be made between the Skelmersdale personnel and the Spares Division Purchasing and Progress Control Departments, for several of the personnel interviewed felt that the Skelmersdale management responded only to the Brakes Division demand and considered the Spares and Service Division to be relatively unimportant; more frequent contacts would help to reasure the Spares Division personnel of the commitment of the Skelmersdale management to the Spares Division business.

4.8 Generality of the Model

No attempt has been made to draw general conclusions from the results of the investigation. The results must be regarded as specific to the relationship between Automotive Products Limited and Dunlop, Skelmersdale at the time of the investigation.

It is possible that the results may be used to support a more general model of buyer behaviour at a later date, but they do not in themselves provide sufficient empirical evidence upon which to build a general model of behaviour. Human behaviour is determined by too many variables for any single investigation to enable any general conclusions to be drawn.

CHAPTER 5

Pricing Policy

5.1 Introduction

As stated in Chapter 1, one of the major objectives of the study of small orders was to develop an effective pricing policy. In a perfectly competitive industry, as envisaged by economists, there is no such thing as a pricing policy (43). A market price exists for any given level of demand; individual firms have merely to decide at what level to supply. Only where the firm has some discretion in setting prices is there any need for a pricing policy; generally one can expect the degree of discretion to increase as one moves from pure competition at one extreme to pure monopoly at the other. The pricing policy adopted must therefore be compatible with the market in which the company operates and will reflect the degree of discretion which the company has.

As was outlined in Chapter 3, the market in which the Lockheed Department operated could be described as duopolist - monopsonist, for there were only two major suppliers and one customer - Automotive Products. The situation was ambiguous however, for although Dunlop was the only major external supplier, it was not a monopolist; it was 'competing' against a supplier which was a wholly-owned subsidiary of the customer, Automotive Products.

To use the word 'competing' is itself ambiguous, for, depending on the internal transfer pricing policy of Automotive Products, the price charged by the internal supplier may have ranged from marginal (variable) cost to market price plus. Maintenance of Dunlop as a supplier may not therefore have been dependent upon price competition, but rather on the desire of Automotive Products to maintain a dual supply with access to Dunlop's expertise in rubber technology (the lower than predicted ranking given to price as a product feature in the buyer behaviour investigation may have stemmed from the adoption of this policy).

The competitive structure implied a further constraint; it was possible that, as the internal supplier gained experience in the production of brake rubbers, the importance of Dunlop as a supplier would be reduced. An attempt to follow an excessively aggressive monopolist pricing policy could have merely accelerated the decline.

The pricing policy which was in use for all products manufactured by the Lockheed Department at the start of the project was a form of the cost-plus approach. Individual product prices had been determined when the brake rubbers business was transferred to Skelmersdale by applying a fixed percentage 'mark-up' to the variable costs of manufacturing each product (thus giving a fixed percentage 'contribution' towards general overhead and profit). Thus the price demanded for a product reflected the standard costs of manufacturing that product. Although production methods had changed since the introduction of the business to Skelmersdale, the individual prices were not generally altered to reflect the individual cost changes. Instead a policy of maintaining the total contribution of the Department had been adopted. Each year the projected contribution of the Lockheed Department was reviewed and a general price increase sought which would maintain an acceptable level of contribution for the whole Department; generally individual prices were not adjusted to reflect individual product costs. Thus, as time progressed, individual product prices were increasingly dissociated from the individual production costs. The only exceptions to this approach were a limited number of high volume, injection moulded products; the prices of these products were individually negotiated with the customer.

After discussion with the Skelmersdale management it was decided that alternative pricing policies should be evaluated and implemented for the Lockheed Department. The primary objective of the investigation was to derive a rational pricing structure for the compression moulded (small order) parts; as the small orders had only a limited effect on the overall contribution of the Department, the prices of these products had not been reviewed since the transfer of the moulding business to Skelmersdale.

The approach adopted was similar to that employed in the Industrial Buyer Behaviour investigations. A literature survey was undertaken in order to generate alternative approaches to pricing, the alternatives were evaluated and a choice of strategy was made on the basis of the evaluation.

5.2 Alternative Pricing Policies

5.2.1 Cost-plus Pricing

The investigation into the purchasing behaviour of Automotive Products personnel indicated that pricing was an important, if not the most important, element in the marketing mix (product price was rated as one of the three most important product features by all the personnel interviewed). Product pricing should therefore be approached as logically and analytically as possible. However, as Lanzilotti et al have pointed out, pricing is rarely a logical process of analysis and decision:

"Repeatedly reference was made to the 'art' or 'feel' of pricing rather than the observance of a formula" (44).

Nevertheless in a study of large American companies Rewoldt, Scott and Warshaw found that pricing was not rated in the top 5 strategies by over half the companies studied (45). Although many companies would probably pay lip service to a strategy which incorporates pricing as a major element, it is likely that few would be regarded as following an active pricing policy when their actions are examined. In other words, although the derivation of product prices is obviously necessary, the derivation may be routinised to such an extent that little thought is given to it.

According to economic theory firms will attempt to maximise profits. Evidence suggests that non profits-maximising policies are the rule rather than the exception (Field, Douglas and Tarpey (45); Oxenfeldt and Baxter (47)). This may, as Harrison and Wilkes (48) pointed out, be due to incorrect estimation of demand, cost, production capacity or future trends; it may also be due to the adoption of pricing policies which are in themselves non profits-maximising.

In order to see why this should be so, it is necessary to determine what pricing objectives firms are pursuing. Lanzilotti (49) lists five common pricing objectives:

(i) Pricing to achieve a target return on investment.

(ii) Stabilisation of price and margin (this is closely related to part (i) since a certain return on investment tends to imply a certain profit margin and vice versa).

(iii) Pricing to realise a target market share.

(iv) Pricing to meet or prevent competition.

(v) Pricing subordinated to product differentiation.

Points (i) and (ii) were the most relevant pricing objectives to the investigation, since they related most closely to the policy adopted by Dunlop, Skelmersdale. That policy was the ubiquitous cost-plus pricing policy.

In surveying the literature the reader might be justified in believing that cost-plus pricing was merely a 'straw man', offered merely as a less attractive alternative to more 'rational' profits maximising policies. The findings of Field et al (1966), Oxenfeldt and Baxter (1961) and the PEP Report on the Determination of Prices (1965) (50) suggest otherwise; the evidence suggests that cost-plus pricing is the most common pricing method currently in use in both the U.K. and U.S.A.

A number of possible explanations have been proposed for the adoption of cost-plus pricing:

5.2.1.1 Advantages of Cost-plus Pricing

Lanzilotti (1958)

5.2.1.1.1 Investment planning is made easier.

5.2.1.1.2 Divisional performance is easier to assess.

5.2.1.1.3 Historically, wartime firms were restricted to 'cost plus fixed fee'.

5.2.1.1.4 Other successful companies have adopted a rate of return approach.

Harrison and Wilkes (1974)

5.2.1.1.5 Fear of government action against 'excessive profits'.

5.2.1.1.6 Production orientation of companies rather than market orientation.

5.2.1.1.7 Tacit agreement within industries to eliminate cut-throat competition (if all have similar costs).

Brown and Jaques (1964) (51)

5.2.1.1.8 Where there are more pricing decisions to be made than the manager responsible for profit can handle.

Related to point 5.2.1.1.8 it is also worth noting that the cost-plus pricing policy is easy to administer. A manager who bases prices upon costs will be avoiding uncertainty by utilising information which is in his possession (the costs) rather than speculating about the nature of the demand curve for the product. In many companies product costs are credited with an objective reality which is far in excess of that which their methods of derivation justify. By using 'objective data to derive the prices it is easy (albeit fallacious) to assume that the prices so-derived are also objective.

Nevertheless, whilst the use of a cost-plus system is not 'rational' in the traditional economic sense, it can be seen that there are a number of operational benefits and historical precedents which make the adoption of the system understandable, if not necessarily logical.

The disadvantages of the cost-plus system must not be overlooked however:

5.2.1.2 Disadvantages of Cost-plus Pricing

5.2.1.2.1 Price Structure Instability

The arbitrary nature of certain costs, together with the use of different production methods, can lead to price structure instability - two similar parts produced by different methods may have vastly different prices which the market does not justify. Differences in the approach adopted by different cost estimates can also lead to structural instability.

5.2.1.2.2 Misdirection of Sales Objectives

The sales department may tend to go for business which, in unit terms, is highly profitable, but a different mix could well utilise resources more effectively.

5.2.1.2.3 Misdirection of Research and Development Priorities

Research may be focussed on 'uneconomic' parts rather than 'economic' parts when the potential savings on the 'economic' product may be more beneficial.

5.2.1.2.4 Disposition of Gains and Losses

When a more efficiency production method is adopted, the benefits will be passed on to the customer unless care is taken. (This may not have been unreasonable if capital expenditure is involved, for the customer to contribute, at least partially, towards the cost of new tooling).

5.2.1.2.5 Opportunity Costs

The most serious disadvantage associated with the use of a cost-plus pricing policy for Lockheed Department products were the opportunity costs incurred. Even if the costs used for price determination were accurate, (past performance indicated that the costs were highly inaccurate) the use of a cost-plus pricing policy meant that Dunlop was unlikely to be charging the price which the customer was prepared to pay. The weakness of the cost-plus approach can best be illustrated as follows:

Taking a single product firm which sets prices at a predetermined mark-up of 100m % on total average costs (AC), the demand for the product is given by the equation $p = f(q)$. The price charged must therefore satisfy two conditions:

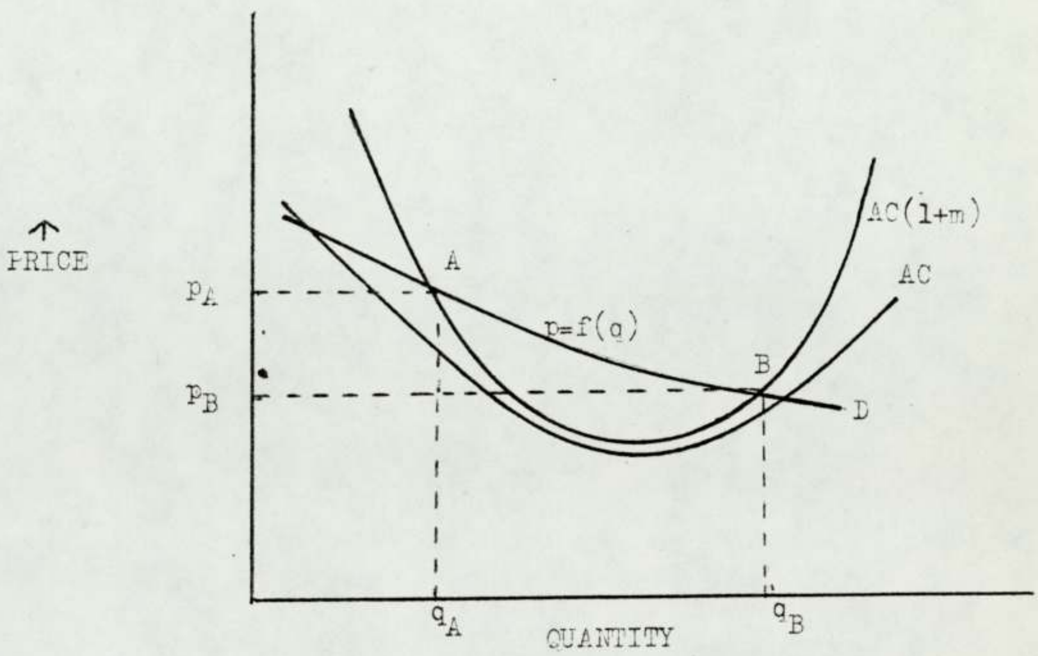
$$p = AC\,(1 + m) \qquad \text{(i)}$$

$$p \quad f\,(q) \qquad \text{(ii)}$$

where p = price, q = quantity

Exhibit 5.1 illustrates these equations:

<u>EXHIBIT 5.1</u> : <u>DEMAND/SUPPLY CURVE</u>



It has been assumed that the demand for Lockheed Department products will be increasingly elastic as the quantity demanded increases (although this does not materially affect the argument - a linear demand curve would still intersect the average total cost curve twice). The demand for small orders was likely to be relatively inelastic, for where Dunlop possessed the only tooling for the part, the customer was unlikely to set up new tooling with an alternative supplier for only a short run. (The cost of new tooling may be regarded as a surcharge over and above the price which the alternative supplier would charge. The surcharge will be distributed over the total number of products produced, thereby affecting a small order price more adversely than a large order price. Since tooling was expensive, it was unlikely that the alternative suppliers 'total price' would be on or below the demand curve for small orders.

It can be seen from Exhibit 5.1 that there are two possible intersections between the demand curve and the cost-plus price curve. To maximise profits the company should choose to operate on the demand curve (rather than below it).

Taking A, B as the two points of intersection, with corresponding prices p_A, p_B and quantities q_A, q_B, it can be shown that the company should choose to supply quantity q_B at price p_B in order to maximise profits:

$\pi = R - C$ (By definition) where π = total profit

R = total revenue

C = total costs

$$C = AC.\,q$$

Thus:

$$\pi_A = R_A - C_A$$

$$R_A = AC(1+m).q_A$$

$$C_A = AC.q_A$$

$$\therefore \pi_A = AC(1+m).q_A - AC.q_A = C_A(1+m) - C_A = mC_A$$

Similarly $\pi_B = mC_B$

$$\pi_B > \pi_A \text{ if } C_B > C_A$$

If the marginal cost is positive, then $C_B > C_A$.

$$\therefore \pi_B > \pi_A$$

To maximise profit therefore, the company will operate at the highest level of output consistent with operating on the demand curve. Dunlop however would not itself decide at what level to supply; the company was asked to supply products at a level determined by the customer q_C.

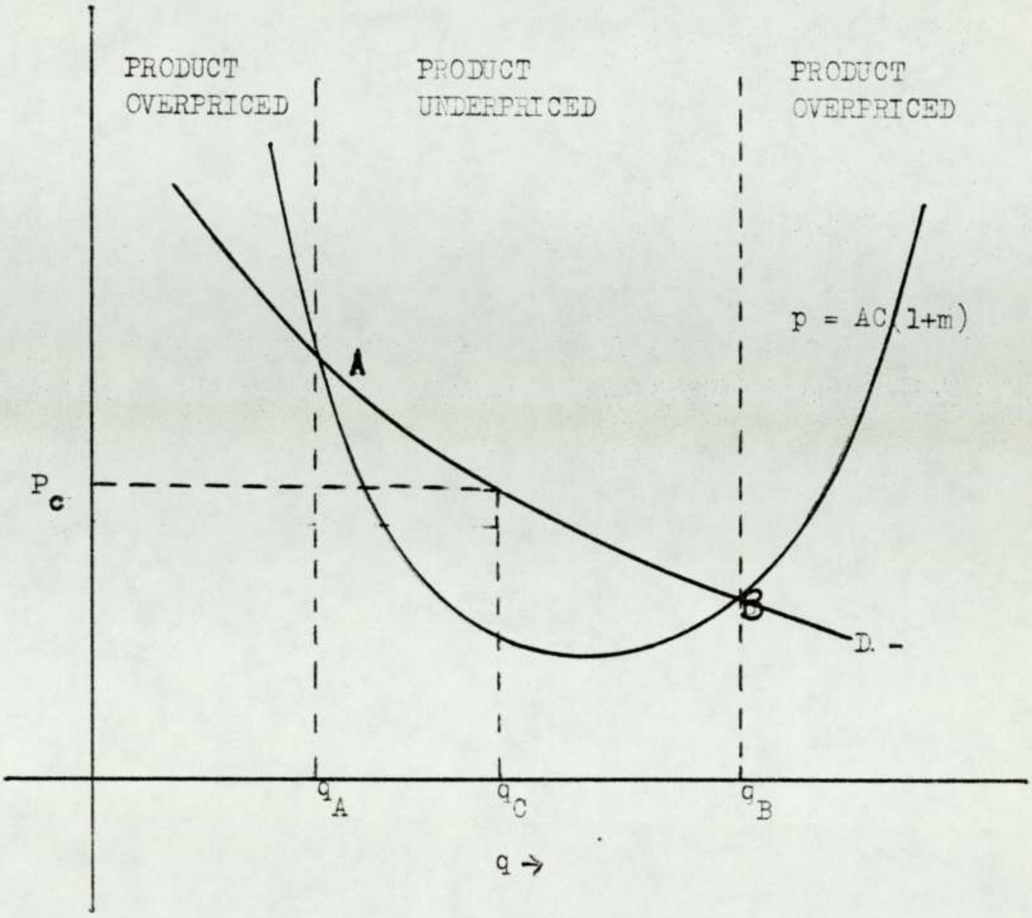
It was unlikely that the quantity required by the customer would coincide with q_B, the maximum profit quantity.

Therefore three distinct situations could occur : (See Exhibit 5.2).

1. If $q_C > q_B$, the cost-plus policy will generate a price which is in excess of the demand price p_C for that outp t and the Company would be unlikely to gain the business.
2. Similarly, if $q_C < q_A$ a price will be quoted in excess of the demand price. However the business is less likely to be lost than in the higher volume situation because of the effect of the tooling 'surcharge' on the competitors price. Furthermore, it is worth remembering that with a highly inelastic demand curve, q_A was likely to be very small.
3. If $q_A < q_C < q_B$ the firm will suffer an opportunity loss by following a cost-plus policy, for it will be quoting a price below the demand price p_C. The total loss in revenue as a result of this policy will be a loss in pure profit and is equal to:

   $(p_C \; q_C - AC.q_C)-(m \; AC \; q_C)=(p_C-AC(1+m))q_C$

EXHIBIT 5.2 : GRAPHICAL ILLUSTRATION OF COST-PLUS PRICING PROBLEMS



Thus it can be seen that cost-plus pricing can lead to opportunity losses to the company and may even result in the total loss of the order for extremely low or extremely high demand quantities.

5.2.2 Product Life Cycle Pricing

It is not uncommon for pricing policy to be linked to the product life cycle, with a pricing policy recommended for each stage of the cycle. Kollat, Blackwell and Robeson (52) for example split the product life cycle into five distinct stages:

Phase I - Development - consumer needs are analysed, product concepts tested, engineering and production techniques developed.

Phase II - Introduction - product brought onto market. Sales slow to take off, profits even slower due to initial need for intense promotion.

Phase III - Growth - the market expands rapidly, competition enters the market.

Phase IV - Maturity - market saturation, price competition intensifies, attempts are made at product differentiation.

Phase V - Decline - product loses customer appeal, overcapacity evidemic, prices and margins decline.

The traditional view of product life cycle pricing is one of decreasing pricing discretion as the product proceeds through its life cycle; as more firms enter the market a situation nearer to that of free competition is approached. Only at the introduction stage does the company have discretion to adopt a pricing policy. Kollat, Blackwell and Robeson suggest two alternative pricing approaches: 'skimming' - prices are set high to gain the maximum profit from the small initial demand, being gradually reduced to generate an increasing demand as output is increased (see Exhibit 5.3), and 'market penetration' - initial prices are set low in order to discourage the potential competition from entering the market (see Exhibit 5.4).

EXHIBIT 5.3 : 'SKIMMING' PRICING POLICY

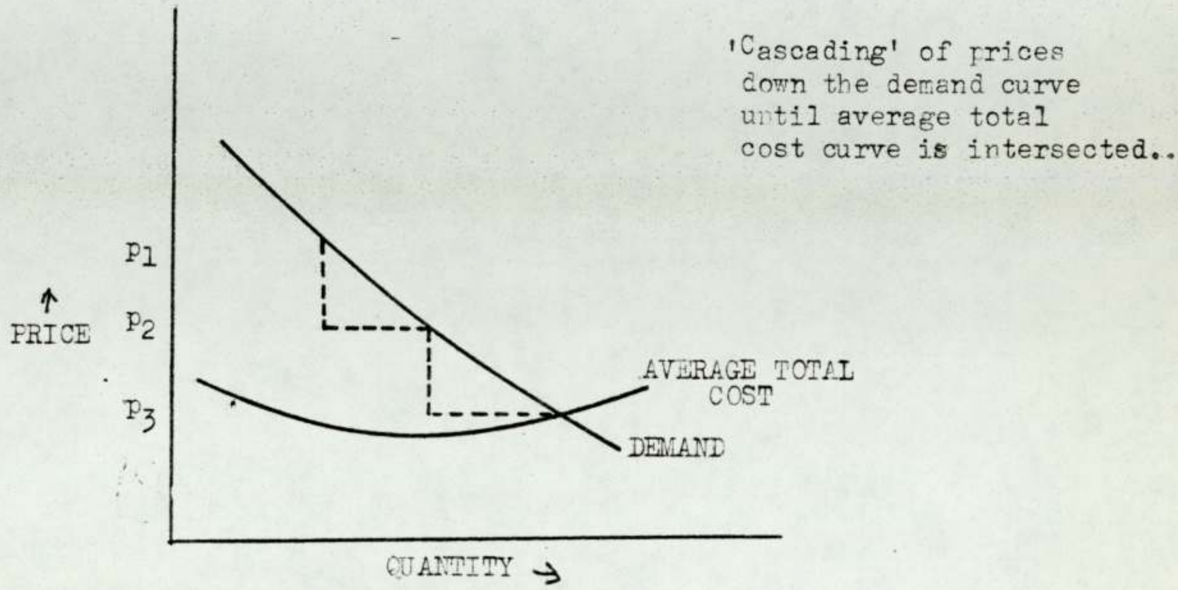
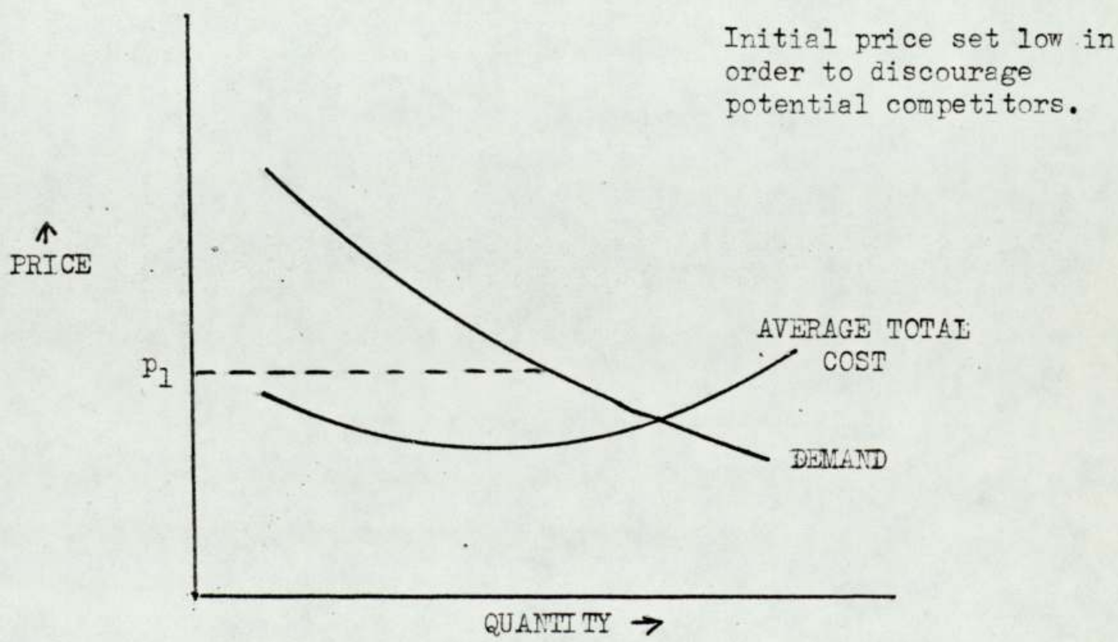


EXHIBIT 5.4 : 'MARKET PENETRATION' PRICING POLICY



As more firms enter the market. (unless they have been sufficiently discouraged by an aggressive market penetration policy), the price of the product will be increasingly determined by the market; the individual firm will therefore have a decreasing pricing discretion as a saturation and decline stage is approached.

Whilst the traditional approach has some credence for undifferentiated consumer goods, the analysis appears to break down when applied to industrial products manufactured to the customer's specifications. Whilst the total demand for the products does undoubtably decrease as the product is replaced there is no evidence to suggest that prices and margins decline at the end of the product form life cycle.

Products at Skelmersdale which were reaching the end of the product form life cycle (as indicated by declining demand for the product) could command very high prices, with correspondingly high contribution rates; Automotive Products were often willing to pay a price surcharge on obsolescent parts if Dunlop was prepared to supply a small quantity of acceptable parts from a damaged mould. The reason for this behaviour is understandable since Dunlop possessed the only serviceable moulds for some of the older parts. Automotive Products were prepared to pay a higher product price in order to ensure that a spares order could be met. Additionally it is possible that Automotive Products could pass the extra cost on to their own customers, for the opportunity cost of having a vehicle off the road due to lack of spares was likely to be considerably greater than the cost of the spares themselves.

An opportunity therefore appeared to exist for Dunlop to adopt a 'reverse cascading' pricing policy as the products reached the end of their life cycles. Unfortunately the approach suffered from two major restrictions when implementation was considered:

1. The approach assumes that the slope of the demand curve is known in order that the price can be set at the correct level. No information was available at Skelmersdale which indicated the slope of the demand curve, highlighting one of the major problems which is encountered in attempting to use an economic analysis approach. As Leighton (53) points out economists tend to take the demand curve as given and then proceed to work out cost and volume relationships; the practising manager is often more concerned with obtaining empirical demand curve data (even though he may not recognise it as such) with costs and margin taking a secondary role.
2. Records of the demand for each product were only available from 1971 onwards (the Automotive Products business having been transferred to Skelmersdale in that year). The demand for the lower volume products tended to be somewhat spasmodic; many low volume products were only scheduled once or twice a year.

It was therefore difficult to determine with any degree of certainty whether the products had reached the end of the product life cycle.

Thus with no certainty about either the nature of the demand curve or the position on the product life cycle curve, product life cycle pricing could be regarded as an elegant theoretical approach which was almost impossible to implement at Skelmersdale.

5.2.3. Product Analysis Pricing

5.2.3.1 .Description of the System

As mentioned in section 5.2.2, it is often very difficult to determine what price the market will bear. Product Analysis Pricing (PAP) is an attempt to achieve market-orientated pricing and as such was considered worthy of evaluation.

Product Analysis Pricing is based upon the philosophy that:

"..... a product is a combination of quantities of different properties". (54)

This system of delegated pricing (where pricing decisions are made by others than the manager responsible for profit, but where the price so obtained must be consistent with his policy) was developed by Lord Wilfred Brown and Dr. Elliot Jaques for use in the Glacier Metal Company Ltd. A number of similarities between the products and markets served by Glacier Metal and Dunlop, Skelmersdale indicated that PAP might be applied in the Lockheed Department:

1. Both companies were involved in making high precision products to the customer specification.
2. Both organisations operated in a derived demand situation in the same market with similar buyer characteristics - the motor indutry.
3. In both companies the costing systems were not sufficiently accurate to permit a cost-plus pricing system to be operated with confidence.
4. The product ranges of both companies were large (Glacier manufactured bearings and bushes for the automotive, marine and heavy industrial sectors).
5. Both companies had problems with processing order enquiries (although in the case of Dunlop it was the slowness of enquiry processing rather than the large number of enquiries which presented the problem).

The basic assumption underlying the operation of PAP is that any product can be analysed into critical features of properties for which the customer is willing to pay a certain price per unit property or feature. Thus the prices which a customer will pay is the sum of the values of the properties present in the product.

The features and properties can be regarded as either 'binary' or 'continuous' (my nomenclature). A 'binary' feature is one which is either present or absent. A 'continuous' property is one which can vary within specified limits, such as size, weight, horsepower etc. Coefficients, tables, graphs etc., are produced initially which will enable any product to be analysed in terms of the feature and properties present and a value assigned to each. The price is a simple summation of the property values. By this means a differential pricing structure is established in which similar parts had similar prices, irrespective of the production methods used to manufacture them.

Initially Brown, who was then Chief Executive of Glacier Metal, was anxious that any comparison of cost and price should be avoided. In a number of interviews conducted with Glacier Metal directors and senior managers (see Appendix C for questionnaire) it was clear that some form of profitability was found necessary in order to prevent the PAP system from 'getting out of control' (55).

The most important point was that the market price should be derived without consideration of the production costs. Once obtained the selling price can then be compared with the costs in order to determine whether it is worthwhile to supply at that price (although the activity of generating the production costs somewhat negates the benefits which Brown claimed for PAP). In other words the cost-plus price should be used as a guide to a decision whether to supply, not as a price determinant.

5.2.3.2 The Method of Price Determination

The product is analysed under the following headings:

5.2.3.2.1 Bought Component Value - the value of any part which the producer buys which appears unaltered in the final product. Not merely the cost of the component to the producer should be included, but also a value for any product aura (product surround in Brown's nomenclature) which the product might possess (such as a reputable brand name).

5.2.3.2.2 Material Value - this should reflect the cost of the material in the product, plus allowances for scrap and wastage to a level which the market finds acceptable.

5.2.3.2.3 Product Property Value - the product should be analysed into the parameters which the market judges to be important. Often these will be parameters of size - weight, volume, area, voltage, horsepower etc. The values will have been determined by analysis of previously obtained market prices. The product property value (PPV) for a product with n different important properties will be:

$$PPV = \sum_{2=1}^{i=n} Qi\ Ti$$

Where Qi = quantity of i th property present

Ti = target price for the i th property per unit property.

5.2.3.2.4 Feature Property Value - the sum of the values of the design features generated in the product by the producer (for example accuracy, finish, holes etc).

The values obtained from the above analysis are then summed to give the 'Standard Value'. To this is added the 'Market Percentage' to give the 'Target Price'. The Market Percentage is a figure which may be added to (or subtracted from) the Standard Value to allow the price quoted to match the prevalent economic conditions and to give the pricing executive discretion in adjusting the price for different markets (for example Glacier used a higher market percentage when quoting for business in Eastern Europe than that which was used when quoting in the more competitive Western markets).

For the market from which the values were derived at the time of the analysis, the Market Percentage is zero. The Standard Value therefore reflects the price obtainable at that time. With time the Standard Value will become increasingly dissociated from the market price in the absolute monetary sense. It is at this stage that the Market Percentage becomes important, for it allows alterations in the Target Prices to be made without affecting the differential price structure, that is, without affecting the relationship of the Standard Value of one part to that of another.

The factors which can effect this market percentage are:

(1) Inflation

(2) Changes in the severity of competition

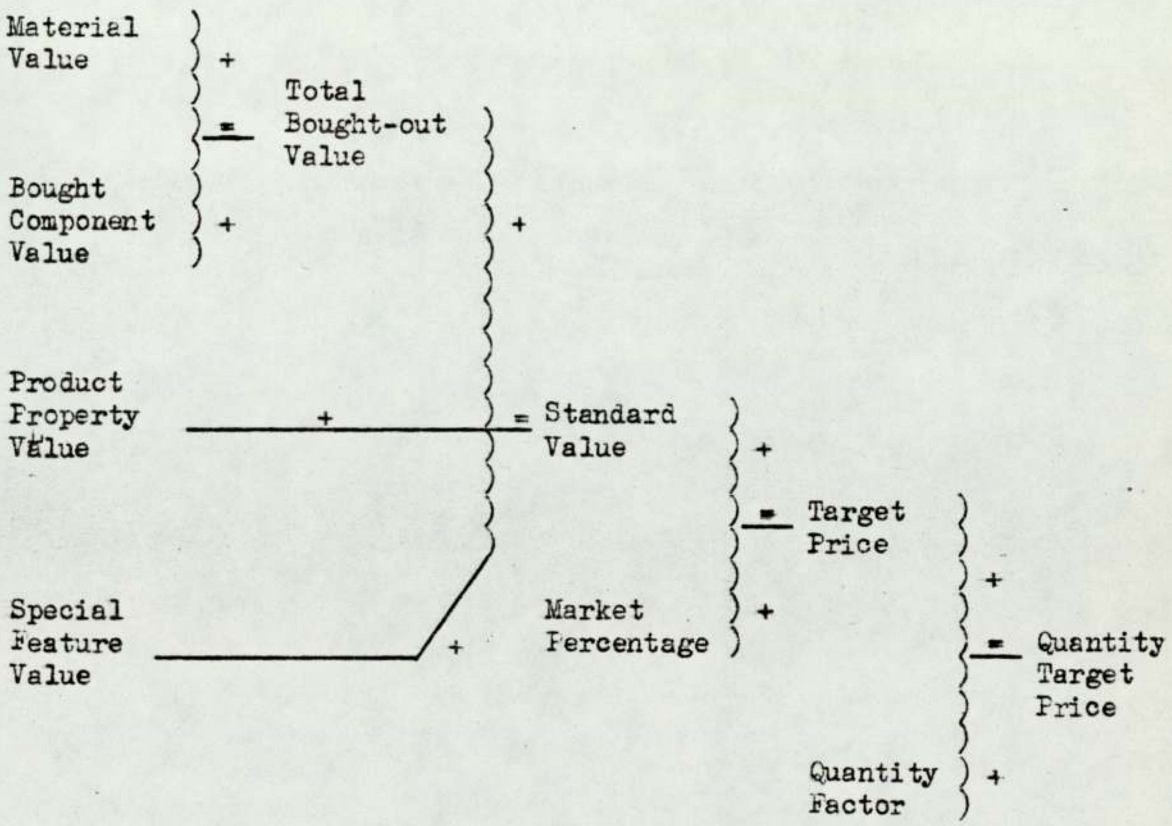
(3) Changes in capacity which may require a different level of market penetration (56).

Thus, whilst one synthesised market price will vary with time, there is the underlying assumption that there will be no change in the way that the prices of the products relate to one another.

In addition, a Quantity Factor is applied to the Target Price to reflect the commercial policy of the company. If the company wishes to discourage small orders and encourage high volume orders it may add a surcharge to the small volume work which will decrease as the size of the order increases. (As operated in Glacier Metal a fixed monetary surcharge was added to the total order price, when divided by the total number of parts in the order, the unit surcharge decreased with increasing order quantity) (57).

The various components of the price are brought together as in Exhibit 5.5.

EXHIBIT 5.5 : HOW THE QUANTITY TARGET PRICE IS DERIVED



5.2.3.3 Advantages of Product Analysis Pricing

The advantages of the PAP system may be summarised as follows:

5.2.3.3.1 Pricing policy does not depend completely on product costing, thereby reducing the errors which stem from inaccurate costs. Similar parts should have similar prices even if they are manufactured by different methods. More accurate product costing might be achieved when its use is limited to budgetary control (thereby eliminating the tendancy to manipulate costs in order to achieve a 'reasonable' price).

5.2.3.3.2 The system allows a rapid response to be made to enquiries without the need for the cost to be estimated (if the prices of similar parts are known). This should also reduce the burden on the estimating departments.

5.2.3.3.3 A rational differential price structure can be created wherein the relationship of the prices reflects the value of the products to the market rather than historical factors. Opportunity costs associated with sub-demand prices should be minimised (assuming that this method can arrive at the market prices - see Section 5.2.3.5).

5.2.3.3.4 A basis for evaluating Sales Department performance is established.

5.2.3.3.5 Changes in production efficiency will not automatically alter the price, allowing the firm to derive some of the benefits of research and development effort.

5.2.3.3.6 The system may be easily computerised. This enables the response to material and bought component price changes to be effected rapidly.

5.2.3.4 An Attempt at Implementation

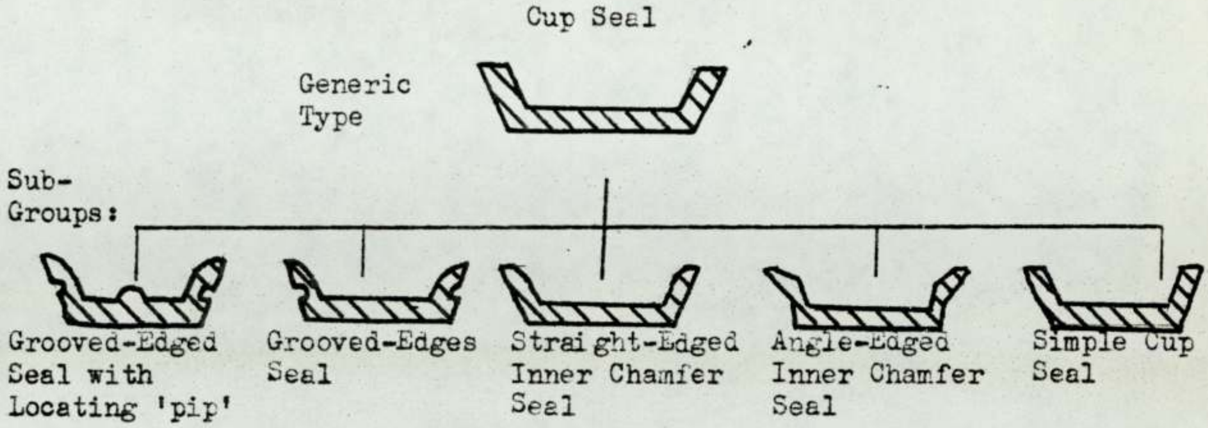
In view of the apparent benefits of Product Analysis Pricing it was decided that implementation of the system should be undertaken for the Lockheed Department products. A rather simpler approach to that described by Brown and Jaques was attempted; the price was to be related to the simple parameters of the product which it was believed the customer would value most highly-that is, those which related directly to the functional performance of the product.

5.2.3.4.1 Methodology

The complete product range of the Lockheed Department was analysed into product groups, the membership of the group being determined by the functional application and basic shape of the product. The product range was therefore subdivided into groups of, for example, single lip master cylinder seals, twin lip master cylinder seals, slave cylinder seals, master cylinder dust covers, slave cylinder dust covers etc.

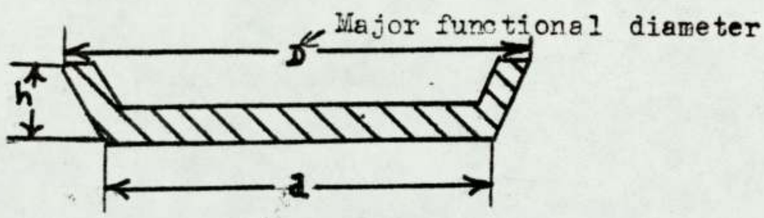
The cup seal product group was chosen as the first group for analysis, since the basic shape of this type of seal was felt to be the simplest. The basic types of seal included in this group are shown in Exhibit 5.6.

EXHIBIT 5.6 : THE CUP SEAL PRODUCT GROUP



The major parameters used in the analysis of the cup seal group were as shown in Exhibit 5.7.

EXHIBIT 5.7 : MAJOR PARAMETERS USED IN PRICE ANALYSIS



Other parameters used : Product Weight (grammes/part) Compound Type

Special Features : Grooved outer wall. Central Locating Pip

The product group was also split in terms of the moulding method (compression or injection) which was used to produce each product (the rationale for this split will be explained at a later stage). A simple graphical plotting of price versus each parameter was undertaken for each sub-group, with log-log plotting and iterative numerical techniques being employed if there appeared to be any curvilinear relationship between the product price and the parameter.

5.2.3.4.2 Results of the Investigation

A comparison between the parameters of the compression moulded products and the selling prices failed to reveal any meaningful relationships between the variables (although it was assumed that there was no interaction between the parameters). The prices of the compression moulded (low volume products did not seem to depend upon the size of the product, the compound type or the weight of the product.

An examination of high volume injection moulded products was more rewarding; the price of injection moulded parts appeared to be related (albeit in a complex manner) to the major functional diameter. The nature of the relationship between price and diameter can be seen in Exhibit 5.7. The analytical techniques applied failed to reveal the algebraic nature of the relationship (see Exhibit 5.8). However it was felt that there was little advantage to be gained by the determination of this relationship; the graph showing a monotonic relationship between price and diameter was felt to be adequate. The discovery of the relationship between product price and major functional diameter prompted an investigation into the pricing of injection moulded products (this investigation was not undertaken by the author). As a result of the investigation a new pricing strategy was adopted for injection moulded products; each product group was divided into a number of size classes, with a common price being charged for every product in the same size class (for example every cup seal in the size class 0.5" - 1.0" was sold at a price of 2 pence). In effect the price curve shown in Exhibit 5.7 was transformed into a number of steps;

the level of the price bands were chosen in such a way that the overall level of contribution which resulted from the new pricing strategy was the same as that which had been generated with the previous strategy.

It is not proposed to examine the injection moulding pricing strategy in detail, for it was not applied to the small order products. The failure to establish a relationship between the price and the product parameters highlighted the major shortcoming of Product Analysis Pricing; the system can be used to synthesise new 'market' prices only if there exists a large number of independently derived market prices. As Brown has said:

"There is no alternative base upon which to build a future price structure except the existing one" (59).

Thus PAP can be used to extend the existing price structure; if the prices used in the derivation of the relationships are market prices, then market prices will be synthesised, if cost-plus prices are used in the derivation then the system can only synthesise prices which reflect cost patterns. It is possible that the customer may also be pre-disposed to accept cost orientated pricing. This could mean that the 'market prices' used by Glacier Metal to establish PAP reflected the costs of manufacture of the products rather than the prices which the customers were willing to pay.

In an interview with a former senior Glacier Metal executive (55) it was suggested that PAP was successful in relating

EXHIBIT 5.7. : PRICE VERSUS DIAMETER FOR INJECTION MOULDED WHEEL CYLINDER CUP SEALS

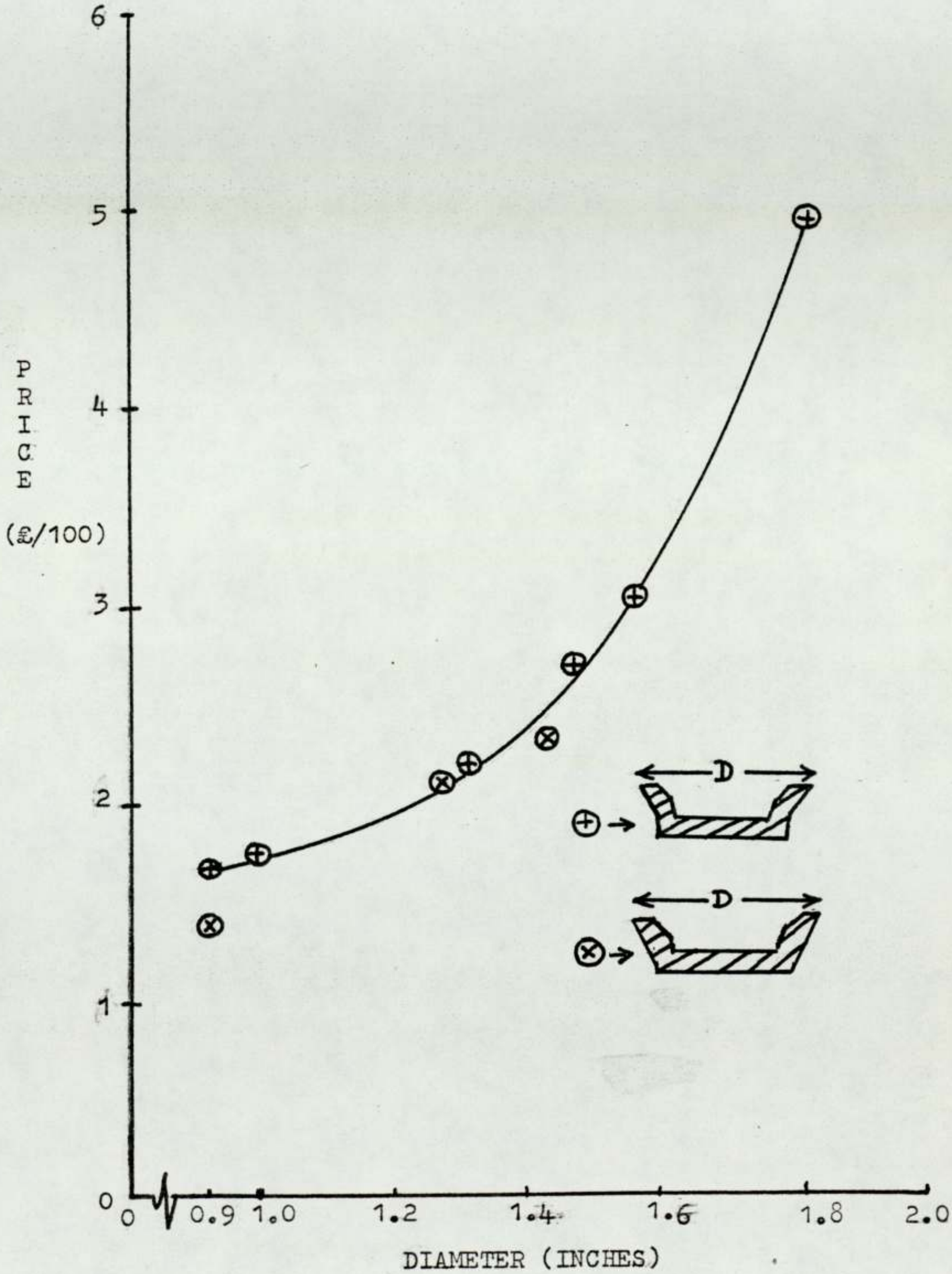
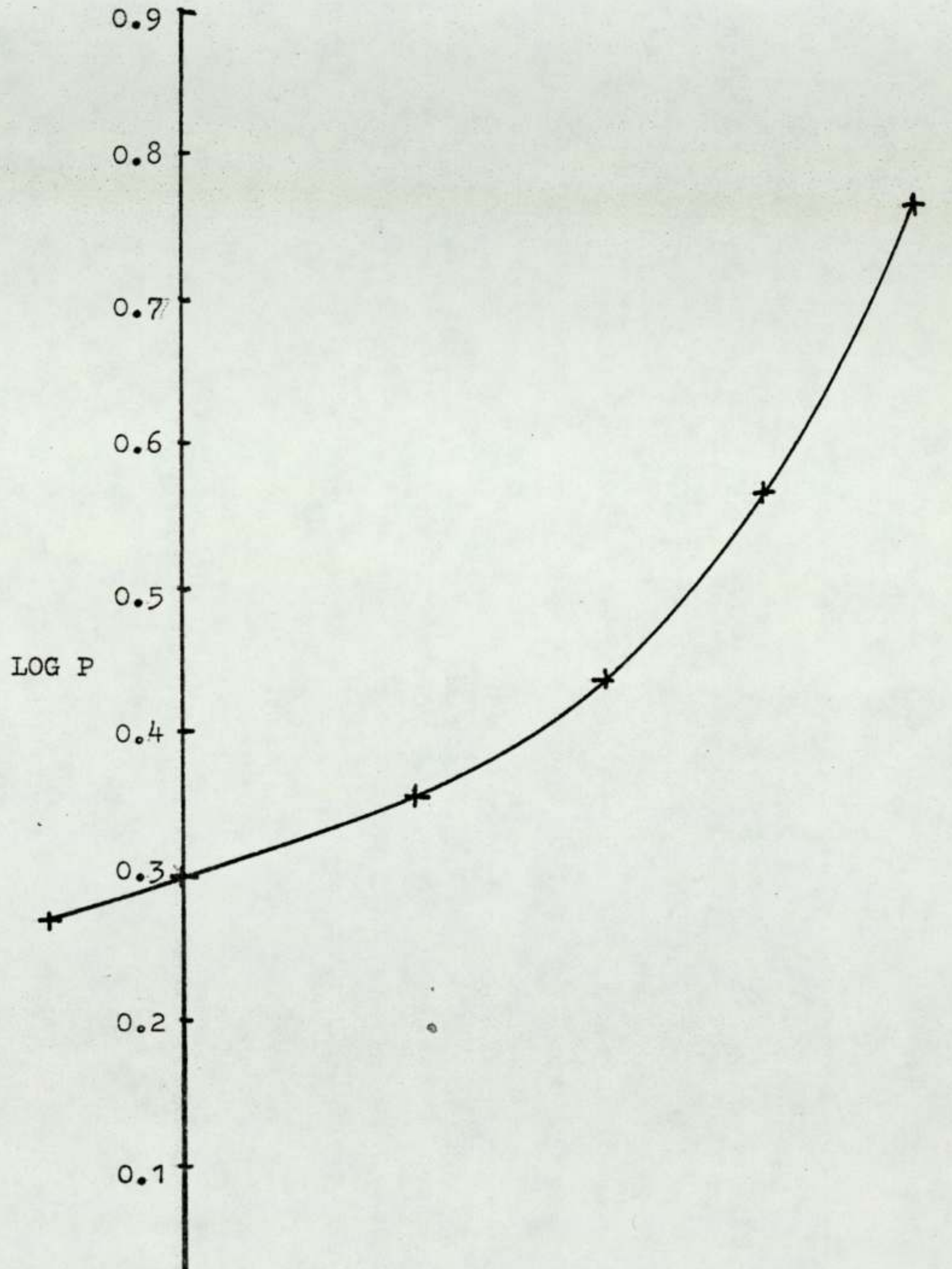


EXHIBIT 5.8. : LOGARITHMIC PLOT OF PRICE VERSUS DIAMETER FOR INJECTION MOULDED CUP SEALS



the product price to the parameters of the product because the parameters themselves affected cost patterns. For example, with automotive bearings, which are similar in design, the customer could have determined the price which he was willing to pay by estimating the input cost of machining. The cost of machining will in turn depend upon the length of the bearing. Thus the price will depend upon the length of the bearing.

In support of this argument it should be noted that PAP was more successful for relatively standardised automotive bearings than it was for thick-walled diesel bearings, the prices of which do not follow cost patterns so closely(53, 55).

It is therefore possible to suggest two equally valid explanations why the prices of high volume injection moulded products could be related to the product parameters while no relationship could be established between compression moulded product prices and the product parameters:

1. The high volume products, being regarded as more significant to both companies, may have been subject to more negotiation between the top organisations. The prices agreed may therefor have reflected the value which Automotive Products attributed to the products; the value may have been related to the operational parameters of the products as Brown's analysis would suggest.

or

2. The high volume products were subject to greater scrutiny by the Dunlop management, who were concerned that the prices

charged for the high volume products reflected the costs of manufacture. Since the parameters of the product affected the manufacturing costs (for example, the greater the diameter of the product, the smaller the number of cavities which could be fitted in an injection mould, thus affecting the number of parts produced per machine cycle) the price of the product would be related to the product parameters if a cost-plus pricing policy were adopted.

5.2.3.5 An Assessment of Product Analysis Pricing

Product Analysis Pricing failed to offer a successful method of small order pricing because of a fundamental flaw in the approach which was only revealed by the attempted implementation, it can only generate a rational pricing structure if the skeleton of that structure is already in existence. The skeleton structure did not exist for small order products; with the aid of hindsight it is clear that Product Analysis Pricing was not likely to be successful under these circumstances.

The exercise was not totally fruitless however, since it promoted the development of a new high volume pricing policy. The success of the new policy was not established by the end of the project at Skelmersdale, but no major problems had emerged.

The attempt to determine a pricing policy which was not related to small order product costs had failed; no suitable alternative to cost-plus pricing had been identified. It was therefore necessary to derive the most appropriate cost-plus pricing policy for small order products. The approach chosen will be described in section 5.3.

5.3 The Choice of a Policy - Quarter Platen Pricing

In order that a cost-plus pricing policy can be successfully operated it is essential that the costs used for the establishment of the prices are as realistic as possible. Unfortunately the product costing system at Skelmersdale did not appear to meet this condition (the weaknesses of the costing system at Skelmersdale will be more fully described in Chapter 7). Before product prices could be established it was therefore necessary to ensure that the product costs used in the price determination reflected what was realistically achievable with the Small Order Section resources.

In particular it was essential that the moulding direct labour cost, which constituted the largest single cost element in the product variable works cost, should be accurately determined. The existing direct labour costs were based upon the assumption that each press platen was loaded with the maximum number of cavities and that the press operator would be fully occupied at all times (see Chapter 6 for an explanation of the nomenclature). The system did not consider whether there was sufficient tooling available to achieve the maximum machine loading. The costs so determined were therefore ideal rather than realistically achievable standards.

In order to overcome these problems it was suggested that a new approach to moulding direct labour cost derivation should be adopted - the Quarter Platen Costing Approach. A detailed rationale of the system, together with a full description, will be given in Chapter 7. From its inception the Quarter Platen system was designed to meet two objectives:

1. To provide accurate standard cost information for labour cost control and stock valuation.

2. To provide information for a pricing system which reflected the fact that the customer met the cost of the design and manufacture of the production tooling. The Small Order Section compression moulds therefore represented an investment by Automotive Products in the Dunlop manufacturing facilities at Skelmersdale.

The pricing policy adopted was designed to generate a product price which reflected the investment by the customer in production moulds for that product. It was intended that the greater the investment in tooling, (that is, the larger the number of compression cavities which were held by Dunlop), the lower the unit price which Automotive Products would be charged. The existing system charged the same unit price, irrespective of the number of cavities which the customer had purchased.

In brief, the Quarter Platen System allocated a unit of press platen area (one quarter of the platen, approximately 9" by 9") to each product. The greater the number of compression cavities which were fitted onto the quarter platen, the greater the number of products which would be moulded per machine cycle, with consequently lower direct labour and machine overhead costs per part. Thus by determining the number of cavities which he purchased the customer would affect the variable cost of production; with a cost-plus pricing policy in operation, this in turn would affect the price which was charged. The product unit price therefore varied in inverse proportion to the number of cavities held for that product (the relationship between price and number of cavities was not directly inversely proportional since there were other costs associated with the manufacture, such as finishing and inspection costs, which did not vary in proportion with the cost of moulding the products).

The concept of the pricing policy was presented to the Skelmersdale management who agreed that a variable cost-plus pricing policy should be adopted for Small Order Section products, with the cost base being derived from the Quarter Platen costing approach. An investigation was then undertaken to determine the detailed cost structure which was to be used to derive the product costs; the findings of this investigation are described in Chapter 7. The full implications of the Quarter Platen Costing/Pricing approach are also described in Chapter 7 (Section 7.6).

5.3.1 <u>An Assessment of the Approach</u>

The Quarter Platen Pricing Policy was still essentially a cost-plus pricing policy and as such, suffered from a number of the weakness of that approach as described in Section 5.2.1.2. In particular in the absence of demand curve data it was not possible to identify sub-demand curve pricing and thereby reduce opportunity costs.

However the approach chosen did minimise price structure instability by offering the customer the facility to reduce the magnitude of the major cost element (the cost of moulding the products) by additional investment. This enabled the customer to make a conventional investment appraisal decision by comparing the cost savings which would accrue to additional expenditure.

Unfortunately the opportunity to make such a decision was never given to Automotive Products during the life of the project at Skelmersdale. Quarter Platen Costing was adopted for the derivation of product standard costs for the financial year commencing January 1976, but Quarter Platen pricing had not been adopted for Lockheed Department products by September 1977 when the project finished at Skelmersdale. Although the Dunlop management agreed that the pricing policy should be implemented as soon as possible, no action was taken to effect the implementation. It can only be concluded that the failure to carry out the agreed policy was symptomatic of the apathy which characterised the production and marketing of small orders; management efforts were almost invariably directed towards the resolution of high volume problems to the detriment of small orders.

The existing policy of adjusting all product prices to achieve an overall level of contribution towards fixed overhead was still in use throughout the department; individual product prices were not adjusted to reflect the costs of manufacture of each product. Since for all small order products, the 'quarter platen' derived cost was greater than or equal to the 'conventionally' derived cost, the commercial attractiveness of a number of the small order products was reduced without any attempt being made to adjust the prices and restore the price/ cost margins. The failure to implement the product cost plus pricing policy can therefore be regarded as making the small order products less commercially viable; the Skelmersdale management must be considered responsible for the decline in the viability of the Small Order Section due to their failure to act on this matter.

CHAPTER 6

The Production Process

At this stage it would be advisable to describe the production processes used to manufacture braking components in greater detail.. A description will be given of the equipment, some comment made on the condition of that equipment and the changes which occurred during the study.

The production process consisted of five principal stages:

Compound Mixing: The ingredients (polymer, vulcanising agents, accelerators, fillers etc) were mixed to form the basic compound.

Rubber Preparation: The compound was transformed into a shape acceptable for the moulding equipment.

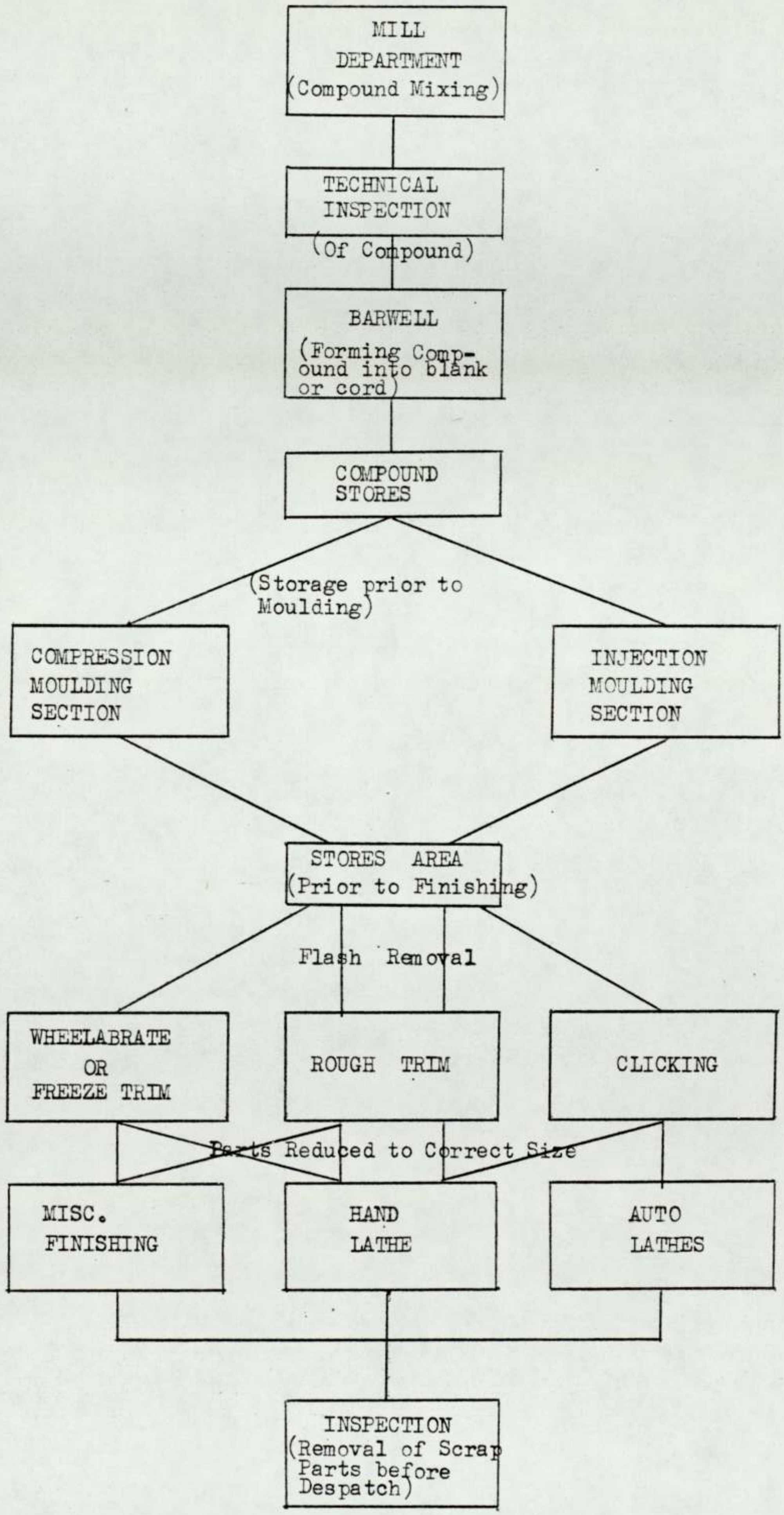
Moulding: The rubber was moulded into the basic shape which the finished component was to take.

Finishing: Excess rubber was removed from the part in order to meet the customer's specifications.

Inspection: Visual inspection of all parts in order to remove any substandard components.

The five stages, summarised in Exhibit 6.1, will now be described in greater detail.

EXHIBIT 6.1 : SIMPLE MODEL OF PRODUCTION STAGES OF MOULDING DEPARTMENT



6.1 Details of the Processes

6.1.1 Compound Mixing

Each component was made in a specified material developed to match the properties specified by the customer. At the start of the investigation 18 different compounds were in regular use for Lockheed Department components.

All compounds for the factory were mixed in the Mill Department which supplied the other manufacturing departments. The ingredients, consisting of the basic polymer, vulcanising agents, accelerators, plasticizers and fillers were mixed by mechanical action and heat; the resultant mixed compound was dropped onto a dump mill in batches of approximately 180 kilogrammes, was cooled and then palleted in sheet form. After sample testing the compound was then despatched to the other production departments.

6.1.2 Rubber Preparation

On entry into the Moulding Department*1 the rubber was formed into a shape acceptable for moulding. This was done by reheating the compound on a warming mill, rolling the resultant sheet to form a cylindrical tube known as a dolly and passing it through a ram extruding machine (a Barwell). The Barwell, which could accept up to 120 kilogrammes of compound at a time, extruded the compound into a long cylindrical tube of approximately 1 inch diameter.

*1 Approximately 18 months after the start of the project the Lockheed Department and General Moulding Department were amalgamated under the control of one Departmental Manager. The new department was known as the Moulding Department.

This strip was known as 'cord'. The machine also had the facility to cut the cord into small pieces as it emerged from the die to form 'blanks'.

There were two basic methods of moulding the rubber: injection moulding, which used continuous cord and compression moulding, which used rubber in blank form.

6.1.3 Moulding

6.1.3.1 Compression Moulding

Compression moulding was the traditional process used to manufacture brake mouldings. In this process an unvulcanised blank of specified weight was placed into a heated metal mould mounted on plates or 'platens'. The plates were mounted in compression presses of 80-100 tons closing force. When the press was closed the combination of heat and pressure caused the rubber to flow and fill the cavity. The flowing of the rubber took place approximately 1 minute after the press was closed, depending on the thickness of the mould and the quantity and type of rubber used. The pressure and heat were maintained for a further time in order to vulcanise ('cure') the rubber, i.e. form the polymer cross links which give rubber its normal elastic properties.

The moulds used to produce Lockheed parts by the compression method were generally of the single 'loose' cavity type, i.e. they produced one part per mould and were generally of a number of fixed heights to allow several different parts to be moulded on the same plate (the heights were usually $1\frac{1}{2}$-3" in $\frac{1}{2}$" increments). The number of moulds which could be fitted on a plate depended on the diameter of the mould. The diameter of the mould was described in terms of the 'nest size', i.e. the number of cavities of that type which could be fitted onto an eighteen inch square compression plate. Moulds were generally classified as 4, 6, 10, 18/20 or 28/30 nest size.

Two types of press were used to manufacture Lockheed compression moulded parts during the life of the project. In 1974 and 1975 steam-heated "two daylight" presses were used, to which two sets of moulds could be fitted per press. In 1976 electrically heated "single daylight" presses were introduced to replace the ageing steam heated equipment. Only one set of moulds could be fitted to each press, the use of electrical heating enabled higher temperatures to be employed; the cure time could be reduced from approximately 10 minutes to 3 minutes for most parts; giving comparable standard minute values per part.

When the cure cycle was complete the parts were removed from the moulds either by pliers or a high pressure airline, or in some cases by the pin-table stripping method. The pin-table stripping method was used for parts of a complex shape which were moulded around a loose core. In order to remove the parts from the mould, the loose cores with attached parts were ejected by means of a table of suitably arranged pins which were presented underneath the mould plate by hydraulic force. The parts were then removed from the cores by application of a high pressure air line.

The pin-table stripping method necessitated the removal of the mould plates from the press in order that the cores could be ejected; this was known as external stripping since parts were removed from the moulds outside the press. All steam presses used external stripping (because parallel opening limited access to the moulds). When electrically heated compression presses were introduced all stripping was performed internally, i.e. performed with the moulds still in the press. The pin-table stripping approach could no longer be used; parts which required this method were either deleted from the product range or manufactured in the laboratory (pre-production section) where steam heated presses were still in use.

After removal from the press the parts were taken to the Count, Sort and Check Section where the operator's claimed output was checked (a payment-by-results scheme was in operation) and the parts were stored prior to finishing.

6.1.3.2 <u>Injection Moulding</u>

Injection moulding of rubber products was introduced approximately 12 years ago using technology adapted from the plastics industry. In this process the rubber was fed into the machine in cord form and was preheated prior to injection into an electrically heated mould. Much shorter cure times could be achieved than with compression moulding due to the partial curing which occurred prior to injection; the rubber required only 45-90 seconds in the mould to be fully cured.

Each injection mould consisted of a number of cavities arranged radially around the injection point, the maximum number of cavities being determined by the diameter and the volume of the parts to be moulded. The cavities could be fed either by a radial runner system or by allowing a small gap between the two mould plates which permitted the rubber to flow into a mat covering the contacting faces of the mould ('flood feeding'). When the cure cycle was completed the mould opened automatically and the parts were removed by high pressure air line (the parts were either in a 'spider' form or mat form depending on the method or injection). The parts were then sent to the Count, Sort and Check Section prior to finishing.

6.1.4 Finishing

All parts were moulded with more compound than was actually required in the finished part to ensure complete filling of the mould. The moulded parts then had to undergo one or more finishing operations in order to remove the excess rubber (known as 'flash').

For the majority of boots and dust covers the flash was either removed by hand or by freeze trimming, i.e. freezing the parts with liquid nitrogen and bombarding them with small pellets in a machine known as a 'Wheelabrator'. The finishing method used was often dictated by the position and thickness of the flash.

Many of the seals produced by injection moulding were in mat form; the parts were removed from the mat by the use of a power press or roller trimming machine. Compression moulded seals did not usually require clicking since they were moulded individually. All seals however had to cut to the customer specified size using a lathe. The parts were fed onto a rotating chuck and held by vacuum to be cut by a trimming knife moving in a horizontal plane (tolerances of $\pm$ 0.01 were normal). Feeding of the parts onto the chuck could be performed either automatically or manually, low volume compression seals were normally cut on hand lathes because of the longer set-up times required for the automatic lathes.

After the cutting and trimming operations some of the parts underwent further operations such as drilling, venting, grinding and washing. A further proportion of critical parts were then oil tested to ensure that they did not swell excessively in the operating fluid; excessive swelling of the component in its final application could result in total failure of the braking system. The parts were then transferred to the Inspection Section.

6.1.5 Inspection

In view of the critical role played by the components in the final application, close inspection prior to despatch was essential. Each component was inspected visually for a number of faults. In addition to sorting the good parts from the reject parts, the inspectors were required to determine at which stage in the production process any faults arose whether moulding or finishing. The part-by-part reject figures were collated on a weekly basis; the resultant Scrap Report was one of the most important control documents used by the production and quality control departments.

Since inspection was an integral part of the process it was regarded as a direct operation, for which standard times were used; as with the moulding and finishing operations a payment-by-results incentive scheme was in operation. Following 100% inspection of parts a check was made on the efficiency of the inspectors, known as a vendor check. This check ensured that the inspectors are selecting at the correct quality levels. A sample was drawn from the inspected batch (the size of the sample being determined by the total batch size) and the parts were re-inspected. Depending on the results of the vendor check, the complete batch was then either sent for despatch or returned to the inspector for re-inspection.

6.2 Equipment Age and Condition

6.2.1 Moulding Presses

The multi-daylight steam presses in use at the start of the project were all approximately 40 years old, having been used by two other companies before finally arriving at Skelmersdale in 1966. The considerable use to which the presses had been subjected exhibited itself in several ways:

1. The platen guides were worn which often resulted in the presses jamming open; this considerably increased machine downtime, especially since the relatively low output of the machines meant that they often came bottom of the Engineering Department Maintenance priorities.
2. The hydraulics used to open and close the presses were in need to refurbishment. Not only did the frequent breakdowns hold up production, but also the oil leaking from the machines often flooded the floor making working conditions extremely unpleasant.
3. Several of the platens were bowed, resulting in misalignment of the moulds and consequently producing high scrap levels.

Whilst none of these problems was insurmountable, the cost of refurbishment at over £2000 per machine was felt to be prohibitive. Therefore at the end of 1975 when three single platen, electrically heated 'Hydramould' presses became surplus to requirements in the Girling Department at Skelmersdale it was decided that these machines should replace the steam presses in the Lockheed Department, which would be sold for scrap. The Hydramould presses were 7 years old and in considerably better condition than the equipment which they replaced. In addition these presses offered two major operating advantages:

1. The use of electrical platen heating enabled higher temperatures to be achieved than with the steam heated presses. Since the curing of rubber is a temperature related chemical process the cure times could be reduced without affecting quality and enabling shorter floor-to-floor cycle times to be achieved. The change of method was also seen as an opportunity to rationalise the cure times for the compression parts which at the start of the project ranged from 8 minutes to 14 minutes for similar parts in similar compounds (see later).
2. The Hydramould presses opened in an 'oyster' fashion which enabled stripping of the parts to be performed with the moulds still inside the press, thus saving the time which had been required to remove the moulds prior to stripping when using the parallel opening steam presses.

At this stage and as somewhat of a digression, the author was requested by Dunlop management to determine the number of machines which would be required and the utilisation which would be expected for the section, which was to form the foundation of a Lockheed Small Order Section (see section 6.3).

6.2.2 Moulds

Little was known about the age or condition of the moulds used to produce compression parts at the start of the project. In order to overcome this area of uncertainty, the author undertook an exercise to determine the age of the moulds and compare with the injection moulds which were used in the manufacture of high volume parts. (The exercise was also used as a means of introducing the author to the nature of the problem and the people involved). An attempt was also made to relate the age of the mould (or the number of charges which had been produced from the mould) to the reject figures.

The following approach was therefore taken:

1. The current (1974) Manufacturing List was examined and the parts contained therein classified into compression/injection and boots/seals. (There were a few parts for which both compression and injection tooling was available. However, the compression tooling was never used when injection tooling was available).
2. The Production Control Department Tooling Records were examined and the date of commission was obtained for each part mould. An injection mould is not strictly comparable with a loose compression mould since the injection mould may contain up to 36 inserts, each of which produced one part per cycle, whilst the compression mould generally only produced one part per cycle. To allow comparability the number of inserts for both injection and compression were used in the comparison. The number of inserts available for each age class is summarised in Table 6.1.

Table 6.1 Number and Age of Inserts as of September 1974

PRODUCTION METHOD	PRODUCT TYPE	NUMBER AND AGE OF INSERTS (YRS)								MEAN AGE (YRS)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7+	
Injection	Seals	370	98	86	221	331	36	0	0	2.8
	Boots	118	54	63	55	21	2	16	0	2.3
Compression	Seals	0	38	27	33	29	11	17	241	7.1
	Boots	6	2	4	21	109	149	107	610	6.4

The distribution of the cavity ages can be seen in Exhibit 6.2.

3. The reject figures for the different classes of part were drawn from the cumulative scrap report. The arithmetic mean number of rejects were compared with the mean mould age data but no statistically significant correlation could be found between the age of a mould and the reject figures for the parts produced from that mould; other factors must have been more important than the simple age or use which was made of the mould.

The major findings of this exercise can be summarised as:

1. Compression moulds were, on average, three times older than the average injection mould. The distributions for compression moulds were strongly negatively skewed showing that the compression moulding process had been established for a considerably longer period than the injection moulding process. Generally any new medium or high volume business which was obtained after the establishment of the injection moulding section was

commissioned for injection moulding; an embargo on the purchase of new compression tooling was issued by the Product Manager. Only occasional replacement of damaged compression tooling was allowed.

The distributions therefore reflect the gradual change which had occurred as the majority of Lockheed business had been transferred from compression to injection moulding.

2. The discovery that the compression moulds were so old raised questions about the condition of the moulds and the extent to which tool condition contributed towards reject levels. A major exercise was undertaken to determine tool conditions and indicate which moulds could be refurbished, which were satisfactory and which must be scrapped. At a later stage in the project a full time tool control section was established whose role was to determine and maintain the conditioning of all tooling (including Lockheed compression moulds) in the North Factory area.

6.2.3 Finishing Equipment

Although the majority of the finishing equipment was relatively aged and had zero book value (with the exception of the Wheelabrator) there appeared to be few problems associated with its operation. The simplicity and ease of maintenance of the majority of the equipment ensured relatively low downtime. In addition the majority of finishing scrap could be attributed to incorrect setting-up (generally of lathes) rather than wear on the machines inherently producing scrap.

6.3 The Establishment of a Small Order Section

In the last quarter of 1975 it was decided by the Dunlop management to establish a small order moulding section, which could be expanded to incorporate finishing facilities at a later date. The reasons for this move can be classified into psychological, operational and administrative categories:

6.3.1 Psychological

When the small order section was incorporated in a high volume production section there had always been a tendency to concentrate on high volume production to the detriment of low volume production. Production supervision did not always devote as much time to ensuring that the standard processes were being followed on low volume production with a high scrap level being the consequence (low volume production is rather less automated than high volume and is therefore more dependent on operator skill). Similarly, whenever there were process or equipment problems the low volume one always came low down in the process engineering and maintenance engineering priorities; this often resulted (it was felt) in greater downtime than was strictly necessary.

Dunlop management believed that by initiating a physical separation there would be a reduced tendancy to think of small volume production merely as the 'tail end' of the total production but rather to consider it as a separate and important entity. It was also felt that separation would encourage a study of a much neglected area and allow easier identification of the major problems associated particularly with small volume production in Skelmersdale.

6.3.2 Operational

Small order production had been regarded for some considerable time by production management as a restriction on efficient high volume production by taking up scarce resources when they are required by the high volume business. By a physical separation it was hoped that the small batch, low running time to set-up time production could be concentrated in an area which was more able to cope with it, leaving the long running production to be achieved unhindered.

6.3.3 Administrative

As long as small order production was undertaken in the same area as high volume production it was difficult to determine the operating characteristics of small orders both in physical and cost terms; the figures obtained for the complete section reflected the operating characteristics of the high volume operation 'swamping out' the small volume results by sheer weight of numbers. For example, reject figures and overhead apportionments were calculated for the complete section; even if the small order figures were significantly deviant from the large order figures they would not affect the overall performance figures appreciably.

Standard times and costs were determined for the complete operation; for small orders this can result in a considerable underestimation of set-up and wasteage allowances.

By physically separating small volume from high volume production it was hoped that an administrative separation would also be achieved which would enable more meaningful performance parameters to be set. In addition a physical separation was expected to assist an effective cost control to operate; cost reports for the complete production area were of only limited value since the high volume figures tended to dominate the results.

6.3.4 Discussion of the Decision

The decision made by Dunlop management to establish a separate small order moulding section illustrates the essential difference in approach between the pragmatic managerial style and that required by a more rigorous academic discipline. The decision was made with little concrete evidence to suggest that it would be a worthwhile exercise; it relied mainly on the instinctive feelings of the production management.

The author was requested by the management to determine what moulding resources would be required and how they should be used (in terms of number of operatives and shifts operated). The resource estimation was to be based upon the Quarter Platen standard time approach which was being developed at the time of the decision and the then current six month tentative forward schedule. A more trustworthy forecast of future demand would have been preferable (and was later undertaken - see Chapter 9) but limited time did not permit a more rigorous approach to be adopted for the decision. The exercise was also used to evaluate the alternative approaches which had been suggested to load the platens and determine product moulding standard minute values (see Chapter 7).

Whilst the decision to establish a separate moulding section was not based upon very firm data, it must be admitted that the existence of a separate section did facilitate the investigation of small order production performance; whether any increase in the efficiency of operation was achieved was difficult to determine.

CHAPTER 7

Costing - The Need For A New Approach

7.1 Rationale

In the last quarter of 1975 it was decided, after discussion with the Product Manager, Mill and Moulded Products Group, that the existing system of scheduling and particularly costing, compression moulded production was unsatisfactory. The major reasons for dissatisfaction with the existing costing and scheduling system were:

7.1.1 Problems with the Existing System

7.1.1.1 Platen Loading

The Industrial Engineering Department provided the Accounts Department with two standard times for each part: the standard stripping time per cavity and the press constants (the total standard time to open and close the presses which were used for compression moulding). The nest size of the moulds was also provided, i.e. the maximum number of cavities of that type which could be loaded on a standard 18" square platen. To determine the standard minute value per hundred parts the press constants were divided by the nest size, added to the cavity stripping time and multiplied by 100. (In order to obtain more easily handled times, standard times in the department were generally quoted in terms of time/100 parts).

The underlying assumption behind this approach was that the press was always fully loaded at all times (relying on the Production Planning and Control Department to fill the platens with compatible parts). The system did not consider whether the tooling (which was purchased by the customer) was available in order to achieve this ideal. Since the selling price was partially determined by the cost to Dunlop, and the cost very dependent on the cost of moulding, it was essential that this cost should have been based upon what was realistically achievable rather than the lowest possible (theoretical) cost.

7.1.1.2 Unoccupied Time

The amount of unoccupied ('process') time was also dependent upon the availability of tooling; with one man operating several machines it was not always possible to schedule each machine such that the man spent no time waiting for the next machine to open. The existing system did not allow for any unoccupied time.

7.1.1.3 Blank Confusion

With the existing system used to schedule compression moulding any number of different parts could be loaded on a single platen (with the constraint that no man should be asked to work a set up with more than 17 different part types in total). There was considerable evidence in the form of quality control reports to suggest that incorrect blanks were sometimes loaded into the moulds. Not only did this confusion affect the ease of moulding and finishing (due to insufficient or excess rubber to make the part) but also constituted a potential safety hazard, since, if the wrong compound were used for seals, premature failure in operation could result.

It was therefore felt desirable that the number of different parts operated on each machine should be restricted as far as was practicable.

7.1.2 <u>Specification of New Costing Approach</u>

Given the weaknesses of the existing system which was used to determine standard minute values it was possible to specify the general characteristics of an improved approach:

7.1.2.1 It should be as simple as possible to operate.

7.1.2.2 It should reflect the potentially achievable tooling for each part so that the customer was offered a choice of:-

(i) High capital investment (in tooling) and lower piece part price.

(ii) Low capital investment and higher piece part price.

7.1.2.3 If, because of the limited availability of tooling, the operative must be unoccupied during the work cycle this time should be costed and included in the variable cost calculation.

7.1.2.4 As little change should be made to the existing system as possible to reduce the need to retrain staff to handle the system.

7.2 Objectives of the Investigation

Since the introduction of the new approach to costing was intended to coincide with the establishment of a separate small order moulding section the exercise to design the labour costing system had a secondary objective to determine what moulding resources, in terms of men and machines, would be required to meet the likely demand for small orders (see Chapter 6).

The objectives of the exercise could therefore be summarised as:

7.2.1 To determine different alternative approaches to labour costing which would posses the characteristics outlined in section 7.1.2 and assess the alternatives in terms of operating implications and costs.

7.2.2 Using the standard times obtained from the alternative chosen, to determine the resources, using this method of platen scheduling, which would be required to meet demand.

7.2.3 To design and implement the system for the financial year commencing January 1976.

7.3 Generation of Alternatives

It was suggested by the Product Manager (Mill and Moulded Products) that a suitable base upon which to build a standard labour cost would be platen area. In effect the customer would be sold a unit of platen area, in units of $\frac{1}{4}$ or $\frac{1}{2}$ platen, which could be used economically (or uneconomically) depending upon the number of moulds purchased for a part. One unit of platen area would be allocated per part and the customer could purchase as many moulds as he wished, from one cavity to the maximum required to fill the $\frac{1}{4}$ (or $\frac{1}{2}$) platen. The greater the number of cavities per $\frac{1}{4}$ (or $\frac{1}{2}$) platen the lower would be the standard minute per part and the unit price charged to the customer would be reduced (if a cost - plus pricing policy were in operation).

The choice of $\frac{1}{4}$ or $\frac{1}{2}$ platen as the unit of platen area was made because it was felt that this represented a reasonable area in view of the relatively low annual schedules for compression parts and the tooling which was available. Any area larger than $\frac{1}{2}$ platen would have required the customer to purchase a large number of cavities which would not have been justified by the likely schedules, even if it made better use of the press area, and would have required a very large number of mould changes to be made each week.

In addition it was suggested that the double daylight presses should be modified to operate only as single daylight with external stripping since it was felt by the Engineering Department that many of the platen jamming and distortion problems could be overcome by this method of operation. The author was asked to evaluate the feasibility in terms of cost of operation for single daylight operation for both quarter and half platen loading schemes.

For the sake of simplicity it was decided to limit the number of different parts handled by any one operative to 16. Thus, if a quarter platen/part approach was adopted one man could operate 2 double daylight presses or 4 single daylight presses; for half platen operation one man could operate 4 double daylight presses or 8 single daylight presses.

The initial investigation was confined to a comparison of quarter versus half platen moulding; a comparison between double daylight and single daylight operation was made at a later stage.

7.4 Quarter Platen Versus Half Platen Loading

7.4.1 Methodology

7.4.1.1 The tentative 6 month schedule (period 8, 1975 to period 3, 1976) provided by Automotive Products was taken as representative of demand for compression moulded products.

7.4.1.2 The number of cavities available for each part number listed as the schedule was determined from Process Engineering Department records, together with the nest size (the number of cavities which could be fitted on a platen) and standard cure time.

7.4.1.3 The standard stripping times for each part were obtained from the Industrial Engineering Department records.

7.4.1.4 By dividing the nest size by 4 (2 for half platen approach) the potential maximum number of cavities which could be loaded on a $\frac{1}{4}$ ($\frac{1}{2}$) platen was determined and compared with the actual number of cavities available. The smallest of the two figures was taken as the $\frac{1}{4}$ ($\frac{1}{2}$) platen loading, (n). Any cavities in excess of that number required to fill $\frac{1}{4}$ ($\frac{1}{2}$) platen were disregarded for the purposes of the calculation unless there were sufficient cavities to fill an extra complete unit of platen area.

7.4.1.5 The annual call-off for each part was increased by the average reject figure obtained from the cumulative Reject Report for 1975. Using the total moulding requirement so obtained two weighted averages were calculated; the weighted average number of cavities per $\frac{1}{4}$ ($\frac{1}{2}$) platen and the weighted average stripping time to load and unload each part on the platen.

The results of this exercise were:

	$\frac{1}{4}$ Platen	$\frac{1}{2}$ Platen
Mean Cavity Stripping Time (basic minutes)	0.086	0.086
Average Cavity Loading Per Unit Platen Area (n)	5.00	4.00

7.4.2 Calculation of Cycle Times

To average cycle time for the two types of press loading could be calculated using the formula:

$$\text{Cycle Time (std minutes)} = \left[X\ (S.N. + P) + Y\right](1 + RA)(1 + CA)$$

Where:

X = No. of platens/press = 2 (for double daylight operation)

S = Stripping Time/Cavity = 0.086 basic minutes

N = No. of Cavities/Platen = 4n ($\frac{1}{4}$ platen), 2n ($\frac{1}{2}$ platen)

P = Platen Constants = time to open and close the press = 0.316 basic mins/platen

Y = Cure Time

RA = Rest Allowance = 18% (a negotiated allowance for the whole department)

CA = Contingency Allowance = 7% (from Industrial Engineering Department Incentive Scheme).

7.4.3 Standardisation of Values

7.4.3.1 Cure Time

At the start of the investigation cure times for compression moulded parts ranged from 8 minutes to 14 minutes. The reasons for this variation were not clear, but it was suggested that the differences in the cure times could be more easily explained in terms of the attitudes prevalent at the times of introduction of the parts to the Department than to any particular technical requirement of the products themselves. In an attempt to standardise the cure times an exercise was undertaken by the Technical Department to determine whether a single standard cure time could be introduced for all compression moulded products.

As a result of the exercise it was found that all parts could be manufactured satisfactorily using a seven minute standard cure time with the exception of four parts.

Since all four parts were 'pin-table' stripping parts which were not to be included in the Small Order Section (see section 7.4.3.2) no particular problem was presented by the cure time; a standard 7 minute cure was assumed for the calculations.

7.4.3.2 Pin-Table Stripping

After examination of the schedule and stripping methods it was recommended that pin-table stripped parts (see Chapter 6 for description of process) should not be included in the Small Order Section. The major reasons for this recommendation were:

(1) Special equipment was required for the presses (the pin-table itself) and yet pin-table work formed less than 3% of the then current 6 month schedule.

(2) Making full use of existing tooling, a pin-table press could not be run in conjunction with another press which used a more conventional form of stripping (air line or plies) without very high machine interference. (The average pin-table set-up required 11 minutes of outside work to fit into a 7 minute cure).

In order to run a pin-table set-up in conjunction with a conventionally stripping press without high intermachine interference would have required:

either (i) An extended (and unnecessary) cure time on the other press, or (ii) Underutilisation of potential pin-table tooling.

(3) After the examination of potential cure times for steam compression manufactured products part types were found which could not be fitted into a standard 7 minute cure; all of these parts were pin-table stripped parts with minimum potential cure times for the available equipment of 10 minutes, 9 minutes and 8 minutes. Thus in addition to the longer than normal work content an abnormally long cure time would also have to be operated.

(4) Quarter (or Half) Platen costing could not be used for the pin-table parts since it was not possible to produce more than one part type from each platen; the pin-table configuration was unique to each type of part. If more than one part type were to be produced from a single pin-table the moulds and pin-tables would have required redesign - an expense which the projected revenue did not justify. Certain managers at Skelmersdale (notably the Product Manager) were reluctant to lose what they felt might be a potentially large area of business (even if the current schedules did not suggest it). Two alternatives were then suggested which would enable some control to be kept of pin-table business in view of future developments. The alternatives were:

(i) To run a separate pin-table press on a one man/one machine set up as the schedule requires (possibly in the Prototype Section).

(ii) Disposal of the parts to a moulding contractor who already sub-contracts for Dunlop on certain difficult parts. If the demand for pin-table parts were to increase to a level which justified a full time set-up in the plant, the work could be brought back into the factory.

After examination of the alternatives, it was decided that alternative (i) should be adopted; pin-table parts were to be manufactured as the schedule required in the pre-production (prototype) section, prices being charged at the prototype rate.

7.4.3.3 Cavity Stripping Times

An examination of the cavity stripping times for parts on the schedule revealed a very large spread of times for parts which was not justified by the range of parts under consideration; very similar parts with the same stripping method often had widely differing stripping times. Two possible explanations were suggested:

7.4.3.3.1 Many of the compression parts had not been re-examined by the Industrial Engineering Department for several years. It was the practice to negotiate the 'standard' minute values in productivity agreements; this often resulted all standard times being reduced by an agreed factor for a particular class of parts. When a new product was introduced subsequent to the productivity agreement the standards determined for the parts were not factorised. Thus as time went on the 'standard' times for the older parts became increasingly removed from the 'time' standard.

7.4.3.3.2 Different assumptions (in terms of platen loading, number of machines operated by one man etc.), had been made by the Industrial Engineering Department in determination of the standards at different times. Little apparent attempt had been made to ensure that all the standards had the same base..

The Industrial Engineering Department was therefore asked to determine the standard stripping times for two classes of parts - those for which pliers were used to remove the finished part from the mould (Class A) and those which relied upon a high pressure air line for part removal (Class B). MTM 2 patterns were used in the determination of the standard times. The results of this exercise were:

EXHIBIT 7.1

	¼ PLATEN LOADING	½ PLATEN LOADING
Average Cavity Loading per unit area	5.0	4.0
Average Stripping Time per part (Basic Minutes)	0.096	0.096

<u>Class A</u> - plier strip

(i) 4 cavities/$\frac{1}{4}$ platen = 0.106 Bm/cavity

(ii) 5 cavities/$\frac{1}{4}$ platen = 0.101 Bm/cavity

(iii) 6 cavities/$\frac{1}{4}$ platen = 0.098 Bm/cavity

<u>Class B</u> - air line strip

(i) 4 cavities/$\frac{1}{4}$ platen = 0.079 Bm/cavity

(ii) 5 cavities/$\frac{1}{4}$ platen = 0.075 Bm/cavity

(iii) 6 cavities/$\frac{1}{4}$ platen = 0.072 Bm/cavity

A similar exercise was undertaken to determine the cavity stripping times for half platen loading. Applying the scheduled volume as a weighting factor for each class of part the average stripping times and cavity loadings were determined, shown in Exhibit 7.1.

<u>Class A</u>

No. of parts = 31

Volume (including scrap) = 271377 parts

% of total volume = 76%.

<u>Class B</u>

No. of parts = 12

Volume (including scrap) = 84503 parts

% of total volume = 24%.

7.4.4 <u>Comparison of Different Loading Systems</u>

There was now sufficient trustworthy information to compare the performance of the two machine loading systems for different numbers of cavities (n) per unit area. The evaluation was performed for three possible situations:

* With the existing tooling which was available for quarter and half platens.
* With the possible purchase of extra tooling to increase the average cavity loading per unit platen area.
* With the transfer of relatively high volume parts to injection moulding.

7.4.4.1 Existing Tooling

7.4.4.1.1 Direct Labour Cost/Part

Cycle Time (std mins) = $[\bar{X}(S.N. + P)+Y](1+RA)(1+CA)$

N = No. of Cavities/Platen =ZN

where n = no. of cavities per unit area

Z = no. of unit areas per platen = 4(¼ platen), 2(½ platen)

S = Stripping Time/Cavity = 0.096 basic mins/cavity

Cycle Time (std mins) = $[2(0.096 \times Zn + 0.316) + 7](1.18)(1.07)$

$= 0.242\ Zn + 9.636$

Cycles/Shift = $\frac{\text{Time Available/Shift}}{\text{Cycle Time}}$

Time Available/Shift = (480 minutes - 14 minutes'empty out' allowance)= 466 std mins.

Cycles/Shift = $\frac{466}{(0.242\ Zn + 9.636)}$

Parts/Shift = Cycles/Shift x Parts/Cycle

Parts/Cycle (complete set up) = 2 ZnM

where M = No. of machines operated per man

Parts/Shift = $\frac{466 \times 2\ ZnM}{(0.242\ Zn + 9.636)}$

$= \frac{932\ ZnM}{(0.242\ Zn + 9.636)}$

Labour Cost per shift = £11.33
(From incentive scheme at std performance)

$$\text{Labour Cost/part} = \frac{\text{Labour Cost/Shift}}{\text{Parts/Shift}} =$$

$$\frac{0.294}{M} + \frac{11.714}{ZnM} \text{ pence/part}$$

$$= 1/M\ (0.294 + \frac{11.714}{Zn})$$

For $\frac{1}{4}$ platen $M = 2,\ Z = 4$

$$\text{Cost/Part (p)} = 0.147 + \frac{1.464}{n}$$

For $\frac{1}{2}$ platen $M = 4,\ Z = 2$

$$\text{Cost/Part (p)} = 0.074 + \frac{1.464}{n}$$

The cost/part for different values of n is calculated in Exhibit 7.2.

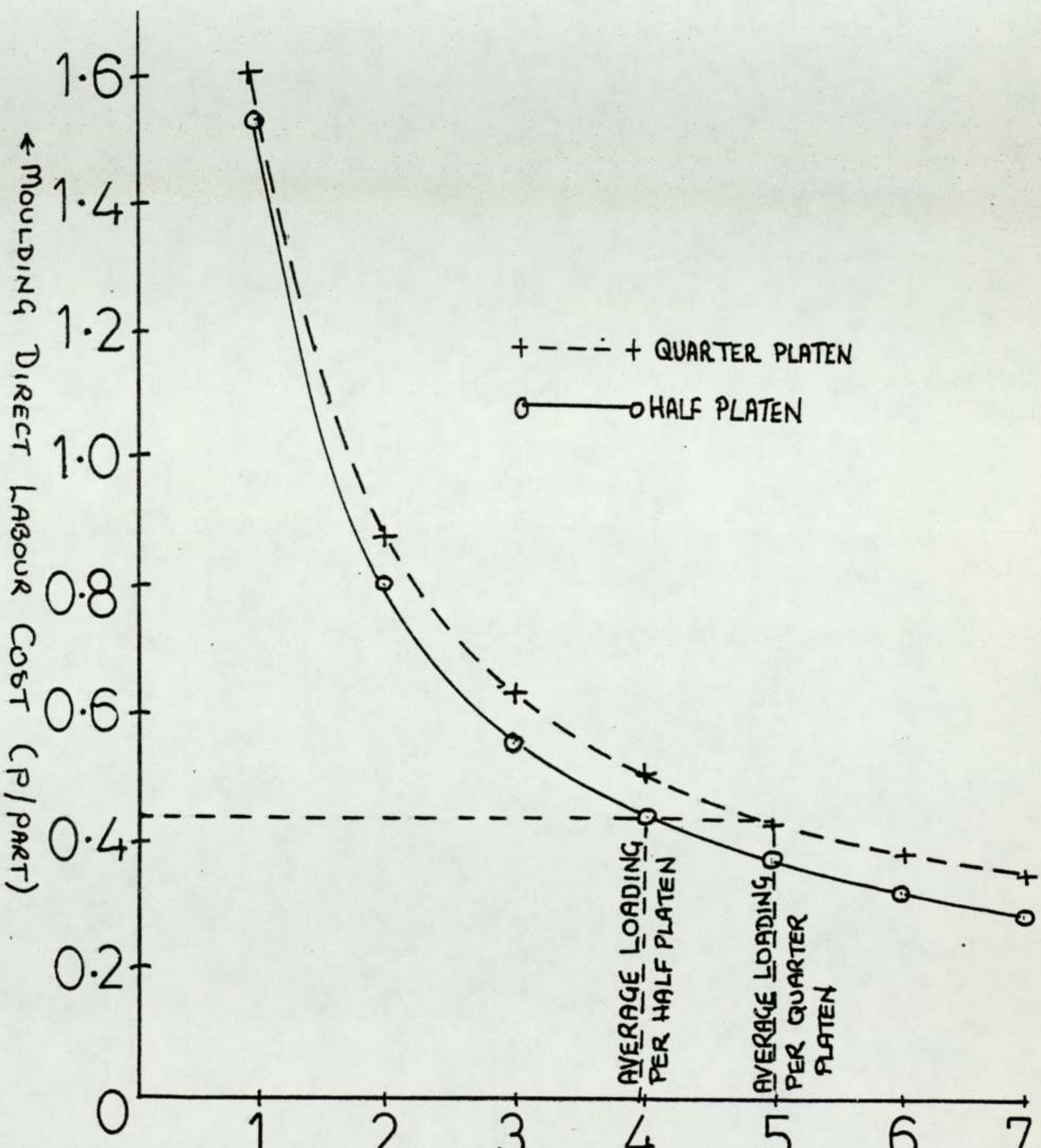
The results of the comparison may be seen in Exhibit 7.3.

In terms of direct moulding labour cost and with the existing tooling, the half platen machine loading system appeared to be as economical as the quarter platen system. Labour costs could not be considered in isolation however, for the half platen loading system required one man to operate four rather than two machines; machine running costs per part are likely to be higher for the half platen operation.

EXHIBIT 7.2 : DIRECT LABOUR COST FOR DIFFERENT PLATEN LOADINGS

n (CAVITIES /PART)	AVERAGE MOULDING LABOUR COST(PART(p/part)	
	¼ PLATEN LOADING	½ PLATEN LOADING
1	1.611	1.538
2	0.879	0.806
3	0.635	0.562
4	0.513	0.440 (Existing tooling)
5	0.440 (Existing tooling)	0.367
6	0.391	0.318
7	0.356	0.283

EXHIBIT 7.3. : DIRECT LABOUR COSTS FOR QUARTER AND HALF PLATEN LOADING



7.4.4.1.2 Machine Running Costs

The cost of utilities (process steam and electricity) was likely to be higher for half platen than quarter platen operation; the difference was examined in order to determine the effect of the running costs on the product costs. It was also possible that maintenance costs would be higher for half platen operation, but this was only to be considered if necessary, since maintenance costs per machine were rather more difficult to determine.

(1) Steam Costs

Unfortunately there was no metering of the steam used by the Lockheed Department presses at the time of the investigation.. It was therefore necessary to use the Engineering Department apportionment of steam usage for a relevant period and determine the number of machines supplied with steam during that period. After consultation with engineering and production staff a number of assumptions were made:

* The apportionment of steam usage was fair.
* The presses were only supplied with steam during working days.
* A press supplied with steam used the same amount of steam whether it was being used for moulding or not.

Cost of Steam

Steam Usage for July 1975 (apportioned process steam, whole Lockheed Department) = 342,585 lbs steam.

1 ft^3 gas = 1.06 lbs steam. Gas cost = 0.1 p/ft^3.

Unit steam cost = 0.106 p/lb steam.

Usage of Steam

Number of working days in period = 12 days = 36 shifts.

Number of machines supplied with steam in period = 6.

Average usage/machine/shift = 1586 lbs steam.

∴ Cost/Machine/Shift = 168p/Machine/Shift.

(2) Electricity Cost

As with steam usage, there was no metering of the presses or sections; usage was only measured for the department as a whole. The Engineering Department retained records of maximum kilowatt usage for all the steam presses used in the Lockheed Department; it was this figure which was used to estimate the electricity cost per machine.

Estimated maximum usage for 16 machines (Jan 1974) = 70kw.

Usage/Shift = 560 kw-hr. Usage/Machine/Shift = 35 kw-hr.

Unit Electricity Cost (from Engineering Department) = 1.107p/kw-hr. Cost/Machine/Shift = 38.75p/machine/shift.

(3) Total Utilities Cost

Total cost of utilities/machine/shift = 168 + 38.75 = 206.75p. Total cost of utilities/shift = 206.75 M.

From Section 7.4.4.1.1 : Parts/Shift = $\frac{932\ ZnM}{(0.242\ Zn + 9.636)}$

Average Utilities Cost/part = $\frac{\text{Total utilities cost/shift}}{\text{Total parts/shift}}$ =

$$\frac{205.75\ M\ (0.242\ Zn + 9.636)}{932\ ZnM} = 0.054 + \frac{2.138}{Zn}$$

Direct Labour Cost/part = $\frac{0.294}{M} + \frac{11.714}{ZnM}$

Utilities Cost/part = $0.054 + \frac{2.138}{Zn}$

Sum of Direct Labour and Utilities Cost/part =

$$\frac{1}{ZnM}\ (0.054\ ZnM + 0.294\ Zn + 2.138\ M + 11.714)$$

For $\frac{1}{4}$ Platen M = 2, Z = 4

$$\text{Cost/part (p)} = \frac{1.999}{n} + 0.201$$

For $\frac{1}{2}$ Platen M = 4, Z = 2

$$\text{Cost/part (p)} = \frac{2.533}{n} + 0.128$$

These formulae were used to determine the direct labour and utilities cost for different platen loadings in Exhibit 7.4 (also summarised in Exhibit 7.5).

7.4.4.1.3 Discussion

As can be seen from Exhibit 7.5, with the existing tooling quarter platen machine loading offered a 21% average saving per part when the cost of utilities was considered. Before half platen loading was completely abandoned however, it was felt that the effect of two possible situations should be made to determine whether there would be any change in the relative advantage of quarter platen over half platen machine loading, namely the purchase of extra tooling and the transference of the higher volume compression parts to injection moulding.

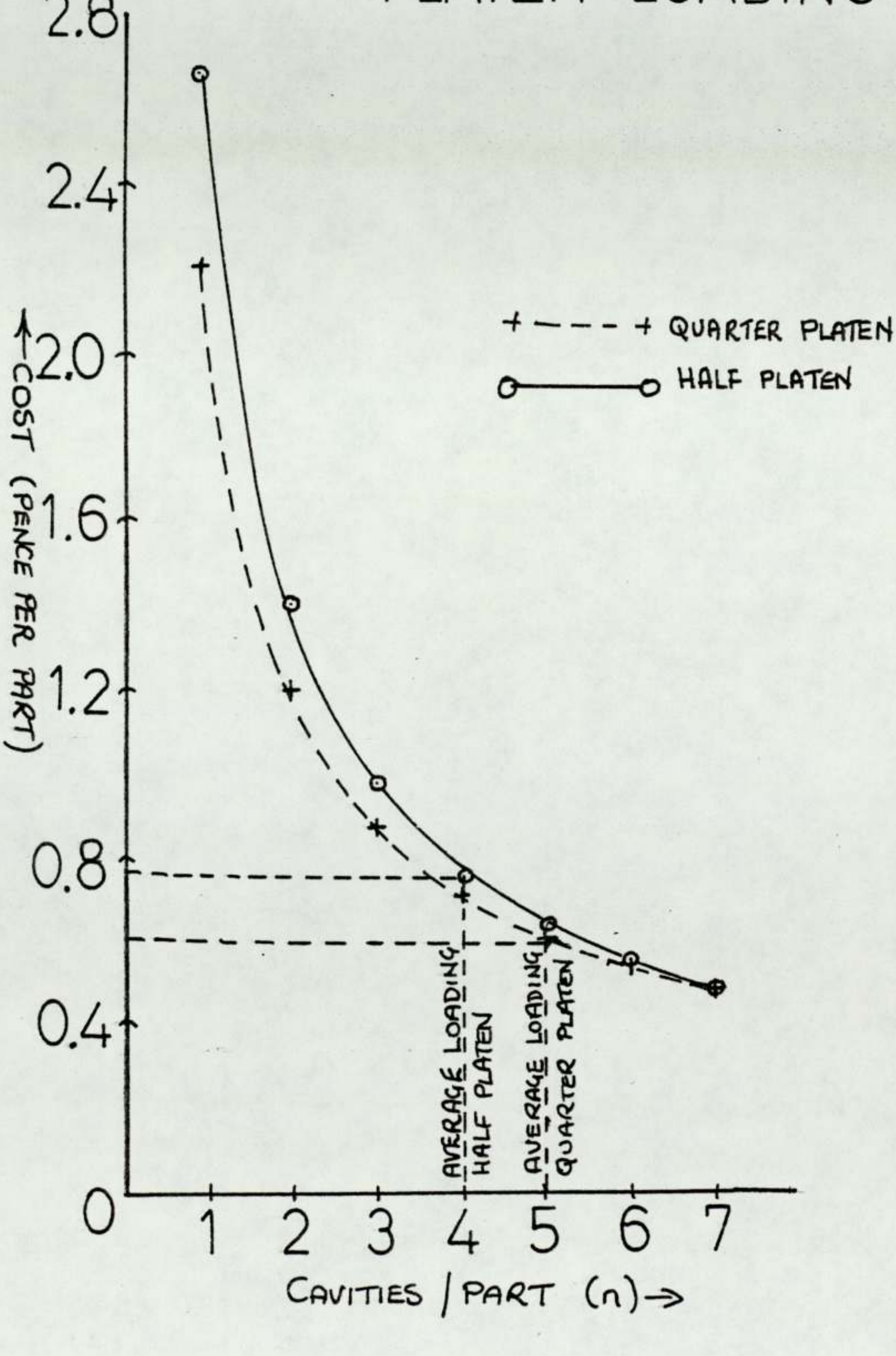
7.4.4.2 Purchase of New Tooling

It was suggested that, by purchase of new tooling, the quarter platen machine loading approach might not offer such a significant advantage over half platen loading. It was also suggested that, it a significant saving could be achieved by purchase of new tooling, Dunlop might purchase the moulds themselves.

EXHIBIT 7.4 : DIRECT LABOUR AND UTILITIES COSTS FOR DIFFERENT PLATEN LOADINGS

n (CAVITIES /PART)	AVERAGE MOULDING LABOUR AND UTILITIES COST (p/part)	
	$\frac{1}{4}$ PLATEN LOADING	$\frac{1}{2}$ PLATEN LOADING
1	2.200	2.661
2	1.201	1.395
3	0.867	0.972
4	0.701	0.761 (Average)
5	0.601 (Average)	0.635
6	0.534	0.550
7	0.487	0.490

EXHIBIT 7.5. : DIRECT LABOUR AND UTILITIES COSTS FOR QUARTER AND HALF PLATEN LOADING



The first stage was to determine the maximum number of cavities which could be operated without intermachine interference (i.e. such that the work content of the other machine(s) fit into the cure time of the lead machine) and thereby maximise labour utilisation.

For 2 daylight operation the work content of each of the other machines (assuming a balanced situation with the work contents of each machine equal) is given by the equation

$$= 2\ (SZn + P)(1 + CA)$$

W = Work Content of each machine(basic minutes)

S = Cavity Stripping Time

Z = No. of unit areas per platen

n = No. of cavities per unit area

P = Platen Constants

CA= Contingency Allowance

M = No. of machines operated per man

The percentage unoccupied time $U = \frac{Y-(M-1)W}{\text{Cycle Time}}$

<u>For the existing situation:</u>

(1) $\frac{1}{4}$ Platen n = 5

$$U = \frac{7 - 4.79}{14.36} = 15\% \text{ Unoccupied Time}$$

(2) $\frac{1}{2}$ Platen n = 4.0

$$U = \frac{7 - 6.96}{11.58} = 0.3\% \text{ Unoccupied Time}$$

An improvement in average tooling could only be made to the quarter platen loading system since the half platen system would fully occupy the operative with the existing tooling.

A maximum of 7 cavities could be operated with the quarter platen system; the maximum being determined by the physical size of the platens, not the machine interference.

With 7 cavities/quarter platen the unoccupied time would have been reduced to 4% and an average saving of 0.114p per part achieved. The capital investment required was estimated at £24,000 (300 extra cavities at £80 per cavity) which, at the current schedule levels, would be paid back in 3½ months. Dunlop management however, decided to defer any capital investment in tooling until after the small order section had been set up and could be seen to be operating smoothly.

7.4.4.3 Loss of High Volume Parts

After discussion with the Product Manager, it was decided to determine the effect of the transfer to the compression moulding section all parts exceeding a 40,000 per annum call-off; with the increasing trend towards injection moulding it was possible that these parts might be transferred to the injection moulding section. The results were:

Mean ¼ platen loading(excluding higher volume parts) = 4.44 cavities/¼ platen.

Mean ½ platen loading(excluding higher volume parts) = 3.64 cavities/½ platen.

Whilst the overall cavity loadings were lower in both cases, the relative positions of the two systems were not altered; quarter platen loading was still favoured.

7.4.4.4 Discussion

The investigations suggested that the quarter platen machine loading was the most economical approach given the availability of tooling (and possible changes to that tooling availability). Whilst only certain costs were considered in choosing the alternative any other costs incurred were likely to act in favour of quarter platen loading, namely:

(i) Machine maintenance costs - there was no evidence to suggest that using the half platen approach would make the presses more reliable than using the quarter platen loading. Since the half platen loading required double the number of machines to achieve comparable levels of production, it was likely that maintenance costs would have been considerably higher for this method of machine loading.

(ii) Fixed costs - with double the number of machines to achieve the same level of output as quarter platen loading a number of associated fixed costs would be increased, for example depreciation (albeit with aged equipment) and costs which are apportioned on the basis of the floor area occupied (such as heating, cleaning, company costs).

It was therefore decided that the quarter platen per part type machine loading system should be used in the estimation of resources exercise and as the basis of the moulding standard costing system.

7.5 Estimation of Small Order Moulding Resources

As was stated in Chapter 6, no reliable longer term forecast of demand for compression moulded parts was available at the time of the decision to establish a separate Lockheed Small Order Section. Furthermore there was not sufficient time to prepare an accurate forecast to assist the decision; the 6 month tentative forward schedule provided by Automotive Products to Dunlop was all that was available and this was taken as representative of likely future demand (a more accurate forecast was later developed by the author for determination of standard budgets - see Chapter 9). The resources estimation was therefore based on the number of machines and man-hours which were required to meet the 6 month schedule within that period given different levels of efficiency (machine availability).

A number of assumptions were made in the estimation of the moulding resources required:

(i) That the 6 month tentative forward schedule was representative of demand.

(ii) All parts would be produced with a 7 minute cure.

(iii) That a quarter platen machine loading system would be used with each quarter platen containing the average quarter platen loading of 5.0 cavities per quarter platen.

(iv) That machine availability would be in the range 60% - 100% of total time available.

(v) The weighted mean stripping time of 0.096 basic minutes per cavity was used throughout.

(vi) Either single daylight or double daylight operation would be used (i.e. with one set of moulds per press or two sets of moulds per press respectively). The major differences assumed for single daylight operation were:

* Platen constants value of 0.350 basic minutes were used for single daylight operation (based on Industrial Engineering Department estimates).
* It was estimated by the Engineering Department that a single daylight press would use 65% of the steam used by a double daylight press and approximately the same amount of electricity.

7.5.1 Methodology

(1) The standard set-up floor-to-floor cycles were calculated using the formula:

$$\text{Work Cycle} = \left[M(S\ Z\ n + P) + \bar{Y}\right](1 + CA)(1 + RA)$$

(2) The total number of parts required in the 6 month (24 working week) period was calculated by applying the individual cumulative reject figures to the parts represented in the schedule and summing to get the total requirement.

(3) For different levels of machine availability the number of standard minutes available per shift for the set up was determined and the number of cycles (and therefore parts) which could be produced per shift was calculated.

(4) By dividing the total schedule requirement by the number of parts produced per 8 hour shift the total number of hours required was calculated.

(5) Using the shift availability matrix the work scheme which would provide the sufficient hours to meet the requirement was chosen and the cost of direct labour and utilities determined.

7.5.2 Determination of Resources

The above described calculations were performed for the following set-ups, all using quarter platen loading:

Type of Press	Set-ups
Double daylight	1 man/2 machines, 2 men/4 machines
Single daylight	1 man/4 machines, 2 men/8 machines

A sample calculation for 1 man/2 machines, double daylight operation will be given.

Work Cycle = $[2(0.096x4x5.0+0.316)+7](1.07)(1.18)=14.48$ SM

Parts produced per cycle = 4x5x2x2 = 80 parts/cycle

Total Schedule requirement = 355880.

The direct labour costs were calculated by reference to the incentive and shift premium payment schemes (it was assumed that when less than three shifts were to be worked per day, the shift scheme chosen would be such that the total labour cost would be minimised). The utilities costs were also calculated as in section 7.4.4.1.2. Exhibits 7.8 and 7.9 summarise the results of the calculations for the four alternatives which were evaluated.

EXHIBIT 7.6 : DETERMINATION OF HOURS REQUIRED

MACHINE AVAIL-ABILITY (%)	MINS AVAIL-ABLE PER SHIFT	LESS 'EMPTY OUT ALL'CE' (MINS)	CYCLES/SHIFT	PARTS/SHIFT	TOTAL HOURS REQ'D (HRS)	SUGGESTED WORK SCHEME	HOURS AVAILABLE WITH SCHEME	% TIME USAGE
60%	288	274	18	1440	1977	4 day 3 shift	2304	86%
70%	366	322	22	1760	1618	3 day 3 shift	1728	94%
80%	384	370	25	2000	1424	4 day 2 shift	1536	93%
90%	432	418	28	2240	1271	4 day 2 shift	1536	83%
100%	480	466	32	2560	1112	3 day 2 shift	1152	97%

EXHIBIT 7.7 : SHIFT AVAILABILITY MATRIX

Hours available in 24 weeks:

		SHIFTS/DAY		
		3	2	1
	* 5	2700	1800	900
Days/Week	4	2304	1536	768
	3	1728	1152	576

* NB For 5 day working a $37\frac{1}{2}$ hour week is assumed.

EXHIBIT 7.8 : SHIFTS OPERABLE TO MEET SCHEDULE, PERIOD 8, 1975 - PERIOD 3, 1976

MACHINE AVAILABILITY %	DOUBLE DAYLIGHT OPERATION		SINGLE DAYLIGHT OPERATION	
	1 MAN - 2 M/C	2 MEN - 4 M/C	1 MAN - 4 M/C	2 MEN - 8 M/C
60%	4 day-3 shift	3 day-2 shift	4 day-3 shift	3 day-2 shift
70%	3 day-3 shift	5 day-1 shift	3 day-3 shift	5 day-1 shift
80%	4 day-2 shift	4 day-1 shift	4 day-2 shift	4 day-1 shift
90%	4 day-2 shift	4 day-1 shift	4 day-2 shift	4 day-1 shift
100%	3 day-2 shift	3 day-1 shift	3 day-2 shift	3 day-1 shift

EXHIBIT 7.9 : TOTAL MOULDING DIRECT LABOUR AND UTILITIES COSTS TO MEET SCHEDULE

MACHINE AVAILABILITY %	DOUBLE DAYLIGHT OPERATION				SINGLE DAYLIGHT OPERATION			
	1 MAN/2 MACHINES		2 MEN/4 MACHINES		1 MAN/4 MACHINES		2 MEN/8 MACHINES	
	DIRECT LABOUR COST	LABOUR & UTILITIES COST	DIRECT LABOUR COST	LABOUR & UTILITIES COST	DIRECT LABOUR COST	LABOUR & UTILITIES COST	DIRECT LABOUR COST	LABOUR & UTILITIES COST
	£	£	£	£	£	£	£	£
60%	3163	4185	3086	4107	2966	4337	2892	4263
70%	2589	3425	2476	3311	2542	3717	2432	3607
80%	2221	2957	2178	2913	2157	3154	2062	3059
90%	1983	2640	1946	2602	1923	2812	1839	2728
100%	1735	2310	1701	2275	1736	2539	1662	2465

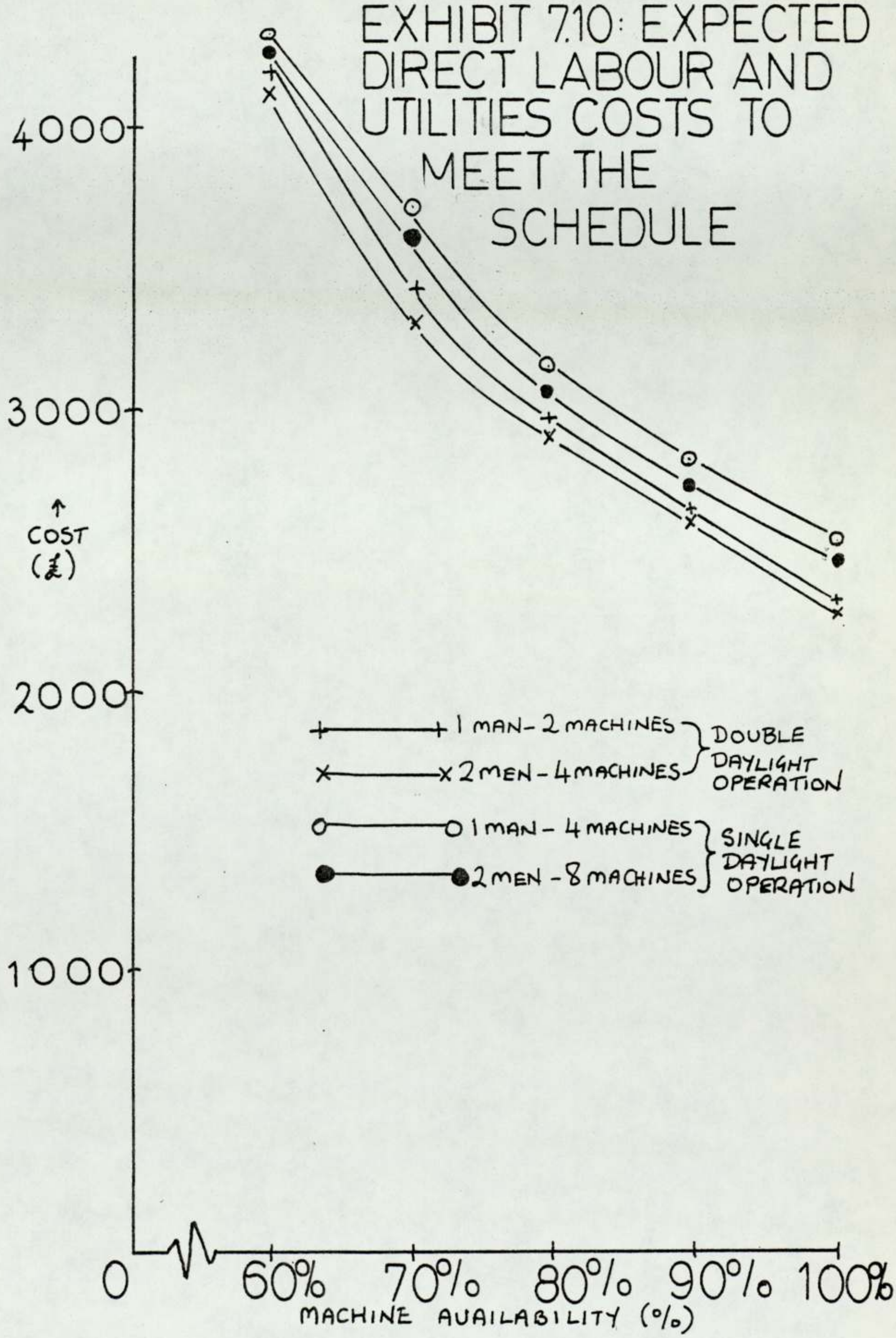


EXHIBIT 7.10: EXPECTED DIRECT LABOUR AND UTILITIES COSTS TO MEET THE SCHEDULE
4000
3000
2000
1000
0
COST (£)
60%
70%
80%
90%
100%
MACHINE AVAILABILITY (%)
1 MAN - 2 MACHINES
2 MEN - 4 MACHINES
DOUBLE DAYLIGHT OPERATION
1 MAN - 4 MACHINES
2 MEN - 8 MACHINES
SINGLE DAYLIGHT OPERATION

7.5.3 Resource Requirements and Recommendations

As can be seen from Exhibit 7.3 there was very little difference in total expected cost for any of the alternatives examined (the small differences between one and two man operation are explained by differences in incentive shift supplements). Double daylight operation appeared to be marginally more economic than single daylight operation throughout the entire range of machine availability. It was therefore recommended that the small order moulding section should consist of two double daylight presses (with possibly one held in reserve) operated by one man per shift. Depending on the machine availability either two or three shifts per day would be operated. The major reasons for this recommendation were:

7.5.3.1 Double daylight operation offered a slight cost advantage over single daylight operation throughout the expected range of machine availability.

7.5.3.2 Maintenance costs were likely to be higher for single daylight operation because double the number of machines were required. Costs were not likely to be doubled however, since the Engineering Department believed that the frequency of individual machine breakdown should have been reduced by single daylight operations.

7.5.3.3 Double daylight operation was the current operating method. It was estimated that at least £2500 per press would have to be spent to convert the presses to single daylight operation; such an expenditure would not have been sanctioned unless considerable operational savings could be achieved.

7.5.3.4 The use of two machines should have been adequate since there was considerable flexibility to increases in the schedule if the need arose. By working the equipment for an extra 3 shift day (only a four day week was currently needed) an increase in schedule of approximately 46% could be accommodated before reaching the capacity of the equipment (at 60% machine availability). At 80% machine availability (a more reasonable target) a 75% increase in schedule could be accommodated by employing extra labour.

7.6 Quarter Platen Costing

7.6.1 For the 1976 Standard Costs

Having determined the number of machines and type of machine loading the author was asked to develop a system which would be in line with the specification outlined in section 7.1.2. The basic requirement was that the standard minute value generated should reflect the number of cavities available for the parts.

After discussion with the Product Manager (Mill and Moulded Products) it was decided that some degree of accuracy and sophistication should be sacrificed in order to ensure speed of implementation of the system and simplicity of operation in the first year. The following steps were therefore taken to determine the standard minute values per part:

(1) A standard floor-to-floor cycle of 16 standard minutes was assumed (the standard cycle for the maximum of 7 cavities/quarter platen was 16.42 standard minutes) which gave an average standard minute value of 1 SM/ $\frac{1}{4}$ platen. This value was 10% higher than the average weighted figure, but it was felt that the use of 1 SM/ $\frac{1}{4}$ platen would be an easy figure to handle; the Product Manager believed that in view of the inaccuracy of the existing system that an inherent inaccuracy of 10% was acceptable in the new approach.

(2) In order to obtain the standard minute value for a particular part the number of cavities available for a quarter platen (n) was divided into the standard minute value for one quarter platen.

Thus:

$$\text{SMV/100 parts} = \frac{100}{n} \quad \text{where } n = \text{number of cavities available per quarter platen}$$

The system contained an inherent logical fault in that the standard cycle is based upon an average quarter platen loading of 5 cavities/$\frac{1}{4}$ platen; in determining the SMV for a particular part the value of n is used, where n may take the value 1-7. The quarter platen standard minute value was based upon an average cycle which was then used to determine the standard minute value for a different number of cavities per quarter platen (n). Whilst this assumption must inevitably have led to some inaccuracy the necessity for speed was felt to outweigh the disadvantages.

(3) A list of the number of cavities available for each part number on the Manufacturing List was determined and sent to the Accounts Department with instructions

detailing how the system should be operated to determine the standard minute value for each part number (see Appendix D).

7.6.1.1 Comparison of Old and New Systems

The greatest disparity between the old and new systems was found where only a limited number of cavities is available per part. The quarter platen system assumed that no other cavities will be loaded on the quarter platen, whilst the old system assumed that all the available space on the platen would be filled with other work.

Perhaps the easiest way to illustrate the difference between the two systems is to determine the standard minute values for different numbers of available cavities using both the quarter platen and the conventional method on the same machine set-up.

(1) Conventional Method

SMV/100 parts =

$$= 100\left(\text{Cavity Stripping Time} + \frac{\text{Platen Constant Value}}{\text{Potential Cavities/Platen}}\right)$$

Assume:

(i) Stripping Time = 0.12 sm /cavity

(ii) Platen Constant Value = 0.40 sm/platen

(iii) Potential loading per platen (nest size) = 28 = P

(iv) Actual Number of Cavities available = Ni, where i = 1.....P/4

$$SMV/100\ parts = 100(0.12+\frac{0.40}{2.8}) = 13.43\ SM/100\ parts$$

for N = 1....P/4

(2) Quarter Platen Costing

$$SMV/100\ parts = \frac{100}{N} \text{ where } N = 1,2,3....P/4$$

N	SMV/100 parts
1	100
2	50
3	33
4	25
5	20
6	17
7	14

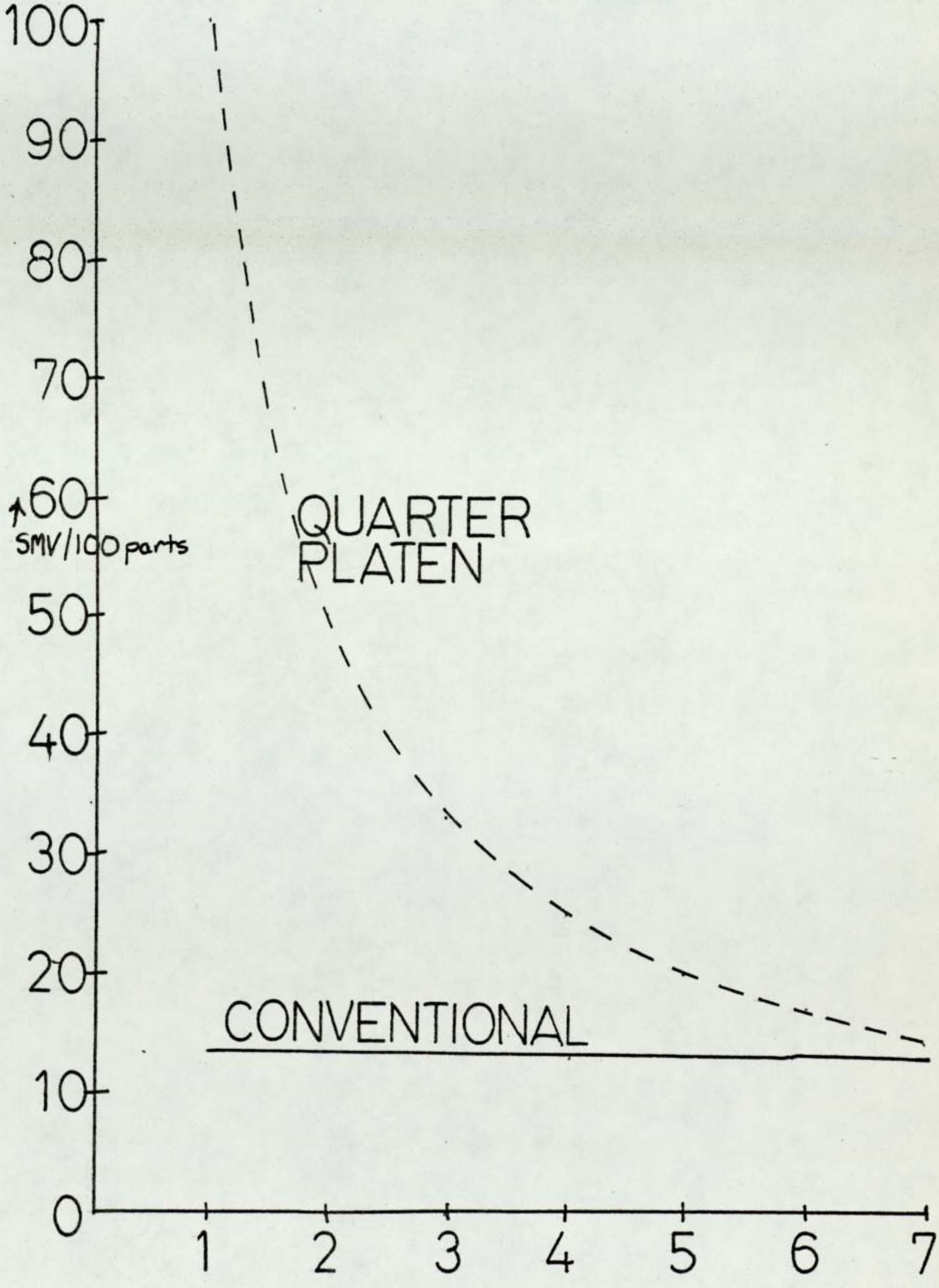
The comparison can be seen more clearly in Exhibit 7.11.

As can be seen from Exhibit 7.11, the quarter platen system approaches the conventional value asymptotically as the number of cavities increases. The basic difference between the two systems can be summarised as:

(i) The quarter platen approach assumed a fixed machine cycle irrespective of the machine loading.

(ii) The conventional system assumed a fixed machine loading (maximum) and no unoccupied time (even though neither assumption could be met with the existing tooling).

EXHIBIT 7.11 : A COMPARISON OF THE CONVENTIONAL AND QUARTER PLATEN APPROACHES

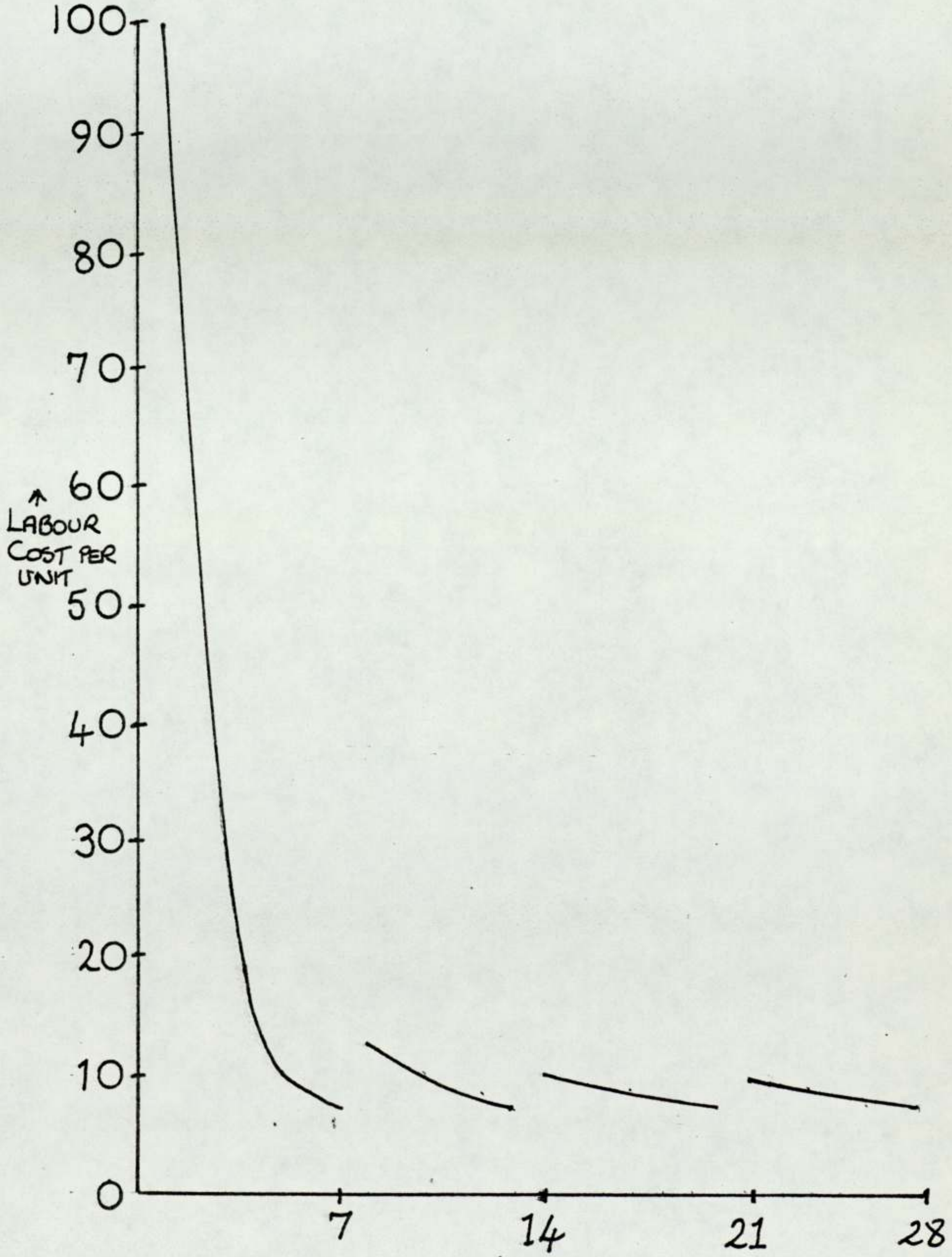


For parts where large numbers of cavities were available the quarter platen approach gave a similar moulding standard minute value to the conventional approach; only those parts where a limited number of cavities were available could have standard times significantly increased and consequently higher standard costs. If a fixed margin pricing policy were adopted the price charged to the customer would vary inversely with the number of cavities i.e. with the amount of investment by the customer.

A problem with the approach would be encountered if the customer should request a number of cavities which was greater than that required to fill one quarter platen; the average standard minute value would increase if two or more quarter platens were required and yet not fully loaded. (For example, if 9 cavities were required when only 7 could be fitted to a quarter platen, then two quarter platens would have to be occupied with an average loading of 4.5 cavities per quarter platen). A 'saw tooth' labour cost curve would therefore be generated, with each peak corresponding to the transition from full quarter platens to an average loading which was less than the maximum (see Exhibit 7.12).

It was not felt to be acceptable to pass on the 'saw tooth' costs to the customer,since for greater investment a higher unit cost would have been charged until the next quarter platen was also

EXHIBIT 7.12 : THE 'SAW TOOTH' COST FUNCTION



filled. It should be remembered that only the moulding labour cost (and any variable costs recovered as a percentage of labour cost) would be affected by the 'saw tooth' cost function. However, a 50% increase in moulding labour cost could still increase the variable works cost by approximately 10%. The fluctuation could be overcome by one of three strategies:

(1) The customer could be told the minimum number of cavities which were required to fulfil the demand together with the corresponding unit price. A unit price could also be quoted resulting from the purchase of cavities to completely fill the quarter platens. For example:

If 8 cavities are required to meet the schedule then the unit price resulting from 8 cavities and 14 cavities should be quoted (if 7 can be fitted on a quarter platen). If 3 cavities are required unit prices should be quoted for 3 cavities and 7 cavities.

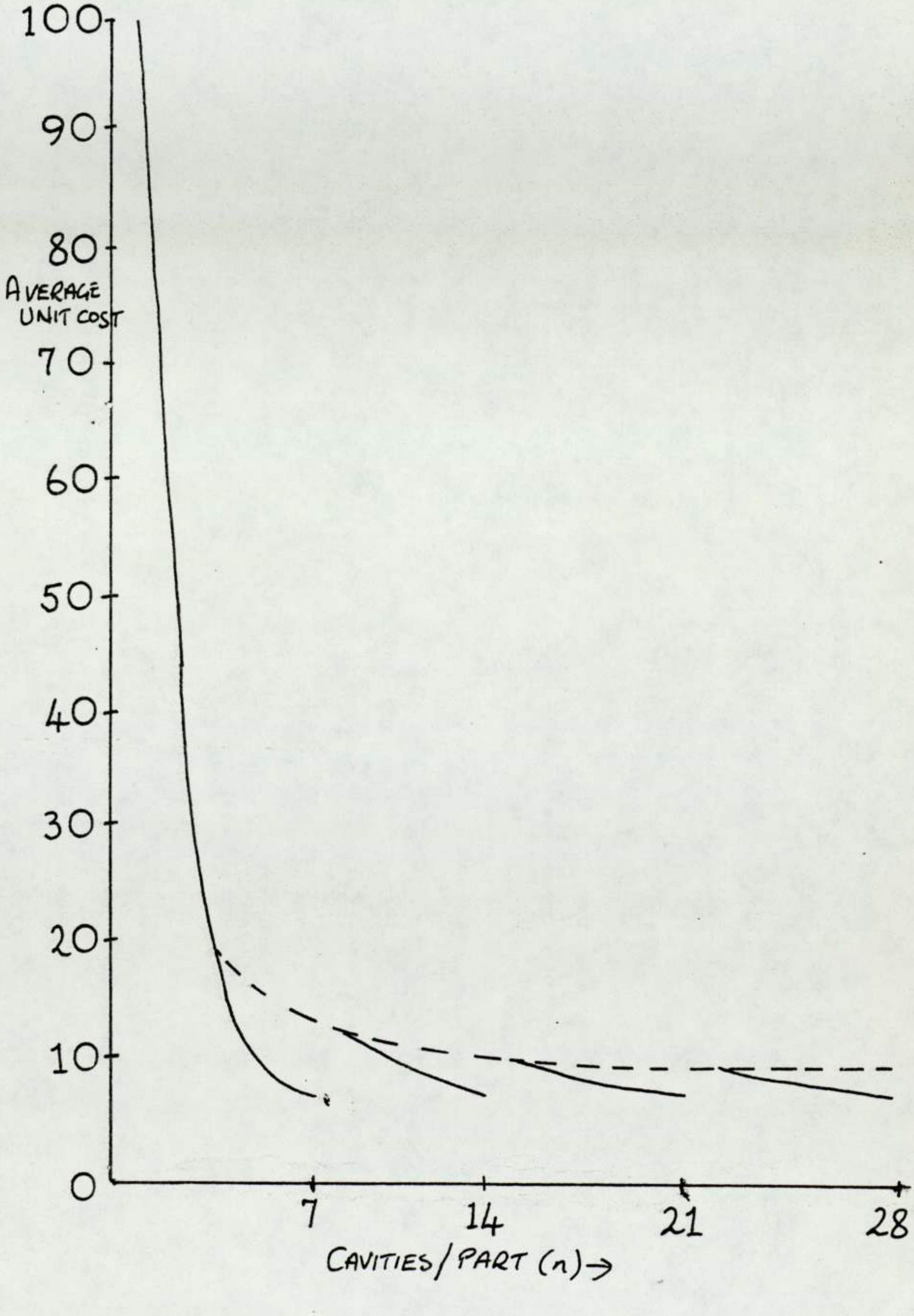
The customer would then be left with a simple two alternative choice; the decision to invest extra capital in tooling can be determined by the likely future demand and return on investment criteria.

(2) The 'saw tooth' cost function could be straightened out as in Exhibit 7.13 so that the unit price would fall monotonically as the number of cavities increased. This strategy would result in Dunlop making extra 'profit' for all parts for which the purchased number of cavities causes the cost function to fall below the dotted line.

(3) Dunlop could absorb all the fluctuations in cavity-dependent costs itself resulting in a single unit price being quoted to the customer which is based upon the number of cavities available up to a maximum of 7 cavities per quarter platen.

The author recommended that alternative (1) should be adopted since it offered a benefit to the customer from increased capital investment whilst restricting the choice to two simple alternatives. Dunlop management deferred the decision to implement the policy however since they felt that, in view of the depressed state of the market and and financial difficulties from which Automotive Products were suffering, capital investment on small order work was unlikely; a price would be charged reflecting the current tooling available.

EXHIBIT 7.13 : 'STRAIGHTENING THE 'SAW TOOTH' COST CURVE



7.6.1.2 Implementation

The quarter platen approach was implemented in time for the determination of the 1976 standard costs and recommendations were made to enable the effectiveness of the system to be assessed (in terms of actual and standard labour costs). Due to labour shortage in the first two months of 1976 and considerable machine breakdowns, few parts were manufactured on the Small Order Section which had been established; by March 1976 Dunlop management decided to replace the ageing double daylight steam compression presses with single daylight electrically heated 'Hydramould' presses. Whilst the quarter platen approach was appropriate to this form of production the figures used in the determination of the moulding standard minutes were based on the obsolete production method. In addition the single platen operation (and different press opening and closing times) the higher temperatures available with electric heating enable cure times of 3 minutes to be achieved without difficulty.

At the start of the operation of the Small Order Section no standard times were available; the Section operated in this manner until October 1976. Whilst some modification of the standard times was attempted by the author in order to assess actual performance (see Chapter 8), the standard times derived for steam compression remained unchanged until January 1977. It was the policy of Dunlop to alter standards (as incorporated in standard costs) only once per year; the standard times derived at the end of 1975 were used in determination of costs throughout 1976 despite the fact that they were based upon obsolete production process which was almost certainly less efficient than the process currently in use. It is possible to speculate that had the Small Order Section been more important in the eyes of the Dunlop management, then the standards might have been altered earlier. However, in the experience of the author there was little inclination to alter any standards throughout the year, irrespective of the importance to the company. Furthermore, since the standard costs were not used significantly to control production there was little pressure from the production management to effect any change especially if the products were overcosted!

7.6.2 For the 1977 Standard Costs.

In preparation of the standard times for the 1977 Standard Costs, certain modifications were made to the 1976 values in order to ensure that the times obtained were in line with the production process used. In addition the assumptions which had been made in determination of the Quarter Platen approach in 1976 were examined and modifications suggested.

7.6.2.1 Alternative Approaches

The Industrial Engineering Department used an MTM pattern to derive the weighted average floor-to-floor work cycle (outside work plus machine cycle). From examination of the MTM pattern it was clear that there were some actions which the operatives must perform irrespective of the number of cavities loaded in the press. There were other actions for which the total time allowed will vary directly with the number of parts loaded in the machine. It was therefore possible to derive an equation to determine the floor-to-floor cycle in terms of a fixed element (which would not vary with different numbers of cavities loaded in the machine) and a variable element which would vary in proportion to the number of cavities operated:

Floor-to-Floor Cycle Time = 4.368 + 0.1224 N
(Standard Minutes)

Fixed Variable

Where N = Number of cavities per platen

Using this formula for a one man/two machine set-up it was found that up to 24 cavities per platen could be operated before interference between the two machines would occur. This figure was therefore taken as the maximum which could be loaded into any one machine. The MTM pattern used was based on the most inefficient method of stripping(plier strip of individual parts) so that any errors will tend to give the operatives more process time rather than interference.

Since a quarter platen was taken as the unit of platen area upon which the standard times were based, there were several different assumptions which could be made about the number of cavities loaded onto the remaining three quarter platens on the machine; these different alternatives led in turn to a number of alternative formulae for calculation of the standard minute value where n cavities are available for a particular part.

7.6.2.1.1 Alternative 1

Assumption: If n cavities are available for one quarter platen it can be assumed that all the other quarter platens are also loaded with n cavities.

Formula: Floor-to-Floor Cycle (FTF)

$= 4.368 + (0.1224 \times 4\ n)$

$$SMV/\tfrac{1}{4}\ \text{platen} = \frac{FTF}{\text{No. of Quarter Platens}}$$

$$SMV/\text{part} = \frac{SMV/\tfrac{1}{4}\ \text{platen}}{n} = 0.0612 + \frac{0.546}{n}\ \text{sm}$$

Critique: Alternative 1 suffers from the weakness that all the other quarter platens will be loaded with the same number of parts/quarter which tends to negate the philosophy of treating each quarter platen as a distinct unit of productive capacity.

7.6.2.1.2 Alternative 2

Assumption: The maximum possible floor-to-floor cycle can be calculated by using the number of cavities per quarter platen which will allow operation without machine interference. The floor-to-floor cycle so obtained can be divided by the total number of quarter platens in the set-up to give a maximum standard minute value per quarter platen.

To determine the standard minute value where n cavities are available the maximum standard minute value per quarter platen is divided by the number of cavities available.

Formula: (for n max) FTF = 4.368+(0.1224x4x6)=7.306sm

$$\text{SMV(max)/Quarter Platen} = \frac{7.306}{8} = 0.913\text{sm}$$

$$\text{SMV/part} = \frac{0.913}{n}$$

Critique: This approach is spurious since it assumes that all ¼ platens will be full (n = 6) to calculate the floor-to-floor cycle and then assumes that a different number of parts (n = 1 ... 6) will be loaded onto the quarer platen. The approach would only be logically correct when all the quarter platens were loaded with 6 cavities.

Although this may appear to be a 'straw man' it was in fact the method used to calculate the 1976 quarter platen values, when the maximum possible cycle (16.4 sm) was divided by the total number of quarter platens (16) to give a quarter platen standard minute value of 1 sm/quarter platen. Whilst the logical fault was pointed out to Dunlop management at the time of derivation, it was felt that such a fault would not significantly affect the overall result.

7.6.2.1.3 Alternative 3

Assumption: Using an approach similar to Alternative 3 it can be assumed that all the quarter platen are loaded with the average number of cavities to determine an average standard minute value per quarter platen. This figure may then be divided by the number of cavities available (n) for any quarter platen to determine the standard minute value per part.

Formula:

Weighted Average floor-to-floor cycle = 6.57 sm (for an average of 4.5 cavities/qtr platen).

Average SMV/qtr platen = 0.82 sm

$$\text{SMV/part} = \frac{0.82}{n}$$

Critique: Since this approach is very similar to that used for Alternative 2, it also suffers from the same logical fault; a particular loading is being assumed to calculate the floor-to-floor cycle and then a different value of n ($n = 1 \ldots 6$) is used to determine the average standard minute value per part. The approach will therefore only give the correct value when the number of cavities available for a particular part (n) is equal to the average quarter platen loading (4.5 cavities/qtr platen). Since it is impossible to have 4.5 cavities the approach can never give the exact answer.

7.6.2.1.4 Alternative 4

Assumption: If n cavities are available for the quarter platen in question it might be assumed that the remaining quarter platens on the machine are loaded with the maximum possible number of cavities (6).

Formula: Total platen loading = 18+17

Floor-to-floor cycle = $4.368+(18+n)0.1224$

Average Time/qtr platen

$$= \frac{4.368 + (18+n)\ 0.1224}{8}$$

$$\text{SMV/part} = \frac{4.368+(18+n)0.1224}{8n} = \frac{0.821}{n} + 0.0153 \text{ sm}$$

Critique: Whilst Alternative 4 does not suffer from the logical inconsistencies of Alternatives 2 and 3, an assumption is still made about the number of cavities loaded on the other quarter platens in the set up. If therefore does not tread each quarter platen as a distinct unit of productivity capacity.

7.6.2.1.5 Alternative 5

Assumption: The total floor-to-floor cycle is dependent both upon the number of cavities operated on the lead machine and a constant factor which does not vary with machine loading. The average amount of constant per quarter platen is fixed, since the number of quarter platens in the set up is fixed and the variable element will vary in direct proportion to the number of cavities loaded on the platen. It is therefore possible to derive an equation which expresses the total standard minute value of the quarter platen in terms of a fixed and a variable element.

Formula: Floor-to-floor cycle = 4.368 + 0.1224 N where N = total number of cavities on the platen.

Constant/qtr platen = $\frac{4.368}{8}$ = 0.546 sm/qtr platen

The total SMV for the quarter platen =

Fixed element + Variable element

$= 0.546 + 0.1224n$

The SMV/part = $\frac{\text{SMV/qtr platen}}{n}$ =

$$\frac{0.546}{n} + 0.1224$$

Critique: Alternative 5 appears to offer the best approach to the calculation of the moulding standard minute value since it makes no assumption about the loadings on the remaining 7 quarter platens to be operated. Thus each quarter platen is regarded as an independent unit of productive capacity, the efficiency of which will depend on the degree of investment by the customer.

A comparison of how the five alternatives differ with different numbers of cavities available is shown in Exhibits 7.14 and 7.15.

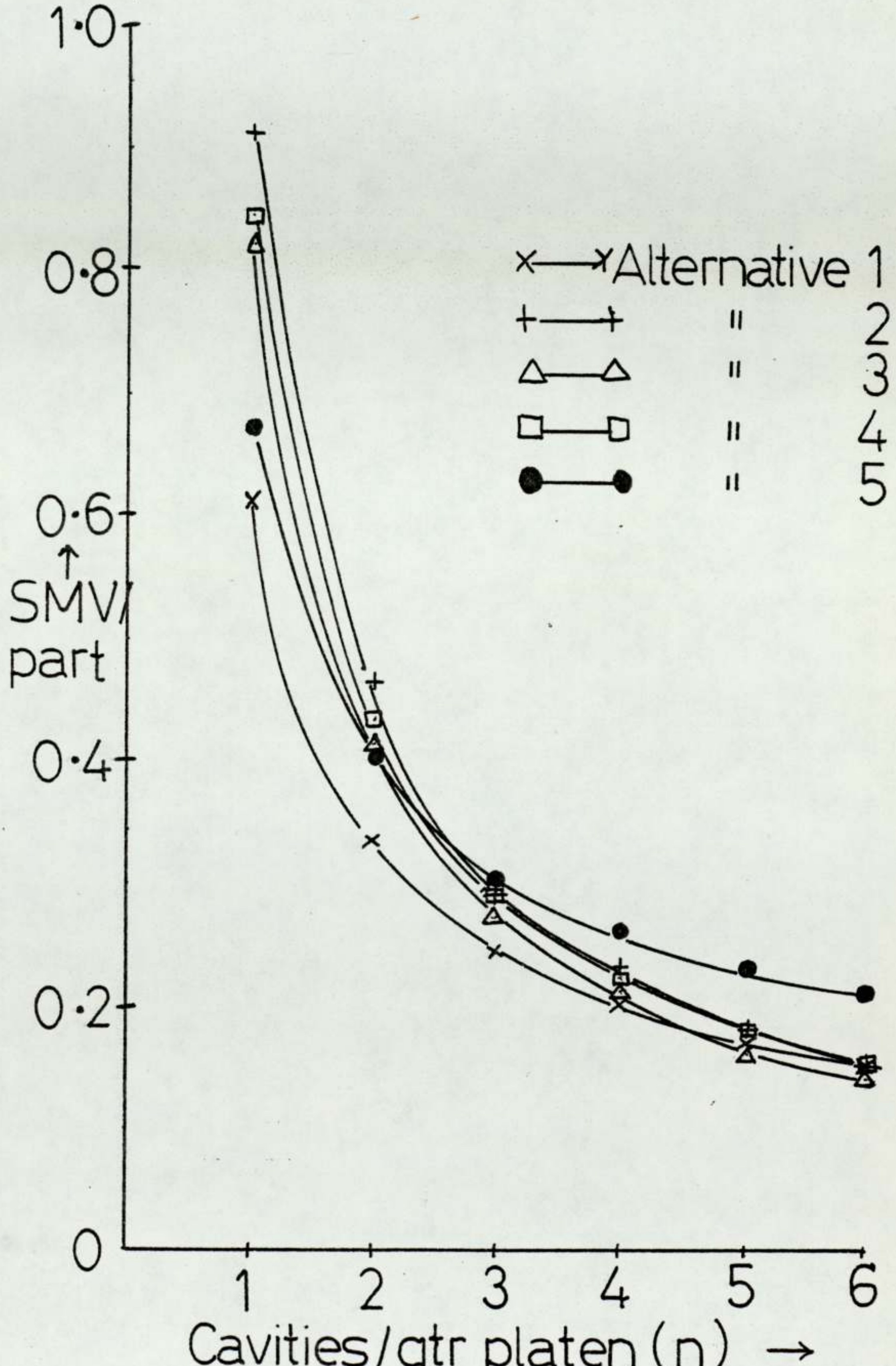
7.6.2.2 Recommendations and Implementations

The author recommended that Alternative 5 should be used for determination of the 1977 standard costs, since it made no assumptions about the cavity loadings on the other quarter platens. However, Dunlop management decided to implement alternative 3 for the 1977 standard costs. They gave their reasons as follows:

EXHIBIT 7.14 : PERFORMANCE OF THE DIFFERENT ALTERNATIVES

n (CAVITIES/ PART)	ALTERNATIVES (SM/PART)				
	1	2	3	4	5
1	0.61	0.91	0.82	0.84	0.67
2	0.33	0.46	0.41	0.43	0.40
3	0.24	0.30	0.27	0.29	0.30
4	0.20	0.23	0.21	0.22	0.26
5	0.17	0.18	0.16	0.18	0.23
6	0.15	0.15	0.14	0.15	0.21

EXHIBIT 7.15. : PERFORMANCE OF THE DIFFERENT ALTERNATIVES



7.6.2.2.1 Alternative 3 was logically identical to the system used to determine the 1976 values; no change in the method of calculation was required and therefore it was felt that fewer mistakes would be likely to be made by Accounts Department staff than with a new method of calculation.

7.6.2.2.2 The approach used in the determination of Alternative 3 was consistent with the incentive scheme which was to be introduced at the same time; a fixed floor-to-floor cycle was to be assumed, based upon the average cavity loading. Whilst the assumption of a fixed cycle could not be justified in industrial engineering terms, it was felt that the introduction of a single cycle would assist efficiency by making the whole approach more simple. The author disagreed with this philosophy, for he felt that the assumption of one fixed cycle on paper did not automatically result in a fixed cycle being achieved on the shop floor. He believed that since the facility existed to determine the floor-to-floor cycle for each machine loading, it should be used to monitor efficiency. Dunlop management unfortunately ignored this argument and implemented the fixed floor-to-floor cycle.

7.6.2.2.3 Alternative 3 offered a much higher standard minute value than Alternative 5 at the low cavity availabilities, which in turn would be reflected in higher costs (and ultimately prices) for those products for which only a small number of cavities was available.

The use of such an argument to justify the choice made illustrates the attributes towards standard times which was generally prevalent at Skelmersdale during the investigation; standard minute values (and consequently costs) were manipulated by management to assist the achievement of subsidiary objectives such as regulation of prices or tighter content of production management. Standards were rarely regarded as objective, realistically achievable targets but rather as instruments of political manipulation.

The author's objections having been overruled, the fixed cycle quarter platen costing and scheduling approach was continued into 1977, based on an average cavity loading of 18 cavities per platen (4.5 per quarter platen). An incentive scheme was simultaneously introduced based on the average cavity loading of 18.

Unfortunately, due to a mistake in the Industrial Engineering Department, the scheme was introduced with a maximum loading of 18 rather an average of 18. As a result the shop floor refused to work more than 18 cavities per platen and the average machine loading fell to 14 cavities per plate; one agreed little could be done to rescind the decision. Thus, the average minute value per part for 1977 was greater than the standard minute value by approximately 8%.

7.7 Discussion

The quarter platen approach used at Skelmersdale must be regarded as a mixture of success and failure. That a system was introduced which generated standard minute values (and labour costs) which were realistically achievable must be regarded as a successful outcome; the relative simplicity of administration compared to the superceded system of determination must be regarded as an additional bonus.

The approach has fallen short of the author's expectations mainly in the implementation stages. During 1976 it was disappointing that there was little encouragement from Dunlop management to modify the values in line with process changes; that such encouragement was not forthcoming may well be due to the fact that the standard times were not used to measure and control production performance in any detailed way. As will be described in Chapter 10, the cost control system used at Skelmersdale was rudimentary, with total departmental labour cost variances produced only on a monthly basis. The main purpose of the standard costs used in the department was to value stock and therefore alterations in standard values were given relatively low priority.

The overall low priority given to the Small Order Section by Dunlop management may further explain why the most accurate alternative (Alternative 5) was rejected for the 1977 standard costs - the extra effort required to operate a slightly different formula was not considered to be worthwhile. The low priority given to the Small Orders may also explain why the cost control system proposed by the author to operate in conjunction with quarter platen derived costs was never fully implemented. It might also be worthwhile to speculate that, had such a system been implemented, a level of cost control would have been possible in the Small Order Section which could not be matched in the rest of the department. In order to determine the actual operations efficiency of the section the author was therefore forced to perform a series of 'one-off' exercises as described in Chapter 8.

Had a cost-plus pricing policy been adopted simultaneously with the quarter platen approach the customer would have been asked to pay a unit price which reflected the degree of his investment in tooling. However, as has been explained in Chapter 5, a 'product group margin'/historical cost-plus approach was used, i.e. prices were determined not on an individual comparison of costs with prices, but rather by a comparison of total revenue for a product group (for example all Small Orders) with the total variable costs for that group. If the overall contribution level was felt to be inadequate a blanket increase was applied across the whole range of product prices; the price structure therefore reflected the price structure of several years before, when prices had been determined by an individual comparison of price and cost.

The overall effect of introducing 'quarter platen costing' was to increase the variable works cost of certain products (those with only a limited number of cavities available) whilst leaving other products initially unaffected (those with large number of cavities available). Failure to implement a pricing policy which reflected these changes resulted in a lower overall contribution for small orders, making small orders less attractive to Dunlop whilst leaving the customer totally unaffected. Once again lack of relative importance to the total operation must be cited as the prime cause.

In summary therefore, it must be concluded that whilst the development of the quarter platen approach was completed successfully, the failure to implement contingent policies for cost control and pricing produced a more limited success than might have been achieved had the management given greater commitment to the philosophy of the quarter platen approach.

In fact the lack of commitment in the latter stages of the project must bring into question whether the stated objectives were sincere or whether in fact the reduction of small order contribution levels might have made the disposal of that area of business more justifiable.

CHAPTER 8

Investigation of Actual Costs

8.1 Objectives of the Investigation

When a method for the determination of standard moulding labour costs had been established an investigation into the actual cost performance of the Lockheed Small Order Section was felt to be the next logical step. Using standard variable cost data small orders made an acceptable level of contribution towards fixed overhead costs. Certain members of the Skelmersdale management team claimed that the actual level of contribution achieved was considerably below the standard level due to inefficient operation increasing the actual costs to levels well in excess of standard. As there was no effective cost control system in operation which could confirm or refute this claim (see Chapter 10), an investigation was undertaken with the following objectives:

8.1.1 To determine the actual direct labour costs incurred during a typical four week period in the Lockheed Small Order Section, to compare with the standard budgets and, if possible, explain any variances.

8.1.2 To determine the labour efficiency and machine utilisation, explain any shortfalls, and indicate where improvements might be made.

8.1.3 To determine the actual cost performance, labour efficiency and machine utilisation for a comparable period of operation for the high volume injection moulding area and compare the results with those for the Small Order Section.

8.2 Methodology

A typical four week period in June 1976 was chosen for the investigation. Information was obtained from three sources:

8.2.1 Direct Operative Work Sheets

Information obtained: (i) Machine Operating Hours.

(ii) Machines operated during the period. Number of parts produced (on a part-by-part basis).

(iii) Machine downtime-duration and cause.

(iv) Standard time per machine cycle ('Charge').

8.2.2 Operative Wage Sheets

Information obtained: (i) Total Hours booked.

(ii) Actual Wage Rate (all Small Order Section workers were paid average earnings since an incentive scheme had not been agreed).

(iii) Wages Paid.

8.2.3 Standard Cost Sheets

Information obtained: (i) Standard Moulding minute value per part.

(ii) Standard grade and rate of moulding operation.

(iii) Standard shift allowance.

(iv) Standard moulding labour cost.

8.3 Notes of the Investigation

8.3.1 Capacity

For three out of the four weeks under consideration the Production Planning Department assumed that one man would operate three machines simultaneously. The Transport and General Workers Union would not allow its members to operate more than two machines at any one time. Therefore two machine utilisation figures are quoted for the first three weeks: (1) that which was theoretically achievable (1 man - 3 machines) and (2) that which was practically achievable (1 man operating two out of three machines). In the fourth week management agreed that one man should operate only 2 machines at any one time.

At the end of the third week the capacity of the Small Order Section was increased with the addition of two electrically heated, single daylight McNeill presses to the existing three Hydramould presses.

8.3.2 Wages Rates

As no agreed incentive scheme was in operation during the study period, the operatives were paid Average Earnings, i.e. the average earning rate achieved on rated work during

during the previous four week period. Since this implied that two operatives of the same grade, working at the same level of performance, may receive different wages, a separate earnings rate had to be calculated for each operative involved.

8.3.3 Standard Times

The standard moulding minute values obtained from the standard cost sheets were based on the quarter platen cost calculations made for the 1976 standard costs. The calculations were based upon the assumption that parts would be moulded on steam-heated, long cure time, double daylight Daniels presses rather than the short cure time, electrically heated presses then in use. The effect of this process change in the standard times will be discussed in section 8.5.

In addition the 1976 Standard Costs included a percentage time allowance for a leading hand. Although this was not a normally acceptable accounting practice, the time allowance was included in the standard minute value for the part, since this was the method used by the Accounts Department to calculate the standard cost. Since, at the time of the investigation, no leading hand was employed in the Small Order Section, an adjustment to the standard times was necessary when a more realistic assessment of performance was attempted.

8.4 Sectional Performance Results

8.4.1 Machine Utilisation

From the information obtained from the Operative Work Sheets multiple activity charts were drawn up for each machine during the study (see Exhibit 8.1).

The results of this exercise were as follows:

Machines used: Hydramoulds Nos. 10, 11, 12.

McNeill's Nos. 3, 4.

8.4.1.1 Key Results

1. The overall machine utilisation for the period was very poor-only 45% of the practically available machine time was used for production. The trend of utilisation was downwards during the period, starting at 70% in Week 1 and falling to 20% in Week 4; the situation was deteriorating.
2. The most significant single cause of the low utilisation was the absence of labour to work the presses. It was apparent that the small order section was considered to be of low priority in the Moulding Department; absenteeism in the high volume areas was overcome by transfer of labour from the small order section. The low priority given to the Small Order Section was emphasised in Weeks 3 and 4 when, although extra machines were added to the section, no labour was made available to operate them.
3. Machine breakdown was exceptionally high in Week 4 (33% of total Machine Time available). Again some of this excessive time could be attributed to the fact that the Engineering Department usually gave priority to the rectification of high volume machine breakdown.

EXHIBIT 8.1. : TYPICAL ACTIVITY BAR CHART

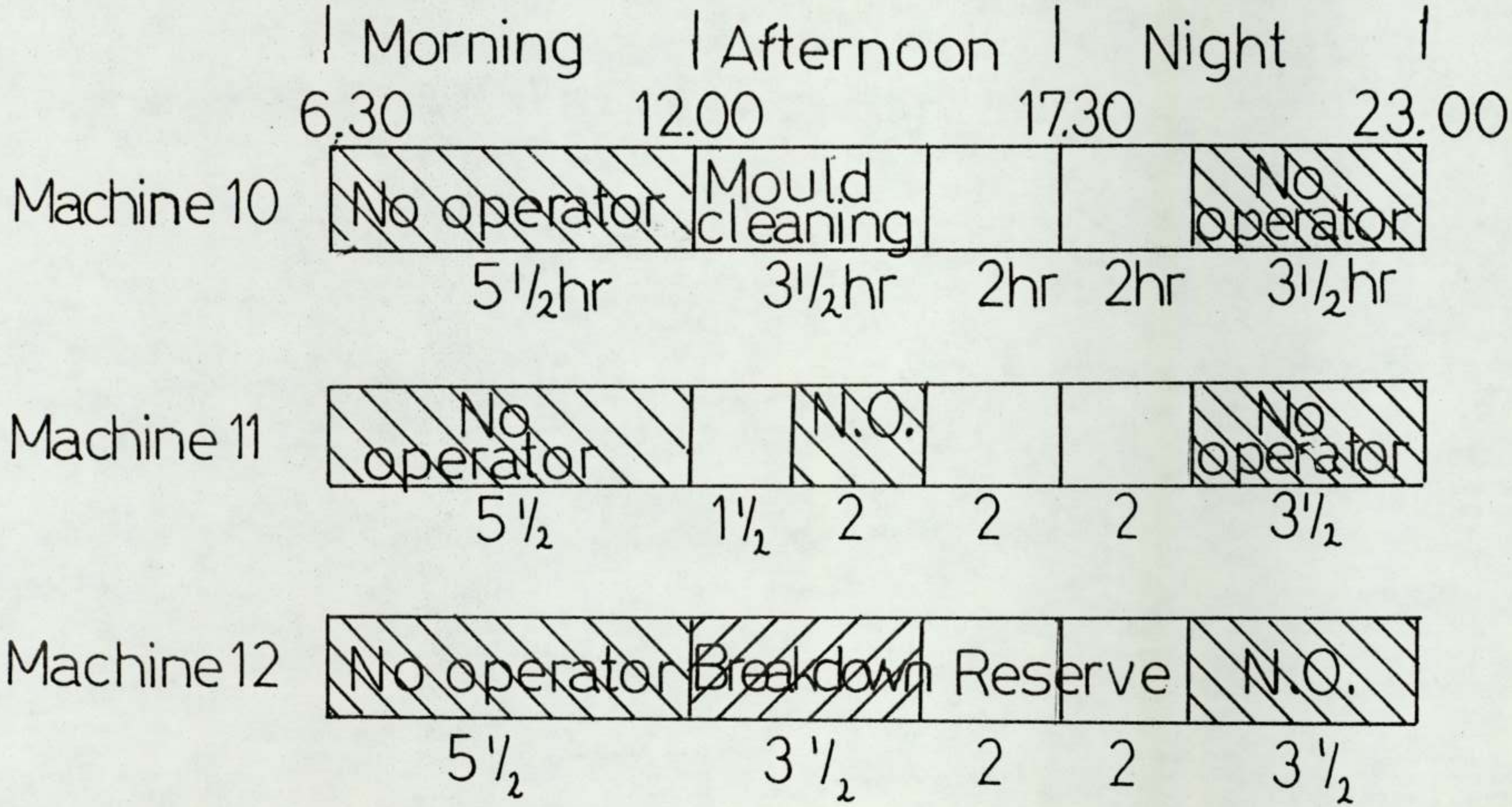


EXHIBIT 8.2 : MACHINE UTILISATION

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	TOTAL (1-4)
Total Machine Hours Available	337.5	337.5	433.5	450.0	1558.5
(Union Allowed Figures in Brackets)	(225)	(225)	(321)		(1221)
Production Hours Booked	157.42	175.23	131.50	88.00	552.00
% Utilisation	47% (70%)	52% (78%)	30% (40%)	20% (20%)	35% (45%)
Reasons for Downtime					
No. Operator	67.92 (20%)	55.50 (16%)	225.25 (52%)	194.50 (43%)	543.17 (35%)
Breakdown	47.00 (14%)	16.92 (5%)	11.75 (3%)	148.50 (33%)	224.17 (14%)
Not-in-Production *1	28.33 (8%)	40.00 (12%)	22.50 (7%)	18.00 (4%)	114.83 (7%)
Reserved Press *2	23.01 (7%)	48.00 (14%)	33.50 (7%)	-	104.51 (7%)
Servicing	4.00 (1%)	-	3.00 (1%)	1.00 (1%)	8.00 (1%)
Miscellaneous	9.32 (3%)	2.00 (1%)	-	-	11.82 (1%)
TOTAL	180.08 (53%)	162.42 (48%)	302.00 (70%)	362.00 (80%)	1006.50 (65%)

*1 Not-in-Production - this term was used rather ambiguously by the operators to mean not in production because of: blank shortage; machine breakdown; product testing by the Process Engineering Department, or reserved press.

*2 Reserved Press - used for the period when the Production Planning Department were assuming 1 man/3 machine operation. The machine not in use was the reserved press; when it was agreed that only 2 presses were to be operated at any one time (in Week 4), the capacity of the third machine was not included in the calculations of machine utilisation.

In addition the investigation showed that there was a tendancy to classify a machine as broken down for some considerable time after the machine had been repaired (this problem was later reduced by ensuring that the Zone Maintenance Engineer confirmed the production department's breakdown analysis).

8.4.2 Labour Efficiency

The output from the Small Order Section in terms of numbers of parts was calculated for each week (using Count, Sort and Check figures) and was converted into Standard Hours Output using the moulding standard minute values from the Standard Cost sheets.

The Production Control Department used different figures to calculate output; a figure of 2.29 standard minutes/charge (3.29 standard minutes/charge in the fourth week) was used, irrespective of the number of parts loaded on a platen. This figure was calculated on the assumption of 18 average stripping time parts per platen. Exhibit 8.3 shows the labour efficiency attained during the reference period, together with a comparison of the planned and achieved outputs in terms of number of charges.

8.4.2.1 Key Results

1. The high labour efficiency (100%) was attributable to one major cause; the Standard Minute Values used in the Standard Cost(VWC) were excessively inflated, since they were based on the long cure time steam compression

EXHIBIT 8.3 : LABOUR EFFICIENCY AND ACHIEVEMENT OF PLANNED OUTPUT

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	TOTAL
Actual Output (Std Hrs)	91.66	106.25	84.36	59.53	341.80
Actual Production Hours Booked	99.08	96.50	83.00	62.75	341.33
Labour Efficiency	93%	110%	102%	95%	100%
Standard Charges Planned	2940	2940	3780	4088	13748
Standard Charges Achieved	976	1096	864	675	3611
% Achievement of Plan	33%	37%	23%	17%	26%
(Adjusted for 1 Man/2 M/c Working)	(50%)	(55%)	(34%)	(17%)	(56%)

method. An attempt was made to give a more realistic assessment of performance by adjusting for the inflated SMV's (see Section 8.5).

In addition, since the operatives were not employed under incentive conditions at the time of the investigation it would not be expected that standard performance (B.S. 100) would be achieved, but rather some level nearer to B.S. 75. Since daywork performance levels were exceeded it is reasonable to suggest that either the standard times were incorrect in that the workforce was willing to exceed daywork performance without financial incentives.

2. Only 26% of the planned output was achieved during the four week period. The shortfall was attributable to the fact that the machines were only operated for 35% of the available time. Even when adjustment was made for 1 man - 2 machine operation (rather than 1 man - 3 machine) only 56% of the possible production was achieved.

8.4.3 Direct Labour Cost Analysis

The actual direct labour cost was obtained from the wage sheets and was compared with the Standard Labour Cost (including shift allowance) for the reference period.

EXHIBIT 8.4 : DIRECT LABOUR COST ANALYSIS

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	TOTAL/AV (1-4)
Standard Direct Hour Rate	£0.03010 /Min	£0.03010 /Min	£0.03010 /Min	£0.03010 /Min	£0.03010 /Min
Standard Value of Output	99.08 Hrs	96.50 Hrs	83.00 Hrs	62.75 Hrs	341.33 Hrs
Standard Direct Wages Cost	£165.52	£191.89	£152.36	£107.52	£617.29
Actual Direct Wages Cost	£166.78	£156.27	£127.97	£ 87.53	£538.55
Actual Direct Wages Rate	£0.02805 /Min	£0.02649 /Min	£0.02570 /Min	£0.02375 /Min	£0.02650 /Min
Direct Wages Cost	(£1.26)	£35.62	£24.39	£19.99	£78.14
Variance made up of:					
1. Direct Wages - Rate Variance	£12.19	£18.01	£21.91	£25.79	£77.82
2. Direct Wages - Efficiency Variance*	(£12.49)	£15.79	£ 2.11	(£4.49)	£ 0.74
* Based upon Dunlop standard times					

8.4.3.1 Key Results

1. The Small order Section Direct Labour Costs showed a positive variance of nearly 13% against standard during the reference period. This was only reassuring in as much that the Moulding Direct Labour Cost, which was used as one of the major determinants of price levels, was not exceeded. However, as control information to production management this was highly misleading for two major reasons:

   A. The greatest portion of the positive variance was due to the rate variance. A £6/week increase in operative wages was included in the Standard Costs from January 1976; in fact it was paid only in July 1976. Thus, during the period in question (June 1976), a positive rate variance would be expected.

   B. Although the direct wages efficiency variance was close to zero, it must be remembered that the inflated steam compression Standard Minute Values were used to assess efficiency (with labour efficiency of 100% one would expect zero efficiency cost variance).

8.5 A More Realistic Assessment of Performance

As was stated in Section 8.4 the cost figures obtained by the exercise did not represent a realistic measure of production performance. In order to achieve a more realistic assessment it was proposed that the following modifications should be made to the figures:

1. Reduce the standard direct labour rate to compensate for the £6 per week allowance incorporated in the standard cost.
2. Estimate the effect of the process change on the standard minute values, adjust them accordingly and remove the leading hand time allowance.

8.5.1 Effect of £6/week allowance

Normal working week = $37\frac{1}{2}$ hours.

£6/week = £0.00267/min.

Standard wage rate = £0.03010/min.

Adjusted wage rate = £0.02743/min.

8.5.2 Effect of Process Changes

Taking the standard platen loading of 18 cavities/platen:

Standard Steam Compression Set-up	Standard Electric Compression Set-up
(a) 18 cavities/platen	18 cavities/platen
(b) 2 platens/machine	1 platen/machine
(c) 1 man/2 machines	1 man/2 machines
(d) Cycle time per set up - 16 SM's	Cycle time per set up - 6.58 SM's
(e) Production/2 machine cycle - 72 parts	Production/2 machine cycle - 36 parts
(f) Average SM/part - 0.2222 SM	Average SM/part - 0.1828 SM
(g) Add 50% for leading hand - 0.3333 SM	No leading Hand
(h) Average SM/part - 0.3333 SM	Average SM/part - 0.1828 SM

$$\text{SMV (Electric)/SMV (Steam)} = \frac{0.1828}{0.3333} = 0.55$$

8.5.3 Performance Against Adjusted Values

8.5.3.1 Labour Efficiency

Total Adjusted Output = 341.80 x 0.55 = 187.99 Std hrs

Total Production Hours Booked = 341.33 hours.

Adjusted Labour Efficiency = 55%

8.5.3.2 Direct Wages Cost Variance

Total Adjusted Output = 187.99 Std Hrs = 11279 SM

Adjusted Direct Wages Rate = £0.02743/min

Adjusted Standard Value of Output = £309.38

Actual Direct Wages Cost = £538.55

Adjusted Direct Wages Cost Variance =(£229.17)

Adjusted Direct Wages Rate Variance = £23.14

Adjusted Direct Wages Efficiency Variance =(£241.98)

8.5.4 Discussion of Adjusted Results

Viewed in the light of the adjusted efficiency and cost figures the performance of the Small Order Section was poor. The problems associated with the section stemmed more from neglect than from the production process itself; insufficient attention was paid to ensure that assumptions made for costing purposes reflected reality or that the section was adequately manned.

If a cost control system had been in operation the pressure from senior factory management to obtain accurate figures may have been greater, since the system could have been used to assess the efficiency of production management. It is also likely that production management would not have allowed such poor machine utilisation to occur if a regular reporting system had been in operation.

8.6 A Comparison with the High Volume Section

In order that the results of the Small Order study could be put into perspective, it was necessary to examine the operation of the high volume production section for a comparable period and thereby determine which problems were unique to the small order production and which were common to both. The results of this comparison may be seen in Exhibits 8.5 - 8.7.

8.6.1 Discussion of Major Differences

8.6.1.1 Machine Utilisation

1. The high volume section operated at a much higher level of machine utilisation than the small order section (72% compared to 35%). The major area of difference was labour absenteeism; generally there was sufficient labour available to operate the high volume injection machines, shortfalls often being overcome at the expense of the small order section. It should be remembered however that since the small order section employed a much smaller number of operatives the absence of only one operative in that section would constitute a much greater proportion of the total downtime than would result in the high volume section.
2. The proportion of machine breakdown time was greater in the small order section than was found in the high volume area (14% compared with 8%). The difference could be attributed to the greater age of the small order section

EXHIBIT 8.5 : COMPARISON OF SMALL VOLUME AND HIGH VOLUME MACHINE UTILISATION

	SMALL ORDER SECTION		HIGH VOLUME SECTION	
Machine Hours Available	1559		6938	
Production Hours Booked	552		4983	
% Machine Utilisation	35%		72%	
Reasons for Downtime(hrs)				
No Operator	543	(35%)	61	(1%)
Breakdown	224	(14%)	553	(8%)
Servicing/Machine Betterment	8	(0.5%)	595	(9%)
Material Shortage	-	(0%)	232	(3%)
Mould Cleaning	12	(1%)	303	(4%)
Miscellaneous	220	(14%)	211	(3%)
TOTAL	1007	(65%)	1955	(28%)

EXHIBIT 8.6 : COMPARISON OF LABOUR EFFICIENCY

	SMALL VOLUME SECTION	HIGH VOLUME SECTION
Actual Output(Std Hours)	341.80	4748
Actual Production Hours Booked	341.33	4734
Labour Efficiency	100%	100%

EXHIBIT 8.7 : DIRECT LABOUR COST COMPARISON

	SMALL VOLUME SECTION	HIGH VOLUME SECTION
Standard Labour Rate	£0.0301 / Min	£0.0376 / Min
Standard Value of Output	341.33 Hrs	4747.67 Hrs
Standard Direct Wages Cost	£617	£10,716
Actual Direct Wages Cost	£538	£ 9,012
Actual Direct Wages Rate	£0.0263 / Min	£0.0317 / Min
Direct Wages Cost Variance	£78.74 (13%)	£1704 (16%)
Direct Wages Rate Variance	£77.82 (13%)	£1676 (16%)
Direct Wages Efficiency Variance	£ 0.74 (0%)	£ 31 (0%)

equipment and also the extra time incurred in waiting for engineering attention in the Small Order area. It is likely that the proportion of machine breakdown time was underestimated for the Small Order Section since some of the time lost due to each operative may have been classified as machine breakdown.

3. A greater proportion of High Volume Section machine time was diverted to Process Engineering Department work. It was not clear from the study however, whether this was merely a reflection of the higher priority given to high volume product development or whether the injection moulding manufacturing process used inherently presented more production problems.
4. Material shortage and mould cleaning downtime constituted a greater proportion of machine downtime for the High Volume Section than for the Small Order Section . It is doubtful that this reflected a more efficient material supply on mould cleaning operation for the Small Order Section, it is more likely that since production targets were rarely met by the Small Order Section, inefficiency of supply or servicing was unlikely to be highlighted.

8.6.1.2 Labour Efficiency

The labour efficiency of the High Volume Section was very high (as with the Small Order Section). There were a number of possible explanations:

1. The basic times may have been 'slack'. As considerable Industrial Engineering Department time and effort had been devoted to examination of this area excessive slack was unlikely to be the cause.
2. The standard minute values were inflated by the addition of a 40% 'leading hand allowance' and a 20% 'relief operator allowance'. Since the number of leading hands was reduced from 1 per 3 machines to 1 per 8 machines and there was only 1 relief operative per shift (as opposed to 3 in the standard) the standard times were inflated more than was necessary. (The inflation of the standard times should not have been made for indirect operatives in any case - see section 8.3.3).

   The change in manning level also contributed towards the positive labour rate variance, since fewer highly paid indirect operatives were employed in the High Volume Section.
3. The average operative earning rate in the High Volume Section was 72 standard minutes per hour - well above the expected performance of 60 standard minutes per hour. Not only did this increase the labour efficiency, but also resulted in a positive labour rate variance due to the design of the incentive scheme. (The total wages increased only slightly for a large increase in operative performance - a 33% increase in performance increased earnings by only 5%).

8.6.1.3 Actual Direct Labour Costs

Both the Small Order Section and High Volume Section showed an overall gain against the standard direct labour cost for the period under investigation. The magnitude of the gain for the High Volume Section was even greater than that of the Small Order Section (16% compared with 13%). In both cases it was the rate variance which had the greater effect, with the efficiency variances near to zero.

In both cases the majority of the variances resulted from costing assumptions which were not consistent with actual cost behaviour. In the case of the High Volume Section the additional factor of above standard operative performance also contributed to the positive labour cost variance.

8.7 General Discussion

The investigation into the Small Order Section performance identified problems which could be classified under the broad headings: 1) lack of administrative concern and 2) inadequate control of the production process. At the time of the investigation no incentive scheme was in operation; it was a further 6 months before any such system was implemented. In addition little effort had been made to ensure that the standard costs were in line with current processes and manning levels. As the High Volume Section investigation showed there was a general reluctance to alter cost standards more frequently than once a year, notwithstanding the effect which this might have on cost performance. The lack of an adequate cost control system was also evidence of the general attitude prevalent in Skelmersdale towards the use of standard costs to control the manufacturing processes.

The absence of a sectional cost control system made it very difficult for production management to identify the major problems associated with the operation of the Small Order Section and to take the appropriate remedial action. As a result, poor machine utilisation and excessive machine breakdown characterised Small Order production without management being made fully aware of the problems. At the same time it was possible for the belief that Small Order actual costs were in excess of the standard costs to be held without any evidence to support the belief.

The investigation showed that, whilst the Small Order operation was certainly not efficient, the standard direct labour costs were not exceeded (even though they were wrong). Therefore there was no evidence to suggest that Small Order parts were failing to reach the standard levels of contribution. Overcosting of Small Order production compensated for inefficiency. Efficiency improvements would have produced actual levels of contribution which were considerably higher than the standard levels which were established.

As a result of the investigation a number of improvements were undertaken to reduce machine breakdowns and increase labour availability. Detailed rewards showing the reasons for machine downtime were established; an examination of the rewards seven months after the original investigation showed that an improvement in machine utilisation from 45% to 78% had been achieved in the period. It is not known whether a comparable improvement in labour efficiency was achieved at the same time. A number of new cost centre codes were established in order to enable production management to identify actual Small Order production costs. Unfortunately a large number of new cost centre codes were also introduced at the same time, the ensuing confusion prevented the gathering of meaningful results before the end of the Small Order study.

CHAPTER 9

Forecasting Small Order Demand

9.1 Objectives

Small orders represented an area of uncertainty for Dunlop management; the objective of the forecasting exercise was to reduce the uncertainty to levels such that strategic decisions could be made about the future of this area of business at Skelmersdale.

The forecast was undertaken for two purposes:

9.1.1 To determine the resources which would be required at Skelmersdale if the demand for small orders was to be met and to determine the extent to which those resources would be utilised. Using the nomenclature of Battersby (60) it was a strategic decision which must be made - to determine the limits of the resources required in the longer term rather than a tactical decision of what the day-to-day resource requirement would be.

9.1.2 An overall level of activity for a possible small order section had to be obtained in order that standard cost budgets could be derived for small order products. Once determined these cost budgets could be used to:

9.1.2.1 Determine the viability of a small order section as a separate cost centre (by comparison with the current selling prices and with alternative products which might be manufactured on small order resources).

9.1.2.2 Provide the basis for a cost control system should the continuation of small order production be deemed worthwhile. Cost control was limited to a monthly report giving material, labour and 'variables' variances against standard for the whole department.

9.2 Forecasting Methods

In selecting a forecasting method all that can be attempted is to reduce the likely forecasting error, always constrained by the extra time and cost involved in obtaining precision and accuracy. The type of forecast used must also be determined by the data which is available for analysis and the output form of the forecast which is required. The forecast of small order demand at Skelmersdale was intended to determine the overall requirement of resources and not the day-by-day demand on resources caused by demand for specific parts. The type of forecast chosen therefore had to reflect the need for medium term (corporate) information rather than short term (operational) information.

Forecasts can take either synthetic or analytical form. Synthetic forecasts depend upon the company having close contacts with the market; these contacts can feed back not only estimates of local market changes, but also describe the 'feel' of the market. The rough quantitative estimates can be added up to give a total synthesis of the market and the judgements and 'hunches' can be sythesised by the sales forecaster to give an overall forecast. This approach was inappropriate for forecasting demand at Skelmersdale because of the structure of the market in which Dunlop were operating; whilst contacts between Dunlop, Skelmersdale and Automotive Products Limited were close, Automotive Products was not the end user of the product. Demand for Lockheed Department products was derived from the 'High Street' demand for vehicles and spares components; there were so many links in the distributive chain that even Automotive Products had become decoupled from end-user demand trends; they knew little more than Dunlop.

Analytical forecasts break down total figures into trends and random elements which can be recombined to give a projection into the future. Since these methods are used on time series (i.e. data on past performance which has been taken at regular intervals) analytical forecasts are often grouped under the generic title of time series analysis.

Analytic forecasting has two major advantages:

* Data can be collected in such a way that it can be analysed in a routine manner with the aid of a computer.

* The error of the forecast can be estimated once assumptions on the nature of the distribution of the errors are made and confidence limits determined.

The major disadvantage of the technique is that it allows little room for the judgement of those closest to the market to modify the forecast or indicate data which may be sufficiently deviant to warrant special treatment. This problem may be overcome by interpretation at two stages in the forecast: at the data collection stage, data known to be deviant may be modified or excluded altogether; at the final stage the analytical forecast may be modified in the light of the forecasters market knowledge. A hybrid forecast is then obtained which combines the best features of analytical and synthetic forecasting.

The final interpretation stage is particularly important when regression techniques are employed i.e. where one is attempting to determine a relationship between an independent variable (time for example) and a dependent variable (for example demand). The use of high order polynomials to fit the data may result in sudden kinks in demand which no behavioural model of the market can explain; the results of the forecast must be modified if this occurs. For the same reason Ockham's razor should be applied to the regression functions - it is advisable to use the simplest curve which will fit the data closely as the basis for the forecast.

9.3 The Choice of Technique

A regression approach was chosen to solve the forecasting problem for Lockheed Department small orders in preference to a moving average technique. The reasons for this choice were:

(1) Moving averages are only suitable where secular trends are negligible compared with random fluctuations in demand - even if a highly sensitive (high α) exponentially weighted average were to be used a considerable lag would be introduced between the forecast and actual values. This would mean that the average would take several periods to respond to a sudden change in the pattern of demand, for example, that which occurred in 1974 - 75. In this case the lag would exceed the period to be forecasted.

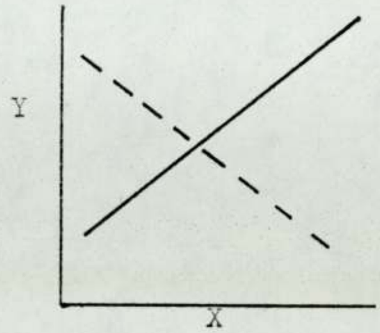
(2) Demand data was available for only the past four years. A starting value would have to be guessed which would considerably affect the forecast for year 5 since the moving average would not have sufficient time to establish itself. Furthermore with the nature of the output required a large number of starting estimates would have to be made; this would only compound the error.

Since no standard non-linear regression package was available on the files of the Aston University computer a programme was written which would perform the following operations:

9.3.1 To fit four simple functions to each group of data by a least squares method and present measures of the precision of the four forecasts in the form of the sum of the squared abolute errors and the sum of the squared percentage errors for each forecast. The four functions which were to be fitted to the data were:

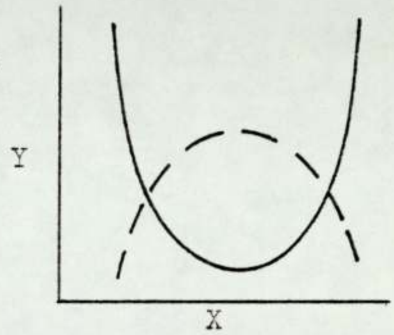
9.3.1.1 Linear Model

$Y = A + B.X$



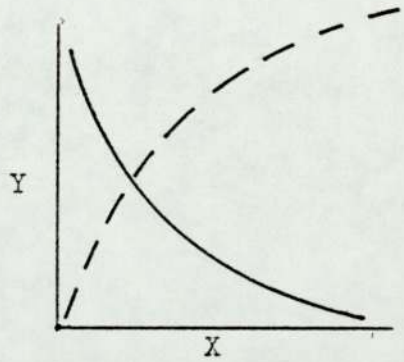
9.3.1.2 Parabolic Model

$Y = A + B.X + C.X^2$



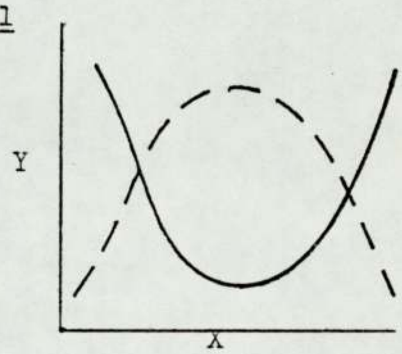
9.3.1.3 Exponential Model

$Y = A.B^X$



9.3.1.4 Log Parabolic Model

$Y = A.B^X \, C^{X^2}$



The four models above were chosen since, by visual inspection of the data the general forms of the curves were felt to be the simplest which would fit the data.

9.3.2 To transform the forecasted demand for each group into standard minute requirement for the forecasted period (1 year) by multiplication by the standard minute value for that group (see later).

9.4 Data Collection and Interpretation

9.4.1 Time Span of Data

Demand and delivery information was available on a part-by-part basis for all products on the current Manufacturing List (the list provided annually by Dunlop to Automotive Products which lists the parts which Dunlop will be willing to supply on request). Automotive Products in return provided a one monthly firm rolling schedule every month (e.g. in January schedules will be provided for February, in February for March and so on). Records cards were kept at Skelmersdale giving the month-by-month schedules for each part number together with actual deliveries made and any changes to the schedule. It was decided to use the schedule data as a measure of historical demand rather than actual deliveries, since delivery performance had been poor in the past and therefore did not reflect the demands of Automotive Products, but rather the ability of Dunlop to meet that demand.

Since a <u>strategic</u> forecast was to be made rather than a tactical forecast, annual schedules were obtained for each part which could be manufactured in the Small Order Section (i.e. by compression moulding). Monthly data was not required because we were attempting to determine what resources would be required and what overall utilisation might be achieved rather than determine the month-by-month variation in the machine requirements. Furthermore since demand for many individual parts was very spasmodic it would be difficult to determine a realistic forecast monthly figure.

This approach did not seem unreasonable, for although only a two month firm schedule was provided a six monthly estimated schedule could also be given, allowing considerable flexibility for Dunlop to determine when and in what quantities to manufacture. In addition, since the majority of Small Order were for the Spares Division of A.P. (over 70%) the pressure exerted upon Dunlop to deliver exactly to schedule were not as great as for original equipment parts.

9.4.2 Data Interpretation and Reduction

Although 174 compression parts were listed on the Manufacturing List, it was felt that only a proportion of those parts were likely to be scheduled in 1977. Since many parts had not been scheduled for several years.

In addition a considerable number of compression parts were included on the Manufacturing List which, due to a change in the moulding process, could not now be produced on the existing equipment. In order that the number of parts considered in the forecasting exercise should be minimised three exclusion rules were applied:

Parts were not to be considered if	No. of Parts Excluded	No. of Parts Left
		174
(1) If they had not been scheduled for at least two out of the past three years.	54	120
(2) If the mould shut height was * greater than the maximum of the Small Order Equipment. (3) If the pin-table part stripping method had to be employed. *	50	70
Number of parts included in the forecast =		70

9.4.3 Process Grouping

The Process Specification sheets were examined for the 70 remaining parts and the operations required to manufacture each part were determined, together with the type and weight of rubber compound required. (This latter information was required to build up standard costs).

The standard minute values of each operation performed were obtained from the Industrial Engineering Incentive Schemes and Accounts Department records. Where no records were available for certain parts the times were estimated by comparison with the times for similar parts which were manufactured in the same way.

* Process Terms - for explanation see Chapter 6.

A list of the operations and times was prepared (see Appendix E). By taking each operation in turn parts were grouped into classes of similar times for each operation, the width of the group being taken as ± 10% of the modal value in each group. For example the Wheelabration (freeze trimming) operation consists of 2 groups:

Operation	Group	Model Value (Sm/100)	Range (SM/100)	Part Numbers in Group	No. of Parts in Group
Wheelabration	10	1.1	1.0-1.2	55,64,70	3
Wheelabration	11	2.0	1.8-2.2	50,51,60-63, 65-68	11

A total of 45 groups were required to cover all the operations and standard times. To obtain the forecasted standard minute requirement for each operation the forecasted standard minute requirement for each group would have to be aggregated. In the example above the forecasted standard minute requirement for groups 10 and 11 would have to be added to give the overall Wheelabration requirement for 1977. The total washing requirement would consist of the sum of the standard minute value forecasts for groups 12, 13 and 14 and so on.

The 45 groups required are shown in Exhibit 9.1.

EXHIBIT 9.1 : PRODUCT GROUPS USED IN THE FORECAST

OPERATION	GROUP No.	MODAL VALUE (SM/100)	RANGE (SM/100)	PART NUMBERS IN GROUP	No. OF PARTS IN GROUP
Moulding	1	82.3	-	1,2,3,4,5,49	6
Moulding	2	41.2	-	6,7,8,9,10,11,12, 13,14,50,51,52,53, 54,55	15
Moulding	3	27.4	-	15,16,17,18,19,20, 21,22,23,24,25,26, 27,28,56	15
Moulding	4	20.6	-	29,30,31,32,33,57	6
Moulding	5	16.5	-	34,35,36,37,58,59, 60,61	8
Moulding	6	13.7	-	38,39,62,63	4
Moulding	7	11.8	-	40,41,42,43,44,45, 46,47,48,64,65,66, 67,68,69,70	16
Barwell	8	0.73	0.71-0.75	1-55,57-62,64-70	68
Barwell	9	1.5	1.35-1.65	56,63	2
Wheelabration	10	1.1	1.0-1.2	55,64,70	3
Wheelabration	11	2.0	1.8-2.2	50,51,56,60,61,62, 63,65,66,67,68	11
Wash	12	0.75	0.7-0.8	60,62,63,65	4
Wash	13	1.0	0.9-1.1	49,50,51,56,58,59, 64,67,68,70	11
Wash	14	1.5	-	61	1
Sort	15	12.0	-	50,61,64,66,68	5
Rough Trim	16	8.0	-	1,18,19,28,34	5
Rough Trim	17	10.0	-	2,4,5,7,9,10,11,14, 15,16,25,29,31,32, 35,36,37,38,39,40, 41,44,46,48,70	25
Rough Trim	18	12.0	-	6,12,13,17,21,22, 23,26,30,33,42,45, 47	13

OPERATION	GROUP No.	MODAL VALUE (SM/100)	RANGE (SM/100)	PART NUMBERS IN GROUP	No. OF PARTS IN GROUP
Rough Trim	19	14.5	14.0-15.0	20,24,27,52,57,69	6
Lathe	20	5.0	4.5-5.5	14,25,26	3
Lathe	21	5.0	5.6-6.5	28,34,47	3
Lathe	22	7.0	6.6-7.5	20,23,42	3
Lathe	23	8.0	7.6-8.5	5,7,10,12,13,15, 22,29,31,32,35,38, 39,40,69	15
Lathe	24	9.0	8.6-9.5	2,9,24,41,48	5
Lathe	25	10.0	9.6-10.5	8,11,20,55	4
Lathe	26	14.0	13.6-14.5	30,45	2
Lathe	27	16.0	15.6-16.5	1,3,4,6.18,19,37, 43,44,46	10
Lathe	28	18.0	17.2-18.8	16.17,27,33,36	5
Punch	29	10.0	-	41	1
Punch	30	14.0	-	35,38	2
Punch	31	18.0	-	40	1
Click	32	2.0	-	8	1
Click	35	5.0	-	43	1
Click	34	12.0	-	3	1
Click	35	15.0	-	59	1
Stone/Drill	36	16.0	15.0-17.0	24,58,49,65	4
B.U. Trim	37	14.0	13.0-15.0	51,58,59	3
B.U. Trim	38	18.0	-	52	1
Grind	39	16.0	-	2	1
Oil Test	40	1.0	-	2,12,15,17.23,24	6
Inspection	41	6.0	5.6-6.5	1,10,15,18,25,28,28, 29,32,42,47,49,54, 57,60,63	15

OPERATION	GROUP No.	MODAL VALUE (SM/100)	RANGE (SM/100)	PART NUMBERS IN GROUP	No. OF PARTS IN GROUP
Inspection	42	7.0	6.6-7.5	3,8,9,11,12,13, 21,22,23,31,33, 35,38,40,48,40, 48,50,51,52,53, 58,59,61,62,65, 66,67,68	27
Inspection	43	9.0	8.6-9.5	19,30,34,43	4
Inspection	44	10.9	10.0-11.7	3,4,5.6,14,16,17, 20,24,26,27,36, 37,41,44,45,46, 55,56,64,69,70	22
Inspection	45	13.4	-	7,39	2

9.4.4 Alternative Groupings

It was originally intended that the annual demand data for each part number (1-70) should be fed into the computer store, with instruction given which would specify which part numbers were to be incorporated into each forecast. However, upon further investigation it emerged that whilst such an exercise was possible, it was likely that the time taken to develop and test the computer programme and to feed in the data would exceed the time to perform the task manually; it was decided that the computer should only be used to fit the curves and calculate the standard minute requirement on each of the 45 groups.

As the collection of individual part demand data into groups was being performed manually another opportunity presented itself; that of forecasting the resource requirements directly on the historical total resource requirements rather than forecasting on number of parts scheduled, aggregating the groups and transforming into standard time requirement. Since it was quite possible that the two different forecast would yield different results (because different curves might be fitted to the data) and different forecasting errors, it was decided that both approaches should be attempted.

9.5 Results

9.5.1 Interpretation

The results of the forecast could not simply be accepted blindly just because a computer was used to determine them;

they must be seen in the light of what is known about the market and the changes which had taken place in recent years.

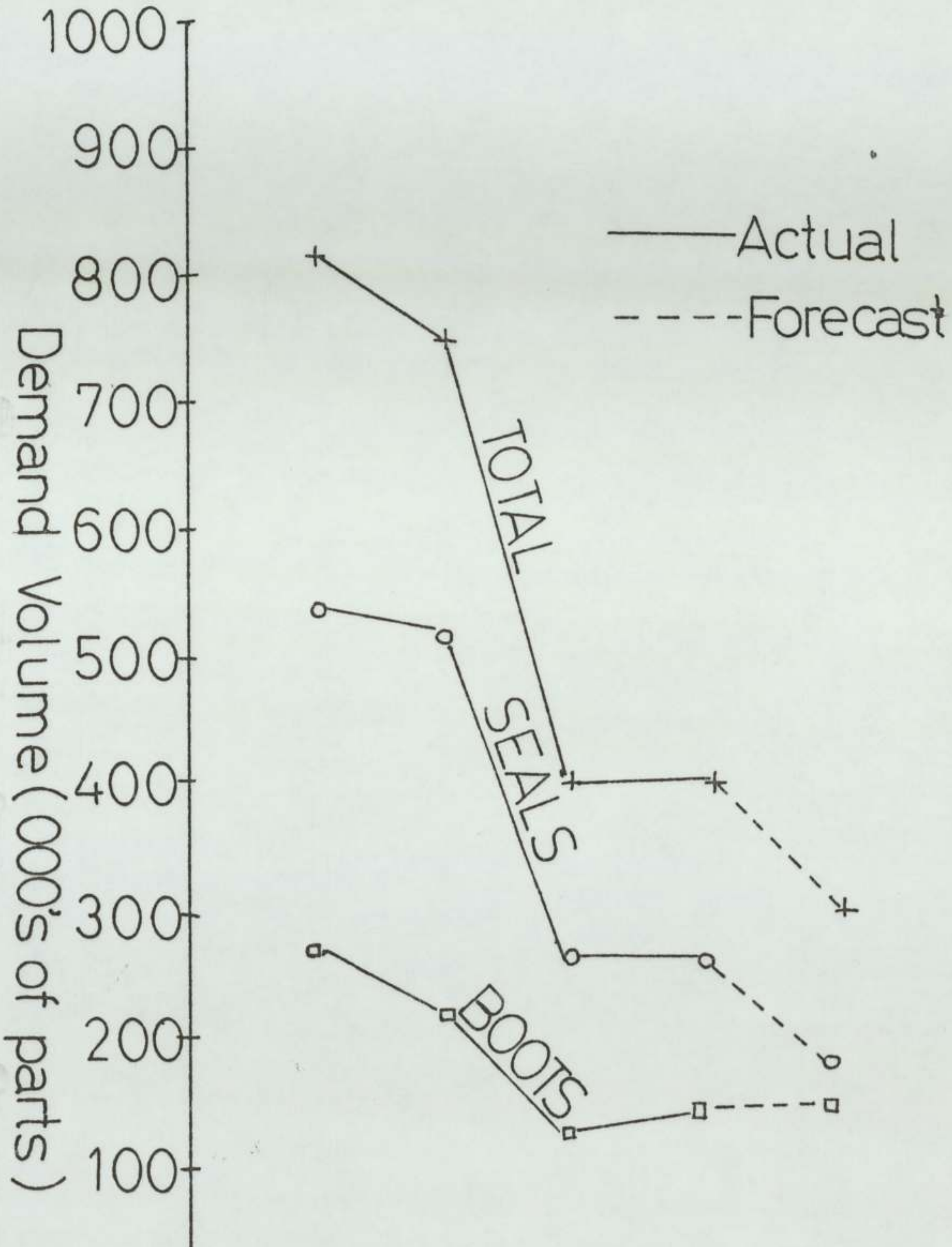
9.5.1.1 Volume Reduction

At the end of 1974 Automotive Products, in common with many companies at that time, suffered a liquidity crisis (the current ratio falling from 1.95 in 1973 to 1.57 in 1974 (61) and responded to this situation by drastically reducing stocks. In addition to this the motor industry suffered a recession which affected original equipment demand as well as spares. The effect of cut backs were additionally amplified by further destocking by successive members of the distributive chain. The net result was that total Lockheed Department activity level fell by 50% during 1975. By the second quarter of 1976 the high volume schedules had returned to virtually pre-slump levels; as can be seen in Exhibit 9.2 small order schedules did not return to previous levels. There were several possible explanations for this failure to recover volume:-

9.5.1.1.1 Technological Change

All the parts classified as small orders for this exercise were moulded by a compression technique. In recent years there had been a move towards

EXHIBIT 9.2. : VOLUME FORECAST - SMALL ORDER SECTION



injection moulding of brake rubbers at Skelmersdale. As the demand for particular brake rubbers fell (generally representing the transition from original equipment use to spares use at the end of the product form life cycle) it could be expected that fewer parts would fall into the low volume compression category and more into the low volume injection category. As the demand for particular compression brake rubber decreased (since the majority are for spares use) it could not be expected that parts disappearing from the small order category would be replaced by parts falling into this category.

This analysis was supported by examining the number of parts scheduled over the past four years and examining the average demand per part:

Year	No. of Parts On Schedule	Volume	Average Call Off/Part/Year
1973	62	818,046	13,194
1974	64	743,646	11,619
1975	60	399,363	6,656
1976	49	415,412	8,477

It should be noted that the number of parts on schedule had fallen since 1973, as had the average demand per part type - we were dealing with a declining area of business.

9.5.1.1.2 Product Policy

Associated with point 9.5.1.1.1 was the fact that Automotive Products had been pursuing a product rationalisation policy in recent years which was given a spur by the cash flow crisis of 1974 -75. The intention was that a greater variety of braking needs would be met by a smaller number of different parts. This would have two main effects on the Dunlop, Skelmersdale business:

* Product form life cycles were likely to lengthen since, with one product being supplied for use in an increasingly large number of applications, the decrease in total demand would be slower - it would take longer for products to fall into the small order category.

* A number of existing small order parts may have disappeared due to product rationalisation, thereby reducing the number of parts on schedule. This would have the effect of increasing average demand for the remaining parts only if another small order part was being used to fulfil the function; if a high volume part was being instead there would be no increase in the average small order demand. Since the average quantity per part number had fallen (excepting the small rise after 1975 which reflects post-crisis recovery) it suggested that this latter form of rationalisation had occurred.

9.5.1.1.3 Competition

With the purchase by Automotive Products of their own rubber company (Alfred Roberts Ltd) it might be expected that an increasing proportion of the business would be sent in that direction. There was no strong evidence to suggest that this occurred, but it was possible that certain parts had been resourced, especially where A.P. felt that the delivery performance of Dunlop, Skelmersdale had been poor.

9.5.2 Interpretative Rules

For the reasons outlined in section 9.5.1, it was unlikely that any real growth in demand could be expected for small order parts. Therefore in cases where the curve fitted caused the forecasted demand to exceed the 1973-1974 levels, the forecasted demand was taken at the 1976 level, on the basis that the most recent data was best compromise. It was possible that some degree of recovery to 1973-1974 levels might be achieved for certain categories; where the forecasted 1977 value did not exceed the 1973 level the forecasted demand was used.

At the other end of the scale, where the extrapolated demand was negative, a figure of zero was used for the forecasted demand.

(For the output form of the computer forecast see Exhibit 9.3).

9.5.3 Resource Requirements

The results of the forecasted annual resource requirements by the two alternative approaches are shown in Exhibit 9.4 (for a graphical representation of the group forecasts see Exhibit 9.5).

Exhibit 9.3. : Typical Computer Output Format

FORECAST FOR PART GROUP 1

LINEAR MODEL - Y = A + BX

TIME PERIOD	DEMAND DATA	FITTED TREND	ABSOLUTE ERROR	PERCENTAGE ERROR
YEAR 1	43211.00	52441.75	-9230.75	-17.60
YEAR 2	70607.00	46015.40	24591.60	53.44
YEAR 3	18100.00	39591.13	-21491.13	-54.28
YEAR 4	39296.00	33165.80	6130.20	18.48
YEAR 5		26740.50		

SUM OF SQUARED ABSOLUTE ERRORS = 1.13940E+09
SUM OF SQUARED PERCENTAGE ERRORS = 6054.
FORECAST STANDARD MINUTE TOTAL = 2.20074E+06

PARABOLIC MODEL - Y = A + B*X + C*X↑2 ✓

TIME PERIOD	DEMAND DATA	FITTED TREND	ABSOLUTE ERROR	PERCENTAGE ERROR
YEAR 1	43211.00	50891.45	-7680.45	-15.09
YEAR 2	70607.00	47565.65	23041.35	48.44
YEAR 3	18100.00	41141.35	-23041.35	-56.01
YEAR 4	39296.00	31615.55	7680.45	24.29
YEAR 5		13939.25		

SUM OF SQUARED ABSOLUTE ERRORS = 1.17979E+09
SUM OF SQUARED PERCENTAGE ERRORS = 6333.97
FORECAST STANDARD MINUTE TOTAL = 1.56262E+06

EXPONENTIAL MODEL - Y = A*(B↑X)

TIME PERIOD	DEMAND DATA	FITTED TREND	ABSOLUTE ERROR	PERCENTAGE ERROR
YEAR 1	43211.00	49131.15	-5920.15	-12.05
YEAR 2	70607.00	41674.03	28932.97	69.43
YEAR 3	18100.00	35343.74	-17243.74	-48.79
YEAR 4	39296.00	29983.46	9312.54	31.06
YEAR 5		25432.64		

SUM OF SQUARED ABSOLUTE ERRORS = 1.25547E+09
SUM OF SQUARED PERCENTAGE ERRORS = 6311.31
FORECAST STANDARD MINUTE TOTAL = 2.09311E+06

LOG.PARABOLIC MODEL - Y = A*(B↑X)*C↑X↑2)

TIME PERIOD	DEMAND DATA	FITTED TREND	ABSOLUTE ERROR	PERCENTAGE ERROR
YEAR 1	43211.00	52748.35	-9537.35	-18.08
YEAR 2	70607.00	38815.26	31791.74	81.90
YEAR 3	18100.00	32924.68	-14824.68	-45.03
YEAR 4	39296.00	32190.94	7105.06	22.07
YEAR 5		35273.61		

SUM OF SQUARED ABSOLUTE ERRORS = 1.37193E+09
SUM OF SQUARED PERCENTAGE ERRORS = 9549.55
FORECAST STANDARD MINUTE TOTAL = 2.98573E+06

EXHIBIT 9.4

RESOURCE	DIRECT RESOURCE FORECAST		AGGREGATED RESOURCE FORECAST	
	Machine Standard Min. Requirement	% Forecasting Error @ 95% Confidence Level	Machine Standard Min. Requirement	% Forecasting Error @ 95% Confidence Level
Barwell	2312	± 43%	2349	± 30%
Moulding	77920	± 63%	86255	± 6%
Wheelabration	854	± 33%	1001	± 25%
Washing	1419	± 14%	1384	± 6%
Sort	9198	± 14%	9198	± 14%
Rough Trim	21753	± 50%	22449	± 12%
Lathe	20256	± 65%	16315	± 8%
Punch	2311	± 64%	1288	± 60%
Click	9251	± 8%	7989	± 4%
Stone/Mill	562	±337%	562	±337%
B.U. Trim	11752	± 6%	9988	± 6%
Grind	480	± 73%	480	± 73%
Oil Test	209	± 13%	210	± 13%
Inspection	23120	± 48%	29509	± 11%

EXHIBIT 9.4

RESOURCE	DIRECT RESOURCE FORECAST		AGGREGATED RESOURCE FORECAST	
	Machine Standard Min. Requirement	% Forecasting Error @ 95% Confidence Level	Machine Standard Min. Requirement	% Forecasting Error @ 95% Confidence Level
Barwell	2312	± 43%	2349	± 30%
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Sort	9198	± 14%	9198	± 14%
Rough Trim	21753	± 50%	22449	± 12%
Lathe	20256	± 65%	16315	± 8%
Punch	2311	± 64%	1288	± 60%
Click	9251	± 8%	7989	± 4%
Stone/Mill	562	±337%	562	±337%
B.U. Trim	11752	± 6%	9988	± 6%
Grind	480	± 73%	480	± 73%
Oil Test	209	± 13%	210	± 13%
Inspection	23120	± 48%	29509	± 11%

EXHIBIT 9.5.: SMALL ORDER RESOURCE REQUIREMENTS (from the aggregated forecast)

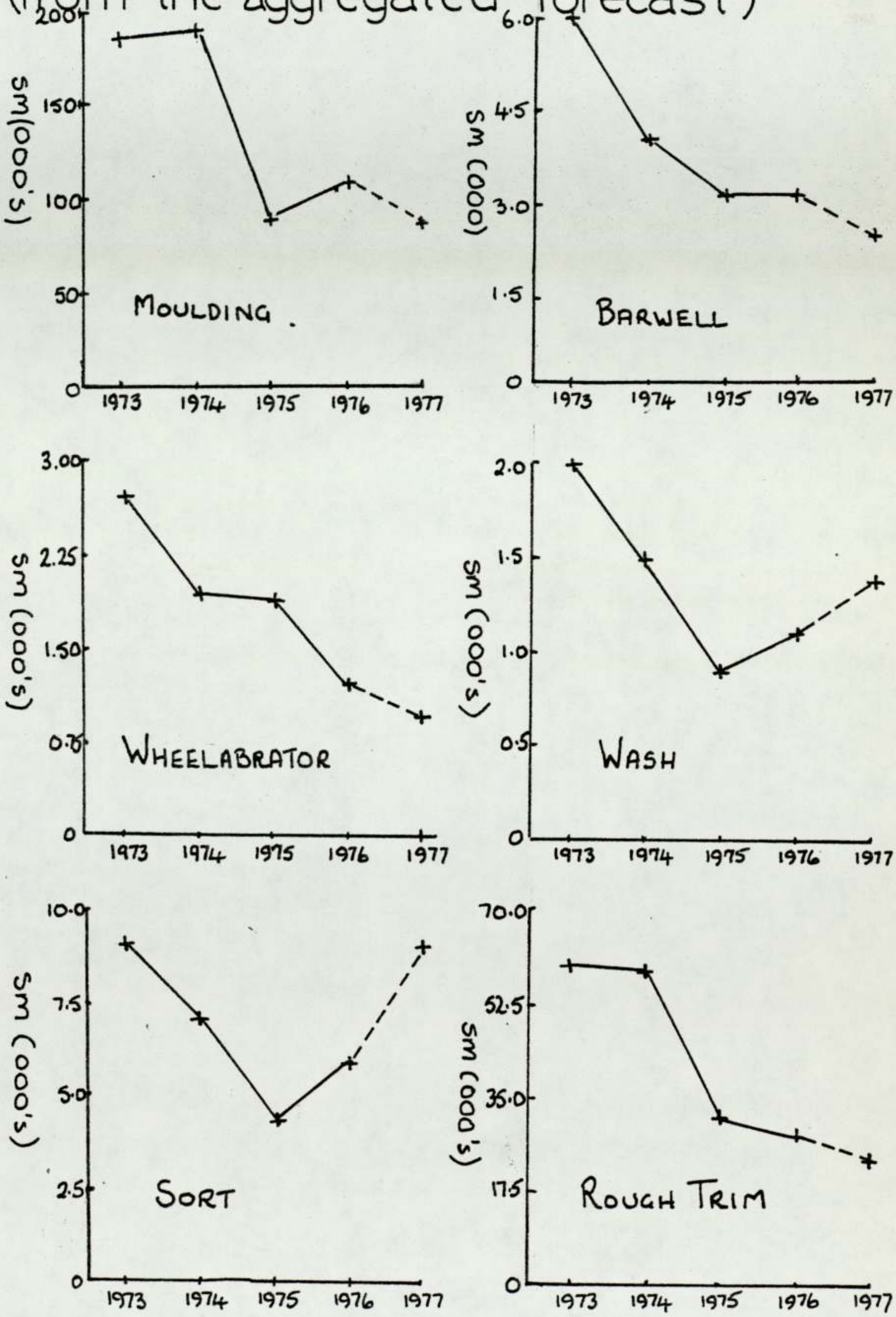


EXHIBIT 9.5. (continued)

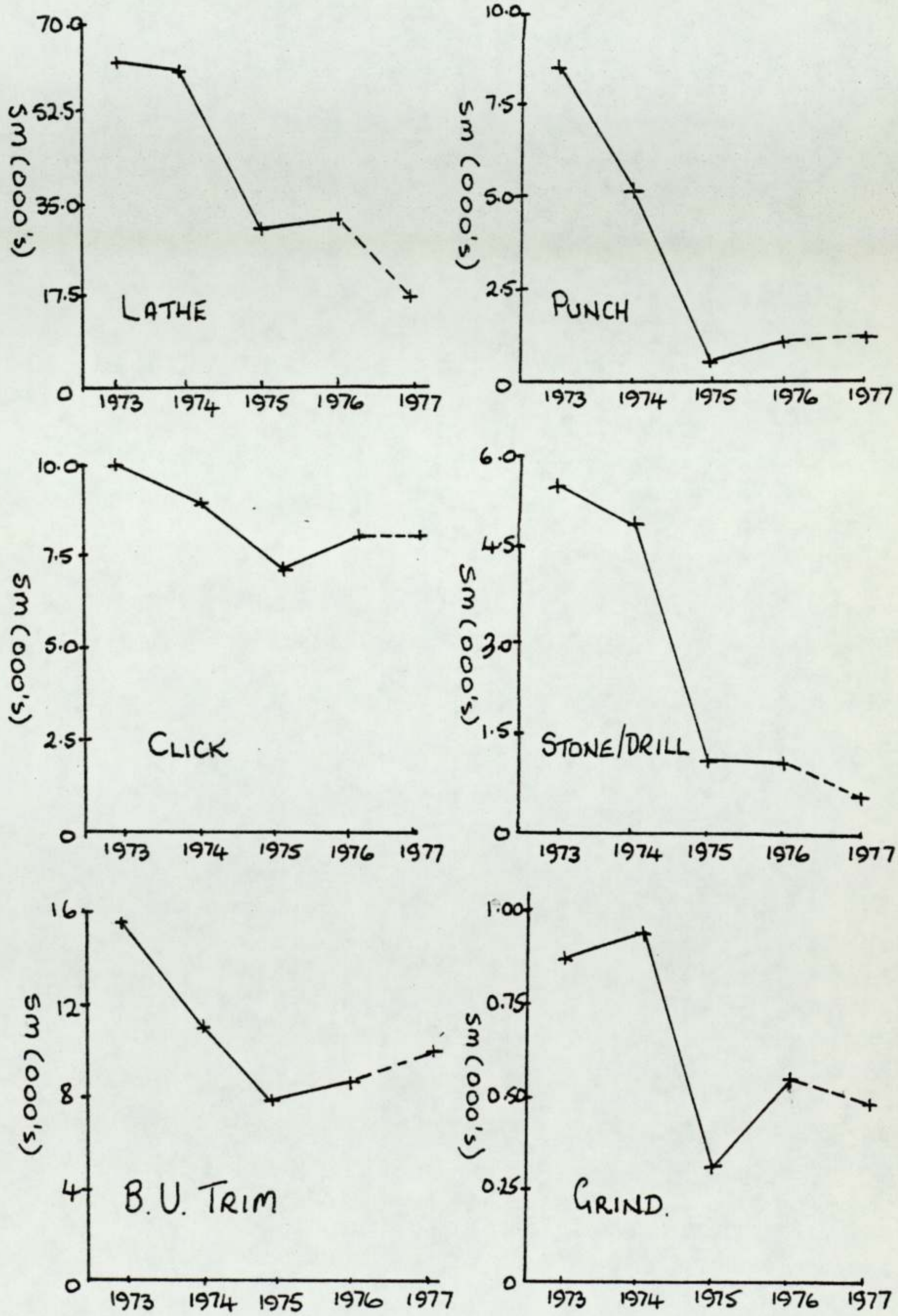
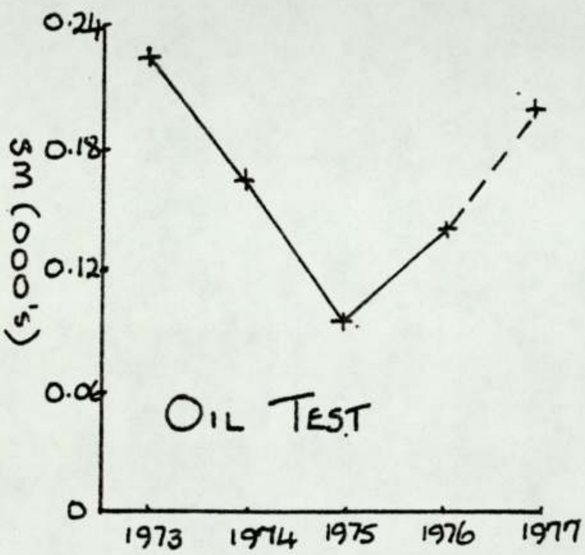
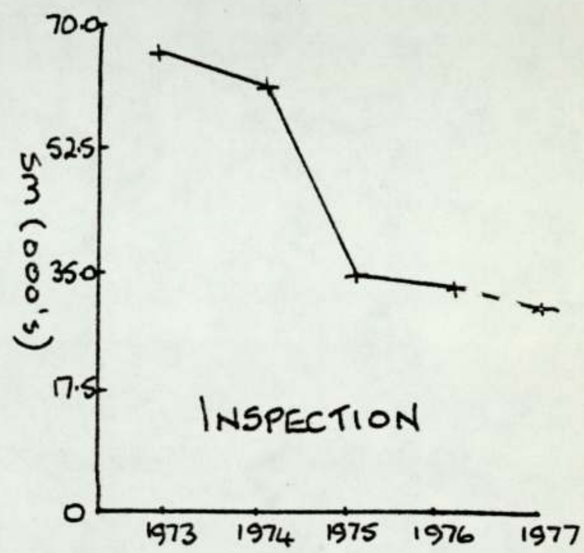


EXHIBIT 9.5. (continued)





9.6 Discussion of Results

9.6.1 Precision

In all cases the percentage forecasting error in the aggregated forecast was less than or equal to that for the direct resource forecast. The reason for this difference can be understood by considering two points:-

9.6.1.1 Where the results of more than one product group must be aggregated to obtain a resource forecast a larger number of data points were used to obtain the forecast than in the direct resource forecast (where there was one data point for each year). Since the standard deviation of the residuals, which is used to estimate the error, depends on the inverse square root of the number of readings, the larger the number of data points, the smaller will be the forecasting error. (Where there was only one product group per resource there will be the same number of readings and the two methods will yield identical forecasts and forecasting errors).

9.6.1.2 Four functions were fitted to the data for each forecast; the best fit was judged to be that which had the lowest sum of percentage error. Where several product group forecasts had to be aggregated to estimate a resource requirements the best curve was fitted separately for each product group. When summed the forecasting errors for each product group tended to cancel each other out and give a lower overall forecasting error than the direct forecast where only one curve was fitted to the total data.

The direct forecast for moulding, for example was derived from fitting the best of four possible functions to four data points. The aggregated forecast was derived from the summation of seven product group forecasts, the best function having been chosen for each group with a total of 28 data points.

Since the aggregated forecasting technique yielded considerably lower errors, the results of this approach were used for activity level estimation.

9.6.2 Arrears

The resource requirements which were forecasted reflected the likely demands which were to be placed on Dunlop, Skelmersdale small order resources in 1977 by the customer schedules. They did not include the work which would have to be undertaken to reduce the considerable small order arrears. Any estimation of the total small order activity would have to take into account the activity which would be required to reduce the arrears.

9.7 The Use of the Forecast

9.7.1 Viability of the Small Order Section

The forecast of the small order resource requirements could now be used to prepare standard cost budgets for the production of small orders in 1977. By comparison with the forecasted sales volume (see Section 10.3.1) it was possible to make an assessment of the financial viability of a completely separate small order section incorporating all the facilities which the forecast suggested would be required.

Additionally, if, as was thought likely, the cost of the inclusion of all the facilities in a separate small order section was found to be prohibitive, the budgets based upon the forecast could be used to determine which could be incorporated into the small order section.

9.7.2 Opportunity Costs

The cost budgets derived from the forecasts could be used to determine the contribution which small order products made towards general fixed overhead. The level of contribution could then be compared with the contribution levels which might be attained by using the facilities to manufacture other products - the opportunity cost of the operation could be estimated.

9.7.3 The Closed Loop

As Battersby suggests, the act of forecasting is a circular process; the forecast itself may affect the eventual outcome so that it differs from the forecasted outcome.

The forecast provided the management at Skelmersdale with a prediction of the future demand for small orders. No similar forecast had ever been provided before. Thus, not only did the forecast help to reduce the uncertainty of the Dunlop management, but it also conditioned their behaviour. For example, a programme was initiated to determine whether several of the operations for which there was only a limited annual requirement (grinding, drilling and oil testing) were really necessary (the results of this investigation were, unfortunately, not available before the end of the project).

Thus it can be seen that the forecast was itself an instrument of change which may have affected the eventual outcome which it predicted; the forecast itself merely indicated what was likely to happen if no changes were made.

CHAPTER 10

An Assessment of Viability

10.1 Objectives

The forecasting exercise provided an estimate of the level of activity for small order resources in 1977. Following on from this exercise the next stage was to use the forecast activity levels to derive budgets which would enable assessment to be made of the viability of small orders in the Skelmersdale environment. Theoretically it should have been possible to assess the viability of this area of business by comparison of the forecast turnover for small orders with budgeted costs derived from the product standard costs currently used in the factory. However, for a number of reasons (see section 2), it was felt that any conclusions which were based on the existing standard costs could be misleading. To overcome the questionable validity of Dunlop standard costs the exercise described in this chapter was undertaken with the following major objectives:

10.1.1 To assess the viability of a small order section by comparison of operating cost budgets with the forecasted turnover. The assessment was based upon the contribution towards general fixed overhead which could be generated by the section together with a comparison with the contribution level which could be generated by alternative products which could be manufactured using small order facilities (where contribution is defined as the difference between the variable costs of manufacture and the sales revenue).

A marginal costing approach was chosen for two reasons:

(i) It was difficult to determine a fair apportionment of general overhead costs which would enable a full absorption cost to be calculated.

(ii) The existing accounting system at Skelmersdale was based upon the marginal approach; since relative profitability can only be determined by comparison of like costs it was decided that the costs determined by the exercise should be compatable (and thereby comparable) with the costing methods currently in use. Furthermore the use of similar types of cost to those currently in use could be used to highlight any difference between the approaches.

10.1.2 The budgets generated by this exercise could be used to determine product standard costs and thus form the basis of a standard costing system should the section prove viable. Once derived the product standard costs could be used to:

(i) Aid cost reduction programmes and effect close cost control (65).

(ii) Assist the development of selling prices in conjunction with market information (66,67,68).

(iii) Value stock and work-in-progress (69).

(iv) Measure relative product profitability and thereby indicate the optimum product mix for profitability.

10.1.3 At this stage it would be advisable to clarify exactly what is meant by standard costs. Standard costs are pre determined costs used to measure performance. They express 'not what a product or activity actually cost, but what it should have cost (70). They should be based on 'careful engineering analysis of direct labour and direct materials needed for a product' (71) together with an 'appropriate share of budgeted overhead' and are calculated 'in relation to a prescribed set of working conditions' (72).

In calculating a standard cost therefore, assumptions must be made concerning the efficiency levels which will be incorporated into the standards. The assumptions can lead to three basic types of standard (73):

10.1.3.1 Basic Cost Standards

These are unchanging standards which provide the basis for comparison of actual costs throughout the years with a base standard. They can be used to detect trends in prices and efficiency but rapidly become obsolete as production methods are changed. For this reason the application of basic cost standards in Skelmersdale would not have been appropriate; the situation , even for small orders, was highly dynamic.

10.1.3.2 Perfection (Theoretical) Standard Costs

Perfection standard costs are the minimum costs that are possible under the best conceivable operating conditions, using existing equipment and specification. The standards so obtained are ideal and therefore rarely achievable. Some managers believe that such ideal standards can act as motivation to tighter cost control and cost reduction, but there is considerable evidence to suggest that standards which cannot be achieved have more dysfunctional effects than benefits and can in fact lower the level of operation of the employees concerned (74, 75, 76, 77, 78). Generally, operating executives will accept standards to the extent that they are attainable, that the data base is acceptable and that the variables measured are controllable by them (79). The use of ideal standards can easily cause the operating executives to regard them as 'pressure instruments' rather than management tools; resentment and disillusionment often result (80).

10.1.3.3 Currently Attainable (Normal) Standard Costs

Currently attainable standard costs should be difficult to achieve, but it should be possible to reach the standard with reasonably efficient operating conditions, allowing for ordinary wastage, machine breakdowns and lost time. They must be sufficiently tight however to ensure that accomplishment of the standard will be regarded as an achievement; the behavioural studies quoted in section 10.1.3.2 suggest that marginal failure is a greater motivator than either overwhelming success or dismal failure.

The major problem with this approach is that it is difficult to assess objectively what is realistically achievable. Whilst some attempts have been made to quantify the desirable level of motivation in quasi-mathematical terms (81) it is usually left to management to determine what is realistic. The bargaining which can then ensure often leads to dysfunctional budgetary slack and a reduction in the motivation to improve efficiency (82).

10.1.3.4 'Estimated' Costs

In addition to the three types of standards there is a further classification of cost type - 'estimated' costs rather than standard costs, whereby existing levels of efficiency are assumed; they are extrapollations of existing operating conditions and offer no incentive to improve efficiency levels (83). Whilst this approach cannot justifiably be called standard costing, Batty (84) has found that nearly ⅓rd of the British companies examined in a 1970 survey used estimated costing under the name of standard costing.

10.1.4 The above discussion of cost types will be particularly relevant to the next section since the standard costing approach which was used in Skelmersdale may be said to be a hybrid of a number of the normal approaches.

10.2 Standard Costing at Skelmersdale

Standard costs were in use at Dunlop, Skelmersdale together with a rudimentary standard costing system. The term 'rudimentary' is used because, although there existed a system for the generation of standard variable works costs, the costs were not used effectively to control the operation.

As Scott (85) states:

"A standard costing system is the employment of standard costs for measuring and controlling the efficiency of the manufacturing operations".

The presence of standard costs does not automatically imply that there is a standard costing system in operation - it must be used for control. The author does not believe that cost reporting in Skelmersdale was sufficiently detailed, nor sufficiently timely to be justifiably called a standard costing system. This claim will be substantiated by a description and critique of the system. In addition the validity of the standard costs used in the system was questionable; a description and critique of the basis for the standards will also be given.

10.2.1 The Standard Costing System

10.2.1.1 Description

10.2.1.1.1 All departmental managers and selected senior management received a monthly Report of Operations which related actual departmental sales performance and fixed factory overhead to the budgeted figures for the month (year-to-date and the previous years figures are also included). In addition the standard variable cost of the output was compared with the actual variable cost for the period (in terms of departmental direct labour, direct material and variable overhead). A single total variance was calculated for each of the three major departmental variable cost elements (see Exhibit 10.1).

10.2.1.1.2 The actual performance level figures presented in the Report of Operations were taken from the Departmental Shop Accounts, which were also produced on a monthly basis and were sent to departmental managers and selected senior management (see Exhibit 10.2). Total direct material, direct labour and variable overhead variances were calculated for each department by comparison of actual cost of output with the standard cost of the output, but no attempt was made to break

EXHIBIT 10.1 : REPORT OF OPERATIONS

G.R.C. DIVISION

SKELMERSDALE FACTORY COST OF PRODUCTION REPORT

MONTH SEPTEMBER 1975 24 WORKING DAYS

	MILL £	MOULDING £	LOCKHEED £	PRECISION DRIVES £	PROOFING £	FABRICATIONS £	HOUSEHOLD GLOVES £	GIRLING £	TOTAL SKELMERSDALE £
STANDARD COST OF SALES									
TOTAL MATERIAL	40674	19825	6285	5580	31610	2912	-	3016	109902
LABOUR	3449	9606	18178	4930	7679	2518	-	21042	67302
VARIABLE EXPENSES	2487	7830	10009	2591	4446	1484	-	11208	40055
TOTAL	46610	37261	34472	13001	43735	6914	-	35266	217259
STANDARD COST OF I.D.T.									
TOTAL MATERIAL	44897	1895	-	-	2017	4	-	254	49067
LABOUR	3566	1978	523	-	211	299	-	1	6578
VARIABLE EXPENSES	2572	1739	349	-	122	149	-	1	4952
TOTAL	51035	5612	872	-	2350	452	-	256	60577
TOTAL OUTPUT AT STANDARD									
TOTAL MATERIAL	85571	21720	6285	5580	33627	2916	-	3270	158969
LABOUR	7015	11584	18701	4830	7890	2817	-	21043	73880
VARIABLE EXPENSES	5059	9569	10358	2591	4568	1633	-	11209	44987
TOTAL	97645	42873	35344	13001	46085	7366	-	35522	277836
VARIATIONS FROM STANDARD									
TOTAL MATERIAL	1120	1250	677	1428	5952	4420	-	2534	15481
LABOUR	1864	4568	10491	3844	13127	1454		10135	45503
VARIABLE EXPENSES	285	1479	4001	2135	7890	626		5467	21903
TOTAL	1029	7357	15369	7407	26969	6500		18256	82887
TOTAL COST OF PRODUCTION	98674	50230	50713	20408	73054	13866	-	53778	360723

EXHIBIT 10.2 : DEPARTMENTAL SHOP ACCOUNTS

MONTH ENDING DECEMBER 1975

DEPARTMENT 3120 LOCKHEED.

INPUT	MAT	METAL / CLOTH	LAB	VAR	TOTAL
OPENING STOCK AT STANDARD	8591	–	11434	7181	27206
STOCK REVALUATION					
TRANSFERS IN – EX MILL DEPT.	5021	–	434	313	5768
TRANSFERS IN – EX CAMB. ST.	–	–	–	–	–
TRANSFERS IN – EX M.D.T.'s.	1703	–	1936	1630	5269
TOTAL TRANSFERS	6724	–	2370	1943	11037
ISSUES RAW MATERIAL STORES.	275	–	–		275
ADJUSTMENT TO PURCHASES.	(275)		275		–
TRANSFERS TO WASTE.	480	–	–	–	480
TOTAL MATERIAL.	15795		14079	9124	38998
TOTAL LABOUR.			21305		21305

VARIABLES

N.H.I.	3244
COMP. PENSION	1702
HOLIDAY PAY	2553
TRAINING WAGES	–
EXPENSE MATERIAL	–
GEN. STORES ISSUES	492
INTER-DEPT. TRANSFERS	
TRANSFERS EX CAMB. ST.	–
ENGINEERS SERVICES	
POWER	1047
GAS	–
STEAM	1039
WATER	228
ENGINEERS MAINTENANCE	11239

		MAT	METAL / CLOTH	LAB	VAR	TOTAL
TOTAL VARIABLES	21544				21544	21544
TOTAL COST INPUT		15795		35384	30668	81847

OUTPUT	MAT	METAL / CLOTH	LAB	VAR	TOTAL
NETT OUTPUT AT STD	5618	–	17021	9684	32325
TRANSFERS OUT	11	–	34	19	64.
COMPOUND TRANSFERS OUT					
TOTAL OUTPUT	5629	–	17055	9703	32387
Debased Compound					
GAIN/LOSS	LOSS 2201		LOSS 7050	LOSS 14737	LOSS 23988
CLOSING STOCK AT STD	7965	–	11279	6228	25472
TOTAL COST OUTPUT	15795	–	35384	30668	81847

CHECKED BY BK J. COMPTOMETER

down the variances into usage, rate, efficiency etc; variances on materials and variable overhead were based on standard costs throughout the document - any variances can be attributed to efficiency and not price).

More detailed breakdowns of the 'Actual' overhead costs were shown on the Shop Accounts but investigation revealed that they resulted from the apportionment of the total actual factory costs for the period on an arbitrary basis to the individual departments; they did not reflect the individual expenditures of the departments.

10.2.1.1.3 In addition to the monthly cost information a number of reports were issued which related to physical performance and were not couched in cost terms. They were:

(1) Weekly Reject and Rework Report
- a report showing the reject and rework percentages for each part type produced in the week. A cumulative year-to-date figure was also presented.

(2) Daily Machine Downtime Analysis - giving details of and reasons for lost time for selected machines in the department. Wherever possible the actual downtime figures were compared with the standard allowances.

(3) Weekly Departmental Production Performance - giving the total number of parts produced from each moulding section compared with the planned output for the section. The report therefore took the form of an activity variance analysis.

(4) Weekly Operator Efficiency Analysis - showing the average earnings (in standard minutes per actual hour) for each operator, together with a breakdown of the number of hours spent under different earning conditions, e.g. on bonus work, on average earnings or at 85% of average earnings, on indirect work etc.

(5) Weekly Maintenance Labour Summary - showing the number of maintenance labour hours booked to each cost centre (i.e. different moulding areas, finishing areas etc), for the week.

(6) Daily Mill Ticket and Return Summary - giving the weight of compound (by compound type) issued to each department together with the weight of compound (by compound type) returned to the Mill area as substandard.

10.2.1.2 Critique of Standard Costing System

10.2.1.2.1 The cost control system provided too little too late to the responsible managers; departmental managers usually did not receive the Shop Accounts (the major control documents) until half way through the next operating period, i.e. up to six weeks after the start of the period to which it referred. By the time that the control document arrived the costs described were regarded as 'water under the bridge' about which little could be done. A cost control document should always arrive before it is too late to take action; if not if defeats the purpose it purports to serve. Backer and Jacobson and others (86 87) have stated that direct material and labour variances should be reported daily, with factory overhead reported on a monthly basis.

In view of the limited accounting resources at Skelmersdale, it was not reasonable to expect daily variance reports to be made; a recommendation was made that direct material and labour variance could be produced on a weekly basis, the report being submitted on the first working day of the next week.

The only usage variances in the Shop Accounts which could be regarded as meaningful for control purposes (in that they related to a comparison of actual with standard rather than apportioned actual with standard) were the direct labour and direct material variances. No indication was made concerning the area in which the variances were incurred; for the Moulding Department for example only two meaningful variances were provided for the whole department, which contained six different moulding sections, several major finishing areas and employed over 170 production workers. The figures were too gross to enable effective control of the sections; they merely indicated the overall efficiency of the whole department and therefore were useful for the assessment of the actual profitability of the operations only.

10.2.1.2.2 Using the nomenclature of Li(88), cost reporting was <u>comparative</u> rather than <u>analytical</u>, i.e. standard and actual costs were compared and variances brought to the attention of responsible management, but the probable causes of the variances were not stated in the report.

It was left to the responsible manager's judgement (and, because of the timing, his memory), together with any information which could be gleaned from the physical performance reports to determine the probable causes of the variances.

Dickey (89) states that operating supervisors can generally accept physical facts quite readily (such as lost time percentages, scrap ratios, breakdown reports, etc) and so reports should be in this form. Senior management at Skelmersdale agreed with this view and on occasion had gone even further by stating that an experienced manager should be able to control the operations effectively by walking round his department - he does not even need the physical performance reports. The author takes the view of Batty (90) that:

(i) Supervisors and managers may not understand the full significance of physical variances; attempts to reduce the variances may therefore be misdirected.

(ii) It is difficult for more senior managers to assess the performance of lower level management fairly unless they are totally familiar with the production processes involved, and comparison made on a consistent basis.

In other words there is no substitute for full and timely cost reporting when an attempt is being made to control costs.

10.2.1.2.3 For reasons which will be clearer after the description of the standard cost build-up, production management did not always regard variances as stemming from departmental inefficiency, but rather from the 'tightness' of the standard costs themselves. Whilst some conflict between production and more senior management over the validity of the standard costs is almost inevitable, there is evidence to suggest that production management had some justification for this grievance.

All standard labour costs which were expected to be incurred in a production area were increased by a factor, the 'Shop Cover Allowance' to cover for inefficient use of facilities in that area. This allowance, originally derived from a 'guesstimate' by the Accounts Department, was intended to allow for the cost of reasonable machine downtime, material shortage stoppages and any other intermittent contingencies. Whilst the incorporation of a 'fudging' factor is abhorent in the derivation of a standard cost some allowance must be made for reasonable machine downtime.

In recent years however, the Shop Cover Allowance was used as a pressure instrument by senior management; the level of the allowance being determined more by the pressure which senior management wished to exert upon production management than by consideration of what allowances were 'reasonable'. Whenever it was felt that standards should be 'tightened' the Shop Cover Allowance was reduced by an arbitrary percentage to achieve that end.

In 1974 and 1975 the total variances against variable works cost for the Lockheed Department were 49% (adverse) and 45% (adverse) respectively. The labour variances for the same periods were 50% (adverse) and 38% (adverse) on standard cost respectively. In the absence of more detailed control information, it was impossible to determine what proportion of these variances could be attributed to the 'tightening' of the standards which was undertaken as a matter of management policy in the period.

10.2.2 The Derivation of Standard Variable Works Costs

10.2.2.1 Description

Standard variable works costs were calculated for each product manufactured in the department, the cost being split into labour, materials and variable overhead elements. The costs included in each element were as follows:

10.2.2.1.1 Material

(1) The raw material cost of the rubber transferred into the Moulding Department from the Mill necessary to manufacture 100 parts.

(2) A wastage allowance which compensated for the extra rubber which was required at the moulding stage to ensure moulding of a complete part.

(3) A reject allowance to allow for a reasonable level of scrap parts which was felt to be inherent in the process. For 1976 and 1977 a blanket figure of 15% rejects (on good parts) was applied to all Lockheed Department

products (previously an individual scrap allowance was made for each product).

10.2.2.1.2 Labour

(1) The direct labour cost for each operation was calculated by multiplying the standard minute value for the operation by the standard labour grade rate for the operation.

(2) A percentage allowance was made for the leading hands (chargehands) and setters who were attached to the production area. This percentage was applied to the standard time for the job. The time so derived was then multiplied by the appropriate leading hand labour grade to give a labour cost.

(3) A percentage shift allowance was then applied to the standard rate. This figure was estimated from the actual shift payments made to direct operatives in the previous financial year.

(4) The Shop Cover Allowance described in section 10.2.1.2.3 was applied to give the 'direct' labour cost.

(5) A percentage allowance to cover for the indirect workers employed in the department is then applied. The indirect allowance percentage was the figure which would be required to recoup the costs of the expected number of indirect workers on the budgeted level of activity for the year in question.

(6) The reject allowance percentage was applied to the result of actions (1) to (5) to give a total departmental labour cost for the product.

(7) The labour cost incurred in preparation of the material transferred into the department was added to the total departmental labour cost to give the total labour cost of the product.

10.2.2.1.3 <u>Variable Overhead</u>

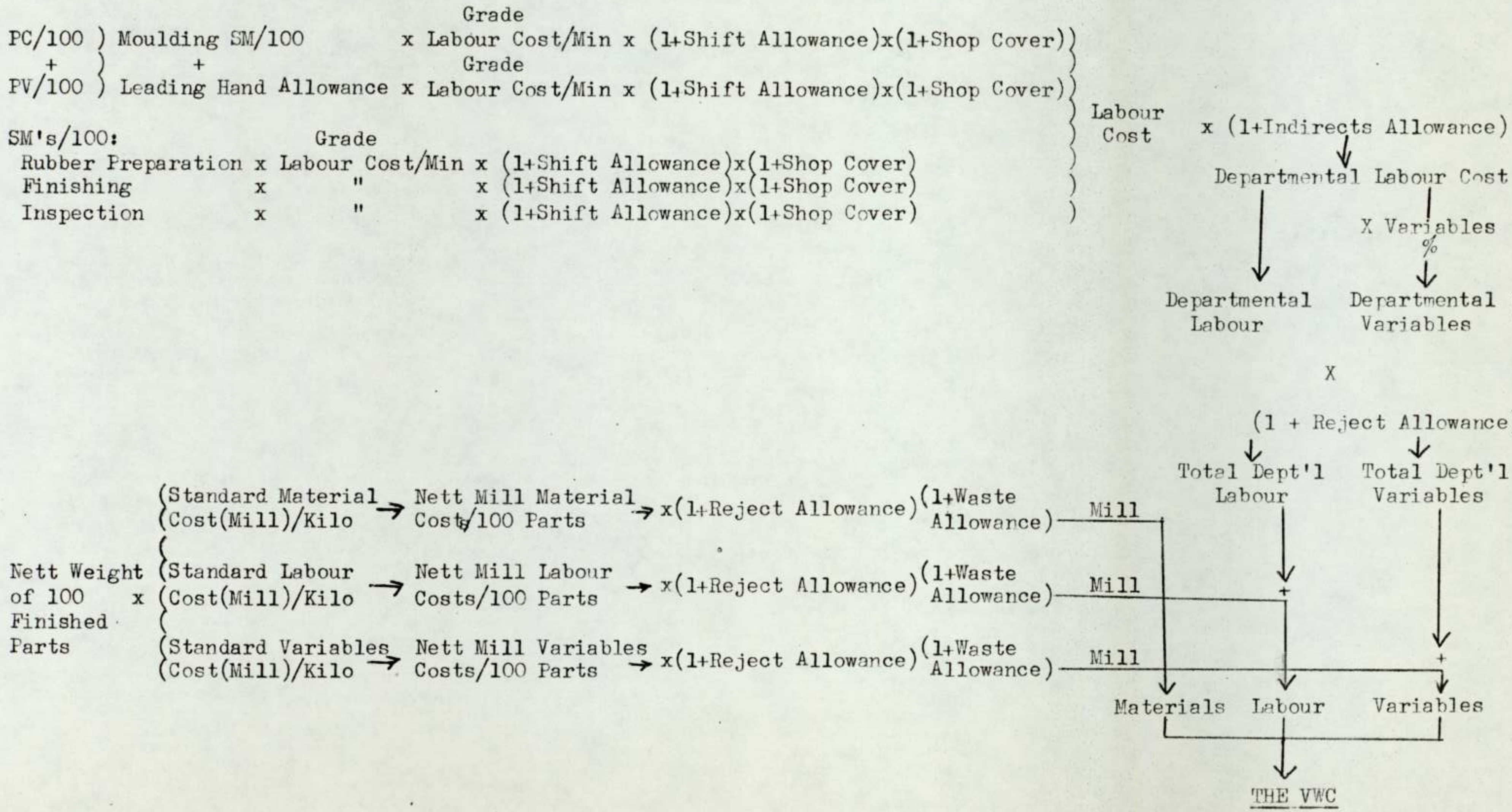
(1) The variable overhead cost of the product was calculated by applying a percentage allowance to the departmental labour cost. The rate was determined to recover the expected variable overhead cost the department on the budgeted labour cost for the year. Variable overhead was meant to include:

* 'Labour Oncost' - employers national insurance contribution.
  - pension scheme contribution.
  - holiday pay.
* Power & Services - electricity
  - steam (process & space heating)
  - water.
* Maintenance - engineering labour and materials.
* General Stores Issues.

(2) The transferred variable overhead cost of material is added to the departmental variable overhead cost to give a total variable overhead cost for the product.

The material, labour and variable overhead costs were combined to give the Variable Works Cost (VWC) as shown by Exhibit 10.3. The VWC was expressed as a cost per 100 units.

EXHIBIT 10.3 : THE VWC - HOW IT IS BUILT UP



10.2.2.2 Critique

10.2.2.2.1 Until the author introduced Quarter Platen Costing the standard minute values calculated for the moulding stage were based upon the assumption of perfect operation rather than currently attainable standards. It was assumed that each platen in the press contained the maximum number of cavities which could be loaded onto the platen (normally 28 cavities per platen) without consideration of whether there were sufficient cavities available to achieve this loading, or whether the customer schedule demanded the loading. Quarter Platen Costing overcame these difficulties by considering the availability of cavities at Skelmersdale as well as the demands put upon tooling by the schedule (see Chapter 7).

The Quarter Platen approach was adopted by the company in 1976 as the method of calculating the moulding standard minute values. Unfortunately, whilst it was agreed that the approach was what was needed to calculate the standard minute values, the standard minute values obtained by the approach have never been in line with current production practice. The 1976 standard costs (calculated in late 1975) were based upon double daylight steam press moulding. At the beginning of 1976 a change was made to single daylight electric compression presses, with a considerably shorter cure time. The effect of the method change, a reduction in the moulding standard minute values of 45%, was never incorporated into the 1976 standards which were therefore excessively overcosted during the year.

For 1977 the adjusted standard minute values were incorporated into the standard costs; the assumption of an average platen loading of 18 cavities per platen formed the basis of the figures. Due to a misunderstanding by the Industrial Engineering Department an incentive scheme was introduced with a maximum of 18 cavities per platen rather than an average number of cavities/platen. The average platen loading was therefore below the calculated value, resulting in a higher average normal minute value per part (see Chapter).

10.2.2.2.2 On 19th December 1974 an agreement was reached between Dunlop Ltd and the Transport and General Workers Union that shift workers in the Skelmersdale factory should in future work a 37½ hour standard week instead of 40 hours per standard week. In an attempt to maintain existing output and earnings levels it was agreed that all standard minute values determined before the agreement date should be multiplied by a factor of between 0.9 and 1.0 (depending on the average earning rate of the section). Any standard minute value determined after the date was not to be factorised however. The Accounts Department used 'standard' minute values in determination of standard costs, some of which were obtained prior to December 1974 and are therefore factorised, others of which were obtained after that date which were proper standard minute values. The situation was therefore somewhat confused, for similar parts requiring similar operations may have differing standard times for the operations - dependent on which the times were determined. (Moulding standard minute values were not affected since they were determined after 1974).

10.2.2.2.3 The practice at Skelmersdale of multiplying the standard moulding time by a percentage figure to estimate the cost of a leading hand is misleading; the time required to manufacture a part is not increased by the presence of a leading hand/setter even if a cost is incurred by his presence. Since the majority of the setters' time is spent in indirect activity his cost should be included as an indirect labour charge, not a direct (although this is against Dunlop Ltd standard practices - see later).

10.2.2.2.4 The 'standard' labour rates employed in the Variable Works Cost were based upon the actual average earnings rates for each grade of labour determined in 1975 and increased by subsequent wage increases on a pro-rata basis. They were not calculated using the incentive schemes currently appopriate to determine the wage rates for standard performances and are in fact expected actual(estimated) labour rates.

10.2.2.2.5 The Shop Cover Allowance suffered from the weakness described in Section 2.1.2.3 in that its magnitude stemmed more from the result of political bargaining than rational determination.

10.2.2.2.6 The indirect labour allowance was applied across the board to all products and production areas in the department without any consideration of which areas made the greatest use of the indirect labour or the differing demands placed upon the resources by different products. With only a rudimentary cost control system the lack of differentation between products and production areas may be acceptable; with a more informative system a more detailed breakdown of the indirect distribution would be required.

The indirects allowance was an 'estimated' figure in that it reflects the expected actual cost of the departmental indirect workers for the year related to the expected direct labour cost of the department. In view of the difficulty in determining the standard indirect distribution required for efficiency production, the adoption of this approach was perhaps understandable.

10.2.2.2.7 Prior to the determination of the 1976 standard costs each product cost incorporated an individual standard reject allowance which was felt to be the reject level inherent in the production of high precision, safety critical components. The individual reject allowance was determined by an examination of the actual reject performance in previous years, taking into consideration the difficulty of moulding the product together with what was felt to be a reasonable target for improvement.

In the 1976 and 1977 standard costs a blanket figure of 15% reject allowance was applied to Lockheed Department products in line with the stated management policy of simplification and rationalisation. The use of the single reject figure was particularly inappropriate for small order parts, especially in view of the different production process (compression moulding), generally older tooling and high proportion of 'start-up' scrap. The use of blanket figures for the department may have been adequate for the control of the department as a whole, but when the figure has been based (as was usually the case) on a weighted (by volume) average figure, small order performance can be significantly deviant from the average without substantially affecting the overall result.

10.2.2.2.8 The number of meters in use which measured the services (electricity, gas, steam, water) provided to the sections was limited. In certain cases the total requirement for the department was not monitored. Without accurate usage figures which could be related to the level of activity of the production areas the total services costs were apportioned on an arbitrary basis by the Engineering Department to the production department; no subdivision was made within the production departments thus frustrating any attempts to monitor and control services costs in the production sections.

10.3 The Determination of Standard Cost Budgets for Small Orders

Since, as has been shown in the previous section, the Dunlop standard costs for small orders were insufficiently detailed and of questionable accuracy it was decided to derive indpendent cost budgets from first principles wherever possible. In addition to the variable costs of production, it was decided to examine the fixed costs associated with the production of small orders and include in the budgets any fixed costs which could be directly attributed to small order production.

A brief description of how the costs in the viability budget were derived will be given together with the reasons why the approaches were chosen.

10.3.1 Derivation of Budgets

10.3.1.1 Budgeted Sales Value

The budgeted sales value of the small order section products was determined as:

Budgeted Sales Value = Forecasted Total Small Order Volume x Forecasted Weighted Average Unit Price

10.3.1.1.1 Forecasted Total Small Order Volume

This value was determined by summing the results of the resource forecasts (see Chapter 9). Since there were a number of operations which were performed on all small order parts a total forecasted volume could be obtained by summing the forecasted individual volume for each of the product groups for that operation. A separate forecast of the total volume was also made using the same computer programme, but this method was found to produce a forecast with a higher percentage error. The results of the forecast were as follows:

Exhibit 10.4 : Alternative Sources of Volume Forecast

SOURCE OF FORECAST	FORECAST VOLUME (parts/yr)
(a) From summation of moulding forecasts	362,738 $\pm$ 6%
(b) From summation of Barwell forecasts	321,750 $\pm$ 30%
(c) From summation of Inspection forecasts	373,540 $\pm$ 11%
(d) From separate Volume forecast	319,133 $\pm$ 43%

The forecast from the Moulding summation was chosen as it had the lowest percentage error over a period of four years.

10.3.1.1.2 Forecasted Weighted Average Unit Price

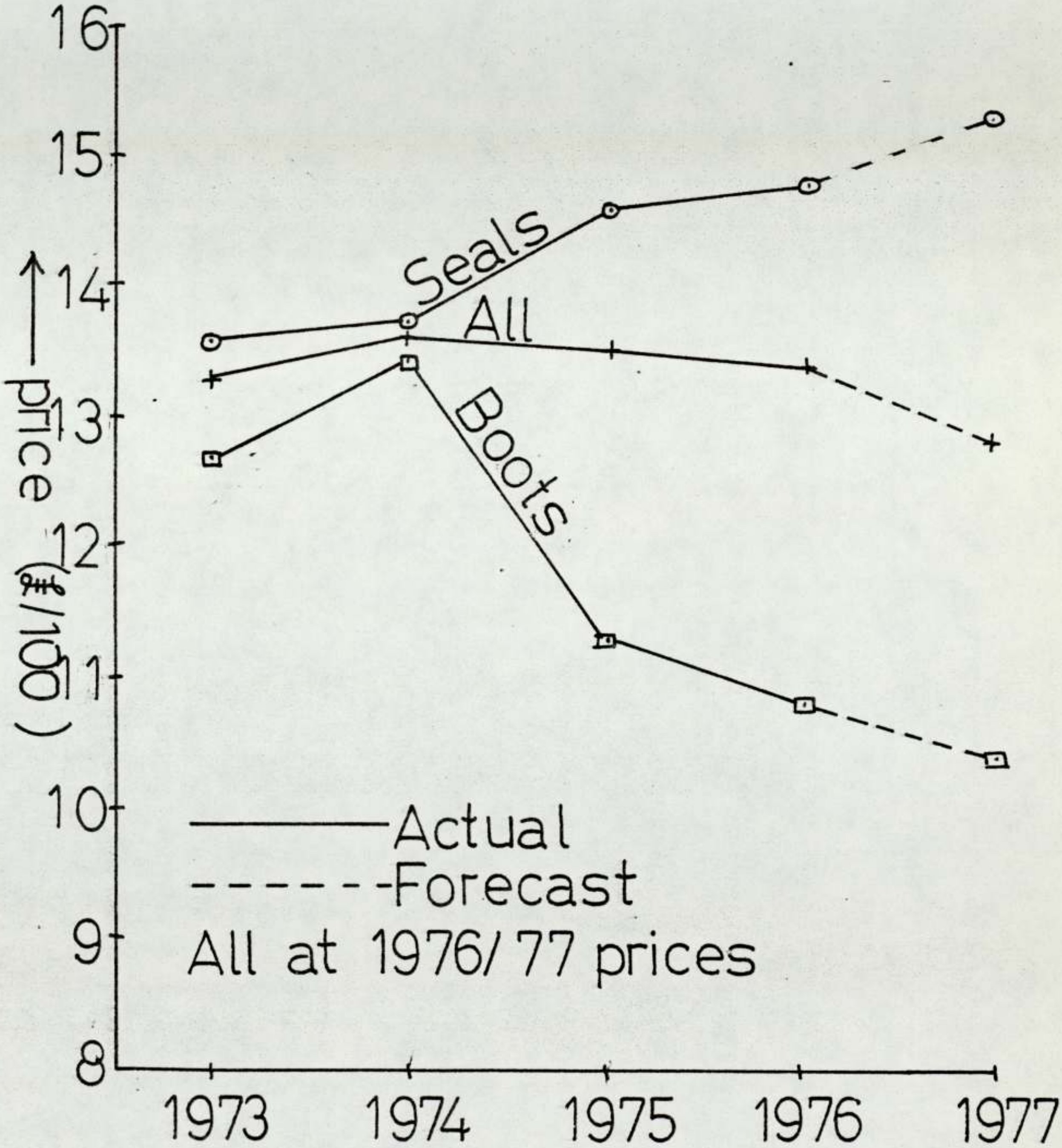
Using the same computer programme as that which was used to generate the resource forecasts, a forecasted average price (at 1976-77 prices) was projected. The forecast reflected trends in product mix which will affect the average unit price; the result of this forecast can be seen in Exhibit 10.5.

Forecasted Average Price = £12,818/100 parts
(at current prices) $\pm$ 1%

10.3.1.2 Variable Costs of Small Order Production

10.3.1.2.1 Material Cost

EXHIBIT 10.5.: RESULTS OF PRICE/ MIX FORECAST



10.3.1.2.1.1 The blank weight and compound type for each product included in the Small Order Section forecasts were obtained from the Process Engineering Specification Sheets.

10.3.1.2.1.2 The transfer cost of each type of compound was obtained from the Accounts Department records.

10.3.1.2.1.3 For each moulding product group the cost of compound for the group at current prices was obtained for 1976.

If P_i = Price of Compound used in product i (per gramme).

W_i = Weight of compound required for product i (gm).

V_i = 1976 requirement for product i.

n = number of products in product group.

$$C_A = \text{1976 Cost of Compound} = \sum_{i=1}^{n} P\,W\,V$$

The budgeted material cost for 1977, C_B, for the product group was taken as:

$$C_B = C_A \frac{x\ F}{\sum_{i=1}^{n} V_i} = \sum_{i=1}^{n} P_i W_i V_i \frac{x\ F}{\sum_{i=1}^{n} V_i}$$

Where F = Forecasted total volume for product group.

The forecasted material costs for each of the seven product groups were summed to give the cost of the material required to meet the forecasted 1977 demand. The approach used is equivalent to determining the weighted average compound cost for each product group for 1977. The assumption that is being made is that the product mix will not alter sufficiently significantly to alter the weighted average price of the group. The results of this exercise were:

EXHIBIT 10.6 : FORECASTED MATERIAL COSTS FOR 1977

Product Group	1976 Demand (V_i) (parts)	1976 Material Cost £ (C_A)	1977 Forecasted Demand (F) (parts)	1977 Forecasted Material Cost (C_B) $= \frac{F}{\Sigma V_i} \times C_A$(£)
1	39296	113.73	18989	54.97
2	29105	164.28	16358	92.33
3	86847	319.36	106419	391.33
4	68250	130.77	52698	100.97
5	69434	205.97	77583	230.14
6	10400	55.92	19133	102.88
7	114081	566.26	71617	355.48
Total	417443	1556.29	362738	1328.10

10.3.1.2.1.4 As has been previously explained some reasonable quantity of rejects is felt to be inherent in the manufacture of the products. Four experienced managers were approached in an attempt to determine what would be a reasonable standard for the small order reject level, given that the actual reject level for small orders for 1976 was 59%. The four managers (Product Manager, Production Manager, Departmental Manager and Production Control Manager) all stated that 25% rejects (on good parts) was a reasonable standard to set. This level was used to determine the standard material cost budget for 1977.

Forecasted Material Cost for good parts = £1328.10.

Cost of Material to make rejects (at 25%) = £332.03.

Total Standard Material Cost = £1660.13

(See Exhibit 10.7 for a diagramatic representation of the material cost build up).

10.3.1.2.2 Direct Wages

The same approach was used for all sections in determination of the wages cost of small order manufacture (summarised in Exhibit 10.8). The elements which were required in the determination of the labour budgets were:

EXHIBIT 10.7 : MATERIAL COST BUDGET - FACTORS INCORPORATED

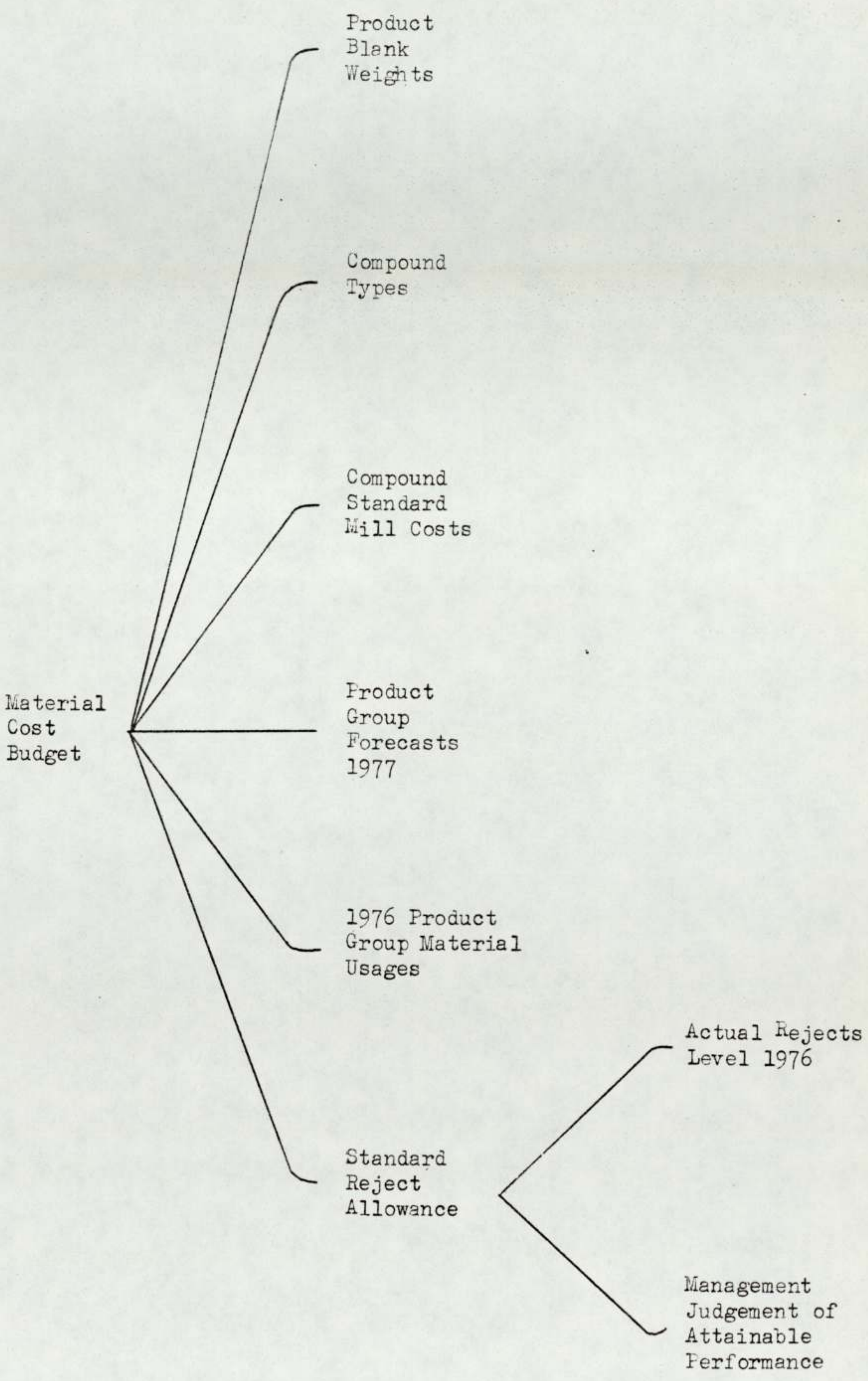


EXHIBIT 10.7 : SOURCES OF INFORMATION FOR LABOUR COST DETERMINATION

ELEMENT	SOURCE OF INFORMATION	COMMENTS
1) Standard Operational Requirements (from forecasts)	Industrial Engineering Incentive Schemes or Accounts Dept Records	Unfactorised times used
	or Ind. Engineering Estimates	Where no schemes in operation
2) Standard labour grade and number of operatives	Manager, moulding and Bonus Section	Obtained for each operation
3) Hourly labour rate (incl. shift allowance)	Wages Dept. Payment Schemes for appropriate grades	Based on standard (B.S.100) performance
4) Reject Allowance	Concensus of management in conjunction with actual reject levels	See Section 10.3.1.2.1.4
5) Labour Fringe Cost		Adds 25% to basic wages
(i) Holiday Pay	Wages Dept. analysis of ratio of holidays to working days for 1977	232 Working days 28 Holidays = Add 11.23% to basic cost for paid holidays
(ii) Employers National Insurance Contribution	From National Insurance Guideline document for Employers	Add 8.78% to basic wage and holiday pay
(iii) Employers Contribution to Company Pension	Analysis of actual contribution made relative to direct wages for department	Add 3.4% to basic wage and holiday pay

A more detailed derivation of the direct labour costs can be found in Appendix G.

10.3.1.2.3 Indirect Wages to Direct Operatives

This refers to the wages which would be paid to direct operatives for unproductive time. During this time it was normal to pay the operatives average earnings; the standard cost of unproductive time would therefore be the total direct labour bill for the section multiplied by the standard downtime percentage appropriate for that section..

It was assumed that direct operatives were not transferable during normal short term breakdowns, mould changes etc., therefore no use will be made of labour which cannot perform normal duties. This means that the full cost of the labour during unproductive time must be absorbed by the section in which the breakdown has occurred.

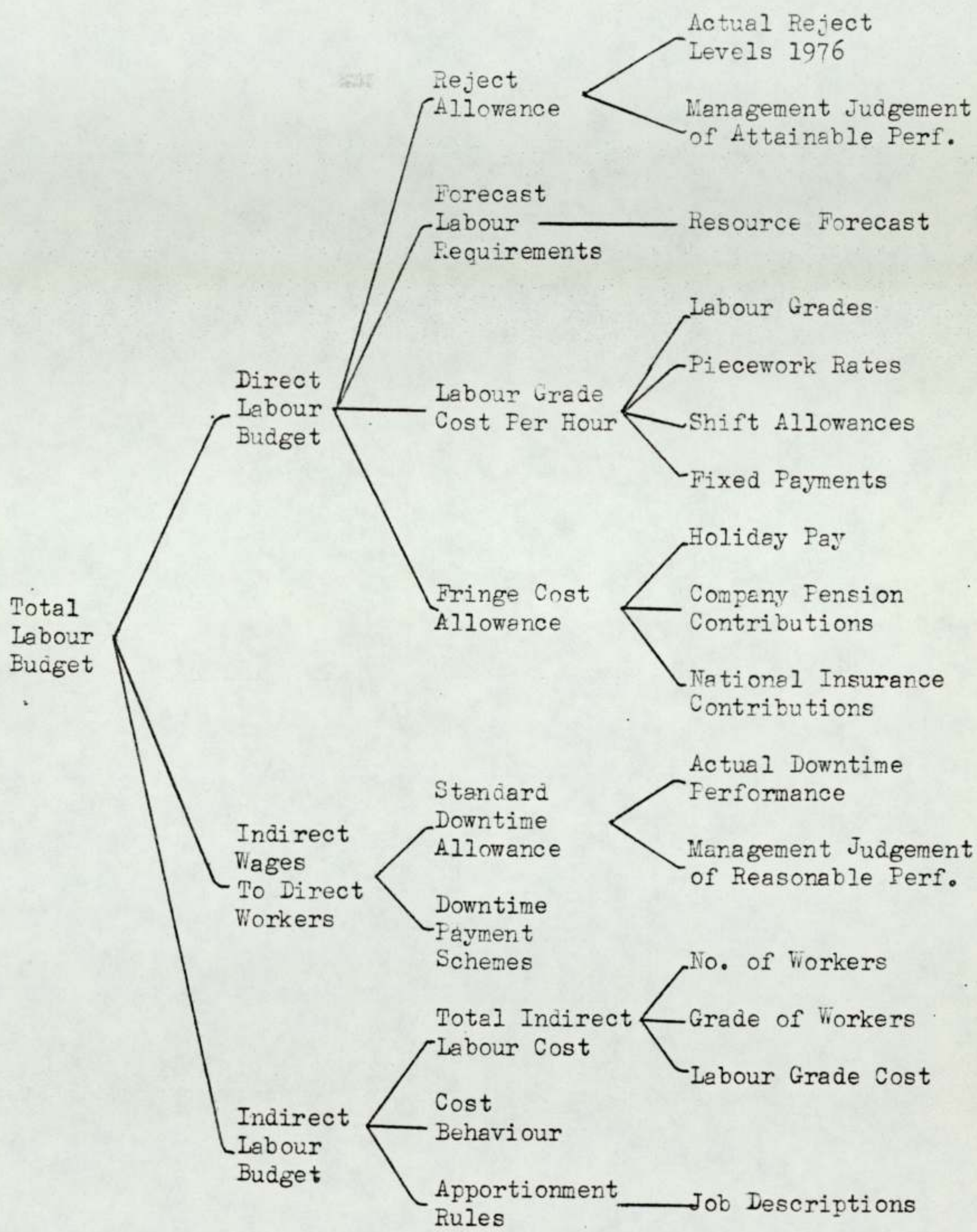
The standard downtime figures were determined by:

(a) Examination of the Management Plan for 1977. Where a standard downtime figure was included in the Plan it was used in the cost calculation. Of the equipment used in the manufacture of small orders only the moulding presses in the small order section had a standard downtime allowance in the 1977 Management Plan.

(b) For the remaining areas the standard downtime was determined by examination of the machine downtime monitoring sheets (where available) and consultation with the Production Manager; the actual performance figures were presented and the Manager asked to provide a standard allowance for each area in view of current actual performance.

See Appendix H for the figures used in the calculation.

EXHIBIT 10.8 : LABOUR COST BUDGET - FACTORS INCORPORATED



10.3.1.2.4 Indirect Wages

In order to determine the indirect wages cost the following actions were necessary:

10.3.1.2.4.1 The number and grade of indirect operatives associated with each area of production was determined from Moulding Department Records.

10.3.1.2.4.2 The payment schemes for each indirect operative were obtained from the Wages Section and an estimated annual cost for the indirect operatives was calculated.

10.3.1.2.4.3 A detailed job description for each operative was obtained in order that some assumptions could be made concerning the cost behaviour of the indirects. The indirect cost behaviour was split into variable and fixed depending on the nature of the work performed. The job descriptions were also used to assist in development of apportionment rules to determine the proportion of the indirect labour cost which could be associated with small order production. In cases where the job description did not give a clear indication of how the cost should be apportioned the Moulding Department Manager was consulted and asked to advise on suitable apportionment rules; a confirmation of the independently derived apportionment rules was also obtained. A full description of the indirect labour costs and apportionment rules is given in Appendix I.

10.3.1.2.5 Variable Overhead Costs

A summary of the factors incorporated in variable overhead costs can be seen in Exhibit 10.10.

10.3.1.2.5.1 Electricity Cost

10.3.1.2.5.1.1 Unit Cost

The unit electricity cost for the department was obtained by examination of the seasonal and daily tariffs charged to the factory (source of information - Engineering Department). The tariff structure (including fixed charge spread over expected total factory usage) was as follows:

EXHIBIT 10.9 : ELECTRICITY TARIFFS 1976 - 77

	High Daily Tariff (08.00-02.00 Hours)	Low Daily Tariff (02.00-08.00 hours)
Nov. 1976 - March 1977	2.3p/kw-hr	1.1p/kw-hr
April 1977 - Oct. 1977	1.6p/kw-hr	0.8p/kw-hr

Only the Barwell and Moulding presses were operated on a three-shift basis and were therefore likely to use some electricity at the lower unit cost. However, since the forecast for the Moulding requirement indicated that two out of three shift operation would be sufficient to meet the schedule it is likely that a morning and afternoon shift programme would be operated (since the labour costs are lower than for the night shift) and would therefore not use electricity at the reduced rate. Similarly the forecast requirement for the Barwell was so small that the blanks could be produced at any time during the three shifts; it was assumed that they could be produced during the high daily tariff period.

The weighted average unit cost for the year calculated from the above assumptions was = £0.0178/kw-hr.

10.3.1.2.5.1.2 Power Consumption

There were only two electricity meters monitoring the total usage of the Moulding Department; with the large number of processes and machines incorporated into the department it was impossible to determine the usage rates for the machines used for small order manufacture. To overcome this problem the Zone Engineer for the Department was asked to provide the maximum continuous power rating for each machine used in small order manufacture; it was assumed that the use of the maximum continuous power rating should compensate for the extra surge of power required during start-up of the machine.

10.3.1.2.5.1.3 Compressed Air

Compressed air was used in the Small Order moulding section to strip the parts from the press and remove excess rubber from the cavities. The approximate duration of the blast was obtained from the Industrial Engineering Department and converted to an electrical power usage using data provided by the Engineering Department. The conversion of the compressed air usage to cost rates and details of other power costs can be found in Appendix J.

10.3.1.2.5.2 Maintenance

The Production Manager (Brake Mouldings and Timing Belts) was asked to estimate the proportion of standard machine downtime (as a percentage) which would be due to maintenance of the equipment. The total maintenance hourly requirement was then obtained for each piece of equipment by multiplying the forecasted machine-hour requirement by the percentage maintenance allowance. The Works Engineer provided an estimated hourly cost for maintenance labour and materials and annual maintenance budgets were calculated for each section. The detailed budgets can be found in Appendix J.

10.3.1.2.5.3 General Stores

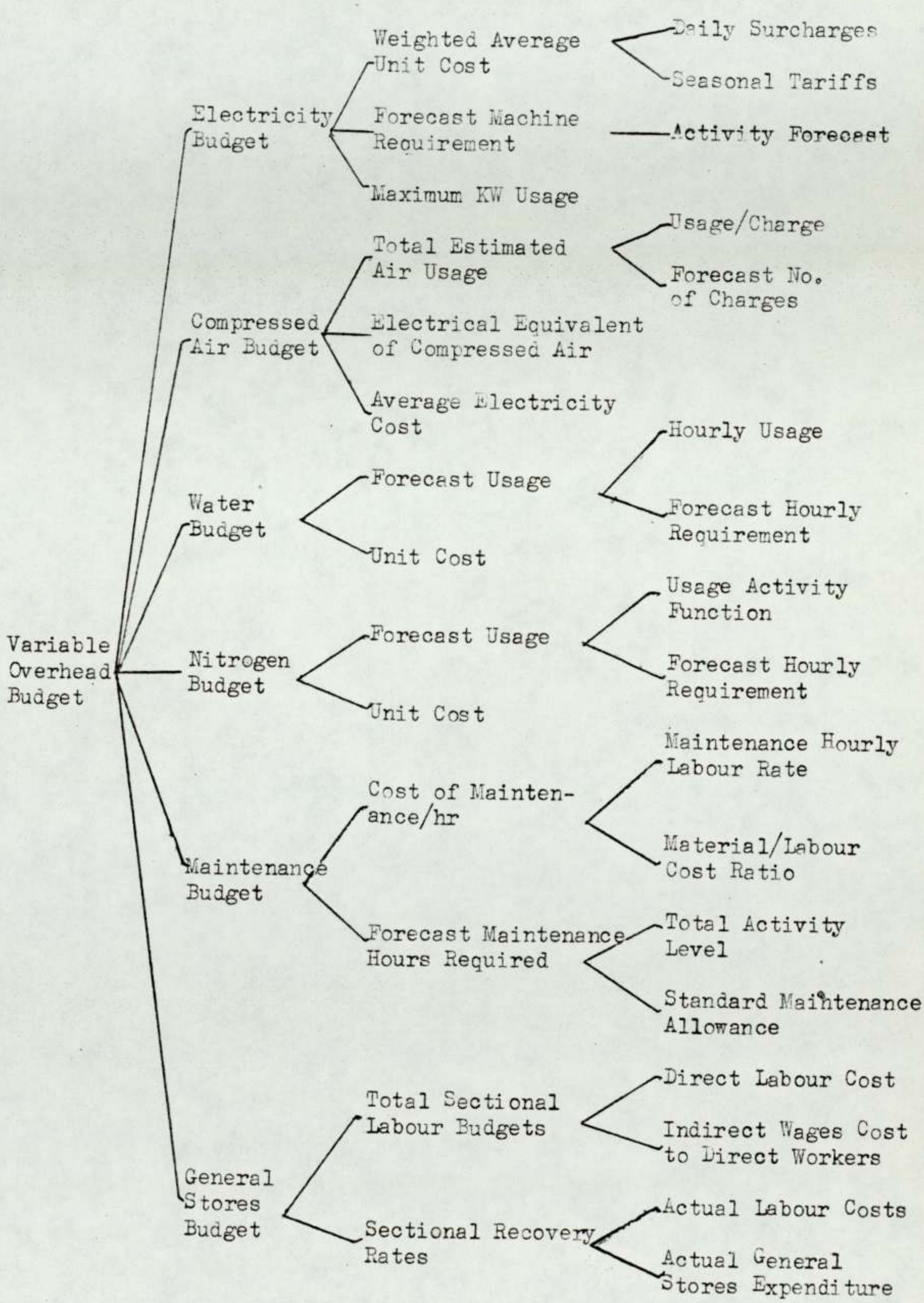
The General Stores issues were not monitored on a cost centre basis even though the cost centre code is stated on the Stores Requisition. To determine the General Stores cost for each section involved in the manufacture of small orders the following actions were therefore performed:

(i) By examination of the Stores Requisition Dockets for a two month period the usage of stores items for each cost centre was obtained.

(ii) The cost of the usage was obtained by multiplying the item usage by the unit cost. (The Stores Requisition did not include the cost since all General Stores items were free issue - the cost of the stores items was debited at the time of purchase to a general overhead account).

(iii) It was assumed that the cost of General Stores Issues would be likely to vary directly with the activity level

EXHIBIT 10.10 : VARIABLE OVERHEAD BUDGET - FACTORS INCORPORATED



(there being no evidence to the contrary). The only figures which were available at Skelmersdale which could be expected to be correlated with activity were the actual direct labour costs (by cost centre) for the period. It was therefore decided to calculate a stores recovery rate for each cost centre based on the actual direct labour costs; to calculate the stores budget for 1977 these rates were applied to the total standard direct labour cost (including indirect wages to direct workers) for each production area. (See Appendix J).

10.3.1.3 Fixed Costs

The fixed costs associated with equipment used to manufacture small orders were determined. Since only the Small Order Section moulding presses could be said to be used only for small order parts the fixed costs could be split into those of a directly attributable nature and those of a more general nature. The major identifiable fixed costs were:

10.3.1.3.1 Indirect Wages

The wages of those indirect workers whose cost could not be expected to vary significantly with the activity level (namely mould storeman, setter and sweeper/serviceman for the Small Order Section and toilet cleaners for the department as a whole). The annual budgeted costs were obtained as described in section 10.3.1.2.4.

10.3.1.3.2 Depreciation

Depreciation figures for each piece of equipment used in small order manufacture was obtained from the Fixed Cost Ledgers in Divisional Headquarters, Manchester. Most of the equipment used was old and has zero book value, the exceptions being:

EXHIBIT 10.11 : FIXED COSTS ASSOCIATED WITH SMALL ORDER PRODUCTION

Directly Attributable Fixed Costs	Total Annual Depreciation (£)
Hydramould Moulding Presses (3 machines)	881
General Fixed Costs	
Barwell	158
Wheelabrator	2241

10.3.1.3.3 Heating Costs

Only total steam usage figures (including both process steam and space heating steam) were available for the factory as a whole. In order to estimate the heating cost for 1977 the following exercises were necessary:

(i) An estimated percentage of the total steam usage for the factory which could be attributed to space heating was obtained from the Engineering Department (40% of total).

(ii) An average heating cost per square foot of factory area was calculated by dividing the factory floor area into the budgeted heating cost. The cost thus obtained was £0.25/ sq. ft/yr.

(iii) The area occupied by equipment used to manufacture small orders was measured; a reasonable working area around the machines was also included in line with Industrial Engineering recommendations.

(iv) The annual heating cost was determined by multiplying the occupied floor area by the annual area cost.

The costs were as follows:

EXHIBIT 10.12 : BUDGETED HEATING COSTS

Machine	Working Area (ft^2)	Annual Heating Cost (£)
Small Order Section (3 machines)	450	112.50
Barwell	1273	318.25
Wheelabrator	690	172.50
Washing Machine	36	9.00
Hand Lathe	64	16.00
Power Press	100	25.00
Drill	64	16.00
B.U. Trim	64	16.00
Inspection	64	16.00
Sort	64	16.00
Rough Trim	64	16.00
Oil Test	64	16.00

10.3.1.3.4 Equipment Rental

The Wheelabrator used liquid nitrogen to freeze the parts before shotblasting. The equipment used for storage of the nitrogen is rented from Air Products Ltd at a cost of £180/month - £2160 per year.

10.3.2 Viability Budget

The individual budgets were combined to give a standard viability budget for 1977 (see Exhibit 10.13). The general fixed costs of other sections have not been subtracted from the sectional margin because:

(i) All the equipment outside the Small Order Section used to manufacture small orders was also shared with high volume production; the disappearance of small order work could have had no effect on the annual fixed costs, since the equipment would still be required. The only effect that the disappearance of small order work produced would have been to marginally increase the recovery rate necessary for full cost absorption (this approach was not used at Skelmersdale so it was not relevant).

(ii) All the depreciation and equipment rental charges were associated with equipment for which the annual small order demand was negligible - the apportioned fraction of the fixed costs would also be likely to be small. A more detailed breakdown of the costs is as follows:

Equipment	Annual Small Order Demand	Annual Depreciation (£)	Annual Equipment Rental
Barwell	49 hrs	158	-
Wheelabrator	21 hrs	2241	2160

(iii) As there was no forecast available for the demand placed upon the Barwell and Wheelabrator by the high volume production it would have been difficult to determine a reasonable basis for apportionment.

(iv) For the cost of toilet cleaners and arguments used in point (i) also apply - there was no evidence to suggest that the cost would be reduced by deletion of the small order work - it was not a relevant cost.

EXHIBIT 10.13 : DEPARTMENTAL VIABILITY BUDGET 1977

	£ p.a.	£ p.a.
BUDGETED SALES VALUE		46496
VARIABLE COSTS OF SMALL ORDER SECTION:		
Material	1660	
Direct Wages	3815	
Indirect Wages to Direct Workers	954	
Indirect Wages (Variable)	1643	
Variable Overhead:		
Electricity	528	
Compressed Air	61	
Maintenance	715	
General Stores	343	
TOTAL SECTIONAL VARIABLE COSTS	9719	9719
SECTIONAL CONTRIBUTION (GROSS)		36777
DIRECTLY ATTRIBUTABLE FIXED COSTS OF SMALL ORDER SECTION:		
Indirect Wages	2875	
Depreciation	881	
Heating	113	
	3869	3869
SECTIONAL CONTRIBUTION (NET)		32908

	£ p.a.	£ p.a.
VARIABLE COST CHARGES FROM OTHER SECTIONS:		
Direct Wages	4096	
Indirect Wages to Direct Workers	91	
Indirect Wages	640	
Variable Overhead	376	
	5203	5203.
SECTIONAL MARGIN		27705 (60% on turnover)
GENERAL FIXED COSTS:		
Depreciation	2399	
Heating	637	
Equipment Rental	2160	
Toilet Cleaners	9820	
TOTAL GENERAL FIXED COSTS	15016	

10.4 Discussion of Results

10.4.1 Comparability

The standard Small Order Sectional Margin indicated a high level of contribution towards general overhead costs, even when the directly allocable fixed costs were subtracted from the variable cost margin. The contribution level of 60% of turnover was comparable with the results of an investigation made into the standard contribution derived from small order sales during a three month period in 1976. The results of this investigation were:

EXHIBIT 10.14 : SALES OPERATION SUMMARY JULY - SEPTEMBER 1976

	JULY 1976	AUGUST 1976	SEPTEMBER 1976	TOTAL QUARTER
Total Sales (£) (incl. returns)	7733	3731	5923	17387
Total VWC (£)	3065	2132	2593	7790
Total Gross Contribution (£)	4668	1600	3330	9597
% Gross Contribution	61%	43%	56%	55%

Since the Dunlop standard costs did not include any directly allocable fixed costs it may be seen that the standard contribution rates would be higher if calculated by using the Dunlop standard costs.

10.4.2 Opportunity Costs

At the beginning of the costing exercise, it was suggested that the resources currently used to manufacture small order parts could be used to manufacture potentially more profitable work. After questioning of the management team at Skelmersdale it was clear that there was currently no business which could be suitably substituted for the small order work; if it were not for the overall inefficiency of the operation there would be considerably greater capacity at Skelmersdale than there would be business to fill it.

The only use which could have been made of the small order facilities was to substitute for other machines in the manufacture of rubber components if the equipment currently used should prove inadequate. The components which might have been made on small order facilities offer contribution rates of only 20-30% of turnover; there appears to be no more profitable alternative to the manufacture of small order braking components for Automotive Products Ltd.

10.4.3 <u>Non-quantifiable Considerations</u>

If the financial results of the viability investigation had proved less encouraging the decision to retain or dispose of small order business would still not have been clear. The effect which the provision of small order work for Automotive Products Ltd had upon the granting of high volume business is not established. It was quite possible that Automotive Products purchasing staff regarded the awarding of high volume business to Skelmersdale as being contingent upon the acceptance of small order work by Dunlop. The small order area of business might therefore have had to be regarded as a 'loss leader' necessary to obtain the larger orders.

However the results of the standard cost investigation did not place the Dunlop management in such a dilemma; both the financial and marketing criteria suggest that small order work should be retained within Dunlop. Against this point it has been argued that the apparently poor small order supply performance of Dunlop Skelmersdale could be damaging to the reputation of the company at Automotive Products and thereby prejudice high volume work (see Chapter 4). However the supply performance of Dunlop was within the control of management at Skelmersdale; the opportunity was available for supply performance to be improved thereby reducing damage to the credibility of Dunlop as a supplier and at the same time retain a potentially lucrative segment of business.

10.4.4 Efficiency

Using standard costs and assuming a near standard performance the small order operation at Skelmersdale appeared to be viable, giving a considerably greater contribution to general overheads than any other potential business which could utilise the small order resources. However, as has been previously described, the Lockheed (Moulding) Department did not have a good record of being able to work within, or near, the standard cost performance.

It was therefore suggested that the actual performance of the small order operation at Skelmersdale could have been such that the contribution level was reduced to such an extent that small orders were no longer viable in the Skelmersdale environment. In the absence of accurate actual costs this claim was difficult to prove or refute using the existing accounting system. In the next Chapter an attempt will be made to overcome these difficulties and test the hypothesis that actual efficiency levels reduce profitability to unacceptably low levels.

CHAPTER 11

Performance/Cost Sensitivity Analysis

11.1 Objectives

The small order operation at Skelmersdale appeared to be viable if the standard cost budgets were used for the assessment. An examination of the past performance of the Lockheed Department suggest that the actual cost performance is likely to be considerably poorer than the standard performance level. A considerable proportion of this difference may be attributed to poor control of the operations by supervision, which the inadequate cost control system cannot highlight. In particular the Dunlop management admitted that considerably less effort had been expended in attempting to control the small order operation than in other areas of the factory. Whilst the lack of control cannot be condoned, some estimation of the extent of the deviation from standard performance should be included in any viable study, if we expect that the less than standard performance will be a semi-permanent feature of the operation.

If a more detailed cost reporting and control system had been in operation in the Department this assessment could have been made by comparison of actual and standard cost performance and an in-depth analysis of variances. In the absence of such a system the best that could be achieved was to compare 'expected actual' performance with standard performance i.e. the standard cost structure could be used as a model of the cost behaviour of the small order operation upon which expected actual deviations from standard can be superimposed. In order to achieve this aim the following actions were required:

11.1.1 The areas of the small order operation which were felt to be significantly deviant from the standard had to be identified.

11.1.2 Once the deviant areas had been identified an attempt had to be made to quantify the extent of the deviance from standard in order that the budgets might be adjusted.

11.1.3 The effect which the expected actual performance would have upon each of the standard budgets had to be determined and incorporated into the budgets to generate 'variances'.

With the determination of expected actual budgets, the expected actual contribution towards general overhead could be determined and a new assessment of the viability of the small order operation made. In addition the exercise should highlight the effect which each of the deviant performance levels has upon the overall contribution level.

11.2 Identification of Major Deviances

Operating Managers and supervisors who came into frequent contact with small orders were approached and asked to indicate the areas in which actual performance was likely to be significantly different from standard. The personnel approached were:

* Product Manager, Brake Mouldings and Turning Belts
* Production Manager, Brake Mouldings and Turning Belts
* Departmental Manager, Moulding Department
* Production Control Manager, Moulding and Mill Group
* Foreman, Moulding Department

Once the deviant areas had been identified an investigation was made into the actual performance level and the extent of the deviation determined. The main areas of deviation found were:

11.2.1 Reject Levels

Overall reject levels were felt to be significantly higher than the standard overall reject allowance of 25% (on good). The reject figure was highly significant since it referred to parts which were rejected at the final inspection stage; it did not include parts which were rejected as substandard during intermediate manufacturing stages. Therefore all operations were performed on the reject part; it cost as much to manufacture a reject part as to manufacture a good part.

An examination of the cumulative reject summary for the year end December 1976 revealed that the overall actual reject level was 59% (on good). This figure was used in subsequent analysis as the expected actual reject figure.

11.2.2 <u>Material Loss</u> (Wastage)

It was claimed that a considerably larger number of blanks had to be made than were actually moulded. This could be due to:

(i) Ageing of the compound which rendered the blanks unusable.

(ii) Losses of blanks between the Barwell (blank production) and Moulding areas.

(iii) Moulding of parts which were rejected at the Moulding stage (and were therefore not included in the Production Control Department records).

In order to estimate the extent of the material wastage the Barwell programme sheets were examined for the first 12 working weeks of 1977 and the number of blanks produced in that period determined. The figure so obtained was compared with the number of parts moulded during the first 13 working weeks. (The Barwell was scheduled one week in advance of likely Moulding requirement. No adjustment for stock carried over from the beginning of the reference period needed to be made, since stocks had been run down over the holiday period).

Blanks produced in weeks 2-13 (1977) = 403,000

Parts moulded in weeks 2-14 (1977) = 229,410

$$\frac{\text{Blanks Produced}}{\text{Parts Moulded}} = 1.76$$

i.e. 76% extra blanks had to be made to achieve the planned moulding level (of which a proportion were rejected at the final inspection stage).

11.2.3 Downtime

11.2.3.1 Overall

It was claimed that overall machine downtime for the Small Order Section moulding presses was likely to be in excess of the 20% overall allowance incorporated in the standard budget. An examination of the Weekly Machine Downtime Analysis for the first 13 weeks of 1977 revealed that overall downtime on the presses was 28% of total time - 8% greater than the standard allowance.

11.2.3.2 Maintenance

The standard budgets for maintenance were based upon 10.5% of total machine time being allowed for maintenance. Using the Machine Downtime Analysis sheets for the first 13 weeks revealed that actual maintenance on the Small Order Section required an average of 13% of the total machine time.

11.2.3.3 Mould Cleaning

It was estimated that a considerably greater time was spent in cleaning the moulds than the standard allowed. Investigation revealed however, that only 13% of total time was spent in mould cleaning rather than 20% in the standard.

The 13% actual figure was used in subsequent analysis.

11.2.4 Machine Productivity

The moulding standard minute values used in the build-up of the standard budgets were based upon an average machine loading of 18 cavities/platen (this being the average projected loading at the time of the calculation of the Quarter Platen Moulding Values). As explained in Chapter 7 however, an incentive scheme was introduced with a maximum loading of 18 cavities/platen which meant that the average must be below that level.

An investigation of the average press loadings for the first quarter of 1977 revealed that an average of 12 cavities were loaded onto each platen. This had two implications:

(i) The average standard time would be increased, since with fewer cavities on each platen, the proportion of mould constant time (to open and close the press for example) per part would increase. The effect of the reduced machine loading can be estimated as follows:

Work Cycle for 2 machines =	4.368 +	X x 0.1224
(From Quarter Platen Calculation)	Fixed Element	Variable Element

where X = number of cavities per platen.

(a) For X = 18

Work Cycle = 4.368 + (18 x 0.1224) = 6.57 sm

Average SMV/part = 0.1825 sm/part

(b) For X = 12

Work Cycle = 4.368 + (12 x 0.1224) = 5.84 sm

Average SMV/part = 0.2432 sm/part

$$\frac{\text{Average SMV/part(12 cavs)}}{\text{Average SMV/part(18 cavs)}} = 1.33$$

It will take 33% longer per part to mould than the standard time.

(ii) The number of charges required to meet the schedule will be increased by 50% (18/12). Thus any costs which depend on the number of charges required rather than the time taken (namely the cost of compressed air) will be increased by 50%.

11.3 Approach to Sensitivity Analysis

The traditional approach to sensitivity analysis is to alter each variable in turn in order to determine the effect which is produced on the final result. The result is said to be most sensitive to the variable which causes the greatest change in the overall result. The assumption underlying the traditional approach is that each variable may be manipulated independently of the others, i.e. there is no significant interaction of effect between the variables. Such an assumption is acceptable where the alterations which are made to the variables are small compared with the magnitude of the variable and therefore where combinations of alterations in several variables will have a negligible effect.

For example, if the total result, Z, is equal to the product of variables X and Y:

$$Z = XY$$

If $X' = X + \Delta X$ and $Y' = Y + \Delta Y$, the traditional approach would give the result:

$$Z' - Z = \Delta XY + \Delta YX$$

The 'full' answer allowing for interaction between the variable is:

$$Z' - Z = \Delta XY + \Delta YX + \Delta X\Delta Y \text{ (interaction term)}$$

If $X = 1$, $Y = 1$ and $\Delta X = 0.1$, $\Delta Y = 0.1$

$$X\ Y = 0.01$$

X Y is only 1% of XY and in many cases the difference caused by the interaction term may be regarded as negligible.

If however, the changes in X and Y are large, the interaction terms become more significant. For example:

$$X = 1, \Delta X = 0.5$$

$$Y = 1, \Delta Y = 0.5$$

$$\Delta X\Delta Y = 0.25 = 25\% \text{ of } XY.$$

In the exercise which was undertaken on the standard budgets the alterations in the variables were large relative to the standard allowances - the interaction effects between the variables can be quite significant and therefore the effect of all the variables altering simultaneously must be determined and not the effect of altering each variable sequentially.

Furthermore there was a sequential dependence of one variable upon another. For example if the time taken to mould the scheduled parts was increased, not only will the direct labour budget be affected, but also the amount of maintenance required (since maintenance time was taken as a fixed proportion of running time) and the cost of operating the machine will increase.

Each of the standard budgets was examined in turn and the effects of alteration of any relevant variables determined. The material cost for example will be affected by:

* Increased reject level which requires extra blanks to be made to achieve the required schedule.
* The material loss of 76%.

11.4 Calculation of 'Variances'

11.4.1 Nomenclature

Let

X = Basic cost of producing good parts

X' = Standard Cost = Basic Cost + standard reject and other standard allowances

X" = 'Expected Actual' = Standard Cost + Sensitivity Cost

EXHIBIT 11.1 : PERFORMANCE VARIABLES USED IN ANALYSIS

DESCRIPTION	SYMBOL	STANDARD ALL.	'EXPECTED ACTUAL' ALLOWANCE
Reject Allowance	R	R (25%)	$R + \Delta R$ (59%)
Blank Loss (Wastage)	W	W (0%)	$W + \Delta W$ (76%)
Mould Cleaning	C	C (20%)	$C + \Delta C$ (13%)
Downtime Allowance	D	D (20%)	$D + \Delta D$ (28%)
Maintenance Percentage Allowance	M	M (10.5%)	$M + \Delta M$ (13%)
Machine Productivity Allowance	P	P (0%)	$P + \Delta P$ (33%)
Number of Charges	S	S	$S + \Delta S$ (1.5S)

11.4.2 Method of Calculation

Each budget incorporated into the Viability Master Budget was examined in turn and the factors which would cause the expected actual budget to be significantly deviant from standard were identified. The overall 'variance' and 'sub-variances' were calculated for each budget; two typical calculations will be decribed in detail in order to clarify the approach.

11.4.3 Sample Calculations

11.4.3.1 Material Cost Budget

X' = Standard Cost = £1660

$$X'' = \text{Expected Actual} = X'\frac{(1+R+\Delta R)}{(1+R)}.\ (1+\Delta W)$$

$$= 1660 \times \frac{1.59}{1.25} \times 1.76 = £3716$$

$X'' - X' = 3716 - 1660 = £2056$

$$X'' - X' = X'\frac{(1+R+\Delta R)}{(1+R)}.(1+\Delta W) - X' = \frac{X'.}{(1+R)}(W+R\Delta W+\Delta R+\Delta R\Delta W).$$

$X'' - X' = \frac{X'}{(1+R)}.\Delta W$ = Material Wastage Cost on Good Parts = £1009.

$+\frac{X'}{(1+R)}.\ R\Delta W$ = Material Wastage Cost on Standard Rejects = £252.

$+\frac{X'}{(1+R)}.\ \Delta R$ = Material Cost of Excess Rejects = £452.

$+\frac{X'}{(1+R)}.\ \Delta R\Delta W$ = Material Wastage Cost on Excess Rejects (Interactive term) = £343.

Total = £2056

11.4.3.2 Variable Indirect Wages Budget

Consists of (i) Mould Cleaner

(ii) Setter

(i) Mould Cleaner

$X' = £814.55$

$$X'' = X'\frac{(1+R+\Delta R)}{(1+R)}.(1+\Delta P).\frac{(C+\Delta C)}{C} = 814.55\left(\frac{1.59\times 1.33\times 0.13}{1.25\times 0.20}\right) = £895.66$$

$X'' - X' = £81.11$

$$X''-X' = \frac{X'}{(1+R)C}((1+R+\Delta R)(1+\Delta P)(C+\Delta C)-(1+R)C)$$

$$= \frac{X'}{(1+R)C}(\Delta PC+CR\Delta P+C\Delta R+C\Delta R\Delta P+\Delta C+\Delta P\Delta C+R\Delta C+R\Delta P\Delta C+\Delta R\Delta C\Delta P+\Delta R\Delta C)$$

$X'' - X' = \frac{X'}{(1+R)C} \Delta PC$ = Mould Cleaning due to extra time taken to mould good parts = £215.04.

$+ \frac{X'}{(1+R)C} CR\Delta P$ = Mould Cleaning due to extra time taken to mould standard rejects = £53.76.

$+ \frac{X'}{(1+R)C} C\Delta R$ = Mould Cleaning due to excess reject manufacture = £221.56.

$+ \frac{X'}{(1+R)C} C\Delta R\Delta P$ = Mould Cleaning due to excess time taken to manufacture excess rejects = £73.11.

$+ \frac{X'}{(1+R)C} C$ = Reduction of cleaning cost on good part manufacture = £228.07.

$+ \frac{X'}{(1+R)C} \Delta P\Delta C$ = Reduction of cleaning cost on excess time taken to manufacture good parts = ∸ £75.26.

$+ \frac{X'}{(1+R)C} R\Delta C$ = Reduction of cleaning cost on moulding of standard rejects = - £57.02.

$+ \frac{X'}{(1+R)C} R\Delta P\Delta C$ = Reduction of cleaning cost on excess time to manufacture standard rejects = - £18.82.

$+ \frac{X'}{(1+R)C} \Delta R\Delta C\Delta P$ = Reduction of cleaning cost on excess time taken to manufacture excess rejects = - £25.59.

$+ \frac{X'}{(1+R)C} \Delta R\Delta C$ = Reduction of cleaning cost on excess reject manufacture = - £77.55.

Total = £81.11.

(ii) Setter

$X' = £829$

$X''-X'\frac{(1+R+\Delta R)}{(1+R)}.(1+\Delta P) = £1402$

$X''-X' = £573$

$X''-X' = \frac{X'}{(1+R)}((1+R+\Delta R)(1+\Delta P)-(1+R)) = \frac{X'}{(1+R)}(\Delta P+R\Delta P+\Delta R+\Delta R\Delta P)$

$X''-X' = \frac{X'}{(1+R)}\Delta P$ = Cost of setter during excess time taken to manufacture good parts = £219.

$+\frac{X'}{(1+R)}R\Delta P$ = Cost of setter during excess time taken to manufacture standard rejects = £55.

$+\frac{X'}{(1+R)}\Delta R$ = Cost of setter during excess reject manufacture = £225.

$+\frac{X'}{(1+R)}\Delta R\Delta P$ = Cost of setter during excess time taken to manufacture excess rejects = £74.

Total = £573.

Total Variable Indirects

$X' = £1644$

$X'' = £2298$

$X''-X' = £654$

EXHIBIT 11.2 : DEVIANT FACTORS RELEVANT TO BUDGET CALCULATIONS

BUDGET	DEVIANT FACTORS RELEVANT
VARIABLE COSTS OF SMALL ORDER SECTION	
Material	R, W
Direct Wages	R, P
Indirect Wages to Direct Workers	R, P, D
Indirect Wages (variable)	(i) Mould Cleaner-R,P,C
	(ii) Setter - R, P
Variable Overhead:	
Electricity	R, P
Compressed Air	R, S
Maintenance	R, P, M
General Stores	R, P, D
DIRECTLY ATTRIBUTABLE FIXED COSTS	
Indirect Wages	-
Depreciation	-
Heating	-
VARIABLE COST CHARGES FROM OTHER SECTIONS	
Direct Wages	(i) Barwell - R, W
	(ii) Others - R
Indirect Wages to Direct Workers	(i) Barwell - R, W
	(ii) Others - R
Indirect Wages	R
Variable Overhead	(i) Barwell - R, W
	(ii) Others - R

11.5 Results

The results of applying the expected actual performance figures to the standard budgets can be seen in Exhibit 11.3. The overall effect of the changes was to reduce the sectional margin from £27705 (60% on budgeted sales value) to £17867 (38% on budgeted sales values).

A diagramatic representation of the effect of the expected actual performance on each budget can be seen in Exhibit 11.4.

11.6 Discussion of Results

11.6.1 Viability

Even when allowance was made for an exceptional level of inefficiency it can be seen that the small order business offered a sufficiently high positive contribution level (38%) when compared with other business which could have used the small order facilities.

It was claimed that small order work placed greater demands per unit production upon general overhead than the high volume business, in particular the process engineering, industrial engineering and production control function. This argument must have some validity since it was unlikely that it took significantly less time to design a mould or determine a standard time for a small order part than a high volume part. In the absence of concrete data on this matter however such claims must be regarded as speculation.

EXHIBIT 11.3 : SENSITIVITY ANALYSIS OF VIABILITY COSTS

	X' STANDARD COST		X" EXPECTED ACTUAL COST		X" - X' 'VARIANCE'		'SUB VARIANCES'		% Variance
	£ p.a.	£ p.a.	£ p.a.	£ p.a.	£ p.a.	£ p.a.		£ p.a.	On Standard
BUDGETED SALES VALUE		46496		46496					
VARIABLE COSTS OF SMALL ORDER SECTION									
Material	1660		3716		2056 (123%)		$\frac{X'}{1+R}\Delta W$	1009	(61%)
							" $R\Delta W$	252	(15%)
							" ΔR	452	(27%)
							" $\Delta R\Delta W$	343	(21%)
Direct Wages	3815		6454		2639 (69%)		$\frac{X'}{1+R}\Delta P$	1007	(26%)
							" $R\Delta P$	252	(7%)
							" ΔR	1038	(27%)
							" $\Delta R\Delta P$	342	(9%)
Indirect Wages to Direct Workers	954		2260		1306 (137%)		$\frac{X'}{1+R}\Delta PD$	252	(27%)
							" $DR\Delta P$	63	(7%)
							" $D\Delta R$	259	(27%)
							" $D\Delta R\Delta P$	86	(9%)
							" ΔD	305	(32%)
							" $\Delta P\Delta D$	101	(11%)
							" $R\Delta D$	61	(6%)
							" $R\Delta P\Delta D$	20	(2%)
							" $\Delta R\Delta D$	104	(11%)
							" $\Delta R\Delta P\Delta D$	34	(4%)

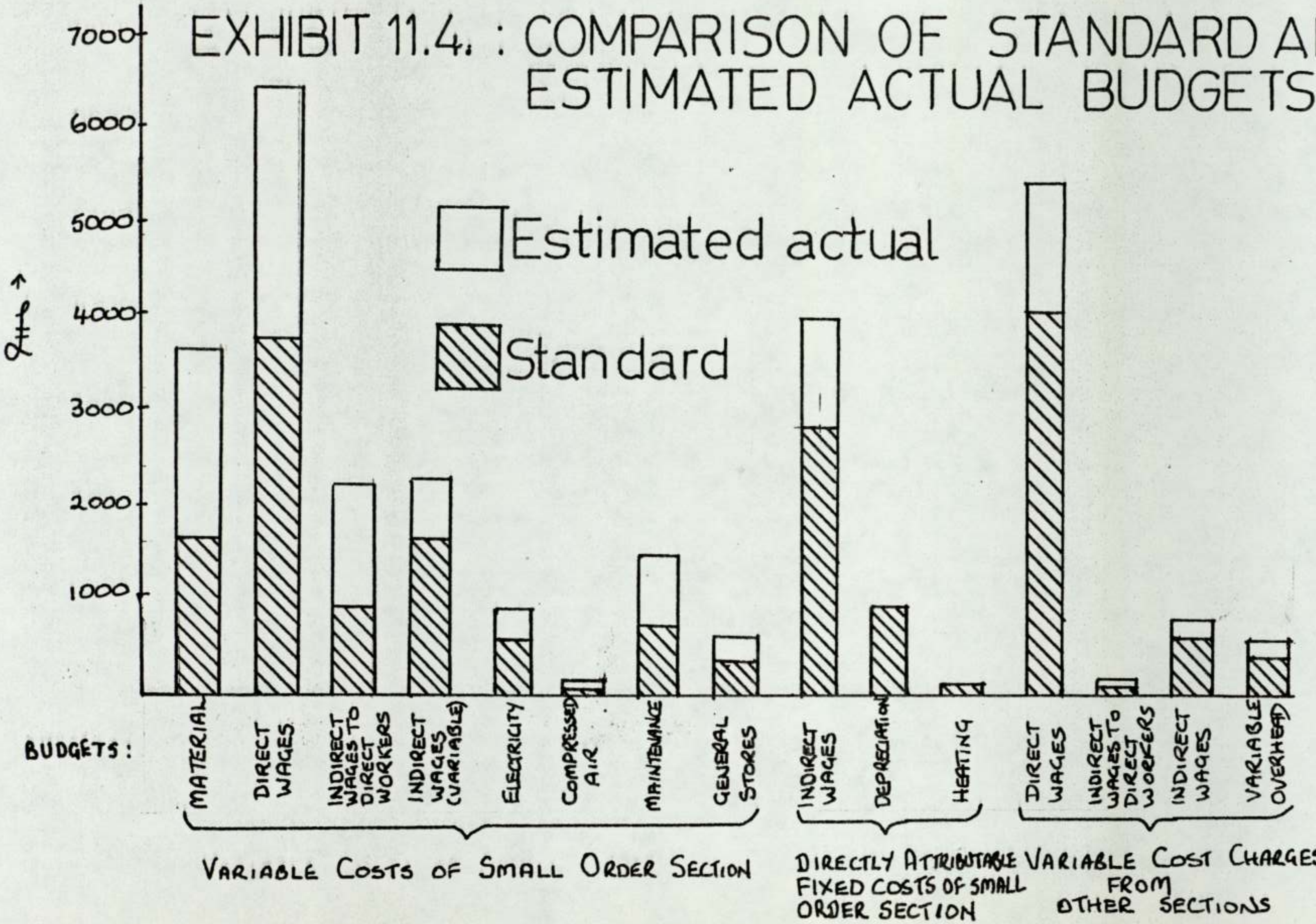
	X' STANDARD COST £ p.a.	£ p.a.	X" EXPECTED ACTUAL COST £ p.a.	£ p.a.	X" - X' 'VARIANCE' £ p.a.	£ p.a.	'SUB VARIANCES'	£ p.a.	% Variance On Standard
Indirect Wages (Variable)	1644		2298		654 (40%)		(1) Mould Cleaner		
							$\frac{X'}{(1+R)}$ ΔPC	215	(13%)
							" CRΔP	54	(3%)
							" CΔR	222	(14%)
							" CΔRΔP	73	(4%)
							" ΔC	-228	14%
							" ΔCΔP	- 75	5%
							" RΔC	- 57	3%
							" RΔPΔC	- 19	1%
							" ΔRΔPΔC	- 26	2%
							" ΔRΔC	- 78	5%
							(11) Setter		
							$\frac{X'}{(1+R)}$ ΔP	219	(13%)
							" RΔP	55	(3%)
							" ΔR	225	(14%)
							" ΔRΔP	74	(5%)
Variable Overhead									
Electricity	528		893		365 (69%)		$\frac{X'}{(1+R)}$ ΔP	139	(26%)
							" RΔP	35	(7%)
							" ΔR	144	(27%)
							" ΔRΔP	47	(9%)
Compressed Air	61		116		55 (90%)		$\frac{X'}{(1+R)}$ (S+ΔS)	24	(39%)
							" RΔS	6	(10%)
							" ΔRS	17	(28%)
							" ΔRΔS	8	(13%)

	X' STANDARD COST		X" EXPECTED ACTUAL COST		X" - X' 'VARIANCE'		'SUB VARIANCES'			% Variance On Standard
	£ p.a.	£ p.a.	£ p.a.	£ p.a.	£ p.a.	£ p.a.			£ p.a.	
Maintenance	715		1498		783 (110%)		$\frac{X'}{(1+R)}M$	ΔPM	189	(26%)
							"	$MR\Delta P$	47	(7%)
							"	$M\Delta R$	194	(27%)
							"	$M\Delta R\Delta P$	64	(9%)
							"	ΔM	136	(19%)
							"	$\Delta P\Delta M$	45	(6%)
							"	$R\Delta M$	34	(5%)
							"	$R\Delta P\Delta M$	11	(2%)
							"	$\Delta R\Delta M$	46	(6%)
							"	$\Delta R\Delta M\Delta P$	15	(2%)
General Stores	343		619		276 (80%)		$\frac{X'}{(1+R)(1+D)}$	ΔP	75	(22%)
							"	$R\Delta P$	19	(6%)
							"	ΔR	78	(23%)
							"	$\Delta R\Delta P$	26	(8%)
							"	$D\Delta P$	15	(4%)
							"	$RD\Delta P$	4	(1%)
							"	ΔRD	16	(5%)
							"	$\Delta R\Delta PD$	5	(1%)
							"	ΔD	18	(5%)
							"	$\Delta D\Delta P$	6	(2%)
							"	$R\Delta D$	5	(1%)
							"	$R\Delta D\Delta P$	2	(1%)
							"	$\Delta R\Delta D$	6	(2%)
							"	$\Delta R\Delta P\Delta D$	2	(1%)
TOTAL SECTIONAL VARIABLE COSTS	9719	9719	17854	17854	8135	8135 (84%)				

	X' STANDARD COST		X" EXPECTED ACTUAL COST		X" - X' 'VARIANCE'		'SUB VARIANCES'		% Variance On Standard
	£ p.a.	£ p.a.	£ p.a.	£ p.a.	£ p.a.	£ p.a.		£ p.a.	
SECTIONAL CONTRIBUTION (GROSS)		36777		28642					
DIRECTLY ATTRIBUTABLE FIXED COSTS OF SECTION									
Indirect Wages	2875		2875		-				
Depreciation	881		881		-				
Heating	113		113		-				
	3869	3869	3369	3369	-				
SECTIONAL CONTRIBUTION (NET)		32908		24773	8135	8135			
VARIABLE COST CHARGES FROM OTHER SECTIONS									
Direct Wages	4096		5425		1329 (32%)		(a) Barwell		
							$\frac{X'}{(1+R)}$ ΔW	135	(3%)
							" $R\Delta W$	34	(1%)
							" ΔR	60	(1%)
							" $\Delta R\Delta W$	46	(1%)
							(b) Others		
							$\frac{X'}{(1+R)}$ ΔR	1054	(26%)

	X' STANDARD COST £ p.a.	£ p.a.	X" EXPECTED ACTUAL COST £ p.a.	£ p.a.	X" - X' 'VARIANCE' £ p.a.	£ p.a.	'SUB VARIANCES'	£ p.a.	% Variance On Standard
Indirect Wages To Direct Operatives	91		140		49 (54%)		(a) Barwell		
							$\frac{X'}{(1+R)}$ ΔW	15	(16%)
							" ΔWR	4	(4%)
							" ΔR	7	(8%)
							" $\Delta R/\Delta W$	5	(5%)
							(b) Others		
							$\frac{X'}{(1+R)}$ ΔR	18	(20%)
Indirect Wages	640		813		173 (27%)		$\frac{X'}{(1+R)}$ ΔR	173	(27%)
Variable Overhead	376		528		152 (40%)		(a) Barwell		
							$\frac{X'}{(1+R)}$ ΔW	32	(9%)
							" ΔWR	8	(2%)
							" ΔR	14	(4%)
							" $\Delta W \Delta R$	11	(3%)
							(b) Others		
							$\frac{X'}{(1+R)}$ ΔR	87	(23%)
	5203,	5203	6906	6906	1703	1703			
SECTIONAL MARGIN		27705 (60% on Turnover)		17867 (38% on Turnover)		9835 (52%)			

EXHIBIT 11.4. : COMPARISON OF STANDARD AND ESTIMATED ACTUAL BUDGETS 1977



It was unlikely that if small order production were completely abandoned at Skelmersdale that any reduction in the general overhead would be achieved; no process engineers or industrial engineers were likely to be dismissed - they were not relevant costs.

On the basis of the financial information available therefore small orders were viable.

11.6.2 Value of Model

The cost budgets used to determine the viability of the small order operation at Skelmersdale represented a cost model of that operation. Such a model could be used predictively in a gross way to predict standard cost behaviour as in Chapter 10. It could also be used to predict the effects which changes in the performance levels would have on the costs as in this chapter. The cost model could, by estimation of the total effects of variable changes on cost performance, direct management attention to the areas where effort could most effectively be concentrated to reduce costs. It also emphasised the point that non-standard performance on one performance variable could not be regarded in isolation from the other performance variables - they interacted in such a way that amplified (or reduced) the effect of the individual changes. In other words the whole (the change in the budget) was greater than the sum of the parts (the changes resulting from changes in the individual performance factors).

The effect of interaction can best be shown by comparing the total 'variance' obtained by the traditional approach of altering each performance variable in turn with the 'interactive' approach which allows all the relevant variables to alter simultaneously.

PERFORMANCE VARIABLE	VARIANCE DUE TO NON-STANDARD PERFORMANCE (£ p.a.)	% OF TOTAL VARIANCE
Reject	1969	31%
Wastage	1490	24%
Downtime	404	6%
Mould Cleaning	- 285	- 5%
Machine Productivity	2670	43%

Total Variance from Traditional Approach= 6248 100%

Total Variance from Interactive Approach= 9835

Difference due to Interaction = 3587

The Interactive Approach generates a total variance of £9835 p.a. compared with £6248 p.a. from the traditional approach. The difference of 57% between the two approaches stems from the considerable interaction which occurs between the variables. At a first examination the traditional approach appears to give a clearer identification of the causes of the variance; from the analysis given for example it would appear that reduced machine productivity is the most significant contributor towards the total variance, followed by excessive reject levels and so on. The clarity of analysis is illusory however, for one is assuming that each performance variable is altered independently from all the other variables which is not the case in the real situation.

The Interactive Approach can be made to generate the Traditional variances by considering sub-variance terms which include only one performance variable deviance (and thereby assuming that all the other deviances are zero) but the assumption made is not in line with the real world where several performance variables are likely to be non-standard at the same time.

Soon after the development of the Interactive Approach it was used to evaluate suggested improvements to the operation of the Small Order Section (See Appendix K); with the costing system then in use at Skelmersdale, it would not have been possible to make an accurate quantitative prediction. The Interactive Model enabled the prediction to be made with little difficulty.

Thus in the Interactive Model the Dunlop management were provided with a means of determining the effects of any changes in the performance variables and identifying those areas where their efforts could best be directed.

CHAPTER 12

Conclusions and Recommendations

12.1 General Difficulties

The research undertaken at Skelmersdale represented an attempt to reduce the uncertainty of the Dunlop management while at the same time making a contribution to the understanding of the problems associated with small order manufacture in an industrial company. These objectives may not be complementary, but such is the problem presented by the interdisciplinary approach wherein the researcher must fulfil both the broader academic and the narrower industrial objectives at one and the same time.

Nevertheless the author believes that through the detailed solution of the practical problems facing the Dunlop management at Skelmersdale, an insight has been gained into the general nature of the small order problem. The main objectives during the research project at Skelmersdale were:

1. To identify the major problems associated with small order manufacture and marketing.
2. To undertake analysis of the relevant data.
3. To make recommendations to the management, and where possible, implementthe recommended solution.

As will have become clear in the preceding chapters, it was not possible to consider the small order problem in isolation from the general state of the brake mouldings business at Skelmersdale. Indeed, in a number of areas the difficulties which were encountered in the analysis and rectification of small order problems were characteristic of the general Skelmersdale situation and could not be related solely to small orders. In summarising the work undertaken in Skelmersdale it is therefore necessary to consider topics which strictly fell outside the study of small orders.

Of the more general issues the most significant was that of the standard costing system in Skelmersdale and the attitude of management towards its use. As was explained in Chapters 7, 8 and 10 standard costs were subject to considerable manipulation by senior management in order to apply more or less pressure to production management. In addition the standard costs were not used, and could not be used because of their simplistic nature, to control production costs in an effective way; too little information was provided too late for any action to be taken by line production management. Furthermore the methods used to establish the costs themselves were not beyond criticism; the use of blanket allowances (the shop cover allowance for example) and the failure to adjust standard costs when processes or manning levels were altered meant that any standard costs, not merely those relating to small order work, had to be scrutinised with extreme care before any meaningful conclusions could be drawn.

It was for this reason that a considerable part of the research work at Skelmersdale was devoted to the establishment of reasonably attainable standard costs which could be used to assess the financial viability of small orders.

In defence of the Dunlop management it must be remembered that the brake mouldings business went through a traumatic recession during the period of the investigation. The Lockheed brakes business had been unprofitable for several years before the 1974-1975 recession; the serious reduction in sales volume came at a time when the new management team at Skelmersdale were attempting to establish the brake mouldings business on a profitable basis. It was almost inevitable that the efforts of the Skelmersdale management were directed towards ensuring the survival of all the business under their control and that a number of the proposals put forward as a result of the research programme were not implemented effectively. It is to the credit of the management team that, when sales volumes recovered from the disastrously low levels of 1975, the brake mouldings business was established on a firm and profitable footing.

12.2 Recommendations

In order to assess the research project at Skelmersdale it could be useful to reconsider the three fundamental questions which were asked about small order work in Chapter 1, namely:

How should small orders be marketed?
How should small orders to manufactured?
How should small orders be costed?

Each of these questions will be considered in turn in order to show the nature of the problem, the recommendations made and the success (or otherwise) of these recommendations when they were implemented.

12.2.1 The Marketing of Small Orders

Little was known at the start of the project about the nature of the market for small orders or the purchasing process which resulted in orders being placed at Skelmersdale. The market destination investigation described in Chapter 3 revealed that the majority (approximately 80% of total sales volume) of the small order business was destined for spares use. This finding had three important implications:

1. Small order prices were not likely to be as critical as in the high volume business, enabling higher profit margins to be obtained (as confirmed by the industrial buyer behaviour investigation).
2. More flexibility in delivery performance would probably be permitted by the customer. (The industrial buyer behaviour study indicated that this opportunity could not be exploited too far).
3. The majority of the small order work was likely to be undertaken for the Spares and Service Division of Automotive Products, which had its own purchasing and material control departments.

The industrial buyer behaviour study enabled the purchasing process in Automotive Products Ltd to be investigated in greater depth and identified the constraints and opportunities which the links between Dunlop Ltd and AP Ltd represented. Most importantly it enabled an assessment to be made of the performance of Dunlop as a supplier. The supply of predominantly high volume products to the Brakes Division in Leamington was considered to be satisfactory by the Automotive Products personnel involved. The Brakes Division personnel also felt that communications between the two companies was both effective and efficient.

The picture which emerged from the Spares and Service Division, Banbury was altogether different; delivery performance was regarded as highly unsatisfactory to the point of resourcing the business with another supplier. (Dunlop Ltd., Precision Rubbers Division). It was felt that the needs of the Spares and Service Division were always regarded as secondary to those of the Brakes Division. Furthermore it was felt that communications between Dunlop, Skelmersdale and Automotive Products Limited were poor; no action had apparently been taken to remedy the critical delivery situation.

As a result of the investigation the following recommendations were made:

1. The delivery of certain critical parts should be improved. A programme was initiated at Skelmersdale to improve the quality levels of the critical parts (high reject levels of the critical parts had resulted in few good parts reaching the customer).
2. Precision Rubbers Division were contacted to discuss the policy implications of a Dunlop Division quoting for business which was currently held by another Dunlop Division. It was unlikely that Dunlop Limited's profitability would benefit from the interdivisional competition, since Precision Rubbers Division had quoted unit prices which were 50-60% of those currently charged by General Rubber Goods Division. It was pointed out that, since Precision Rubbers Division was not an approved supplier of the compound used for the small orders, the Skelmersdale factory could control the transfer by limiting the amount of material which it supplied to Precision Rubbers. It should be noted, however, that whilst some preliminary discussions had taken place between Automotive Products, Precision Rubber and General Rubber Goods management, no transfer had been effected by the end of the project in 1977.
3. It was recommended that more regular visits to Banbury should be made by the involved Dunlop personnel in order to allow the feelings of the Spares Division personnel to be known and acted upon. This recommendation was accepted and implemented.

4. It was agreed that delivery performance should be assessed by a comparison between the number of parts delivered against schedule for <u>each</u> product on the schedule and not as previously where the <u>total</u> number of parts delivered was compared with the total number of scheduled parts. (The satisfactory delivery performance of the high volume (injection moulded) parts had disguised the fact that the delivery performance for the low volume (compression moulded) products was poor.
5. It was recommended that a pricing policy should be devised which took advantage of the relatively inelastic demand for small order components.

As described in Chapter 5 a number of attempts were made to derive a market-orientated pricing policy i.e. one which reflected the prices which the customer was prepared to pay rather than the costs of manufacture. The Product Analysis Pricing model of Brown and Jaques was examined in particular detail since it seemed highly appropriate to the brake mouldings business. Unfortunately the PAP approach was shown to work only where a market-orientated price structure was already established. That a simplified form of the approach had some success when applied to the high volume brake mouldings was indicative that the system had some merit where the price structure was already essentially market-orientated. For the determination of small order prices a different approach was required.

After an examination of the alternatives available it was finally decided that a cost-plus pricing approach should be adopted, albeit modified to allow the customer to affect the price which he was asked to pay by choosing the level of capital investment in tooling which he was prepared to undertake. It is regretable that the Skelmersdale management, whilst agreeing to the implementation of the policy and contributing considerably to its development, did not make any more to implement it (the approach was based upon Quarter Platen Costing). Thus whilst the cost structure was altered by the adoption of the Quarter Platen Costing approach, prices were not adjusted in line with the revised structure. The situation was exacerbated by the refusal to allow new tooling for Small Order Section products to be purchased by the customer. The explanation given for this embargo was that while the future of the small order business at Skelmersdale was in doubt it would be irresponsible to increase the involvement in this business. It was also claimed that an excessive demand for the services of the Process Engineering Department would be created if new tooling had to be designed and put into production.

This explanation must be regarded with some suspicion for the following reasons:

1. Automotive Products normally paid for the full cost of new moulds, including development costs. This would have

meant that the majority of the design and development work could have been undertaken by a design consultancy company at the expense of AP Ltd.

2. The embargo was not lifted even after analysis had shown that small orders were financially attractive if manufactured efficiently with the resources available at Skelmersdale.
3. It was acknowledged that a number of the quality problems which were encountered with small orders could be overcome by the purchase of new tooling.

The failure to implement Quarter Platen Pricing or allow new tooling to be purchased raised the question of the commitment of Skelmersdale to the solution of the small order problem. As had been the case in previous years, high volume problems were given first priority.

In summary, the major elements of the small order marketing policy were as follows:

1. Improve deliveries to the Spares and Service Division, Banbury through improved manufacturing efficiency.
2. Increase the frequency of visits to the Spares and Service Division..
3. Implement the Quarter Platen Pricing Policy at the first possible opportunity.
4. Allow the customer to purchase new tooling as required, in line with the Quarter Platen Policy.

12.2.2 The Manufacture of Small Orders

The investigations revealed a number of problems associated with the manufacture of small order brake mouldings. The problems, together with the probable causes and the suggested remedial actions are shown in Exhibit 12.1.

The overall conclusion which can be drawn from an examination of the manufacturing problems is that small orders suffered from neglect by all the departments concerned with manufacturing in Skelmersdale. No major maintenance of the ageing steam-heated compression presses was undertaken until the equipment had deteriorated to such an extent that replacement was the only alternative. Even after the presses had been replaced by more modern compression presses machine downtime was excessive due to the low priority which small order manufacture was given by the Engineering Department. The compression moulds themselves were subject to a similar deterioration; before the compression moulds were made subject to regular inspection by the Tool Control Section, tool condition was not normally examined until the number of reject parts produced had reached a significantly higher level than normal.

Even after the Small Order Section had been established, little effort was made to ensure that it was adequately manned, the Section's labour frequently being transferred to cover for absenteeism in the high volume area.

EXHIBIT 12.1 : MANUFACTURING PROBLEMS ASSOCIATED WITH SMALL ORDERS

PROBLEM	PROBABLE CAUSE	SUGGESTED REMEDIAL ACTION	DATE OF RECOMMENDATION
1. High reject levels	1.1 Old tooling in poor condition	1.1.1 Moulds to be examined by Tool Control section. Faulty moulds to be refurbished. (Implemented)	January 1975
		1.1.2 New moulds to be purchased if necessary (Not implemented)	September 1976
	1.2 Faulty loading of rubber blanks	1.2.1 Loading points to be marked on mould face. (Partially implemented)	June 1977
		1.2.2 Quality-related incentive scheme (under consideration at end of project)	January 1977
	1.3 Multi-daylight presses excessively worn allowing platen distortion	1.3.1 Multi-daylight presses to be replaced by newer, single daylight presses. (Implemented)	January 1976
2. Excessive machine downtime	2.1 Multi-daylight presses beyond useful working life	See point 1.3.1.	
	2.2 Excessive downtime booked by production personnel	2.2.1 Maintenance Zone Engineer to examine production downtime analysis and sign if agreed. (Implemented)	June 1976
	2.3 Low Engineering Department priority	2.3.1 Problem believed to be inherent small order problem. No solution proposed	-

PROBLEM	PROBABLE CAUSE	SUGGESTED REMEDIAL ACTION	DATE OF RECOMMENDATION
3. Poor labour utilisation	3.1 Small order section labour used to cover for high volume section absenteeism	3.1.1 Brought to attention of senior management. Instruction issued preventing further labour transfer	June 1976
		3.1.2 Additional labour recruited and trained	June 1976
4. Poor use of platen area	4.1 Incorrect implementation of Quarter Platen costing recommendations (18 cavities per platen taken as a maximum rather than an average)	4.1.1 Error pointed out February 1977. No action taken by August 1977	February 1977
5. Excessive material usage	5.1 Excessive moulding rejects	5.1.1 See points 1.1.1 - 1.3.1	-
	5.2 Inadequate monitoring of Barwell claimed output	5.2.1 Material transfer control system proposed. (Not implemented)	October 1976

It was only after the matter had been brought to the attention of the senior management that this practice ceased.

Reject levels remained at a regrettably high level for the greater part of the project at Skelmersdale. Significant reductions in the reject levels of certain parts were achieved towards the end of the project as a result of an investigation by the Process Engineering Department, the first major investigation which had been undertaken in three years. The investigation had revealed two major causes of excessive rejects:

1. The shape and size of the rubber blanks which were loaded into the compression moulds were not always compatible with the shape of the moulded product. As a result, the rubber did not flow to form a complete, strong component when heat and pressure were applied. A number of the blanks were redesigned to facilitate plastic flow.
2. The position of the blank in the mould was also found to be critical if a fully formed part was to be made. The optimum loading position was found for each product investigated. It was then proposed to mark the moulds to identify the best loading point. The Interactive Cost model developed by the author (see Chapter 11) was used to evaluate the likely benefits of the revised loading system. (The Transport and General Workers Union demanded additional payment for its members to load the

blanks in a specific part of the mould. The Interactive Cost model was used to compare the likely cost savings with the additional labour cost - see Appendix K).

A further potential cause of high reject levels was suggested by the author; the payment-by-results incentive scheme in force in the Small Order related to the quantity of output, not its quality. Operatives were therefore paid as much to produce reject parts as they were to produce good parts. There was therefore little incentive to take the extra care during loading and stripping of the component which could have reduced reject levels. A proposal that the quality related incentive scheme should be introduced was not regarded with any enthusiasm by the management. A further lack of interest was shown when the error which had been made in the preparation of the incentive scheme was pointed out. Even though the error resulted in a moulding labour cost which was, on average, 33% higher than that which could be achieved with the existing costing no effort was made to negotiate a change in the incentive scheme.

In summary, it was clear that small order manufacture was considered to have a low priority by the majority of the manufacturing personnel at Skelmersdale. In the absence of any individual in a position of authority at the factory to make a case for the requirements of small orders, resources were inevitably directed almost completely towards the needs of the high volume business.

12.2.3 The Costing of Small Orders

Accurate costing of small order manufacture represented the key to answer the question of whether small order work should be retained at the Skelmersdale factory. Providing that small orders could be supplied in the quantities specified by the customer and could be delivered on time, the arguments to retain the small order business were strong even if they were not easily quantifiable when the problem was regarded from a marketing standpoint. The supply of both high volume and low volume orders from one factory represented a complete marketing package which offered a number of advantages to the customer:

1. Transport and administrative costs were lower.
2. The compound used for small orders was similar or identical to that used for high volume orders; the fewer the sources of compound used, the more likely that the material would be of a consistent quality.
3. Automotive Products preferred the supply of safety critical components to be undertaken by a large company which would possess the resources to meet any claims resulting from faulty manufacture. It was felt that a small company undertaking the manufacture of small orders would not have the necessary resources to meet any large liability claims with the result that Automotive Products would have to meet the claims from their own resources (the assumption being made that a large company would not be likely to accept the small order business without being guaranteed the high volume business).

The offer of small orders to Automotive Products could therefore be regarded as a means of attracting the high volume business to Skelmersdale. The extent to which the supply of small orders ensured continued orders for high volume was difficult to quantify but it could certainly be said that such arguments favoured the retention of the small order business.

In order to decide whether small orders should be retained at Skelmersdale it was necessary to balance the arguments for retention against the costs (real or opportunity) which the company incurred by retaining the business. Cost in this sense means the difference between the benefit which the company gained by the manufacture and sale of small orders and the benefits which would accrue from the pursual of alternative strategies available to it (for example two strategies which were available to the company were: (1) to cease production of small orders and not utilise the manufacturing resources at all or (2) to use the resources to manufacture alternative products). This cost was a measure of the sacrifice which the company had to make in order to supply Automotive Products Limited with small order products.

In order to identify the benefit which the company gained it was necessary to determine the difference between the revenue which the company gained from the sale of small orders and the costs which it incurred in manufacture.

It was possible to identify the historical revenue which had been gained by the sale of these products. It was also possible to predict future revenue by forecasting the future sales volume and applying the likely selling prices. With the costing system in use at Skelmersdale it was not possible to identify the costs of manufacture quite so readily. Chapter 10 describes how many of the small order costs were based upon an apportionment of the average costs for the whole Lockheed Department and did not truly describe the behaviour of the costs which were incurred in small order manufacture (for example the shop cover allowance and blanket reject allowance). Furthermore where costs were included which were solely related to small order production (moulding direct labour costs for example), the basis for the costs was often either out-of-date or was based upon incorrect assumptions. It was therefore necessary to establish costs which reflected more accurately the manufacture of small orders.

The exercises described in Chapters 7-11 were undertaken with this objective in mind. More specifically there were two objectives:

1. To establish the realistically achievable costs associated with the manufacture of small orders at Skelmersdale.
2. To estimate, by using the records of physical performance which were available, the actual costs incurred in small order manufacture (the standard costing system at Skelmersdale was not adequate for this purpose).

The investigation revealed that, given reasonably achievable levels of efficiency, the small order business could offer 60% of revenue as contribution towards the recovery of fixed costs and profit. This meant that with a forecast turnover for 1977 of £46,000, a contribution of £28,000 would be made. This rate of contribution was approximately 50% higher than that achieved for high volume orders and it was felt by the Skelmersdale management that this higher rate of contribution more than compensated for the assumed greater demands which small orders placed on the resources of the Skelmersdale factory compared with large volume orders.

Even when actual levels of efficiency were considered (Chapter 11) a contribution rate of 38% could be achieved, meaning that a contribution of nearly £18,000 would be made. The main conclusion of this investigation was therefore that the benefit derived from the use of the Skelmersdale small order manufacturing resources to supply products to Automotive Products Limited exceeded the benefit which could be gained by applying the best alternative strategy (that of holding the equipment in reserve in case of breakdown in other areas). Furthermore, by ensuring that proper control was maintained of the manufacturing process, the small order business could represent a financially attractive portion of the total brake mouldings business.

The favourable financial results also meant that the difficulty presented by balancing quantifiable and non-quantifiable recommendations was avoided; the results of both the marketing and financial investigations suggested that small order manufacture should be retained at Skelmersdale. A number of improvements were necessary before the full potential of the small orders business could be realised, but essentially the business represented a viable proposition.

12.2.4 Organisational Implications

The problems associated with marketing and manufacture of small orders did not often require a highly sophisticated approach to achieve a solution. The problems were numerous as many aspects of small orders at Skelmersdale showed evidence of neglect of several years duration.

The neglect which small orders had suffered, together with the failure to implement a number of the recommendations described in the preceding chapters, suggested that a further element should be added to the proposed solution. The missing element was the organisational structure and delegation of responsibility for small orders. The organisational structure was such that each functional manager (production, production control, costing, industrial engineering, sales etc) was responsible for some aspect of both high volume and low volume manufacture or sales. When faced with the problem of allocation of action priorities, each manager tended to give precedence to the more pressing high volume matters (quite correctly in many cases because of their greater effect on the state of the whole business). Given the considerable uncertainty under which the managers were operating at the time of the project, there was rarely sufficient time left which could be devoted to the solution of small order problems.

Small orders were therefore in a position analogous to that of a political party which, under a 'first past the post' electoral system, could receive the second highest number of votes in each constituency and yet not gain a single seat in Parliament. In other words the total small order problem did not receive the attention which it warranted because each aspect of the problem was considered in isolation, was compared with high volume problems facing the functional manager and was allocated a low priority. This difficulty arose because there was no single manager who was responsible for all aspects of the small order problem.

If one manager had been made responsible for all aspects of the manufacturing and marketing of small orders, the author believes that a stronger case could have been made for the allocation of at least some of the service resources (in particular process engineering, industrial engineering and accounting) to be devoted to overcoming the difficulties. Such a manager should report directly to the Product Manager and would, in effect, have been a 'mini Product Manager' for small orders. The cost of employing a manager solely to deal with small orders (approximately £4500-5000 including fringe costs) must be considered in relation to the potential cost savings which could be made if many of the proposals described in the preceding chapters had been fully implemented; the difference between the estimated actual variable costs of manufacture (£28,000 p.a.) and the realistically achievable costs (£18,000 p.a.) was more than double the likely cost of employing a small order section manager. Thus, only half of the potential savings need have been gained to cover the cost of the appointment. Additional savings could also have been made by, for example, increasing the number of moulds (see Chapter 7). Furthermore, the appointment of a single manager responsible for small orders would have gone some considerable way to overcoming the complaints of the Spares and Service Division that insufficient attention was paid by the Dunlop management to the small order sales.

Whilst it was possible that the proposed improvements would have been made without the presence of a single accountable and responsible manager, full implementation would be made more likely if he were appointed. As supporting evidence to this hypothesis it should be noted that whilst a number of proposals made by the author during the project were fully accepted by the Skelmersdale Management, the implementation of the proposals was not as successful as it might have been.

The author could not fulfil the role of 'Small Order Manager' even if this were expected, whilst remaining an IHD student, without being involved in the day-to-day running of the section; this would have almost certainly prejudiced the completion of the research project. In addition, it was unlikely that the staff union (the Association of Scientific, Technical and Managerial Staffs) would have permitted the author to assume a managerial role while he remained an IHD student, since at the time of the project a voluntary redundancy scheme was in operation for the Skelmersdale staff; the union was therefore likely to insist that the post be filled by one of its members.

The appointment of a manager responsible for all aspects of small order manufacture and marketing was not made during the life of the project at Skelmersdale. It is therefore only possible to speculate on the possible success of such an appointment. The presence of a responsible manager would not in itself have guaranteed the efficient handling of small orders in the Skelmersdale factory but it would have helped to ensure that the recommendations which were made concerning the pricing and costing of small orders were implemented. The presence of a responsible manager could have also helped to ensure that the momentum which was gained during the investigation by the Process Engineering Department was maintained. In the absence of any appointment however it was not possible to determine a priori the effect which a 'Small Order Manager' could have had.

12.3 General Inferences and Speculation

It is not possible to draw generally applicable conclusions from a single investigation into small orders in one factory. The investigation only permits a tentative analytical framework to be proposed indicating the critical problems which are likely to be encountered. The details of the framework are as follows:

12.3.1 Marketing

12.3.1.1 Price Structure

There is a danger that, either through neglect or incorrect costing assumptions, price structure instability may occur wherein similar products (in terms of product characteristics) have dissimilar prices. Care must be taken to ensure that the price structure is, and is seen to be, rational. The difficulty of ensuring rationality can be exacerbated by the adoption of an absorption costing approach, where, not only must the variable costs be questioned, but also the rules used to apportion fixed costs.

The questionability of fixed cost apportionment rules can be avoided if only direct material and direct labour costs are used as a basis for price determination. This approach can present problems if the overhead requirement (either variable or fixed) varies significantly between different groups of products; a true cost-plus policy would not then be followed. If one product is <u>known</u> to have a different cost pattern from another, then there is no reason why the full costs (or relevant parts thereof) should not be used to derive selling prices; it is essential to ensure that prices are not established by examining full costs which are assumed to be different without strong supporting evidence to confirm the differences.

12.3.1.2 Customer Service

Efforts must be made, within the realms of what is economic, to ensure that an adequate level of communication is maintained with the customer concerning small orders. In the absence of good communications there is a possibility that the supplier may not be aware that a problem exists (especially if he is using a volume-orientated parameter, such as the total number of products delivered, to assess performance).

It is difficult to establish a priori at what point communications breakdown can become critical. It would be when the demand volume falls below a certain level or when the product becomes a 'spares only' item. All that can be recommended is that the complete product range be examined periodically (perhaps at six monthly intervals) in order to determine whether there is any class or group of products which is not the subject of regular (but possibly infrequent) communication with the customer and about which there is a paucity of in-house control information. In the case of Skelmersdale for example a review of communications with Automotive Products Limited would have indicated that low volume spares supplied to the Spares and Service Division were rarely the subject of communication with the customer; further investigation would have revealed that a problem existed.

12.3.2 Manufacturing

12.3.2.1 Production Method

A method of production should be chosen which is appropriate to small batch production (in terms of production rate, set-up times etc). The production technologies at Skelmersdale were already established in a manner which seemed appropriate to both small and large batch production. There was, unfortunately, insufficient time during the life of the project to determine if a breakdown point (in terms of cost and batch size) existed for the two different production methods.

12.3.2.2 Age and Conditions of Equipment

The condition of equipment must be examined regularly and action taken to ensure that deterioration does not occur as a result of neglect. If a case can be made for the replacement of equipment, it should be replaced irrespective of whether it is used for small order or high volume production.

12.3.2.3 Separation of Production Resources

A separation of the production facilities for small order and high volume work not only helps to eliminate interference between the two types of production, but also assists the establishment of effective cost control and enables specific investigations to be undertaken more easily. A physical separation also makes it more likely that a different cost structure will be established for the small order products (see section 12.3.3).

The difficulty does not lie in the identification of the potential benefits of a physical separation, but in the determination of the products to be manufactured in the small order section and the production resources to be included in the section. In the Skelmersdale investigation a convenient technological split (albeit an arbitrary one) already existed in that some products were moulded using the traditional compression moulding technique while others were produced using the more recent injection moulding method. An investigation still had to be undertaken to determine what other production resources were required for the section; on economic grounds it was decided that only moulding equipment should be included in the small order section (see Chapters 9 and 10).

If a convenient technological break point exists (as at Skelmersdale) then it is sensible to make use of it when considering a physical separation of resources. If such a breakpoint does not exist then the decision to separate is made more difficult; the only clear recommendation which can be made is that a sufficient number of products be chosen to fully occupy the recommended number of machines and/or men.

12.3.2.4 Production Performance Assessment

Care must be taken to ensure that volume dependent parameters are not used on their own to assess the performance of the production unit, for the greater total volume of the high volume work will tend to mask the actual small order performance. (In Skelmersdale the yardstick of production used was the total number of parts produced per week. Poor output performance of the Small Order Section was almost completely masked by the total number of high volume products manufactured).

A more useful and analytical assessment of production achievement generally can be obtained by comparing the number of standard hours produced with the number of actual hours spent in manufacturing the products in any given period. The standard hour approach offers considerable advantages over the total number of products approach to output measurement; small order output performance is not likely to be masked by high volume results. In addition the assessment of performance is not dependent upon product mix as it is when the total number of products are summed, especially when there is a broad variation in standard manufacturing time.

The use of standard hours output as a means of assessing production efficiency offers such advantages over the simple summation of physical output that its use is recommended in all situations and not just in those situations where small order problems are to be investigated.

12.3.3 Costing

12.3.3.1 Standard Costs

The cost behaviour of small order production can be different from high volume production. It is also possible that the allocation of overhead costs for small orders would be different from that of high volume work. It is therefore unwise to use the same cost standards for both types of product unless it can be shown that cost behaviour is similar. The use of blanket cost standards (for example reject allowances, efficiency factors) may give misleading results when applied to small order product cost and budget construction. The inaccuracies of the small order costs may not be detected if cost control is limited to information concerning the costs incurred in the production of both large and small orders; the costs incurred during high volume production will tend to mask those incurred during small order production. It is therefore possible for the overall cost performance of a department to be judged satisfactory without any appreciation being gained into the actual cost performance of small order production.

It is therefore desirable that separate small order cost budgets should be established, an exercise which is facilitated by a physical separation of the small order and large order production.

12.3.3.2 Cost Control

As was stated in Chapter 10, it is essential that timely and accurate cost performance reports should be provided. The meaning of the terms 'timely' and 'accurate' must obviously be related to the environment in which the cost reports are to be used and should consider such factors as: the duration of production runs, the time span of control of the manager receiving the reports and the pattern of cost incurrence. As a general rule cost performance reports should be provided as rapidly as is consistent with a level of accuracy such that major cost variances will be clearly identified and enable effective remedial action to be taken.

The provision of timely and accurate cost information is essential for the efficient functioning of production management. Accurate cost monitoring can also help to prevent(or confirm) the occurence of unsubstantiated beliefs concerning the actual costs of small order product which almost inevitably prevail when no concrete information is provided.

12.3.4 Organisation

Providing that the small order business can carry the burden of additional overhead, the appointment of a manager responsible for all aspects of the small order business (and who will, therefore, be profit responsible) will be likely to ensure that small orders are not neglected. The difficulty which arises is that of deciding whether the appointment of a responsible manager can be justified. The reasons why a manager might be appointed are manifold: the elimination of excessive disruption of high volume production, low profitability, high customer complaint or reject levels, represent just a few. Against the potential benefits must be balanced the costs of employing the manager. In other words a cost benefit analysis must be undertaken before the decision to appoint a small order manager can be made. The problem is therefore somewhat paradoxical, since the analysis of the problem is one aspect of the role which the manager would be expected to undertake. In the Skelmersdale situation the analytical role (but not managerial role) was performed by the author at a relatively low cost to the company because of the Science Research Council grants which it received for the duration of the project. In many other organisations it is unlikely that an in-depth investigation would be undertaken at such a low cost. The senior line manager with a small order problem is therefore left with a number of alternatives:

(1) To undertake an investigation to identify the potential benefits of employing a profit responsible small order manager and appoint him if justified.

(2) To appoint a small order manager in the hope that his costs of employment will be more than offset by the

savings which he will be able to make. The greater the turnover of the business and the greater the small order problem, the more likely it is that this approach will be adopted.

Nevertheless it is not possible to determine a priori whether a manager should be appointed with or without analysis, especially since the major objective of the appointment would be to overcome neglect. Neglect is the greatest single enemy of an efficient small order operation; the three year Skelmersdale project was dedicated to the defeat of this enemy.

APPENDIX A : PROJECT PROFILE - AN EXPERIMENT IN CONSENSUS

An exercise to identify the major objectives of the study - July 1975

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Aim of Study

Using the ten hypotheses listed in the report "Rationale for a small order study in the Lockheed Department, Dunlop Ltd., Skelmersdale" (9.6.75) as a basis, to obtain a consensus of Dunlop management opinion on possible directions for the research project.

The report listed all the benefits that it was thought reasonable to expect from the study of small orders, but with no priority being given to any particular directions.

Methodology

With only limited time available for the investigation, the investigator aimed to use as much of the available paperwork as possible. To this end the report "Rationale for a small order study..." was circulated to the test group, with page 3 deleted (which contained comments on the value of one of the hypotheses). Subjects were asked, either verbally or in writing (see sample letter - Appendix I) to rate each hypotheses, independently of all the others, on a 10 point scale; 1 out of 10 being unimportant to Dunlop, 10 out of 10 extremely important. It was explained that the hypotheses were not to be ranked in order.

As far as possible the same instructions were given to each subject (those above). However it was not possible to avoid a period of some 1½ - 2 weeks between the administration of the questionnaire to the first subject and that to the last. Furthermore, the subjects did not fill in the ratings with the investigator present, so the conditions at the time of completing the form were not standardised.

It would have taken too long to have tested the statements embodying the hypotheses for bias, so they were allowed to stand without such a test. Similarly, to reduce the risks of 'middling' would have been desirable, but time, again, made that impossible.

Subject Group

A group of six Dunlop managers was chosen for the study: they were felt to be the managers whose co-operation is most necessary for the success of the small order study, and who are, at least in part, familiar with the work undertaken so far.

The subjects were as follows:

1) E.J.McG - IHD student, investigator in the following study. This subject did the rating exercise before its presentation to the other subjects in order to prevent knowledge of other results affecting his assessment.

2) DKT - Product Manager, Mill and Moulded Products. Industrial IHD Supervisor, most senior line manager in the area where the research is to be undertaken. (North Factory).
Background: post held for 2 years. Previous experience in large oil company and management consultancy.

3) KSC - Project Manager, Business Development Group. Associate IHD supervisor.
Background: Post held for approximately 1 year. Previous experience - ex IHD student based in the North Factory.

4) UR - Production Control Manager, North Factory. One of the most experienced managers in the manufacture of brake rubbers. Responsible for all North Factory scheduling. Also forms important communication link with Automotive Products.
Background: Position held for 5 years +.

5) HK - Works Manager, Skelmersdale. Originally industrial supervisor for the project. Little contact with the project since November 1974.
Background: Present post helf for approximately 1½ years. Previously Works Manager at Dunlop G.R.G. Manchester.

6) EI - Production Manager, North Factory, answering to DKT. Very closely involved with the project at the beginning, less so now.
Background: Post held for approximately 1 year. Previous experience as Project Manager and Departmental Manager, General Moulding Department.

7) CK - Departmental Manager, Lockheed Department. Not closely associated with the project. His main concern is with efficiency improvements and scrap reduction, and is not involved in obtaining business or scheduling production.
Background: Present post held for approximately 1 year. Previous experience as Senior Industrial Engineer, Skelmersdale.

Results

Hypotheses used in test.

1) A physical separation of small orders from the high volume work will allow better and more predictable high volume production scheduling.

2) By separating small volume work from high volume work (either physically, or administratively, or both) more accurate cost control may be achieved. (The present system is principally concerned with high volume costs, small volume costs being very inaccurate).

3) A more sophisticated costing system may be developed to determine the causes of the high cost variance in the Lockheed Department.

4) A physical separation of small orders should reduce interference (at least in the main production department) and lead to more efficient labour utilisation.

5) Higher customer service levels may be achieved due to the increased flexibility of operation of a small order section. It should be easier to meet a small order rapidly in a special section than to try and fit it into a large department schedule where high volume parts must take priority of necessity.

6) A better understanding of product life cycles might be achieved, with the development of a clear policy towards mould retention.

Some prediction of the life of a party may be possible and a decision made on whether to retain the business or dispose of the mould.

7) An improved pricing policy may be developed for small orders which compensates Dunlop for the extra set-up time and planning per part.

8) By administratively separating the small orders from the large, small orders should receive a fairer share of management time. At present virtually all management effort is concentrated on high volume work.

9) The members of a small tightly-knit group are likely to be more highly motivated than those in a large group. This may result in:
   a) Greater job satisfaction.
   b) Lower labour turnover or reduced absenteeism.
   c) Greater management worker co-operation, giving more accurate production and reject figures.

10) By separating low and high volume orders two basic moulding technologies will be separated. Most (but not all) small orders are compression moulded, and conversely most high volume parts are injection moulded. The separation should allow a much better study of the two moulding technologies to be made in terms of:
    i) The true costs of operation of compression and injection machines, with the construction of operating cost curves.

ii) The type of part which is best suited to the different methods of production.

iii) The relative flexibility of the two production methods.

SUBJECT RATINGS

HYPOTHESIS NUMBER	EJM	DKT	KSC	UR	HK	EI	CK*7	MEAN	MEAN EXCL. CK
1	7	5	5	2*3	8	6	6	5.5	5.5
2	9	8	8	7	10	10	1	7.5	8.5
3	8	6	8	9	10	10	4	8.0	8.5
4	6	7	7	5	8	5	10	7.0	6.5
5	3	8*1	6	3	5	4	4	4.5	5.0
6	7	5	5	4	3	7	2	4.5	5.0
7	9	8	8	10*4	10	10	1	8.0	9.0
8	5	7	4	6	3	5	3	4.5	5.0
9	2	9*2	3	8	3	7	5	5.5	5.5
10	8	8	7	1*5	10	10	9	7.5	7.5

*1 - *7 See 'Notes on Results'

EXHIBIT I INDIVIDUAL HYPOTHESIS RATINGS

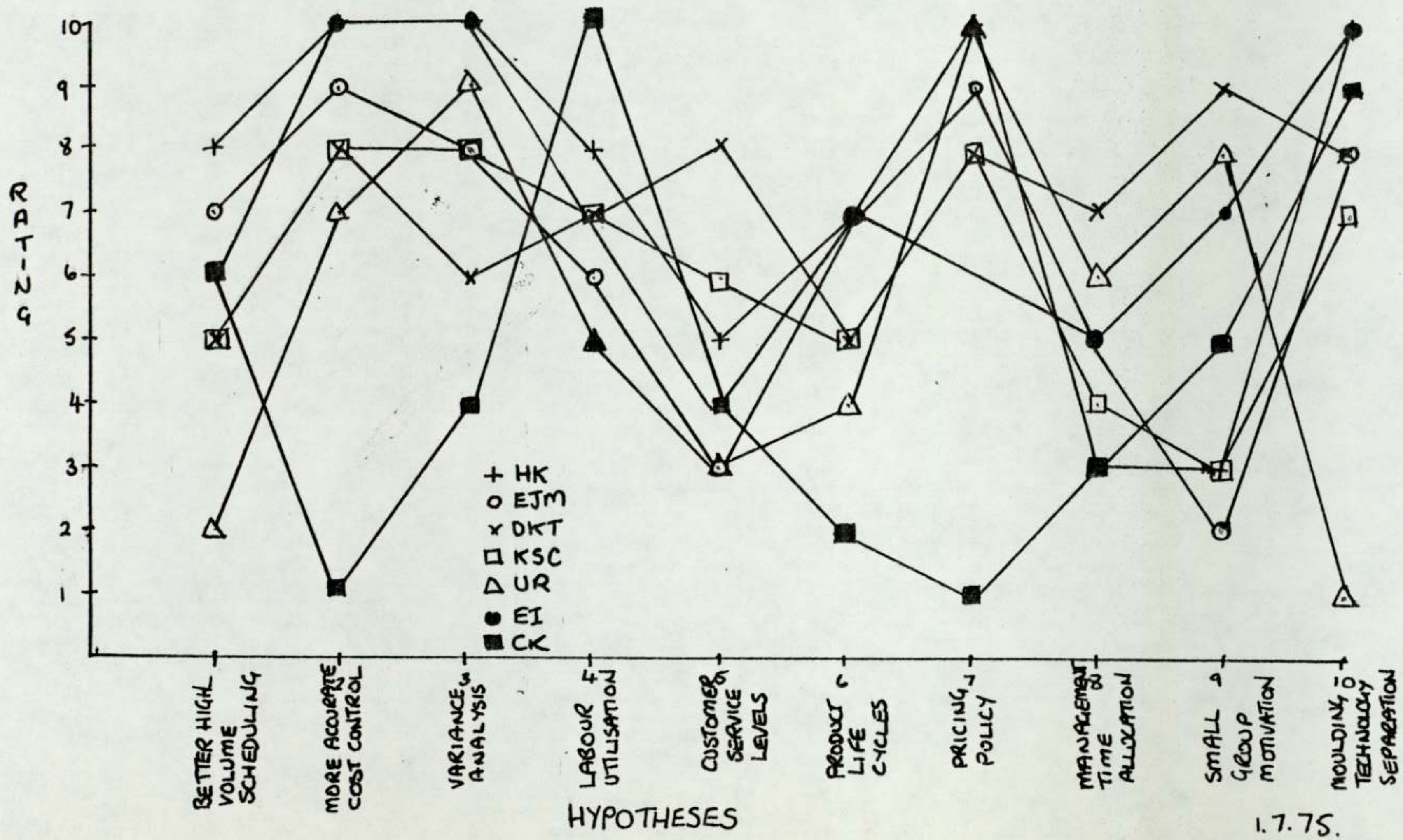
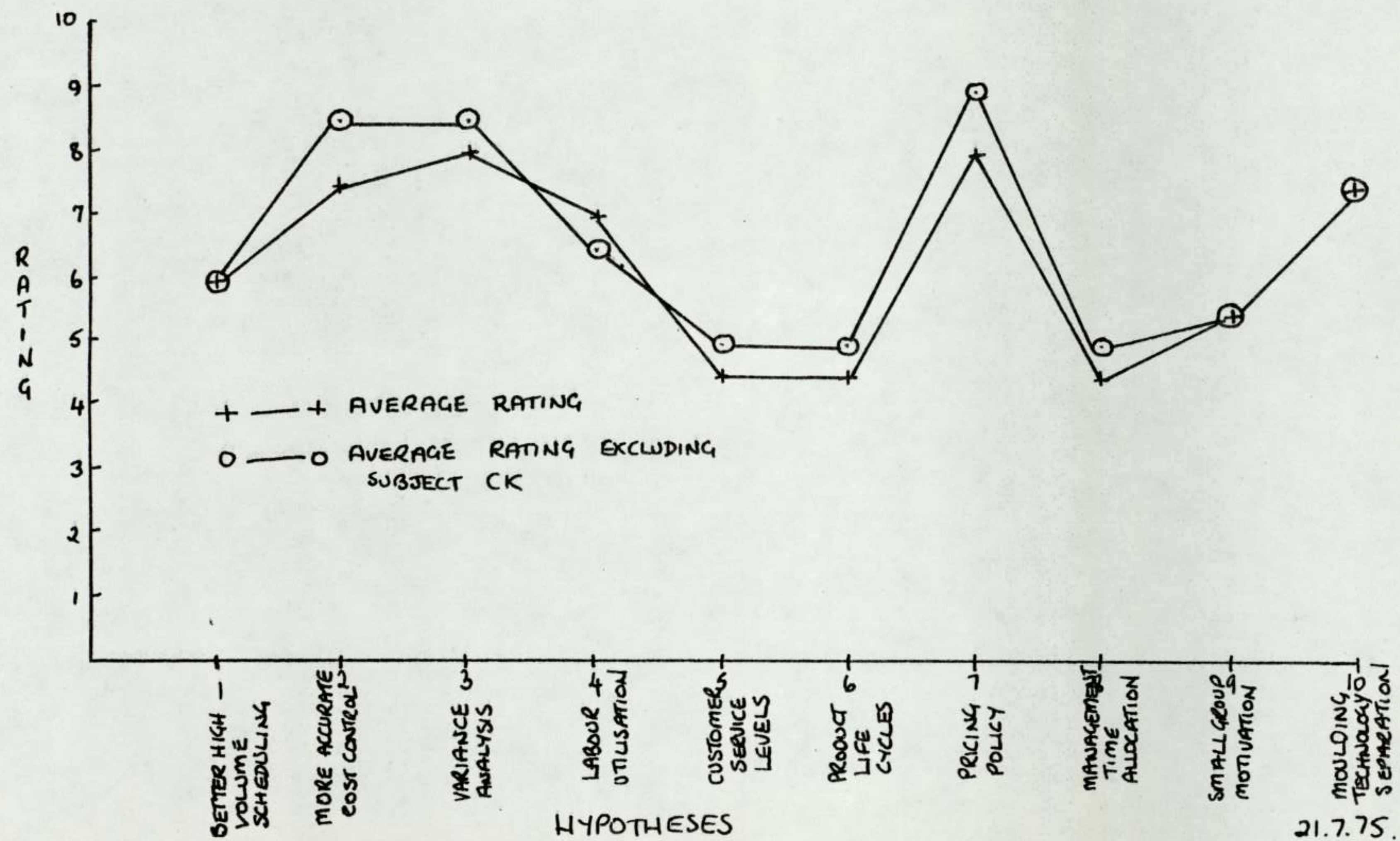


EXHIBIT II : AVERAGE HYPOTHESIS RATINGS



Notes on Results (background information on certain results)

*1 DKT had been highly criticised by Automotive Products for poor small order service. This criticism had an immediacy which possibly affects the rating given to this point.

*2 DKT thinks that there would be little academic value in the study of small group motivation, but feels that one of the major reasons for having a small order section would be to reduce scrap levels (he believes that human factors are very important in producing high scrap levels).

*3 UR, as production control manager, is responsible for all production scheduling, and therefore might have felt that hypothesis 1 was an implied criticism of the current scheduling system. His rating may therefore reflect a reaction to this implied criticism.

*4 UR is frequently involved in the pricing of small orders, but has admitted the lack of real criteria to determine the best price level.

*5 A low value was given to this point by UR who explained this by saying he felt that most of the points made in hypothesis 10 were incorporated in the other hypotheses.

*6 EI felt that hypothesis 1 should not be overstressed because:

a) The existing frequency of mould cleaning on <u>all</u> moulds, every mould is cleaned at least every 24 hours.

b) The periodic benefit of fill-in jobs (EI felt that UR often relied on small runs to fill in the time between large jobs).

*7 Exhibit 1 shows that CK is generally out of step with the other subjects, so mean ratings have been calculated both for the whole group, and for the group excluding CK (exhibit II). The results of subject CK may perhaps be understood better by consideration of the following points:

i) CK feels his brief is to reduce scrap levels and manage the labour resources at his disposal. This would explain the very high rating given to hypothesis 4 (labour utilisation); the industrial engineering background may also encourage such an attitude.

ii) CK is highly concerned with the production of parts at low scrap levels, and the relative costs and efficiencies of the two basic moulding methods. It is therefore rather surprising that he rates the achievement of more accurate cost control and better variance analysis so poorly. Possible explanations of these anomolies may be:

a) Failure of more senior management to provide CK with sufficient cost data for him to feel responsible for control of costs.

or b) Scepticism that the project would promote better cost control.

or c) CK may have taken the hypotheses concerning cost control as implied criticism of his ability to control costs.

or d) A belief that cost control is not his area of responsibility. This may be as a result of the role which he has been asked to perform.

iii) Very low ratings are given to the marketing-orientated hypotheses: product life cycles and pricing policy. This probably reflects the fact that CK is not involved at all in obtaining the business; he is presented with a 'fait accompli' - business is obtained for the department and presented to the departmental manager already scheduled.

Discussion of Results

An approximate project profile has emerged from the analysis:

1) Pricing policy is regarded by all subjects (with the exception of CK) as being of primary importance.

2) In association with point 1; with a cost-plus pricing system, before a price can be established, costs must be accurately known. Therefore all subjects (except CK give a high rating to accurate cost control and an explanation of the high departmental cost variance.

3) It is felt by most subjects that a separation of compression and injection moulding would allow a better study of the two moulding technologies to be made.

4) Improved high volume scheduling and small group motivation are given equal rating by the subjects. The ratings for small group motivation fall into two distinct groups (again with the exception of CK). Three subjects (DKT, UR and EI) rate small group motivation quite highly, whilst three other subjects rate it very poorly (EJM, KSC and HK). It may be significant that the three high-rating subjects are all directly concerned with production manager and production control manager), whilst the other group is more remote from production (IHD student, project manager and works manager).

It is possible that the production orientated managers are more aware of the importance of instilling high motivation in the work-force, and see the study as a potential way of increasing motivation. There are two cautionary notes however;

i) The work 'motivation' is a rather indiscriminately used term to cover a multitude of sins. Academics in particular have used the term blithely without perhaps considering the meaning of the term; quite frequently they use 'motivation' where 'incentive provision' would be more appropriate. Motivation is an internally generated 'push', incentive an extrinsically derived 'pull'. (See F. Herzberg - "One more time, how do you motivate employees" - Harvard Business Review, Jan - Feb 1968). Perhaps the members of the high rating group have fallen into a pit dug by well meaning academics?.

ii) It may well be that the high rating subjects do not believe that any reasonable academic study can be made, but rather that highly motivated employees will be the result of setting up a small order section..

5) Customer service levels, product life cycles and management time allocation are all rated equally and relatively poorly. This result is particularly significant since product life cycle information has been particularly elusive; the rating results suggest that not too much time should be devoted to answering the product life cycle questions.

Project Profile

An attempt has been made to identify the 'customer' at the company level, in order that the project may be relevant to the needs of Dunlop Ltd., Skelmersdale. If the satisfaction of the Dunlop managers most involved is the major criterion, then the project profile thus obtained should be used as the main guide in determining the directions of the project.

Certain basic directions are suggested:

i) Pricing/marketing
ii) Administrative systems with particular emphasis on accurate cost control.
iii) A study of the two basic moulding technologies.

APPENDIX I

Typical Subject Instruction Sheet

2? JUN 1975

G.R.G. DIVISION

From E.J. McGrath, IHD student
Ref EJM/EJM
Date 20.6.75.
Ext 328

Dear Sir,

When I first joined the Company you expressed your views on the value of a small order study and the possible directions that this might take; I would be very grateful for your help in this matter now.

I have produced a report (enclosed) which outlines 10 hypotheses relating to the possible benefits to the Lockheed Department of either:

(a) setting up a separate small order section,
or (b) producing separate small order administrative systems.

I hope to obtain a concensus of Dunlop management opninion on the possible value of the answers to these questions to the company and feel that your views are essential. If you are able to co-operate I would be grateful if you would rate each hypothesis, independently of all the others, on a 10 point scale; 1out of 10 being unimportant to Dunlop, 10 out of 10 extremely important.(I do not wish the hypotheses to be ranked in order). Any additional comments would also be gratefully received.

I realise that you may not be totally familiar with all the work which I have undertaken at Skelmersdale, but feel that a detailed knowledge of the work is not essential to assess the value of the tests of the hypotheses to Dunlop. Once a concensus is obtained I hope to ensure that the direction of the project is compatible with the requirements of the Company.

I hope that you will be able to help.

Yours sincerely,

E.J. McGrath

E.J. McGrath.

cc C.J. Shaw.

APPENDIX II

Hypothesis Test Sheets

Rationale for a small order study in the Lockheed Department, Dunlop Ltd., Skelmersdale

Hypotheses

1) A physical separation of small orders from the high volume work will allow better and more predictable high volume production scheduling.

2) By separating small volume work from high volume work (either physically, or administratively, or both) more accurate cost control may be achieved. (The present system is principally concerned with high volume costs, small volume costs being very inaccurate).

3) A more sophisticated costing system may be developed to determine the causes of the high cost variance in the Lockheed Department.

4) A physical separation of small orders should reduce interference (at least in the main production department) and lead to more efficient labour utilisation.

5) Higher customer service levels may be achieved due to the increased flexibility of operation of a small order section. It should be easier to meet a small order rapidly in a special section than to try and fit it into a large department schedule where high volume parts must take priority of necessity.

6) A better understanding of product life cycles might be achieved, with the development of a clear policy towards mould retention. Some prediction of the life of a part may be possible and a decision made on whether to retain the business or dispose of the mould.

7) An improved pricing policy may be developed for small orders which compensates Dunlop for the extra set-up time and planning per part.

8) By administratively separating the small orders from the large, small orders should receive a fairer share of management time. At present virtually all management effort is concentrated on high volume work.

9) The members of a small tightly-knit group are likely to be more highly motivated than those in a large group. This may result in:

   (a) Greater job satisfaction.
   (b) Lower labour turnover or reduced absenteeism.
   (c) Greater management worker co-operation, giving more accurate production and reject figures.

10) By separating low and high volume orders two basic moulding technologies will be separated. Most (but not all) small orders are compression moulded, and conversely most high volume parts are injection moulded. The separation should allow a much better study of the two moulding technologies to be made in terms of:

   (i) The true costs of operation of compression and injection machines, with the construction of operating cost curves.

(ii) The type of part which is best suited to the different methods of production.

(iii) The relative flexibility of the two production methods.

APPENDIX B

QUESTIONNAIRE ON INDUSTRIAL BUYER BEHAVIOUR - AUTOMOTIVE PRODUCTS LTD

INTRODUCTION

Description of I.H.D. and general purpose of the questions. Making a study of Industrial Buyer Behaviour and would like to discuss general topics leading to more specific questions on the nature of buying in A.P. The academic nature of the investigation should be stressed in view of the searching nature of certain questions.

QUESTIONS

1) What goals are set for the purchasing function in A.P. by Senior Management? And what constraints (if any) are placed upon Purchasing by the general policy?

2) What is your attitude towards purchasing management techniques such as PERT, value analysis, optimum batch size? Do you use any of them?

3) How is the purchasing function organised in A.P?

4) Are other internal departments involved in the purchasing of new components? How?

5) Is the purchasing of existing components different? Are different people or departments involved?

6) Are competitive bids always sought for components? If so, how many potential suppliers are selected to submit quotations?

7) Do you consider companies who have not supplied previously?

8) What factors do A.P. consider when assessing a new supplier?

9) Who is responsible for the final decision to source a new component?

10) Does the purchasing of components for the Spares Division differ from the purchasing of components for original equipment?

11) I would now like you to examine this sheet and rank in order of importance the factors which you consider to be most important in the different buying situations described.

SHOW CARD 1

12) What is your opinion of Dunlop as a Supplier?
Please rate the performance of Dunlop Skelmersdale in the following areas.

SHOW CARD 2

13) How is the status of Dunlop affected by the relationship between A.P. and Alfred Roberts?

14) Is any standard method of assessing the performance of A.P. buyers used (refer to the Ford Motor Company system)?

15) Can you suggest the names of any others in your organisation who would be able to help me to understand the buying process in Automotive Products?

SHEET 1

Please rank the following factors in descending order of importance in the purchasing situations described.

1) Buying Situation: Initial purchase of a new component

FACTOR	RANK (1,2,3...etc)
Delivery to order	
Price	
Familiarity with supplier	
Product Quality	
Flexibility to product specification changes	
Access to Research Expertise	
Speed of Response to Enquiries	
Others (Please specify)	

2) Buying Situation: Repeat purchase of an original equipment component

FACTOR	RANK
Delivery to Order	
Price	
Familiarity with supplier	
Product Quality	
Flexibility to Product Specification changes	
Access to Research Expertise	
Speed of Response to Enquiries	
Others (Please specify)	

3) <u>Buying Situation</u>: Repeat purchase of a spares component

FACTOR	RANK
Delivery to Order	
Price	
Familiarity with supplier	
Product Quality	
Flexibility to Product Specification changes	
Access to Research Expertise	
Speed of Response to Enquiries	
Others (Please specify)	

SHEET 2

Please rate the performance of:

Your WORST supplier

Your BEST supplier

DUNLOP, SKELMERSDALE

in the following areas.

Use a scale of 1 to 10 (1-very poor, 10-excellent)

AREA	SUPPLIER		
	WORST	BEST	DUNLOP
1. Price			
2. Delivery			
3. Quality			
4. Response to Schedule Changes			
5. Availability of compound/ product research facilities			
6. Speed of response to Quotation Requests			

APPENDIX C

QUESTIONNAIRE ON PRODUCT ANALYSIS PRICING - GLACIER METAL LTD

Product Analysis Pricing

1) Why was PAP adopted in Glacier Metal - was its structure determined by the structure of the market or by the organisational structure of the company?

2) What other pricing policies were considered?

3) What advantages (and disadvantages) do you feel that if offers compared to other pricing policies?

4) "With PAP much emphasis is placed upon the Chief Executive's ability (and that of his colleagues) to judge the market prices of the products accurately" - would you say that that was a fair statement?

5) If the Chief Executive had sufficient time to determine each price himself, would PAP still be justified?

6) Executives joining Glacier for the first time must find PAP very different from anything else within their experience - how is it introduced to them?

7) What techniques were used to arrive at the product property and feature values?

8) Were many of the product property and feature relationships linear?

If not, how were the equations determined?

9) Was a computer used in the determination of the values?

10) How does PAP currently operate in Glacier Metal?

11) Did the introduction of PAP necessitate or promote any organisational changes?

12) Is PAP used for all products?

13) Would you judge PAP to be effective?

What criteria do you use to judge effectiveness?

14) What problems are there with the operation of PAP?

15) How do you consider they could be remedied?

16) Once the target price is determined, the Chief Executive must consider the product surround and make policy adjustments - does this relatively subjective element not negate the apparent objectivity of PAP? If not, how does it operate?

17) Are you aware of any other companies using PAP. If not, why do you think that other firms have been so reluctant to use it?

18) PAP has been suggested as a means of:

a) Assessing factory performance

b) Valuing stock.

What is your opinion of its suitability for these purposes?

19) Has Glacier Metal ever used PAP for measurement of output, or for valuation of stock? Was it successful?

APPENDIX D.

INSTRUCTIONS CONCERNING THE OPERATION OF THE QUARTER PLATEN COSTING SYSTEM SENT TO THE ACCOUNTS DEPARTMENT, OCTOBER 1976

DUNLOP G.R.G. DIVISION

To Mr. H. Mather, Cost Analyst, Skelmersdale.
From E. McGrath, IHD Student, Skelmersdale.
Ref EM/ES
Date 26.10.76 Ext 240

Re: Quarter Platen Costing of Lockheed Small Order Section Compression Parts, 1977

Enclosed is a list of parts with the number of cavities which will be fitted on a quarter platen (N). To obtain the moulding standard minute values per 100 parts use the formula:-

$$SMV/100 = \frac{82.3}{N} \text{ sm's}$$

e.g. If 3 cavities are available (i.e. N = 3)

$$SMV/100 = \frac{82.3}{3} = 27.4 \text{ sm's}/100$$

The system assumes a standard minute value of 0.823 Sm/1/4 platen and is valid for all Lockheed Small Order compression work. It is not to be used for Lockheed work which is undertaken in the laboratory.

The list should cover all the necessary parts for the 1977 standards. If parts have been ommitted, or more information is required, contact me on the above extension.

E.J. McGrath.

c.c. Messrs. C.J. Shaw
D. Harper
B. Jones
P. Gwilliam
T. Quinn

D3 LOCKHEED COMPRESSION SEALS 1977

Part No.	Cavities Available	Nest Size	Potential 1/4 Platen Loading	(Actual 1/4 Platen Loading)
121	3	28	7	3
544	2	30	7	2
678	1	28	7	1
750	6	28	7	6
928	1	20	5	1
8617	9	28	7	7
8831	1	28	7	1
8832	4	30	7	4
9503	3	28	7	3
9511	1	28	7	1
9576	5	30	7	5
9964	3	30	7	3
10220	10	20	5	5
12822	3	28	7	3
J.19176	9	6	1	1
19746	3	28	7	3
21096	10	28	7	7
24952	2	30	7	2
24954	3	30	7	3
25002	5	28	7	5
25003	11	28	7	7
25005	5	28	7	5
25010	4	28	7	4
25014	23	28	7	7
25387	8	28	7	7
25514	H			
25587	-			
25736	2	6	1	1
25825	5	28	7	5
27067	-			
27434	2	28	7	2

LOCKHEED COMPRESSION SEALS 1977

Part No.	Cavities Available	Nest Size	Potential 1/4 Platen Loading	(Actual 1/4 Platen Loading)
27518	8	30	7	7
27522	25	28	7	7
27525	4	28	7	4
27552	5	30	7	5
27675	5	18	4	4
27818	3	18	4	3
28112	4	28	7	4
29779	5	28	7	5
30832	3	28	7	3
31250	7	30	7	7
32168	1	20	5	1
32548	2	20	5	2
34640	3	30	7	3
34889	1	28	7	1
35597	1	28	7	1
36059	2	28	7	2
37121	2	28	7	2
37122	2	18	4	2
38539	2	30	7	2
38545	5	28	7	5
39509	6	28	7	6
80168	2	28	7	2
81250	1	28	7	1
81776	3	30	7	3
81778	13	30	7	7
81783	1	20	5	1
82536	2	28	7	2
83397	1	28	7	1
85347	3	28	7	3
85617	4	28	7	4
85946	10	30	7	7

Part No.	Cavities Available	Nest Size	Potential 1/4 Platen Loading	(Actual 1/4 Platen Loading)
87227	2	28	7	2
88906	5	30	7	5
91355	2	30	7	2
92113	3	30	7	3
92130	7	30	7	7
92328	6	30	7	6
94713	13	30	7	7
97855	5	30	7	5
102964	2	18/20	5	2
106213	10	2	1	1
107149	23	28	7	7
109831	4	30	7	4
109833	5	30	7	5
109882	22	30	7	7
3812-722	1	30	7	1
3842-622	10	30	7	7
3842-714	3	18	4	3
3848-803	2	18	4	2
3854-751	3	28	7	3
3857-709	3	18	7	3
3862-423	7	30	7	7
3862-435	5	28	7	5
3871-464	3	28	7	3
3871-474	5	28	7	5
3871-722	3	28	7	3
3871-723	3	28	7	3
3872-418	7	28	7	7
3872-424	3	28	7	3
3872-713	3	28	7	3
3872-715	8	8	1	1
3873-415	10	28	7	7

Part No.	Cavities Available	Nest Size	Potential 1/4 Platen Loading	(Actual 1/4 Platen Loading)
3873-714	3	28	7	3
3874-411	2	30	7	2
3875-422	3	18/20	5	3
3875-716	3	18	4	3
3875-719	8	28	7	7
3875-722	1	28	7	1
3876-413	5	18/20	5	5
3877-715	7	10	2	2

 LOCKHEED COMPRESSION BOOTS

Part No.	Cavities Available	Nest Size	Potential 1/4 Platen Loading	(Actual 1/4 Platen Loading)
132	1	20	5	1
542	1	30	7	1
1668	6	20	5	5
2759	8	30	7	7
J.3609	21	30	7	7
5107	13	28	7	7
5632	11	28	7	7
J.6907	4	18/20	5	4
J.7485	1	18/20	5	1
J.7870	5	18/20	5	5
J.7998	5	20	5	5
J.8039	6	20	5	5
J.8043	4	20	5	4
J.8532	8	6	1	1
H.9209	2	30	7	2
J.9562	6	10	2	2
11751	4	20	5	4
J11929	10	20	5	5
12493	2	14	3	2
H.16042	1	18	3	1
J.19174	2	28	7	2
J.19175	2	28	7	2
24959	4	10	2	2
24960	1	18	4	1
24961	2	18	4	2
24962	1	30	7	1
24968	2	20	5	2
24970	2	18	4	2
24971	2	30	7	2
24972	3	20	5	3
24975	2	20	5	2

Part No.	Cavities Available	Nest Size	Potential 1/4 Platen Loading	(Actual 1/4 Platen Loading)
24978	4	28	7	4
29578	17	20	5	5
31010	3	18	4	3
31176	7	30	7	7
31773	4	30	7	4
33087	5	20	5	5
33348	14	20	5	5
33350	10	20	5	5
34639	1	28	7	1
34859	6	28	7	6
37468	3	28	7	3
38182	9	28	7	7
39508	4	30	7	4
83173	5	20	5	5
87439	17	30	7	7
89576	3	28	7	3
106646	28	10	2	2
3811-719	3	28	7	3
3811-720	5	18	4	4
3812-717	6	18	4	4
3812-720	6	6	2	2
3812-743	3	30	7	3
3817-725	18	18	4	4
3817-737	36	18		4

EJM/ES 4.11.76

APPENDIX E

OPERATIONS AND TIMES FOR SMALL ORDER PARTS

PROCESS SUMMARY SMALL ORDER SECTION

SEALS

							STANDARD MINS/100 PARTS												
PART No.	A.P. PART No.	CAVITIES	COMPOUND	BLANK WT	MOULDING SM	BARWELL SM	WHEELABRATE	WASH	SORT	ROUGH TRIM	LATHE	PUNCH	CLICK	STONE	B.U. TRIM	GRIND	DRILL	OIL TEST	INSPECT
1	25825	1	1702	3.7	82.3	0.73				8.0	16.0								6.1
2	3812-722	1	1775	7.3	82.3	0.73				10.0	9.0					16.0		1.0	7.4
3	8831	1	1701	3.3	82.3	0.73					16.0		12.0						11.2
4	32168	1	1701	16.0	82.3	0.79				10.0	16.0								11.7
5	35597	1	1778C	3.7	82.3	0.73				10.0	8.0								10.0
6	3872-715	(2)	1701	3.3	41.2	0.73				12.0	16.0								11.5
7	544	2	1716	6.8	41.2	0.73				10.0	8.0								13.4
8	556	2	1701	13.4	41.2	0.79					10.0		2.04						7.0
9	24952	2	1701	6.3	41.2	0.73				10.0	9.0								7.0
10	37121	2	1778	2.5	41.2	0.71				10.0	8.0								6.1
11	37122	2	1778	12.5	41.2	0.76				10.0	10.0								7.0

SEALS

PART No.	A.P. PART No.	CAVI-TIES	COMP OUND	BLANK WT	MOULD ING SM	BAR-WELL SM	STANDARD MINS/100 PARTS WHEEL-ABRATE	WASH	SORT	ROUGH TRIM	LATHE	PUNCH	CLICK	STONE	B.U. TRIM	GRIND	DRILL	OIL TEST	INSPECT
12	102964	2	1778C	9.3	41.2	0.76				12.0	8.0							1.0	7.0
13	3848-803	2	1701	15.8	41.2	0.79				12.0	8.0								7.0
14	3874-411	2	1701	6.2	41.2	0.73				10.0	5.0								11.5
15	3857-709	3	1779	1.3	27.4	0.71				10.0	8.0							1.0	6.3
16	3872-713	3	1701	3.2	27.4	0.73				10.0	18.8								11.5
17	3875-716	3	1778	5.8	27.4	0.73				12.0	17.86							1.0	11.5
18	3871-722	3	1771	1.3	27.4	0.71				8.0	16.0								6.1
19	3871-723	3	1778	1.3	27.4	0.71				8.0	16.0								8.8
20	9503	3	1701	5.5	27.4	0.73				15.0	9.8								10.1
21	9964	3	1701	1.8	27.4	0.71				12.0	6.9								6.6
22	12822	3	1701	6.1	27.4	0.73				12.0	8.4								7.0
23	19746	3	1778C	4.7	27.4	0.73				12.0	7.0							1.0	7.0
24	27818	3	1701	5.1	27.4	0.73				14.0	9.0						16.3	1.0	11.5

SEALS

PART No.	A.P. PART No.	CAVITIES	COMPOUND	BLANK WT	MOULDING SM	BARWELL SM	WHEELABRATE	STANDARD MINS/100 PARTS WASH	SORT	ROUGH TRIM	LATHE	PUNCH	CLICK	STONE	B.U. TRIM	GRIND	DRILL	OIL TEST	INSPECT
25	30832	3	1701	5.5	27.4	0.73				10.0	4.6								5.1
26	81776	3	1701	9.9	27.4	0.76				12.0	5.2								10.2
27	85347	3	1778C	5.3	27.4	0.73				14.0	18.0								11.7
28	3872-424	3	1701	2.2	27.4	0.71				8.0	6.0								6.3
29	109831	3	1701	3.2	20.6	0.73				10.0	8.0								6.1
30	8832	3	1701	3.9	20.6	0.73				12.0	14.3								8.8
31	27525	3	1701	3.3	20.6	0.73				10.0	8.0								7.0
32	28112	3	1701	2.3	20.6	0.71				10.0	8.0								6.3
33	31773	3	1784	5.2	20.6	0.73				12.0	18.0								7.1
34	97855	5	1701	3.9	16.5	0.73				8.0	6.0								9.0
35	109733	5	1701	2.7	16.5	0.73				10.0	8.0	14.0							7.0
36	25002	5	1702	5.7	16.5	0.73				10.0	18.0								11.7
37	29779	5	1779	9.8	16.5	0.76				10.0	16.0								10.1

SEALS

PART No.	A.P. PART No.	CAVI-TIES	COMP OUND	BLANK WT	MOULD ING SM	BAR-WELL SM	WHEEL-ABRATE	STANDARD MINS/100 PARTS WASH	SORT	ROUGH TRIM	LATHE	PUNCH	CLICK	STONE	B.U. TRIM	GRIND	DRILL	OIL TEST	INSPECT
38	92328	6	1701	1.7	13.7	0.71				10.0	8.0	14.0							7.0
39	750	6	1701	10.5	13.7	0.76				10.0	8.0								13.4
40	9230	7	1778	1.8	11.8	0.71				10.0	8.0	18.0							6.6
41	3862-423	7	1701	1.3	11.8	0.71				10.0	9.0	10.0							10.0
42	31250	7	1701	1.8	11.8	0.71				12.0	6.9								6.1
43	85946	10	1778	2.8	11.8	0.73					16.0		5.0						8.8
44	109782	22	1701	3.2	11.8	0.73				10.0	16.0								10.0
45	10220	9	1701	5.1	11.8	0.73				12.0	14.3								10.1
46	25003	11	1702	4.7	11.8	0.73				10.0	16.0								11.7
47	25387	8	1701	3.8	11.8	0.73				12.0	6.1								6.4
48	27522	25	1701	4.4	11.8	0.73				10.0	9.0								7.0

BOOTS

PART No.	A.P. PART No.	CAVITIES	COMPOUND	BLANK WT	MOULDING SM	BARWELL SM	WHEELABRATE	WASH	SORT	ROUGH TRIM	LATHE	PUNCH	CLICK	STONE	B.U. TRIM	GRIND	DRILL	OIL TEST	INSPECT
								STANDARD MINS/100 PARTS											
49	H16042	1	1784	7.2	82.3	0.73		1.0						15.0					5.8
50	105671	2	1778	5.8	41.2	0.73	2.0	1.0	12.0										7.4
51	H9209	2	1784	10.7	41.2	0.76	2.0	1.1							15.0				7.4
52	J19175	2	1784	7.2	41.2	0.73				15.0					18.0				7.4
53	24961	2	1784	16.7	41.2	0.79													5.8
54	24971	2	1784	5.7	41.2	0.73													7.4
55	32548	2	1710	7.3	41.2	0.73	1.0				10.0								10.0
56	3812-743	3	1784	2x8.3	27.4	1.52	1.8	1.1											10.2
57	24959	4	1784	4.8	20.6	0.73				15.0									5.8
58	J7870	5	1784	7.7	16.5	0.76		1.1							13.0		15.0		7.4

BOOTS

PART No.	A.P. PART No.	CAVI-TIES	COMP OUND	BLANK WT	MOULD ING SM	BAR-WELL SM	STANDARD MINS/100 PARTS WHEEL-ABRATE	WASH	SORT	ROUGH TRIM	LATHE	PUNCH	CLICK	STONE	B.U. TRIM	GRIND	DRILL	OIL TEST	INSPECT
59	J7998	5	1784	3.3	16.5	0.73		1.1					15.0		13.0				7.4
60	83173	5	1784	5.4	16.5	0.73	1.8	0.8											5.8
61	3811-720	5	1788	7.2	16.5	0.73	2.0	1.5	12.0										7.4
62	1668	6	1784	14.3	13.7	0.79	1.8	0.7											7.4
63	34759	6	1784	1x8.8 1x2.7	13.7	1.49	1.8	0.7											5.8
64	33350	7	1784	6.3	11.8	0.73	1.0	1.0	12.0										10.0
65	2759	8	1784	6.2	11.8	0.73	1.8	0.8						15.0					7.4
66	5107	13	1784	9.8	11.8	0.76	2.3	1.1	12.0										7.4
67	5632	11	1784	11.0	11.8	0.76	2.0	1.0											7.4
68	29578	17	1784	17.3	11.8	0.79	1.8	1.0	12.0										7.4

BOOTS

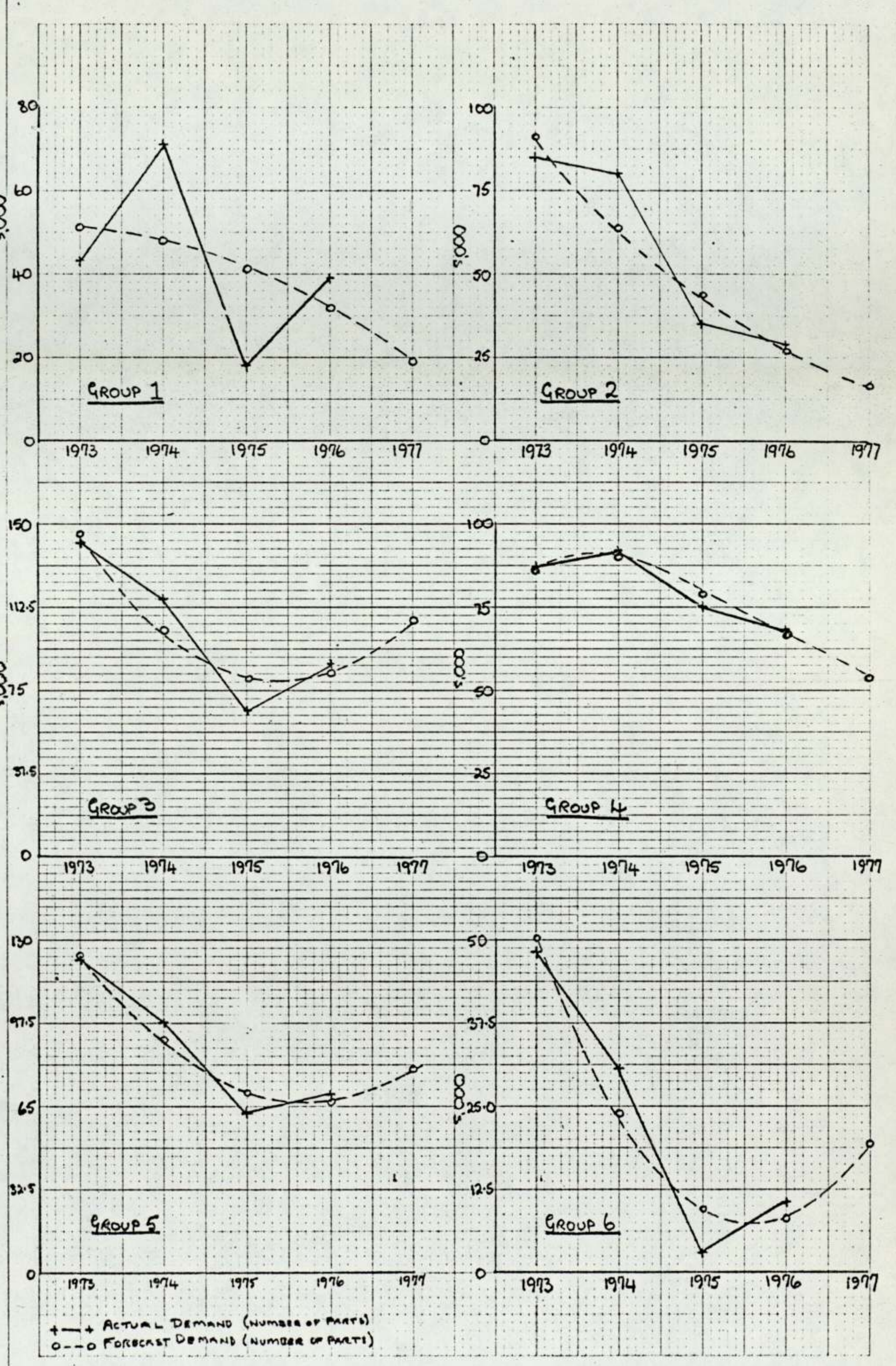
PART No.	A.P. PART No.	CAVI-TIES	COMP OUND	BLANK WT	MOULD ING SM	BAR-WELL SM	WHEEL-ABRATE	WASH	SORT	ROUGH TRIM	LATHE	PUNCH	CLICK	STONE	B.U. TRIM	GRIND	DRILL	OIL TEST	INSPECT
								STANDARD MINS/100 PARTS											
69	33348	14	1784	6.3	11.8	0.73				15.0	8.0								11.4
70	81778	13	1701	0.7	11.8	0.71	1.2	0.9		10.0									10.0

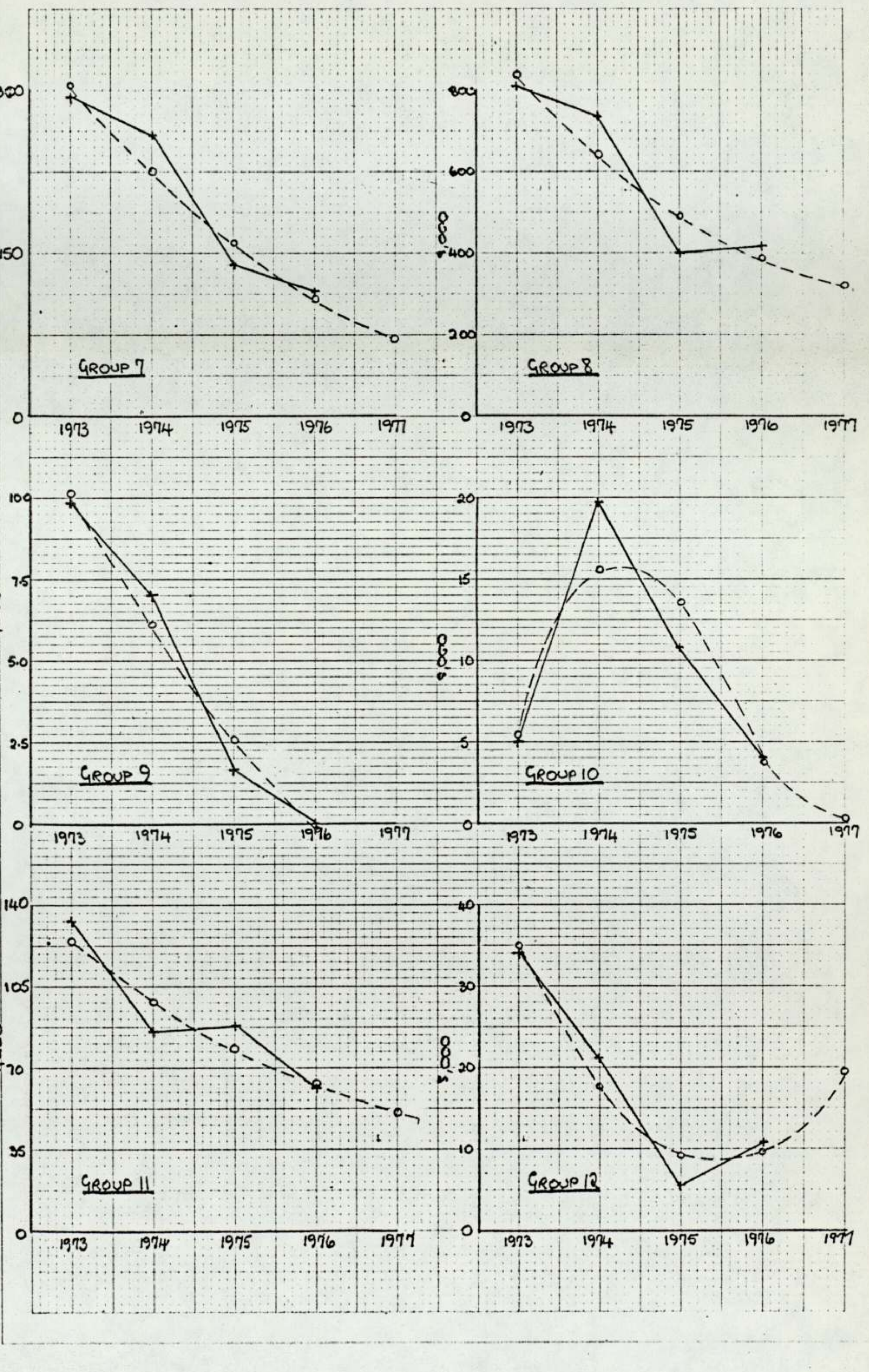
APPENDIX F

GRAPHICAL REPRESENTATION OF THE COMPUTER FORECASTS

FOR PRODUCT GROUPS 1 - 45

PRODUCT GROUP FORECASTS FOR SMALL ORDERS

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GROUP 9
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2.5
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1974
1975
1976
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GROUP 10
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20
15
10
5
0
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1974
1975
1976
1977
GROUP 11
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140
105
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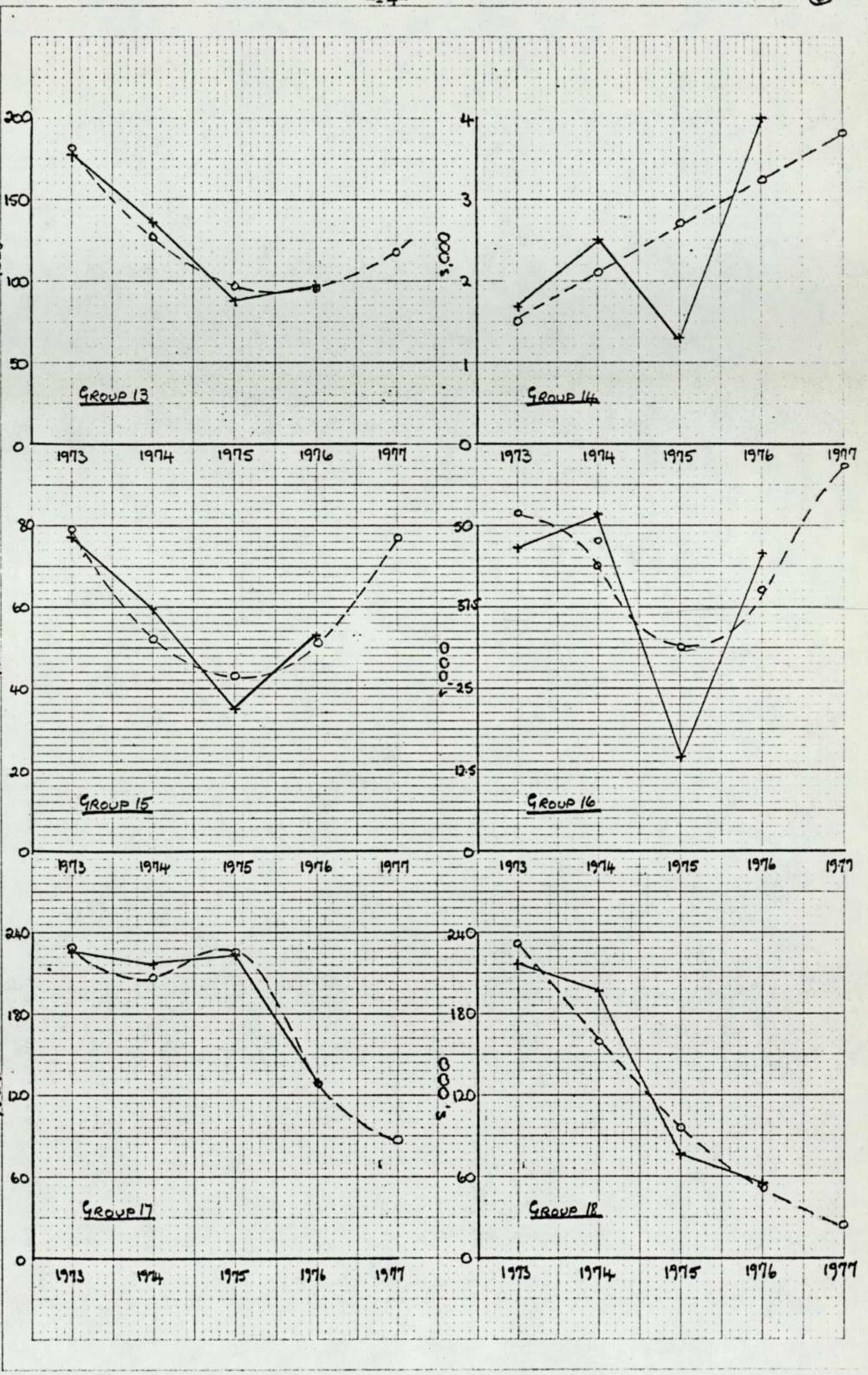

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GROUP 16
GROUP 17
GROUP 18
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1974
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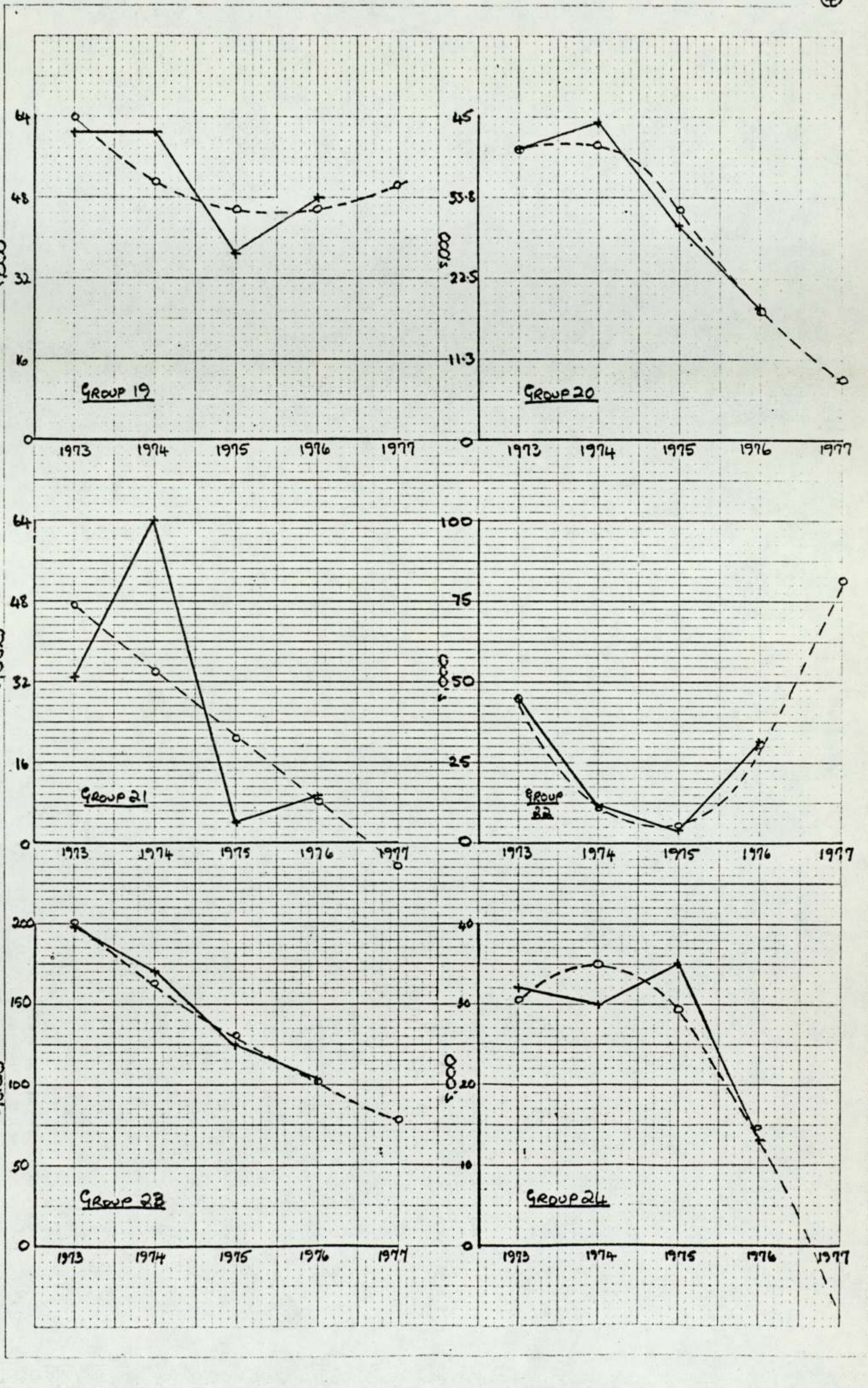
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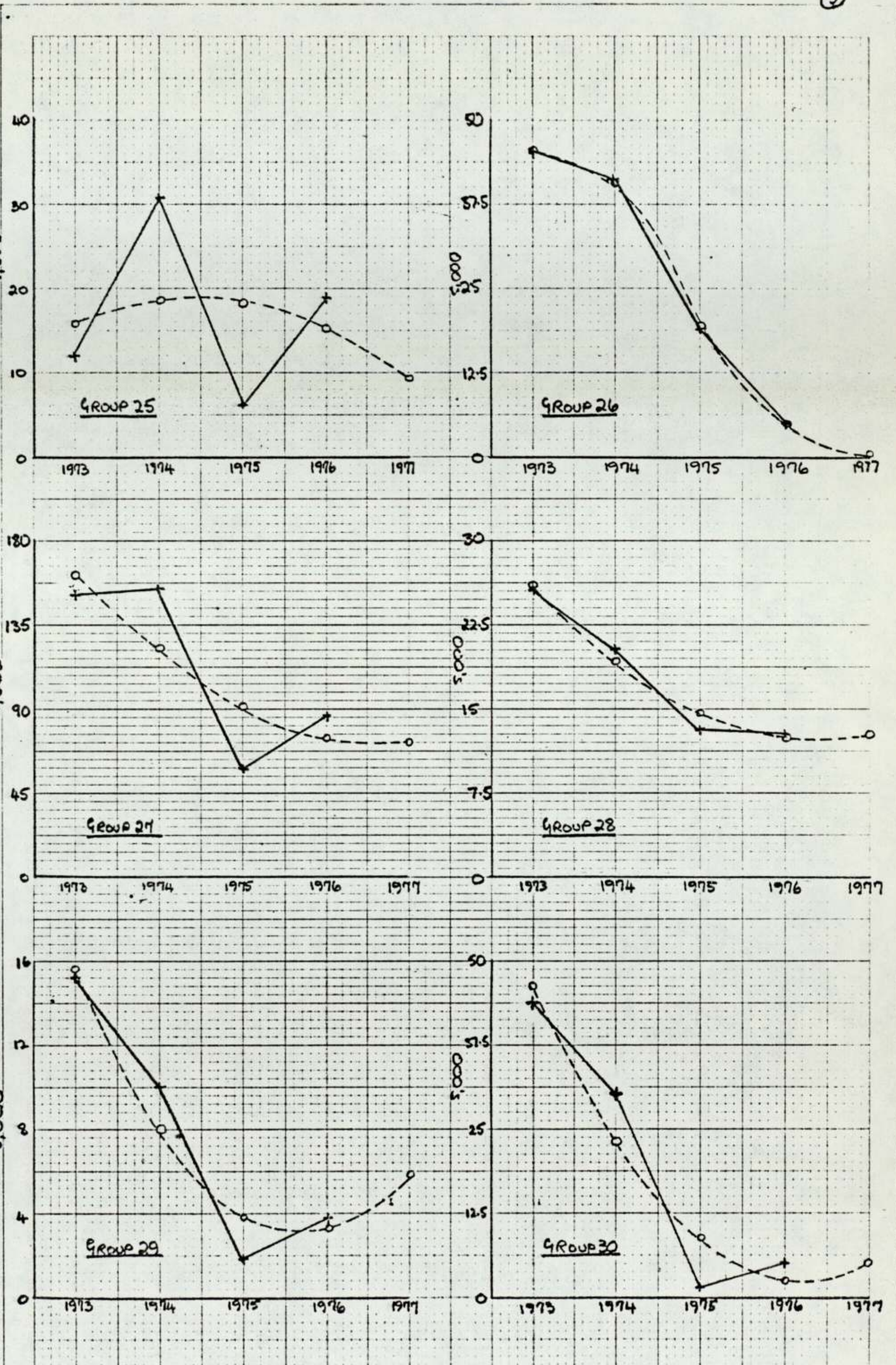
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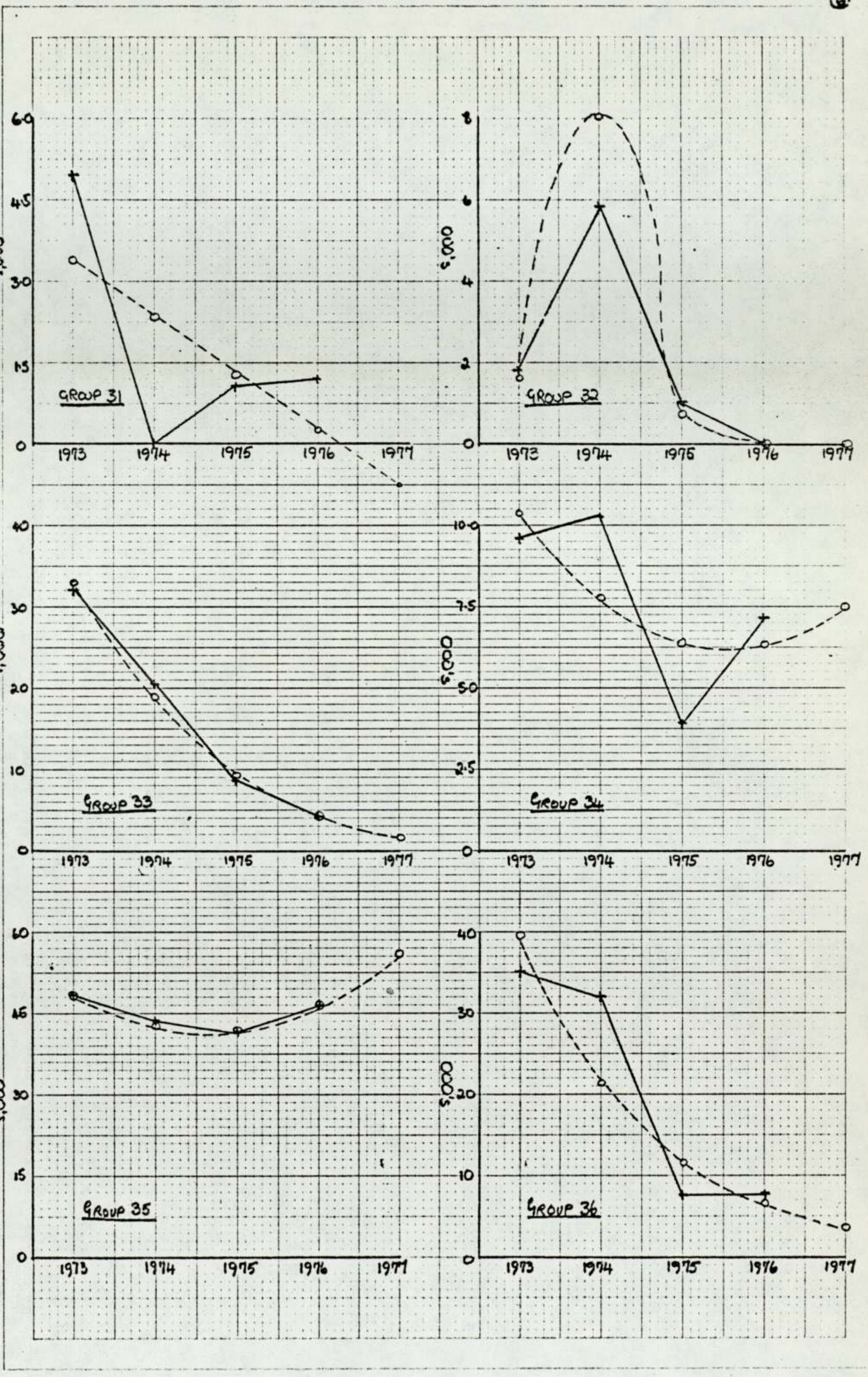

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2
0
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1973
1974
1975
1976
1977
GROUP 33
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30
20
10
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1973
1974
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5.0
2.5
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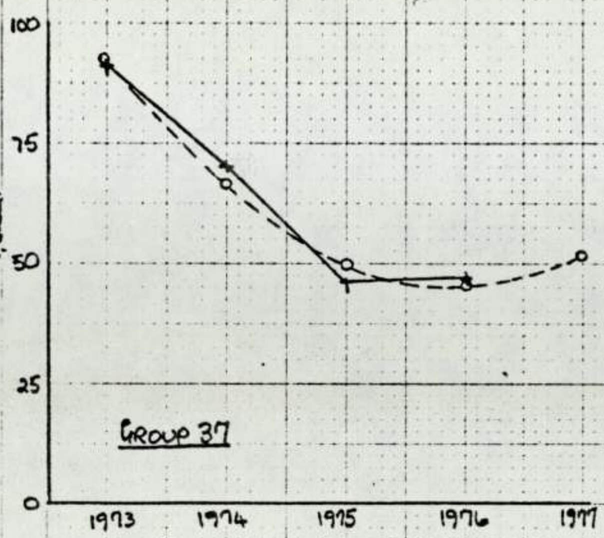
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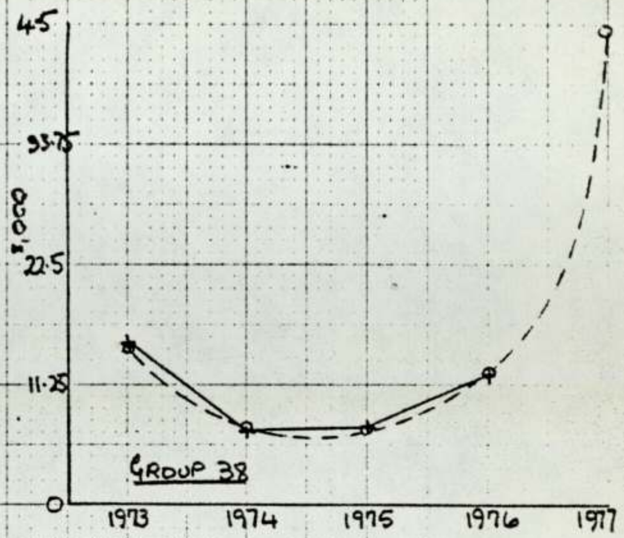
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1975
1976
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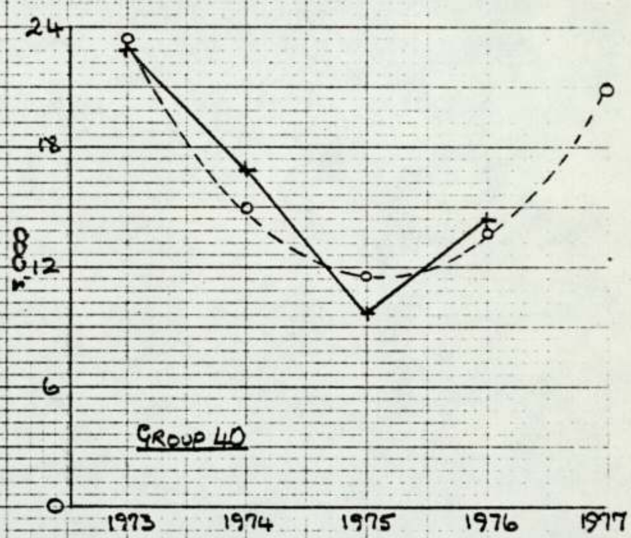
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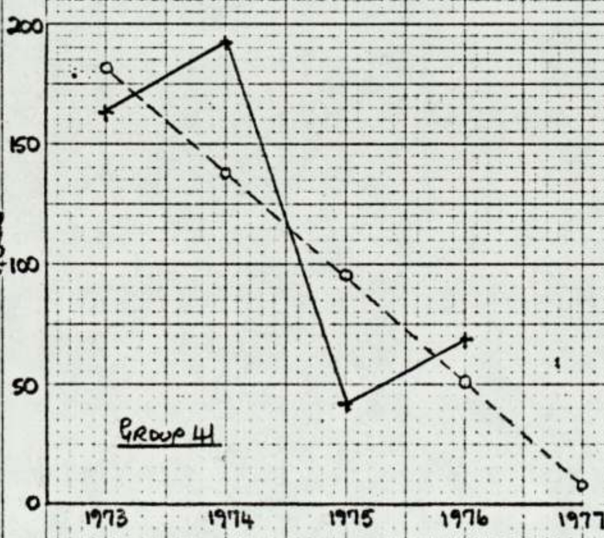
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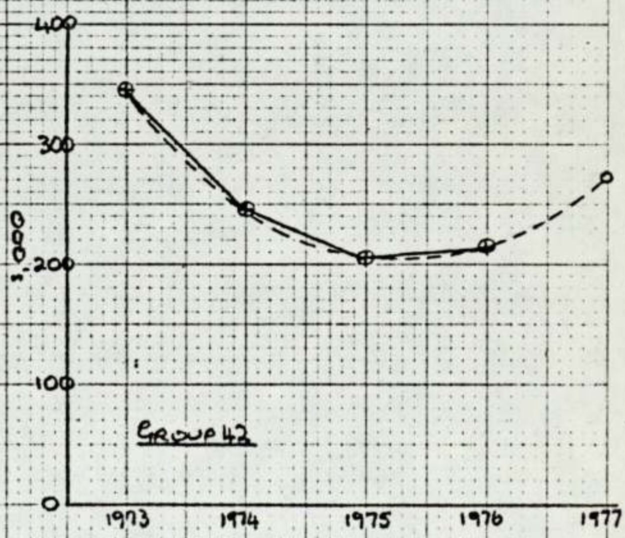
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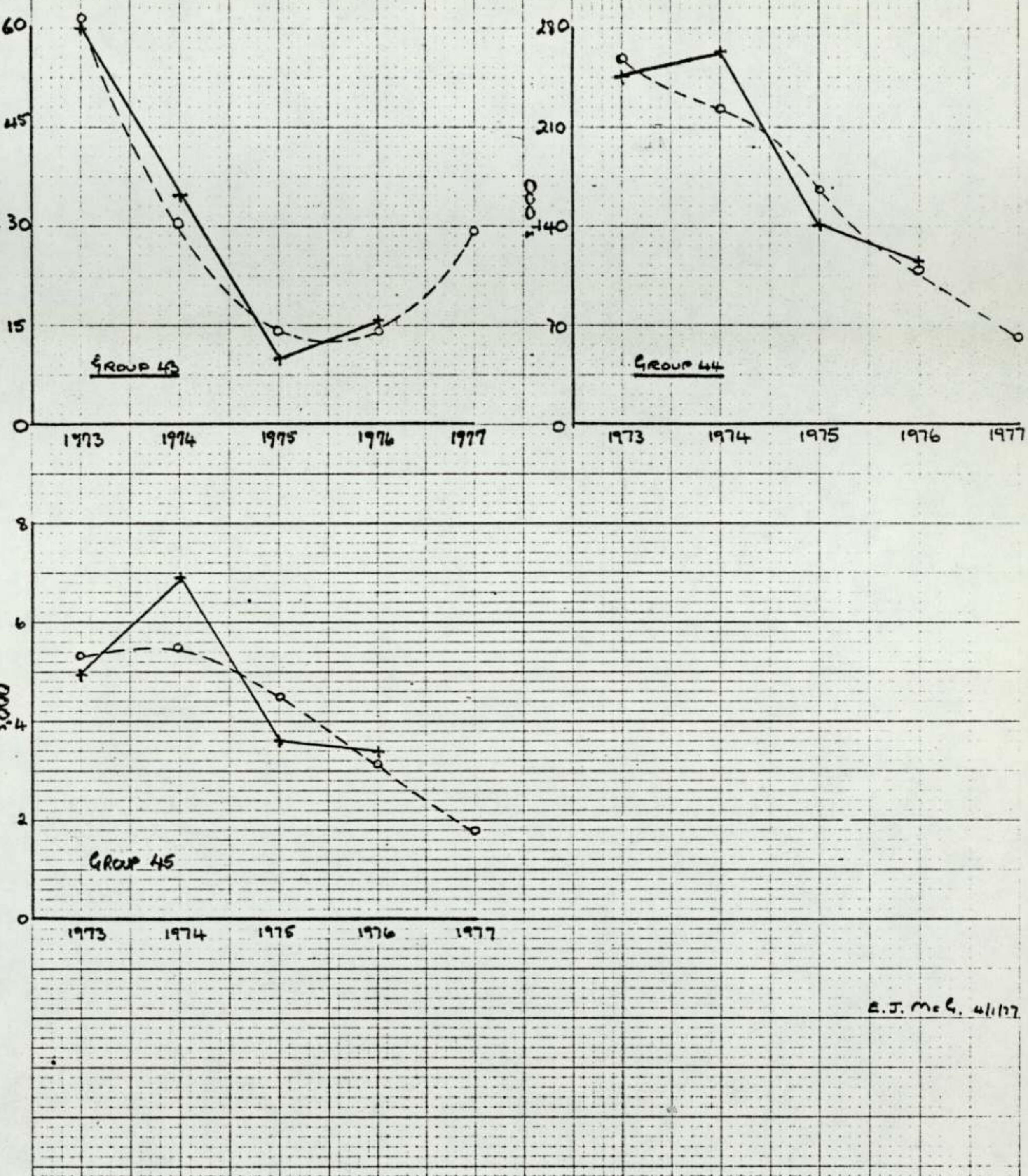
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,000
Group 44
1973
1974
1975
1976
1977
8
6
4
2
0
,000
Group 45
1973
1974
1975
1976
1977

E.J. McG. 4/1/77

APPENDIX G

DERIVATION OF DIRECT LABOUR COSTS

G.1

OPERATION	LABOUR GRADE	BASIC HOURLY COST (£) (INCL. SHIFT ALLOWANCE)	TOTAL HOURLY COST (INCL. FRINGE COSTS AND REJECTS)(£)	FORECAST ANNUAL REQ'MENT (STD HRS)	BUDGETED ANNUAL COST (£)
Moulding	U	1.698	2.653	1438	3814.98
Barwell	X W	1.869 1.762	2.920 2.753	39 39	114.33 107.78
Wheelabration	W	1.577	2.464	17	41.10
Washing	T	1.481	2.314	23	53.38
Sort	T	1.481	2.314	153	354.75
Rough Trim	T	1.481	2.314	374	865.81
Lathe	T	1.481	2.314	272	629.24
Punch	T	1.481	2.314	21	49.68
Click	T	1.481	2.314	133	308.12
Stone/Drill	T	1.481	2.314	9	21.68
B.U. Trim	T	1.481	2.314	166	385.22
Grind	T	1.481	2.314	8	18.51
Oil Test	T	1.481	2.314	4	8.10
Inspection	T	1.481	2.314	492	1138.10

APPENDIX H

DERIVATION OF INDIRECT WAGES TO DIRECT OPERATIVES

H.1

Standard downtime figures are expressed as a percentage of Total operated time. The number of hours downtime is therefore given by the formula:

$$\text{Standard Downtime (hrs)} = \frac{\text{Standard Requirement (hrs)}}{(1 - \text{Standard Downtime \%})}$$

OPERATION	STANDARD LABOUR REQ'MENT (INCL REJECTS) (HRS)	LABOUR COST/HR (INCL FRINGE COSTS)(£)	STANDARD DOWNTIME ALLOWANCE	STANDARD HOURS DOWNTIME	LABOUR COST OF DOWNTIME (£)
Moulding	1796.98	2.123	20%	449.25	953.53
Barwell	48.94	4.539	10%	5.44	24.69
Wheelabration	20.85	1.971	20%	5.21	10.27
Washing	28.84	1.851	5%	1.52	2.81
Sort	191.63	1.851	1%	1.94	3.59
Rough Trim	467.69	1.851	1%	4.72	8.74
Lathe	339.90	1.851	2%	6.94	12.85
Punch	26.84	1.851	2%	0.55	1.02
Click	166.44	1.851	2%	3.40	6.29
Stone/Drill	11.71	1.851	2%	0.24	0.44
B.U. Trim	208.09	1.851	2%	4.26	7.89
Grind	10.00	1.851	2%	0.20	0.37
Oil Test	4.38	1.851	1%	0.04	0.07
Inspection	614.78	1.851	1%	6.21	11.50

APPENDIX I

DERIVATION OF INDIRECT LABOUR COSTS AND APPORTIONMENT RULES

I.1 SMALL ORDER SECTION

I.1.1 Variable Indirects

JOB TITLE	SECTION	NUMBER OF WORKERS	JOB DESCRIPTION	APPORTIONMENT RULES	BUDGETED ANNUAL COST (£)
Mould Cleaner	North Factory Moulding	3 (1 per shift)	Transports moulds to and from moulding section. Cleans and returns to moulding.	Desirable cleaning rate = 1/24 hrs Time required = 1.25 hrs @ £2.31/hr (toolmaker) + 1.18 @ £2.16/hr (mould cleaner) Cost of clean = £10.88/2m/c/24 hrs Forecast m/c requirement= 1796.8hrs Cost = $1796.8 \times \frac{10.88}{24}$ = £814.55	814.55
Setter	Hydramould Line (including Small Order Section)	3 (1 per shift)	Sets machine temperature and time controls; patrols line to monitor quality levels.	Number of machines patrolled = 16 Number of Small Order Section = 3 Apportion cost on number of machines within control = 3/16 Hourly cost = £2.46/hr Apportioned cost/hr = £0.46/hr Forecast m/c requirement= 1796.8hrs Cost = 1796.8 x 0.46 = £828.86	828.86

I.1.2 Fixed Indirects

JOB TITLE	SECTION	NUMBER OF WORKERS	JOB DESCRIPTION	APPORTIONMENT RULES	BUDGETED ANNUAL COST (£)
Mould Storeman	Mould Stores, North Factory Moulding	1	Keeps records of mould movements and usage; issues emergency works orders; responsible for mould movements; monitors mould condition.	Estimates that spends 25% of total time on Small Order Moulds. Annual Labour Cost = £3879 Apportioned annual cost = $\frac{3879}{4}$	969.76
Toolsetter	Tool Room, North Factory	1	Removes plate from press; transports to tool room and replaces moulds as appropriate; returns to press and bolts on ready for production.	Each mould normally changed once per week. Standard Mould Change Time=3.25hrs No. of changes/set-up/week=6.50hrs Labour cost = £2.31/hr Annual Cost(46 wks/yr) = £691.44	691.44
Sweeper/ Serviceman	Moulding Department	8	Keeps production area tidy and clean. Brings blank tins to presses and removes moulded parts to Count, Sort and Check.	Apportion on floor area: Area of Small Order Section = 2805 ft^2 Whole Department = 71736 ft^2 Total Annual Cost = £31041.60 @ £1.79/hr Apportioned Cost = $31041.60 \times \frac{2805}{71736}$ = £1213.78	1213.78

I.2 VARIABLE INDIRECTS IN OTHER SECTIONS

JOB TITLE	SECTION	NUMBER OF WORKERS	JOB DESCRIPTION	APPORTIONMENT RULES	BUDGETED ANNUAL COST (£)
Part Finished Storekeeper	Count, Sort & Check	3	Count or Check Weigh parts and compare output with operator job sheets. Sorts out mixed parts.	Apportion on basis of forecasted small order volume through section compared with total volume of work through the section. S.O. parts through section= 453,423 (incl. rejects) Total throughput = 41,220,272 (incl. rejects) Apportionment factor = 1.1% Total cost @ £2.13/hr = £11884.62 Apportioned Cost = £130.73	130.73
Knife Sharpener	Finishing Section	1	Sharpens and for lathes; dresses grinding wheels for finishing area.	Apportion on number of parts i.e. 1.1% Total Annual Cost = £3950.96 @ £2.13/hr. Apportioned cost = £43.46	43.46
Packer	Despatch	2	Fill cartons with good parts and completes relevant documents.	Apportion on volume throughput basis i.e. 1.1% Total Annual Cost = £6904.52 @ £1.86/hr. Apportioned Cost = £75.95	75.95

I.2 VARIABLE INDIRECTS IN OTHER SECTIONS (CONTINUED)

JOB TITLE	SECTION	NUMBER OF WORKERS	JOB DESCRIPTION	APPORTIONMENT RULES	BUDGETED ANNUAL COST (£)
Check Weigher	Inspection	4	Check weighs inspection work; distributes work to inspectors; collect inspection work and verify inspection figures.	4 check weighers to 37 inspectors Recover as a percentage of Inspection Cost. Total Cost of 37 inspectors = £127992.59 Total Cost of 4 check weighers = £14147.73 % Cost of Check Weighers = 11% Apportioned Cost = £126.45	126.45
Vendor Checker	Inspection	8	Checks reject figures of inspectors to maintain quality levels (checks on sample basis). Passes accepted batches to dispatch.	8 vendor checkers to 37 inspectors. Recover as proportion of Inspection cost. Cost of inspectors = £127992.59 Cost of 8 vendor checkers = £28905.34 @ £1.95 % Cost of Vendor Checkers = 23% Apportioned Cost = £264.39	264.39

APPENDIX J

VARIABLE OVERHEAD COSTS

J.1 ELECTRICITY

Weighted Average Unit Cost = £0.0178/kw-hr.

OPERATION	FORECASTED ANNUAL REQUIREMENT (STD HRS)	POWER CONSUMPTION (KW)	BUDGETED ANNUAL COST (£)
Moulding	1796.98	16.5	527.77
Barwell	48.94	5.0	4.36
Wheelabration	20.85	9.64	3.58
Washing	28.84	5.75	2.95
Hand Lathe	339.90	2.63	15.91
Power Press	193.28	4.38	15.07
B.U. Trim	208.09	0.44	1.66
Drill	11.71	0.44	0.09
Grind	10.00	0.44	0.08

J.2 WATER

Washing machines only:

Consumption = 100 gallons/hr.

Cost of Water = £0.52/1000 gallon.

Forecasted Annual Requirement = 28.84 Std Hrs.

Budgeted Annual Cost = £1.50.

J.3 COMPRESSED AIR

Moulding Presses only:

(i) Conversion

1. 100 cu ft of compressed air required 14 horsepower to generate.
2. Rate of flow from mozzle aperature @ 80 p.s.i. = 20 cu ft/min.
3. Approximate duration of air blast = 3 sec(1 per charge)
4. Volume of air per charge = $\frac{3}{60}$ x 20 = 1 cu ft.
5. Power to generate one blast = 0.14 hp.
6. 1 hp = 0.746 kw.
7. Power usage/charge = 0.14 x 0.746 kw = 0.1044 kw/charge.

(ii) Cost Estimation

1. Standard Minutes/charge = 3.29 sm.
2. Standard charges/hr = 18.24 from 2 machine set-up.
3. Power used/hr = 18.24 x 0.1044 = 1.904 kw.
4. Average cost of electricity = £0.0178/kw-hr.
5. Cost of operation per hour = 1.904 x 0.0178 = £0.0339/hr.
6. Forecasted annual requirement = 1796.8 std hrs.
7. Budgeted Annual Cost = 1796.8 x 0.0339 = £60.91.

J.4 NITROGEN

Wheelabrator only:

1. Parts through W/brator in three month period = 3,004,428 (from analysis of operator work sheets).
2. Average standard minute value of batch = 0.7 sm/100 (Industrial Engineering Department estimate).

3. Standard hourly output of Wheelabrator in period =

$$\frac{3,004,428 \times 0.7}{60 \times 100} = 350.52 \text{ std hr.}$$

4. Nitrogen delivered in period = 38265 m^3

(From invoices in period)

5. Cost of Nitrogen = £5.042/100 m^3

(Accounts Dept. Records)

6. Average cost of Nitrogen per standard hour = $\frac{38265 \times 0.0542}{350.52}$

= £5.92/std hr.

7. Forecasted Annual Requirement = 20.85 std hrs.

8. Budgeted Annual Nitrogen Cost = £123.37.

J.5 MAINTENANCE

1. Cost of Maintenance Labour (including fringe costs) = £2.28/hr.

(Accounts Department Records)

2. Cost of Maintenance Material:

From Works Engineer's estimate: £0.75 spent on material for every £1 labour cost incurred.

3. Hourly Maintenance Cost = 2.28 x 1.75 = £3.03/hr.

OPERATION	TOTAL TIME REQUIREMENT (INCL DOWN-TIME AND REJECTS) (HRS)	STANDARD DOWNTIME ALLOWANCE (ON TOTAL) (%)	STANDARD ENGINEERING ALLOWANCE (%)	BREAKDOWN ALLOWANCE (HRS)	BUDGETED MAINTENANCE COST (£)
Moulding	2246.2	20%	10.5%	235.9	714.78
Barwell	54.4	10%	6%	3.3	10.00
W/bration	26.1	20%	20%	5.21	15.79
Wash	30.4	5%	5%	1.52	4.61
Sort	193.6	1%	0%	-	-
Rough Trim	472.4	1%	0%	-	-

OPERATION	TOTAL TIME REQUIREMENT (INCL DOWN-TIME AND REJECTS) (HRS)	STANDARD DOWNTIME ALLOWANCE (ON TOTAL) (%)	STANDARD ENGINEERING ALLOWANCE (%)	BREAKDOWN ALLOWANCE (HRS)	BUDGETED MAINTENANCE COST (£)
Lathe	346.8	2%	1%	3.47	10.51
Punch	27.4	2%	1%	0.27	0.82
Click	169.8	2%	1%	1.70	5.15
Stone/ Drill	12.0	2%	1%	0.12	0.36
B.U.Trim	212.3	2%	1%	2.12	6.42
Grind	10.2	2%	1%	0.10	0.30
Oil Test	4.4	1%	0%	-	-
Inspection	620.9	1%	0%	-	-

J.6 <u>GENERAL STORES</u>

Period used for analysis: Wks 36 - 43 (inclusive), 1976.

SECTION	TOTAL WAGES PAID WKS 36-43 A (£)	GENERAL STORES EXPENDITURE WKS 36-43 B (£)	PERCENTAGE GENERAL STORES EXP. $C = \frac{B}{A} \times 100\%$ (£)	FORECASTED DIRECT WAGES COST 1977(EXCL. FRINGE COSTS)(£)D	BUDGETED GENERAL STORES EXPENDITURE E = D x C
Moulding	10160.80	883.28	9%	3814.81	343.33
Barwell	1367.04	264.00	19%	197.45	37.52
Finishing	5825.92	296.24	5%	2231.95	111.60
Inspect-ion	12754.40	52.88	0.4%	919.68	3.68

APPENDIX K

AN APPLICATION OF THE INTERACTIVE COST MODEL

The memorandum included in this appendix illustrates the use of the Interactive Cost Model to evaluate a proposal to change the method of loading the presses in the Small Order Section.

No detail was given of the operation of the Model in the memorandum as it was felt that this would have confused the target personnel who were not familiar with the model. The changes which were incorporated into the model to allow assessment to be made were as follows:

1. Productivity Allowance

It was estimated that a one second per blank allowance should be given to inspect the blanks prior to loading.

The standard floor-to-floor cycle would therefore be increased:

(i) Standard Cycle(with standard number of cavities) = 4.368+(18x0.1224)=6.57 SM
Average SMV/part = 0.1825

(ii) Actual Cycle(with actual number of cavities) = 4.368+(12x0.1224)=5.84 SM
Average SMV/part = 0.2432 SM

(iii) Actual Cycle(with allowance for blank inspection) = 4.368+(12x0.1411)=6.06 SM
Average SMV/part = 0.2526 SM

The adjusted value of ΔP (Machine Productivity Allowance)

$$= \frac{0.2526}{0.1825} = 0.38$$

2. Reject Allowance

It was estimated that the improved method of blank loading would reduce the actual reject level from the current 59% (on good production) to 20%, (in the nomenclature of the model, reducing ΔR from + 34% to - 5%). Allowing for the increased labour cost which would result in a lower output from the small order section it was calculated that an annual saving of £5661 would be made if the proposed reject level were attained.

In order to determine the effect of failure to achieve the targeted reduction in reject levels the expected reject level was varied from 10% (R = - 15%) to 70% (R = + 45%) and the savings calculated for each reject level. As the attached memorandum shows, the extra costs incurred in using the proposed blank loading system would be offset if the reject level were reduced from the current 59% to 56% (this was the 'breakeven' reject level). It was therefore recommended that the new method should be adopted, since the expected reduction in reject level (39%) was much greater than the breakdown reduction (3%).

DUNLOP G.R.G. DIVISION

To J.R. Bainbridge, Moulded Products Manager.
From E.J. McGrath, IHD Student.
Ref EJMcG/MMW.
Date 4th July, 1977. Ext 271.

SMALL ORDER BLANK LOADING

1. Objective

Mr. J. Durnan (Process Engineer) has suggested that by loading blanks into the cavities cut end down a considerable reduction in reject levels might be achieved. The T.G.W.U. will only use this method of loading if given a time allowance to do so. The purpose of this exercise is to estimate the potential savings which could be expected by loading in this manner and to determine what is the minimum level of reject reduction which is necessary to compensate for the extra labour and variable costs incurred.

2. Methodology

The estimated changes in cycle time and reject levels were fed into the Sensitivity Analysis Cost model which I have recently developed. The model was used to determine the effect of the changes on all variable costs from the Mill to final inspection.

3. Information Required

3.1. Moulding Cycle Time

Mr. D. Fearon (Industrial Engineer) estimates that inspection of each blank to determine which is the cut face will take approximately 1 second per blank. With the current average platen loading of 12 cavities/platen the cycle time will be increased by approximately 15%.

3.2. Reject Reduction

Mr. Durnan's investigations suggest that a potential reduction in reject levels from the current 59% to 11% overall might be achieved for Small Order Section parts. However, in view of the less than ideal production conditions it was felt that an overall reduction to 20% might be expected. In order to assess the sensitivity of the method change however a range of possible reject levels were used in the model (from 10% rejects to 70% rejects).

Continued ....

3.3. Estimated Annual Savings

In order to estimate the annual savings the 1977 budgets (based on a computer forecast of demand) were used. However percentage savings on expected actual variable cost were also calculated which should hold whatever the level of activity.

4. Results

The net savings on variable cost for different possible reject levels were as follows:-

Forecast budget 1977 = £24,760.

Reject Level (R') %	Estimated Net Annual Saving (£)	% Saving On Variable Cost (%)
10	7221	29
15	6441	26
20	5661	23
25	4881	20
30	4101	17
35	3321	13
40	2541	10
45	1761	7
50	981	4
55	201	1
59 (current)	- 423	- 2
70	-2139	- 9

Formula for Net Saving:

$$\text{Net Annual Saving} = 4881 - \frac{(R'' - R)}{(R' - R)}$$

R = Standard Reject Allowance = 25%.
R' = Current Actual Reject Level = 59%.
R'' = Potential Reject Level

'Breakeven' Reject Level:

$$4881 - \frac{(R'' - R)}{(R' - R)} = 0$$

$R'' = 56\%$.

Continued ....

5. Discussions

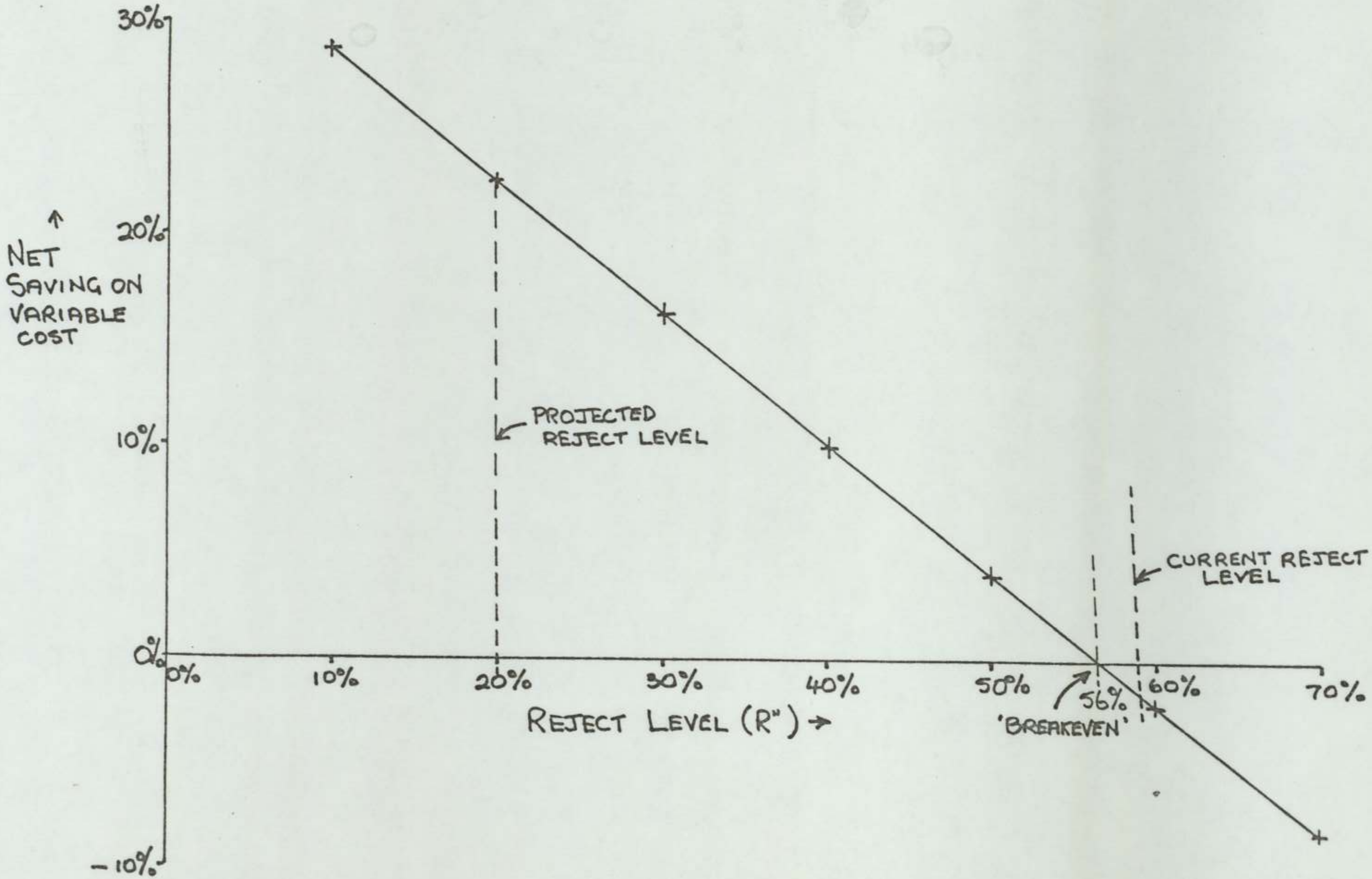
With the predicted reject level of 20% overall a potential saving on variable cost of £5,661 could be made per year by using the new loading method (assuming current levels of activity). However even if there is considerable error in the estimation a reduction in reject levels of only 3% would be required to cover the cost of the increased time allowance; a reduction well in excess of this figure is to be expected.

It would therefore appear to be very worthwhile to grant an extra time allowance in order to reduce reject levels from the Small Order Section.

E.J. McGRATH.

c.c Moulding Foremen.
M. Foy.
A. Stephenson.
C. Wassell.
R. Martland.
J. Durnan.

NET % SAVING VERSUS PROJECTED REJECT LEVEL



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