HANDLING COMPLEXITY IN A SMALL ENGINEERING BUSINESS

IN TWO VOLUMES.

VOLUME I.

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HANDLING COMPLEXITY IN A SMALL ENGINEERING BUSINESS

THESIS SUMMARY

The research consists of a field study investigation of the problems faced by a small unit production engineering division of a large corporation and centres around problems of manufacturing control and internal coordination. The sponsoring corporation ("The Union") limited the investigation to Plant and Equipment Division (P & E.D.), Coventry ; this handicapped somewhat the analysis of how changes in P & E.D. affected other parts of the Union.

The researcher was based in Production Planning Department but gained first-hand knowledge of machine shop production control, assembly shop kitmarshalling and pre-production coordination of efforts.

Following description of the Division and its operating enviroment, a theoretical model of the characteristics of each type of production (labour-intensive tooling and high-value special-purpose equipment) is proposed. It is believed that the latter has not been comprehensively analysed in this way by previous researchers. Likely problems of combining the two products are assessed and an appropriate structure is considered. Support is found for Woodward's theory that internal coordination is vital; interestingly the researcher's project deals with 'the unsuccessful case', which Woodward omitted. Control problems in jobbing manufacture noted by earlier researchers are corroborated.

Various attempts to deal with P & E.D. problems are outlined, culminating in the decision to simplify the Division's operations by closing the tooling side of the business. The results for the first twelve months after this closure are then examined.

The conclusions may be summarised thus:

1. Lack of information was crucial.
2. Better coordination achieved some success.
3. Privileged customers caused more problems than product differences.
4. Conventional measures of financial performance are unsuitable for service activities.
5. The Division is now dangerously dependent on the rubber technology industry.

Ultimately "The tool for handling complexity is organisation" (Beer,1). The Division's organisation contained insufficient control variety to handle its operations; the preferred response was to reduce the complexity of operations.

SMALL ENGINEERING BUSINESS: HANDLING COMPLEXITY

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INTRODUCTION.

The direction of this piece of research has altered considerably since the author was employed by the Central Personnel Department of the Dunlop Union, in London, to look at "forward planning" in a small division of Engineering Group, Coventry. All businesses have a dynamic, constantly changing environment and their success or failure often depends upon how rapidly and appropriately they react to this - given always that it is the ultimate wish of the firm to be the prime-mover, or instigator of change for positive reasons in line with their strategic objective.

The subject of the research, Plant & Equipment Division, could obviously not lie dormant until the results of my work on its problems were known. This was especially true since the aim of the study was immediately altered upon my secondment to the Production Planning (or Programming) Manager. No forward planning, he noted, was possible until the current financial and organizational situation of the Division had been considerably improved. In only one year since its birth in 1970 had the Division been able to declare a profit before interest and tax, yet that one year indicated that it was possible to justify its profit centre status. Management was ill-informed about shop floor activities, and communication within the producing units was almost entirely informal, supplemented only by hand-written lists.

My work was concerned with analysis of the existing situation for the purposes of coming to conclusions as to where the roots of Plant & Equipment Division's problems lay. Initially my attention was directed by management to the machine shop unit, where it was generally held that the major faults lay. The complaints centred around the uncontrollable nature of operations within the unit. My studies led me to the conclusion not only that this was to be expected, because of the degree of uncertainty connected with unit manufacturing, but also that the low efficiency of this unit partly resulted from deficiencies in the administrative, production support departments.

I spent some time discussing possible computer 'packages' for production scheduling in an attempt to bring the machine shop under closer management control. Inevitably with a divisional turnover of only £2½-3 million per year, the major constraint here was financial. I concluded that the real solution was to encourage closer monitoring of operators' activities by shop floor supervisors.

In the absence of previous research, I constructed a theoretical model showing the organizational characteristics and difficulties of a firm attempting to combine the two basic product types found within the Division - unit toolmaking and high-value unique-purpose machinery. In the light of this, the purely functional organizational structure chosen by the Division seemed ill-advised, but this and other problems identified were not as significant a cause of its operational difficulties as its position as service agent and 'captive' supplier of tooling for the rest of Engineering Group. By tradition, orders for these customers had achieved a privileged position in work queues on the machine shop floor.

The Division's General Manager decided a drastic course of action was necessary to overcome the deleterious effect which the 'uncontrollable' unit was having on the potentially profitable construction of special-purpose equipment in the assembly area. Closure of the machine shop unit, and dispersal to Group customers of the tooling facilities, was seen as the only way to overcome the disruptive effect of tooling orders from other members of the Dunlop Union on parts kits for equipment orders. This would also leave the Division free to choose whether it was more cost-effective to produce non-standard parts internally, or sub-contract manufacture to outside suppliers.

My research moved to two new areas associated with this decision. First, as I considered that there had been a more logical solution than dispersal of the tooling operation, namely the establishment of a separate tooling division, I examined the effects on other operating divisions within Engineering Group. This investigation was less than satisfactory in that direct financial comparisons could not be made, given year-to-year fluctuations in the tooling requirements of these divisions. If, however, one could take the favourable comments made at face value, it seemed that my own fears as to the effects on overall Group profitability were unfounded.

Second, I looked at the changes which the new position required of the Division itself, in terms of both new organizational requirements, and its long term prospects. I concluded that existing arrangements were likely to continue to work adequately as long as the Division remained basically underloaded, but that improvements were needed if it were to reach the true potential capacity of its existing workforce. At the same time, it was still dangerously dependent on the Union market, and particularly on machinery connected with tyre manufacture. Fairly immediate expansion of both markets and product range was needed if Plant & Equipment Division's long term future was to be assured.

ACKNOWLEDGEMENTS.

Whilst the work contained in the following pages, and the opinions expressed, are entirely my own, a great many people have assisted at various stages and I should like to express my appreciation: to Alastair Cochran, Raul Espejo, and Mike Pidd at Aston University; David Air, Mike Farebrother, David Nicklin and John Turner at Dunlop; my father for tireless reading and correction of successive proofs; Sally, Derek and Gwen for the typing; Ian and Guy for assistance with some of the diagrams. My debt to previous authors is individually referenced within the text.

CHAPTER 1

PLANT AND EQUIPMENT DIVISION - LOCATION AND DEVELOPMENT PRIOR TO THE START OF THE PROJECT IN NOVEMBER, 1974

The purpose of a more detailed description of the subject division at this stage is to explain the specific environment within which the organisational and systems models given in the next Chapter were called to operate.

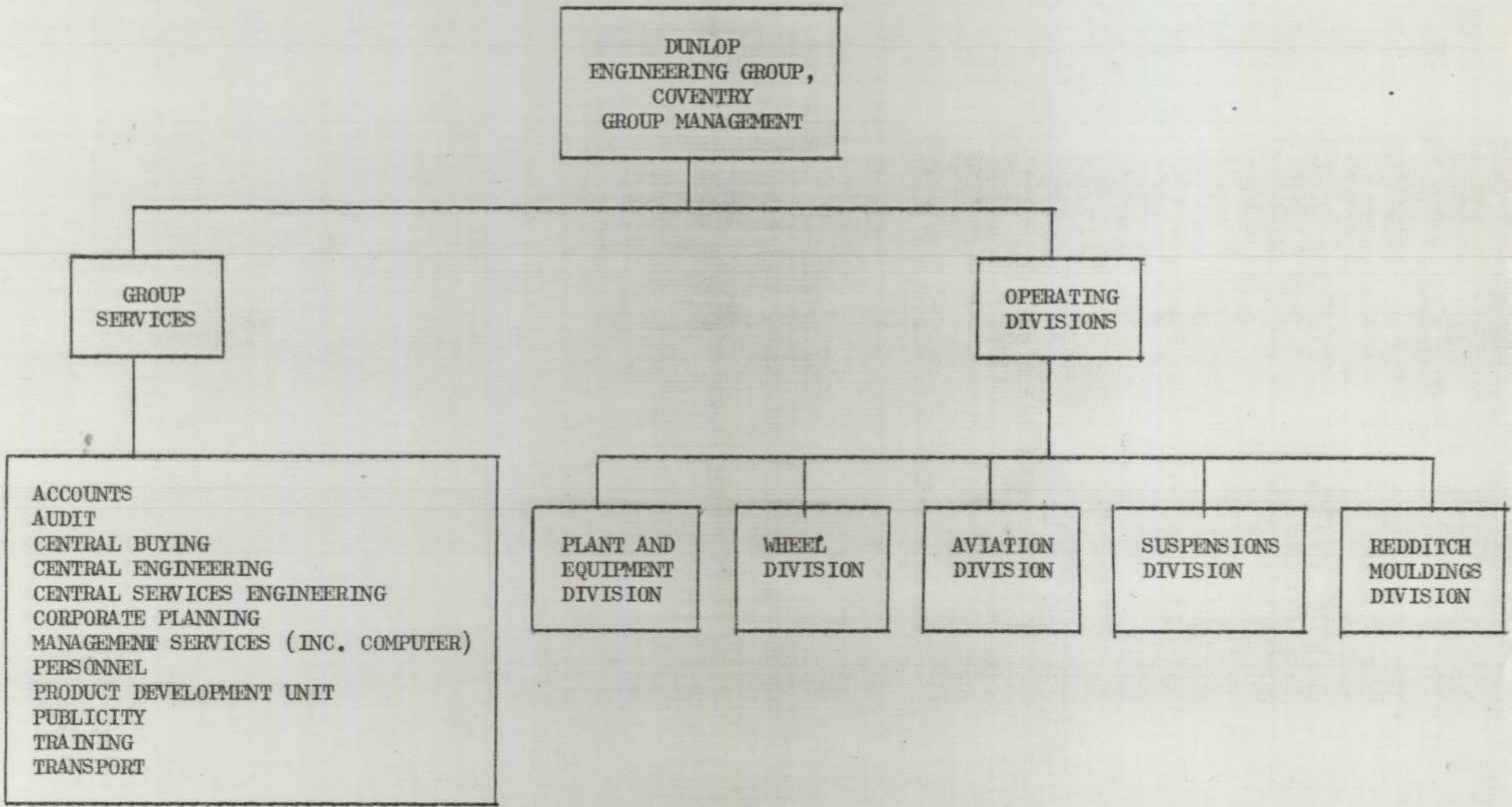
Originally conceived as a machine tool manufacturing unit, a cost centre which served the requirements of Dunlop Engineering Group, subsequent developments had already altered the position by the time the project started and given the subject division, at least nominally, the status of a profit centre.

1.1 Site

Plant and Equipment Division (hereafter P & ED) is part of the Engineering Group of Dunlop Holdings Limited. The main production units of the Division are on the Group's industrial site at Holbrook Lane, Coventry, although there is a small subsidiary factory at Benson Street, Leicester. The project concerns only the Coventry-based units of the Division. The Leicester works may be seen as almost a separate business, responsible to the same Divisional General Manager, but run by its own administrative unit. It was defined, by the company, as being outside the scope of this project and is thus treated as no more than an environmental factor to the Coventry system.

The composition of Engineering Group in November, 1974

Figure 1.1 DUNLOP ENGINEERING GROUP, COVENTRY (AS AT NOVEMBER, 1974)



is shown in Figure 1.1. Of the other operating divisions, Aviation, Rim and Wheel and Redditch Mouldings were on the same industrial site as P & ED, while Suspensions Division was on an individual site about three-quarters of a mile closer to the centre of Coventry.

P & ED's Coventry operations were made up of three separate units, located as shown in the site plans (Figure 1.2):-

a. A Machine Shop, often referred to as "The Toolroom" in reference to its origins.

b. An Assembly area, where special purpose machines were built.

c. An Office area, incorporating all the pre-production planning and administrative departments.

Wild notes three basic principles for deciding plant layout:-

- minimise materials handling and movement
- minimise work in progress and maximise turnover
- maximise utilisation of facilities of space and labour (1)

Reference to the site plan will demonstrate that the first and third of these were being ignored by P & ED, even before consideration is given to the internal layout of the units. This was largely the incidental result of the historical development of the division and its status within the Engineering Group.

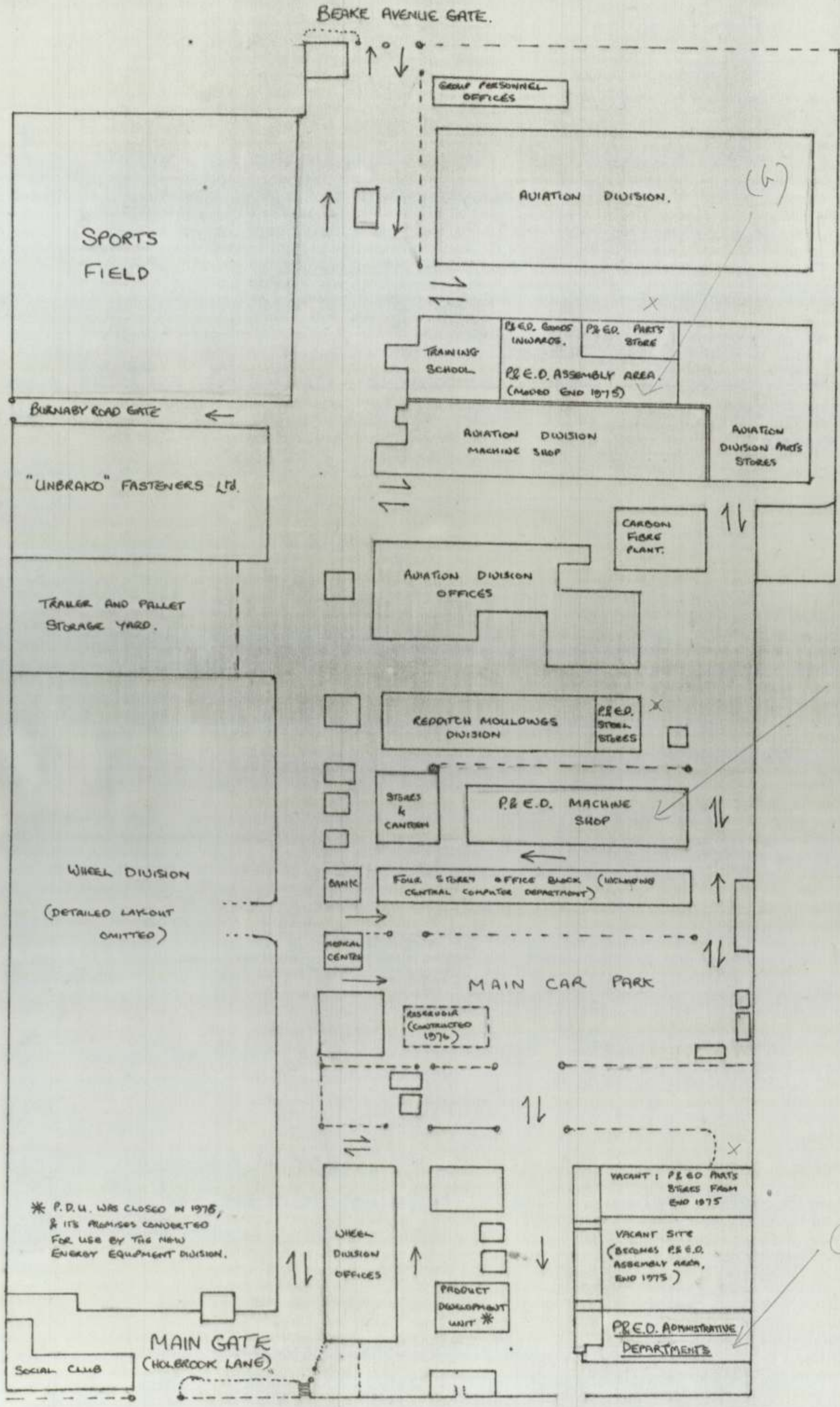


FIGURE 1.2 DUNLOP ENGINEERING GROUP, COVENTRY — SITE PLAN

1.2 Historical Development: Up to the end of 1974

The "ad hoc" growth of P & ED is depicted in Figure 1.3 which shows development up to the present date in order to give a complete picture. Explanatory notes on each of the stages preceding the start of the project are given below.

1.2.1 Aviation Division Toolroom

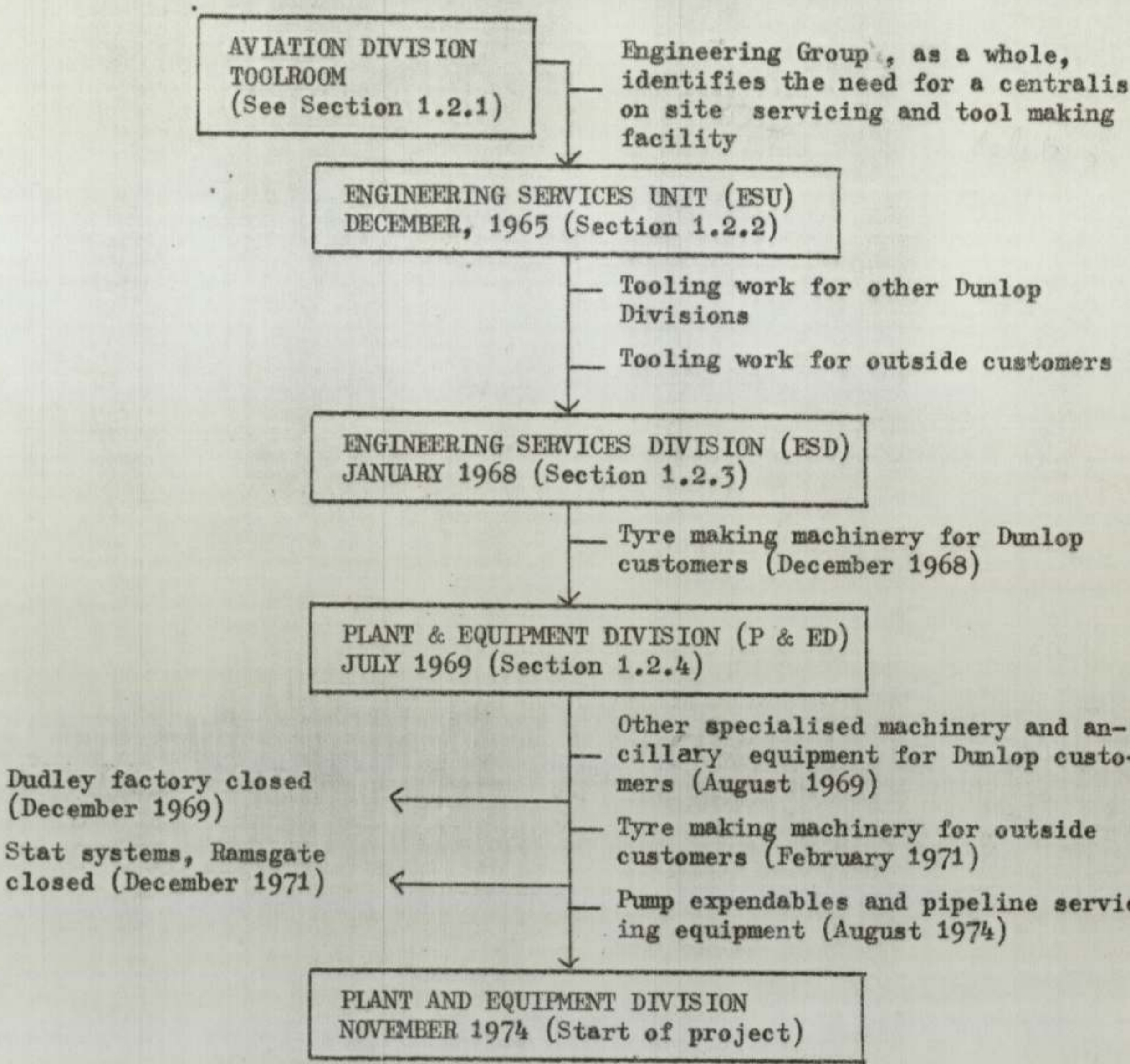
Aviation Division's tooling requirements had always been extensive enough and specialised enough to require the maintenance of a permanent on site tooling facility. This was situated in the area described on the site plan as the P & ED Machine Shop. Work would be done on a sub-contract arrangement for other divisions, if capacity was available.

1.2.2 Engineering Services Unit (ESU)

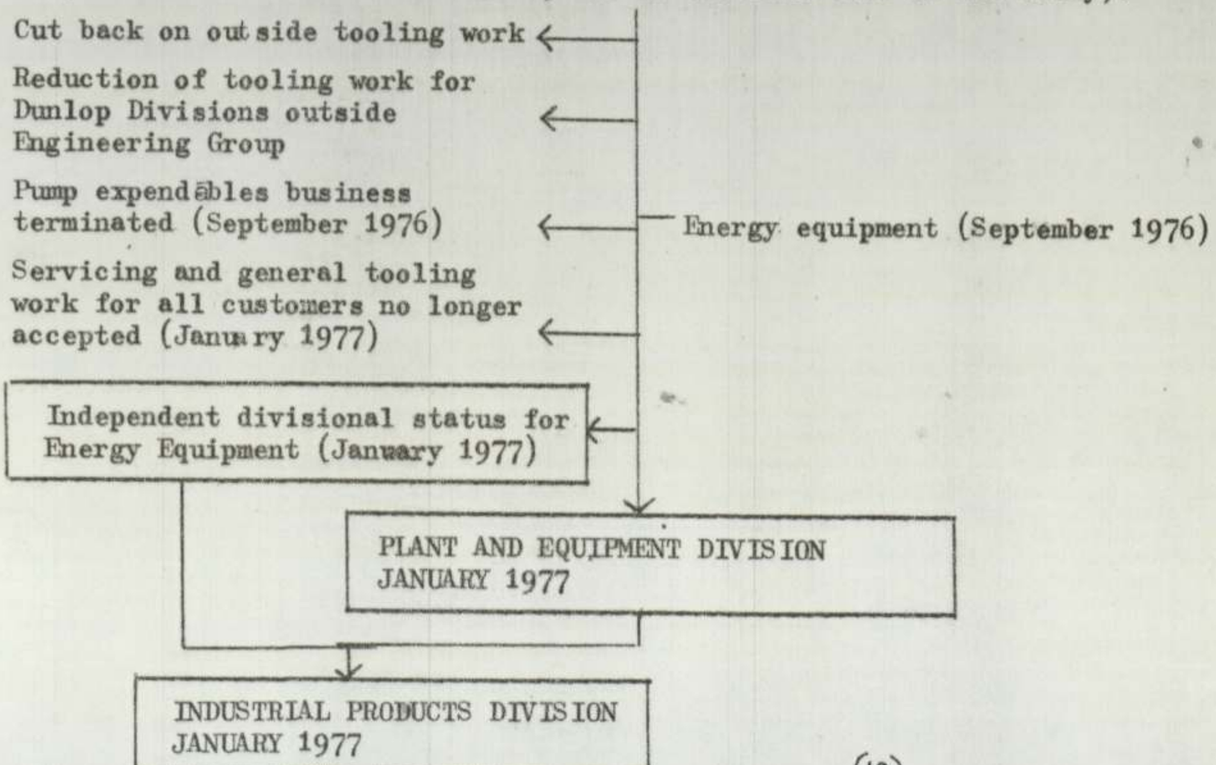
At a time when the economic future of the British motor car industry seemed to offer prospects of continued growth, the Rim & Wheel & Suspensions Divisions at Coventry found their tooling and breakdown servicing requirements expanding to a level where maintenance of an on site facility to cover these needs was justified. The group management decided that, rather than each division setting up its own toolroom, a central servicing unit should be set up to cope with the demands of the group as a whole.

Thus, at the end of 1965, the Engineering Services Unit was established. The facilities and capacity available were determined on the basis of the estimated requirements of all the operating divisions taken together. Its status was that of a cost centre and it was maintained on the basis of contributions from each of the user divisions, in proportion to the amount of

Figure 1.3 STAGES IN THE DEVELOPMENT OF PLANT AND EQUIPMENT DIVISION. (SECTION REFERENCES REFER TO THE TEXT)



(Subsequent developments are shown here to give a total picture, but as they were to some extent the result of attempts to deal with the firm's problems they are not covered in Section 1, but in the main text of the study).



its capacity which they took up. It offered a comprehensive service for break-downs and also expertise in all forms of tooling work, making press tools, form tools, jigs and fixtures required by other divisions. All activities, including the administration of the unit centred upon the Aviation Division toolroom.

1.2.3 Engineering Services Division (ESD)

ESU became a division in its own right (ESD) at the beginning of 1968, and commenced charging for jobs on a piecework basis. Nominally, divisional status made it a profit centre, but it was found in practice that charges levied for tooling and servicing work still left a deficit, to be made good from Group funds, because of such overheads as unproductive time, or "downtime". Indeed, it had been the evidence, in this form, that the Coventry divisions did not require the full capacity of the toolroom which had created the grounds for advancement to divisional status.

Investigations showed that there was a market for the specialised tool making skills of the Coventry toolroom in supplying the requirements both of other Dunlop Divisions and of outside firms. Product variety expanded along with market horizons and ESD took on work from outside, which included making moulds for rubber and plastics. Divisional status was seen as essential in conducting negotiations for such work, because it gave the organisation a profit-orientated identity in the external market.

To the other members of the Engineering Group the expansion of ESD seemed to offer the prospect of a reduction of the subsidy, levied on them, to underwrite the continued on site provision of tool making and breakdown servicing facilities. There was already a downturn in the economic fortunes of the British automotive and aviation industries and this directly affected orders received by Rim and Wheel, Suspensions, and Aviation Divisions at Coventry. The continuation of the central servicing facility was still seen as important, however, in the interests of minimising any interruptions to the flow of production within these divisions, and the variety of manufacturing machines needed to deal with such jobs made it important to maintain as large a toolroom as possible. The economic downturn might still have proved to be short term, with regard to these industries, and retention of a substantial toolmaking resource would provide the flexibility of capacity to cover any urgent demands for new tools created by the gaining of new contracts.

The logical solution was to offer spare toolroom capacity to other customers, in order to avoid having to carry it as a costly overhead, rather than reducing capacity by laying off skilled machinists who might prove difficult to replace in the event of improved economic conditions. It was evidently felt by the Group Directorate that this method provided the best chance of maximising profits in the long term although it left a degree of uncertainty about the new Division's short term prospects, because of the unpredictability of demand, which all tooling manufacturers suffer from.

In this way the Division took on the form of a hybrid: in theory, divisional status made it a profit centre, but it remained bound in its relations with other members of Engineering Group, for whom it was still required to act as a central tooling and servicing resource. ESD had no genuine choice but to accept orders from Group customers. Its piecework charges were governed by internal transfer prices, and were expected to be competitive with outside sub-contractors. With this restriction on its freedom of action, ESD had not really moved from cost centre status; it certainly was not equivalent in status to the other operating divisions of the Group.

1.2.4 Plant and Equipment Division

In the middle of 1969 (July) the situation changed completely. At the Fort Dunlop tyre factory, in Birmingham, a new tyre-making machine was being developed. It was decided to use the expertise and capacity available at ESD., Coventry, to produce the non-proprietary parts needed for these machines, and further, that an assembly unit should be set up, in a vacant area on the Holbrook Lane site, to build the machines. The venture was sufficiently successful to determine that future tyre building machines and ancillary equipment would be manufactured at Coventry. In acknowledgement of its extended product range, the Division was re-named Plant and Equipment Division. The machinery "sideline" promised a further reduction for other members of Engineering Group in the amount required to subsidise the operations of the central tooling resource. The arrangements for the support of this resource are noted, but badly explained, in a Management Services report, prepared at the end of 1969:-

> "All divisions in the Engineering Group pay a levy of 12½% of their estimated annual tool bills to Plant and Equipment Division. Invoices to these divisions are subject to a discount of 15% to encourage them to use the

services available". (2)

For P & ED, the charges represented an expansion of the true profit centre side of the business, but also an increased responsibility for balancing its revenue and expenses. Thus, for example, downtime became the problem of the staff controlling the new Division, and accurate estimating became a high priority for calculating job costs to ensure the required profit margins. The tyre machinery business increased the work load in the Purchasing Department and the Estimating Department. Also, draughtsmen and technical staff had to be taken on.

In the early days, the new business did not demand a radical expansion of the administrative staff. The report mentioned above noted that, at the time of its publication, 90% of total turnover consisted of jigs, tools and fixtures (3) although it also noted that a division of the manufacturing facilities had already taken place, in response to the site requirements of the machine building business:-

> Machining and toolwork take place in the Tool Room or Machine Shop. Machining includes work for tyre making machines and other large assemblies. The other area is the Assembly Shop or Number Six Factory where nearly all the activity is machine assembly". (4)

At this stage there was no sales force as such, the function being covered by a Sales Engineer:-

"He liaises with potential customers on technical problems and promotes new business generally. To back him up is a team of project design draughtsmen. Most sales are to members of the Dunlop Group and particularly the Engineering Group". (5)

The situation had already changed considerably, however, by the end of 1970. Figure 1.4 shows that machinery accounted for almost half of that year's turnover, and also shows sales to outside customers reaching a significant level, for example, in 1971.

Figure 1.4 PERCENTAGES OF TURNOVER MADE UP BY (a) SPECIAL PURPOSE MACHINERY AND (b) TOTAL SALES OUTSIDE THE DUNLOP UNION

YEAR	PERCENTAGE OF TOTAL TURNOVER (a) All Special Purpose Machinery	(b) Total sales to outside customers (including machinery)
1970	48	Not identified - presume "0"
1971	57	30½
1972	52	20½
1973	63	16
1974	43½	15

Figures based upon Product Results Annual Summary Tables - 1970 - 1974 (Appendix 1)

These changes forced an expansion of the administrative side of the Division with which the existing offices, on the Machine Shop floor, were unable to cope. The result of negotiations for new facilities was the three scattered units shown in the site plan, figure 1.2. P & ED found parts manufacture for major machines to be well within the abilities of its machinists, and, more important, the final product was potentially profitable. Its reaction was predictable - it looked for opportunities to open up external markets for its range of machines and to find new types of machines to build and sell to other industries.

A publicity leaflet from 1973 voiced its ambition to provide all types of special purpose machinery:-

> "A comprehensive service is offered to industry for the design, manufacture and installation of special purpose machinery. Complete facilities are available for the design of these machines, from the initial feasibility study through to final detail design, including electrical, hydraulic and pneumatic control systems. In the last few years, the division has found that this is a service for which industry has a very definite requirement. Work handled under this heading has had applications in the Rubber, Plastics, Chemical, and Nuclear processing industries and includes associated material handling equipment".(6)

The division's results did not live up to these ambitions. Only once in the six years from 1970 to 1975 did the division record a net profit before any allowance for interest and tax, and the total deficit over the six years was in excess of £1 million (details in section 1.6). Other divisions within the Group found themselves requiring less and less of the available toolmaking capacity. Indeed, costs on non-urgent machine shop jobs were actually higher than quotations of outside firms*, despite the allowed discount, and divisions were allowing work to trickle to such cheaper sources, forcing P & ED's management to push increasingly unsuitable machinery parts onto the shop floor for manufacture, in order to fill available capacity.

It was estimated that at this time as many as 60% of the parts for any special purpose machine were manufactured in the machine shop, whereas the division's Chief Inspector was of the opinion that perhaps 5%, at the most, genuinely required the toolmaking grade of skill. P & EDs management was convinced that it would show better results, as a profit centre, if it were able to sub-contract the work requiring lower grades of skill to outside suppliers.

The major justification for the continued existence of the Machine Shop was thus the need for breakdown servicing and reconditioning of machine tools. Unless toolmaking work could be placed on a competitive footing, vis-a-vis outside suppliers, the need to pay towards off-setting P & ED's losses would become even less acceptable to the other divisions of the Engineering Group.

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* The explanation for this lies in the different methods of paying wages adopted by P & ED from outside tooling sub-contractors. Whereas P & ED's machinists were paid at a fixed hourly rate (1.4.2.3) without any productivity bonus, outside sub-contractors paid a much lower basic hourly rate to workers, and boosted this with performance bonuses. This had the added advantage that when work was slack, the machinists were quick to look for alternative employment, since their wages were radically affected by the amount of unproductive time booked during any week.

The task confronting the new General Manager on his arrival in 1974 was to turn P & ED into a genuine profit centre, or at least to organise it so that it would break even each year without Group assistance. In an effort to get some control over production, the General Manager appointed a Production Planning Manager, with the initial task of devising and implementing control procedures for the Machine Shop area.

1.2.5 Subsequent Development

The diagram of changes, figure 1.3, goes beyond this point to bring the Division up to the present day, but no discussion of further changes is intended at this point. Such changes effectively concern some of the attempts made to handle the division's problems and will thus be dealt with in Chapter 4 of this thesis.

1.2.6 The distinction between "cost centre" and "profit centre"

The terms "cost centre" and "profit centre" have been freely used in the preceding sections and it seems essential, as a footnote, to clarify, as far as possible, the meaning which they are taken to have. The following definitions are taken from C. T. Horngren's work "Cost Accounting".

> "A cost center is the smallest part of an organisation for which costs are accumulated..." (7)

> "...Profit center is used indiscriminately to describe segments that are always assigned responsibility for revenue and expenses but may or may not be assigned responsibility for the related invested capital ... Normally, the profit center is the major organisational

device used to maximise decentralisation. Nevertheless, decentralisation and creation of profit centers are not necessarily synonomous terms ... A company may have many divisions called profit centers, but their managers may have little leeway in making decisions". (8)

Profit centre status does not, thus, imply independence of action or autonomy for the manager of the division concerned:-

"In short, the labels of profit center and cost center are sometimes deceptive as clues to the degree of decentralisation". (9)

Applied to the situation under consideration, the decentralised profit centre, or more properly the investment centre, would be Engineering Group as a whole, with each of the operating divisions being a separate profit centre, for the purpose of accounting for revenue and expenditures. The Group Services, which originally included ESU, are the cost centres. Ultimately Coventry is judged on the basis of the performance of the Group as a whole. Evidently the Group was prepared to carry any annual loss recorded by ESD and P & ED on the grounds that its indirect contribution to the profits of the other divisions, by minimising disruption to their production processes, compensated for its inability to show a profit.

This must lead to the conclusion that, under the terms of Horngren's definition, there is reason to question whether the description "profit centre" can be accurately applied to ESD or to P & ED. The continued existence of the Division was not ultimately dependent upon its ability to cover its expenditures out of its own revenue.

It is interesting, however, that Horngen has significantly changed the wording of his definition of a profit centre, in the latest edition of his work, because of some confusion which he felt still existed within the question of decentralisation:-

> "A profit center is any subunit or segment of an organisation that is assigned both revenues and expenses ... Note that (this definition) does not contain one word about decentralisation ... (defined as) the relative freedom to make decisions". (10)

In strict accounting terms, it would appear that P & ED would thus be regarded as an "unprofitable profit centre". Its lack of independence of action and the definite effect which outside interference had upon its potential to operate profitably meant, however, that its performance was not directly comparable with the other "operating divisions" within Engineering Group.

1.3 Factory Layout

The following three diagrams (Figures 1.5, 1.6 and 1.7) show the internal layout of each of the three units of P & ED. They are fairly self-explanatory, but a few observations are made below on each of them.

1.3.1 The Machine Shop (Figure 1.5)

The method of organisation chosen for the machining facilities within the Machine Shop is what Wild refers to as "Layout by Process or Functional Layout". He regards it as:-

Figure 1.5 MACHINE SHOP LAY-OUT, PLANT AND EQUIPMENT DIVISION (NOVEMBER, 1974)

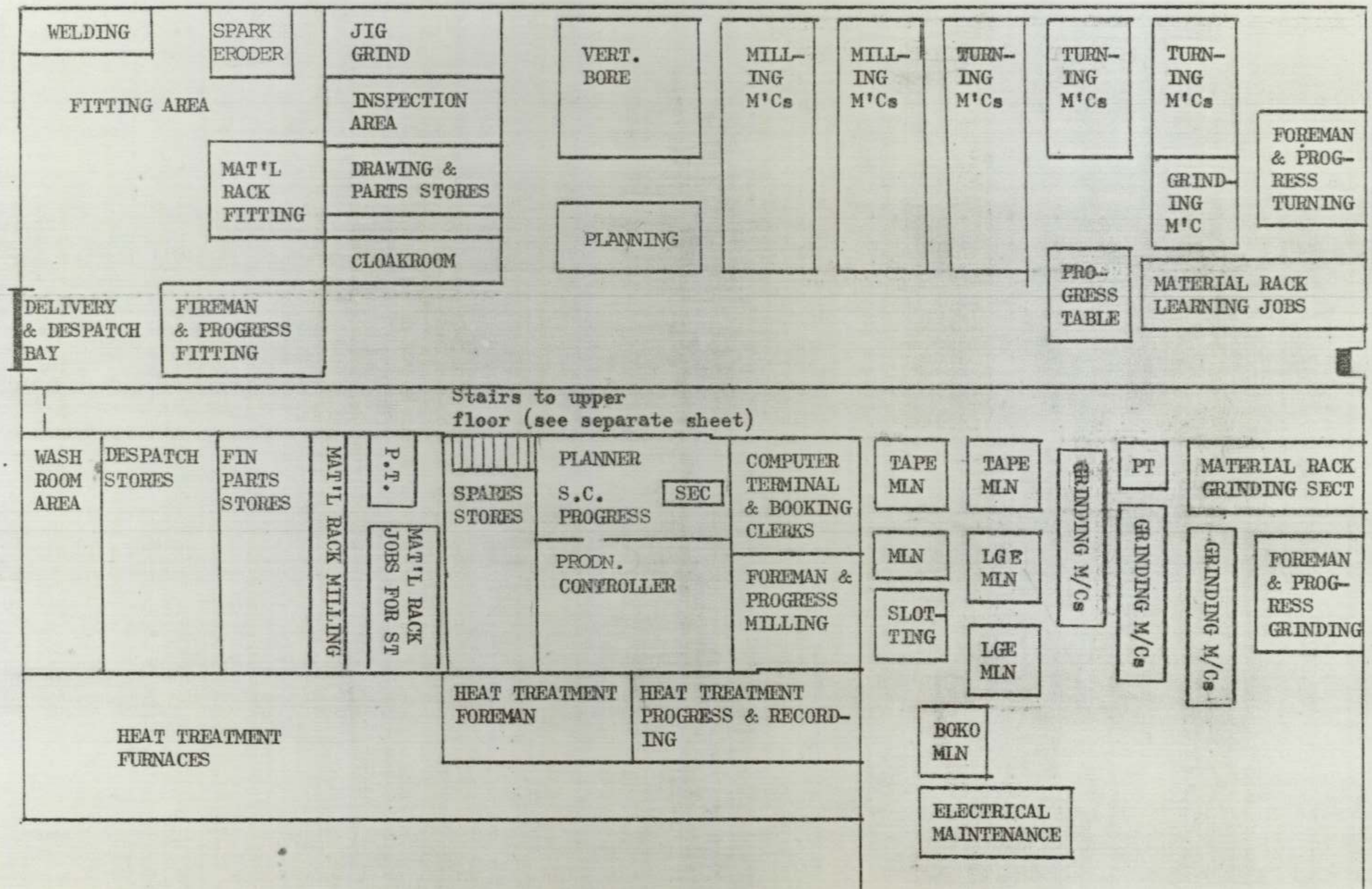

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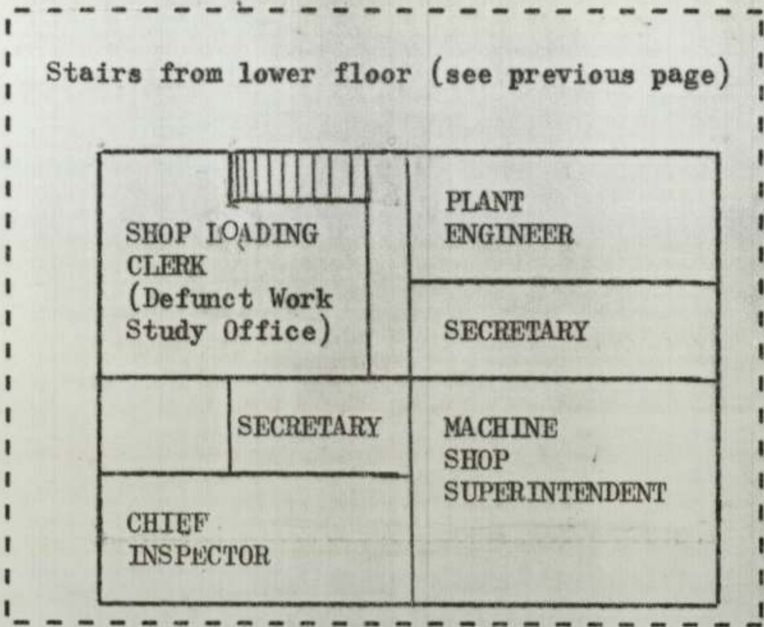
Figure 1.5 (continued)



UPPER FLOOR IN OFFICE AREA

"appropriate where small quantities of a large range of products are to be manufactured, perhaps the best example being jobbing production. The nature of the layout permits flexibility in production, i.e. complex products, requiring processing in every one of the functional departments, may be made alongside simple products requiring processing in only a few departments". (11)

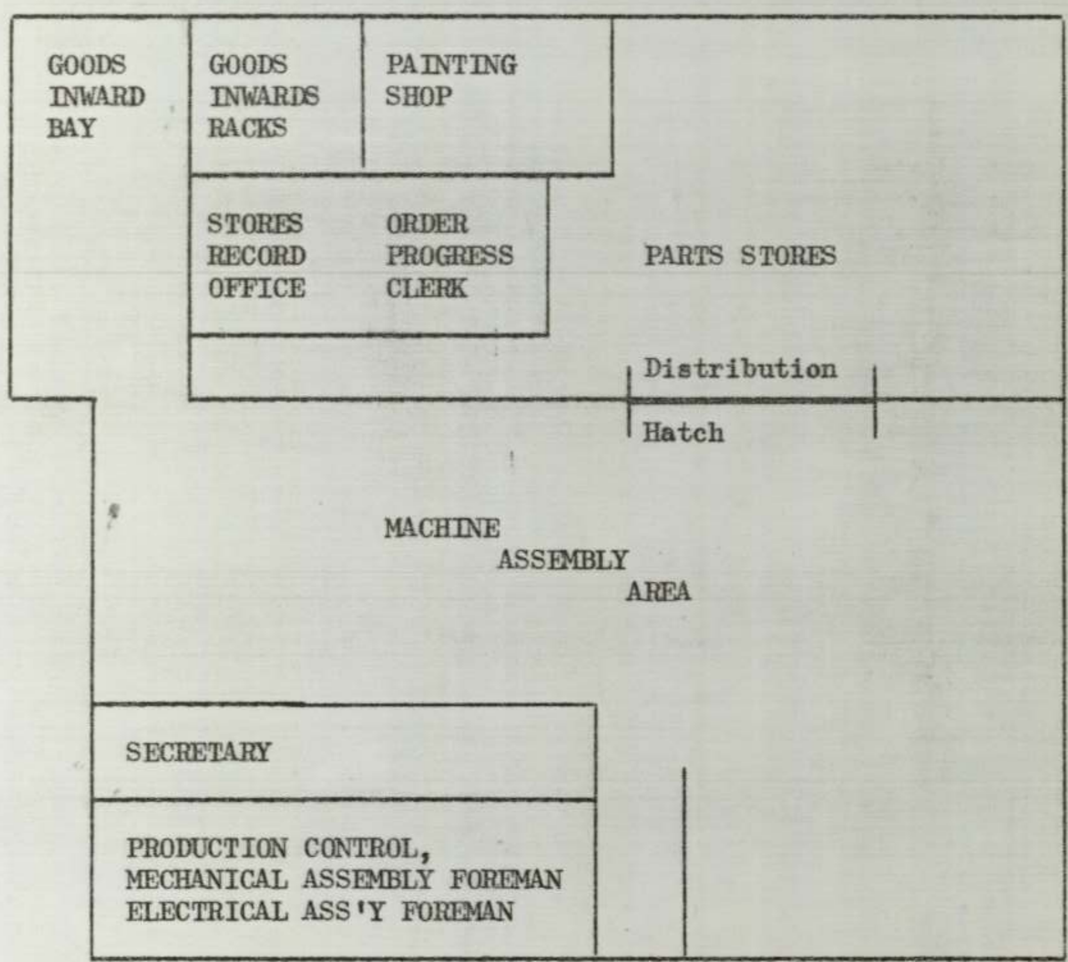
This is, therefore, the method of layout which one would expect to find in a toolmaking machine shop. The list of characteristics which Wild considers go with "Layout by Process" are discussed in Section 2.

1.3.2 The Assembly Area (Figure 1.6)

In this area the products are less diverse but their vital characteristic is one of size. Although this varied a great deal, all the machines constructed were of sufficient size to make it impractical to move them from one group of specialist workers to another. The system was thus adopted of assigning groups of fitters to take machines through from the stage of inspecting the kits of parts for shortages to completion of the build. Construction of the electrical panels required was slightly different, the early stages being done at the electrician's bench, but eventually these too would be worked on at the allotted building site for the machine.

Wild refers to this type of organisation as "Layout by Fixed Position". (12). Because of its size, it is no longer the product which moves, but the processing staff who come to it. In extreme cases, where very large machines were involved, it

Figure 1.6 <u>P. & E. D. ASSEMBLY SHOP LAY OUT (November, 1974)</u>



scale?

proved necessary to partially strip them down, for transportation, after they had been examined by the customer at Coventry, and to submit to a second inspection following on site commissioning in the customer's factory.

The space available for machine building in the "Number 6" assembly area would have allowed the construction of at least six moderate sized machines at any one time. But although there were sufficient fitters available to cope with this number, the order book was never sufficiently filled with a future load to produce this situation. The electrical and mechanical assembly foremen thus tended to double up the number of fitters normally used for building machines to minimise both downtime bookings and machinery build times. It is therefore quite possible, even probable, that the foremen were not using the most economical number of men to build the machine. The only real solution to this problem was to achieve a fuller order book.

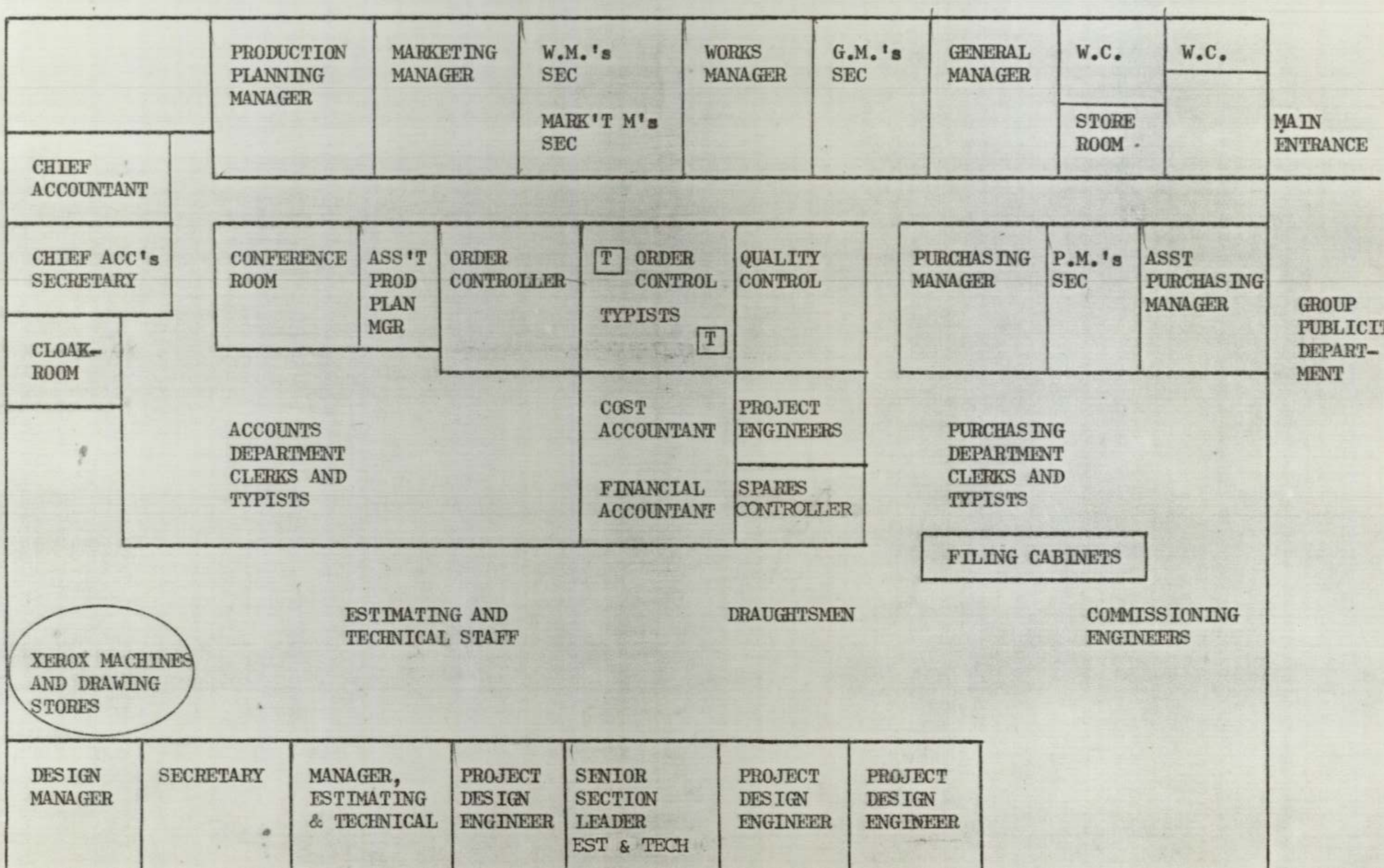
1.3.3 The Administrative Departments (Figure 1.7)

In explanation of the figure it should be said that the whole of the office area, with the exception of the row of offices from the Production Planning Manager's to the General Manager's was based on an open plan format, and that room divisions shown in other parts of the plan represent half metal, half window prefabricated partitions.

Briefly, the advantages of the open plan layout are:-

1. Ease of communication between departments where there is a need to work closely together, guarding against departmental insularity and allowing a greater degree

Figure 1.7 P.E.D. ADMINISTRATIVE AREA LAY OUT (November, 1974)



of liaison and co-operation between staff at lower levels.

2. All levels of management are well placed to gauge the work being put in by their subordinates.

3. Absence of walls makes the offices easier and cheaper to set up and to clean.

4. Contact between personnel should help create unity of purpose and will enhance workers' morale and the social side of their job satisfaction, creating a good working atmosphere.

On the other hand, the disadvantages are:-

1. Lack of privacy - which may be particularly important to Senior Managers.

2. A high noise level - for example in the Purchasing Department, four buyers and two typists were working in a fairly small area, which could create problems with 'phone calls. Many orders were placed by 'phone, with paperwork to follow, in order to save time, and a few parts of the technical specifications wrongly conveyed, or wrongly understood, might produce unnecessary production delays.

3. Encouragement to conversations with no relevance to work - the price of satisfying the social needs and

creating a good working atmosphere amongst employees.

4. All areas are laid open for visiting clients to take in at a glance, which increases the need to keep areas orderly.

Subsequent changes reflected the General Manager's recognition that his senior subordinates, particularly those who were likely to receive visitors, required, and were entitled to, a greater degree of privacy.

1.4 Machines, Manpower and Materials

It is in the nature of a jobbing type of business that demand for machining facilities will fluctuate within the various machine groups at unequal rates. To compensate for such demand changes jobbing businesses employ skilled machinists with a high potential degree of labour mobility and generally also have more machines than operators on the shop floor. This situation applied in P & ED's machine shop. Policy on material stocks was determined by balancing the cost of having capital tied up in stocks against the urgency of the service required by the customer.

1.4.1 Machining Facilities

A list of P & ED's machining resources is given as Appendix 2 to this chapter. The list was drawn up as a prospective coding list for use with a computerised data collection system. It was not proposed to distinguish the sub-groups for this system, and as the Management Services' report of November, 1969 pointed out:-

"The definition of a machine group for loading purposes is vague at present. The existing groupings imply that all jobs can be done on any machine within that group. The loaders agree that a further sub-division of the groups is required". (13)

No further sub-division had taken place by the end of 1974. The resulting problems for shop loading and load analysis will be examined in Chapter 3.

P & ED offered a wide range of machinery, as the list shows, including tape controlled machines and a spark eroder and jig grind machine for intricate work with low tolerances. Gear cutting and plating work had to be sub-contracted, as did the larger items requiring heat treatment.

The division's own Inspection Department controlled the quality of all parts produced internally and also checked components before and after heat treatment and sub-contracted operations. Internal rejections were the responsibility of the foreman of the section where the faulty work had been carried out. Rejects to sub-contractors were handled by the sub-contract progress clerk.

1.4.2 Manpower Resources

The changes outlined in section 1.3 resulted in the addition of a number of pre-production administrative staff to the division's work force, and also to the employment of extra electrical and mechanical fitters. The figures given in the table below, figure 1.8, are for Plant and Equipment Division as a whole and thus include the Leicester works throughout, a subsidiary at Dudley to its closure at the end of 1969, and a works at Ramsgate - originally specialising in "Stat Systems", but subsequently diversifying into general tooling because of a lack of demand for the basic product - which was closed during 1971.

Figure 1.8 Year End Figures for Operatives and Staff in P & ED as a whole (14)

YEAR	OPERATIVES	STAFF	RATIO OP:ST
1968	341	119	2.87
1969	472	207	2.28
1970	378	161	2.35
1971	306	140	2.19
1972	299	137	2.18
1973	288	141	2.04
1974	259	126	2.05

1.4.2.1 Machine Shop Labour Force - Consequences of Historical Development

In the Machine Shop, however, the labour force had changed very little. The machinists, who had originally worked in the Aviation Toolroom, had simply changed from one employing Dunlop Division to another. This accounts for their continued orientation towards quality of product, rather than efficiency of production, and the same was also true of the supervisory staff. Wild is certainly correct in his judgement that process layout permits specialist supervision (15), but a side effect of this is that foremen are generally created by seniority, from within the ranks, rather than because of demonstrated administrative competence. Their "forte" was thus dealing with machining problems, not in making out or following work schedules.

These aspects of shop floor work force traditions and attitudes will be examined, in relation to the problems which they created or exacerbated in terms of planning of production, in Chapter 3. For the present, it is sufficient to state that the criterion by which foremen judged their own performance was their ability to keep the maximum percentage of their section productively employed.

They and the machinists recounted with pride their ability, in the days of the Aviation Toolroom, to lay aside the work they were currently involved on and deal immediately with an emergency repair job, or a rush modification. Even the Machine Shop Superintendent, himself an ex-foreman, recalled operating a turning machine himself, after the end of a day shift, in order to produce an item which was delaying production elsewhere on the site.

Such traditions and methods of working died hard. In terms of job satisfaction, the pleasure with which the stories are recounted speaks for itself. This type of work offered initiative and responsibility to individual machinists and a sense of the importance of the work being done.

1.4.2.2 Traditional Independence of Machinists

The operators were used to working without any defined control procedures, and any special instructions connected with a job were passed on by word of mouth, or on scraps of paper. The absence of rigid control systems gave them a measure of independence which they came to regard as some sort of recognition, on the part of the management, of their advanced skills. This situation was likely to enhance job satisfaction, and reduce to a minimum the number of items of work rejected on the grounds of faulty workmanship. These advantages are worthy of consideration, particularly as it had been the division's reputation for quality which had been instrumental in securing valuable contracts with the nuclear processing industry.

But the concomitant costs and disadvantages of minimum management interference with shop-floor operations merit equal attention. In the special purpose machinery business, for example, the quality requirement for manufactured parts was lower, and production by a given date, within a cost budget, was a far more significant factor.

The problems caused by a conflict between priorities of quality and cost will be studied further in Chapter 3.

1.4.2.3 Operative Wages

The wages of the machinists and fitters were not linked to any attempt to measure their productivity, but rested on a flat rate per hour for time booked on their clocking-in cards. Unions and management had failed to reach agreement on an incentive payment scheme. The workers could then afford to disregard machining time allowances put against particular operations and retain as their prime concern the quality of their workmanship.

1.4.2.4 The Ratio Between Operatives and Staff at P & ED, Coventry

As a consequence of the special purpose machinery business, there was a far lower ratio of operatives to staff employees than would be expected for a purely tooling type of firm. The consequence of this was that there were a greater number of indirect staff to be carried as an overhead. This was bound to have an effect on the contributions required to make a profit on toolroom work if all the division's business was assessed together, rather than the overheads being apportioned between the different business types to reflect levels of administrative involvement.

Figure 1.9 demonstrates the higher ratio at Coventry, by comparison with the purely tooling subsidiary at Leicester. The comparison is slightly unfair, in that the Leicester factory made occasional use of administrative facilities available at Coventry.

The term "operatives" refers to employees paid on an hourly rate and the figures thus include labourers, progress chasers, storemen, inspectors and heat treatment personnel as well as machinists and fitters. "Staff" are employees paid at a fixed weekly or monthly rate.

Figure 1.9 Comparison of Operative: Staff Ratio at P & ED, Leicester, with the Ratio at P & ED, Coventry (16)

YEAR END	COVENTRY			LEICESTER		
	OPERATIVES	STAFF	RATIO	OPERATIVES	STAFF	RATIO
1973	239	131	1.82	49	10	4.9
1974	210	119	1.76	49	7	7

1.4.3 Material Stocks

At the time the project started, P & ED had its own material store, with stocks of commonly used types and dimensions of steels to the value of £40,000. The store contained equipment for cutting material to required lengths and a staff of two cutters and a records clerk, under the control of a foreman (who was also responsible for the Heat Treatment area in the machine shop).

"Free-of-Charge" material from all customers was also initially delivered to the store. Loads of cut and assigned material were transported to the machine shop floor by fork lift truck when a sufficient quantity had accumulated. There were no facilities in the material store for holding material pending due start of operations in the machine shop.

In accordance with a divisional management decision that stocks of steel should be run down to avoid having capital tied up there was no automatic ordering system for the maintenance of minimum stock levels. The Division went even further than this by selling off material which it did not foresee using in the immediate future.

The Division's Purchasing Department then had to deal with orders for material for specific jobs, where before it had only placed orders for material upon notification that required types and dimensions were not currently in stock in the steel store. Records of materials in stock were kept solely by the stores clerk and even these were not a definitive guide to the availability of material for a particular job. Only the total footage of each type and dimension of material which was in stock was shown in the records. A physical check by one of the store's staff was then necessary, where stocks were short, to confirm that the actual dimensions required could be cut from the stock held. Requisitions were made out by the store and passed to the Purchasing Department for any materials which were not available from stock. These materials would then be purchased from outside stockists. The problem is summarised by Christopher and Wild:-

> "... holding of stocks of items ... is not achieved without cost, and although such costs may be partly or wholly offset by the effects of the benefits, ... efficient control of stock-holdings is essential if least-cost operation consistent with maximum operational benefit is to be achieved". (17)

1.5 <u>Policy on the Question of Making or Buying Components</u>

In general this question was only relevant to the manufacture of special purpose machinery. The traditional advantages of each policy are described by Wild as follows:-

<u>Advantages of "Make"</u>:- (a) Reduce dependence on other companies.

(b) Avoid facing the consequences of their labour disputes.

(c) Determine and control own quality levels.

(d) Preserve any trade secrets.

Advantages of "Buy":-

(a) May make it possible to obtain items more quickly.

(b) Benefit from the continual development programme of other firms in specific products.

(c) May reduce the costs of storage, handling and paperwork.

(d) Releases firm's own facilities for possibily more productive employment. (18)

P & ED's policy, in line with the first two advantages of "Buy" noted above, was to purchase proprietary parts, such as nuts, bolts, bearings, motors and gearboxes, from outside suppliers. On parts which were peculiar to the product in question, the policy was not clear cut. There was a basic choice between supplying drawings for sub-contractors to make parts and manufacturing them in the machine shop. It seems that in placing a large proportion on the machine shop the job planners were less concerned with any of the advantages noted above than with filling up spare capacity:- If there is spare capacity, (d) of "Buy" doesn't arise. This again is due for further consideration in the section on P & ED problems (Chapter 3).

1.6 Divisional Financial Results

As an indication of the extent of the operations of P & ED, a few general statistics are included at this point, to show the

Figure 1.10 <u>P & ED. FINANCIAL Results, 1970 - 1974. All Figures in "£'s"</u> *

YEAR	TOTAL TURNOVER	CONTRIBUTION	NET RESULT (AFTER DEDUCTION OF APPORTIONED OVERHEADS)	CONTRIBUTION %		EXTRA TURNOVER REQUIRED TO BREAK EVEN	
				BUDGETED	ACTUAL	AT BUDGETED %	AT ACTUAL %
1970	2,242,472	436,956	- 375,829	32.8	19.5	235,530	1,927,328
1971	2,184,415	584,406	- 138,795	28	27	398,446	514,056
1972	1,981,172	596,433	- 17,419	27	30	292,356	58,063
1973	2,524,333	710,042	+ 23,090	29	28	-	-
1974	1,894,974	466,434	- 376,681	27	25	1,227,674	1,504,724

* Taken from P & ED Accounts Department Product Results Summaries (1970 - 1974) - see Appendix 1

annual turnover for the years 1970 - 1974. The last two columns are included to give a preliminary idea of the size of P & ED's financial problems.

Comments on the above figures will be more relevant in the discussion of the Division's problems in Chapter 3. A few points which are obvious from the figures alone may be mentioned here however:-

a. 1970 is obviously not a typical year:- In the following years actual contribution percentages come quite close to predictions.

b. Turnover is below the level needed to break even in four of the five years:- The necessary turnover level, at the estimated percentage contibution, is between £2.5 million and £2.6 million, rising however to over £3 million in the final year of the figures.

c. The trend for 1970 - 1973 must have been encouraging, and the 1973 result proves that the Division was capable of reaching a turnover target of £2.5 million, and of breaking even. The reasons for the reversal of the trend in 1974 will be examined later, in Chapter 3.

d. The contribution percentages would have needed to be substantially higher to break even in the loss making years at the turnover levels achieved:- The required figures were:-

1970	$36\frac{1}{4}$ %
1971	33 %
1972	31 %
1974	44.5%

1.7 Summary

The pur pose of this Chapter has been to present a backcloth for the problem. Many of the problem areas have been introduced here because it is felt that they represent a true part of the historical environment of the business under study. Specific detailed examination of these areas has been avoided as they are due for scrutiny in Chapter 3, with reference to the "model" or "ideal" situation constructed in the pages which directly follow this.

The pro ject started in November, 1974 and covered the period up to the end of 1977, although collection of figures for the final year took place during the first months of 1978.

CHAPTER 2

THE MODEL, OR "IDEAL", SYSTEM OF ORGANISATION

2.1 The Aim of this Investigation

The purpose of constructing an ideal system for the organisation and control of the subject firm, at this stage, is to set up a hypothetical situation against which the actual business can be examined in Chapter 3.

The following pages draw on the work of various specialists in production management, systems and organisational analysis, with a view to demonstrating the problems to be expected within this type of manufacturing situation and the possible methods of managing and, where possible, actually solving these problems.

The first part of the model lays out the characteristics which would be expected to be found within a jobbing manufacturing plant, noting in particular the traditional difficulty of controlling production operations in this type of environment. This was the area with which the management of the subject firm expressed the greatest dissatisfaction: The order in which jobs were completed was almost totally unpredictable, as was the time which machining operation took. As Wild notes:-

> "In intermittent manufacture it is possible to construct production schedules for each order or product, but inevitably such schedules are frequently inaccurate and often unrealistic. Consequently their use, whilst necessary, makes for difficulties in production control. Inaccuracy

in production planning results from the fact that a variety of products are to be made, each likely to require processing for different durations on different machines and in a different order. Often such products have not been made before and consequently the operation times, which are the basis of production planning, have only been estimated from previous experience." (1)

It would be incorrect, however, to produce a model which did not take P & ED's other business, the construction of special purpose machinery and ancillary equipment, into account. Indeed it is the combination of the two distinct types of production, and the interdependant relationship which existed between them, which makes the firm worthy of study. Conclusions will thus be drawn as to variations from the strict toolmaking model which might be expected as a consequence of involvement in this other business.

Although the problem, as identified by the management of P & ED, concerned how to make the machine shop tooling operation profitable, and how to ensure that it provided the necessary support, in the form of parts manufacture, for the construction of special purpose machinery, any organisation systems needed to be relevant to the Division as a whole. The dangers of leaving to chance the external effects, on the assembly and administrative areas of P & ED, of any system devised purely to improve matters in the machine shop are all too evident. The need to adopt a holistic approach to such a study is noted by Kast and Rosenzweig:-

"Holism is the view that all systems are composed of inter-related sub-systems. The whole is not just the sum of the parts, but the system itself can be explained only as a totality ... The holistic view is basic to the systems approach. In traditional organisation theory, as well as in many of the sciences, the sub-systems have been studied separately, with a view to later putting the parts together into the whole. The systems approach emphasises that this is not possible and that the starting point has to be with the total system". (2)

In this case, it is also important to take into account some factors of the environment, within which the system is to operate, which have a very direct influence. The aim of the project is to decide upon the best way in which the subject division could be organised and controlled, in order to fulfil its own, internal, prime objective of making a profit and justifying its continued existence. But this cannot be discussed in isolation from an important part of its political environment. As a member of a "Group" and, ultimately, of the Dunlop Holdings Corporation, its over-riding objective must be that the Group and the Union should make a profit, to justify the existence of the whole.

The ramifications of any changes made in P & ED, to improve its own performance, must be examined in relation to any additional costs to be incurred by Engineering Group, directly or indirectly, as a consequence. Methods which will assist the Division in achieving its own objective must be discarded as counter-productive if it can be shown that they would have an adverse effect on the success of the larger organisation of which it is a part.

The relationship is well expressed by Beer, in "Brain of the Firm", when discussing potential problems at the interfaces between sub-systems within his cybernetic model for an organisation:-

> "Here then is a major snag; it is the hoary old problem of central control written in a new form ... The snag is endemic to large-scale organisation. Firstly there is the (system) one/two interface. This has to do with recognising that there are other autonomous divisions than my own, and that they have rights as well. Especially, these others have the right not to be undermined by me, however pure my own motives are. Secondly there is the (system) one/three interface. This has to do with recognising that my own autonomous division is part of a corporation, and that it too has rights. Especially, sad as it seems, the corporation has the right to inhibit and if necessary to liquidate my autonomous division". (3)

The "rights" of the higher levels of the organisation, and of companion divisions, operate as constraints upon the type of action which it is allowable for P & ED to take in order to achieve its divisional objectives. But in return for acceptance of these restrictions, the broader organisation provides advantages for member divisions - if there had been no advantage, the corporation wouldn't have been founded in the first place. The main benefit to the subject division is the very immediate one of finance. In isolation, without the corporation to underwrite losses, P & ED would have gone out of existence before the end of 1974. Further, it may be doubted whether, on the strength of its operations as a toolmaking unit, it would have been able to raise sufficient capital to expand into the machine building business, when the opportunity arose.

While the division is constrained, in its dealings with other members of the Union, by internal transfer price policy, it benefits from membership in that some of the other divisions provide what is effectively a captive market for some of its products. Also, corporate quality standards may restrict, but all divisions are then able to enjoy the Union's overall prestige and reputation in the market place.

It would be wrong to dwell too long here on the pros and cons of the corporate ethic. Essentially it is a system of "give and take" where, in accordance with holistic principles it is assumed that the whole will be capable of creating greater opportunities than the individual parts, in return for some sub-ordination in terms of the amount of independence of action which those parts enjoy. Hicks states the case logically:-

> "The very essence of an organisation is that persons interacting in the organisation do so because they expect the organisation to provide value they otherwise might not have".(4)

Likewise, when groups of organisations "engage in co-operative interaction, they have the potential of creating values". As long as the individual objectives of all the units within a corporate body are compatible with a single "superordinate" or higher objective, it is likely that all will gain from incorporation. (5)

2.2 Characteristic Features of the Types of Manufacturing in which the Subject Firm was Involved

In the following sections the characteristics associated with two different types of business will be examined in turn:-

1. A jobbing shop, manufacturing machine tools (Section 2.3).

2. A machine assembly shop, producing high value equipment, usually in unit quantities (Section 2.4).

Conclusions will then be drawn as to the areas where there is a degree of similarity, and areas where there are basic and essential differences, which one would expect to find reflected in the method of organisation of a single firm attempting to combine the two. (Section 2.5).

To facilitate comparison in the final part of the section, the same factors will be examined as they apply in each type of firm, which means that negative features will be mentioned in some areas. The list has been organised into three parts:-

1. Inputs:- Site; labour; equipment; materials.
2. Processing:- Layout; production planning; production control; production activities.
3. Outputs:- Products; sales; general economic characteristics.

This is not felt to be an entirely satisfactory classification, since some of the characteristics are relevant to more than a single area. However, the advantages which this will offer at the comparison stage suggest that it is a better approach than a simple listing of features.

A summary of the main features to be discussed is given at the start of each of the sections, noting the conclusions which were reached. In general it seems that the special purpose machine assembly type of production has been the subject of less literature and debate than the more problematical jobbing type of production. Many of the conclusions as to the essential characteristics of the former have thus been drawn as a result of observations of strengths and weaknesses within that portion of the subject firm.

Figure 2.1 Summary of Characteristics of Jobbing Production

1. INPUTS

a.	Site	- Covered area:- Permanent location for machines. - Dimensions governed by machines, not products.
b.	Labour	- Highly skilled direct labour:- Considerable mobility. - Specialist supervisory staff. - Higher percentage of indirect employees than in mass production.
c.	Equipment	- General purpose, often expensive, machinery and associated materials handling equipment. - Wide variety of types of machine. - More machines than operators.
d.	Materials	- Mostly raw materials:- Few proprietary parts. - Make or Buy decisions only necessary when capacity is overloaded.

2. PROCESSING

a.	Layout	- By process, or functional layout.
b.	Production Planning	- Simple:- Only short planning horizon possible. - Almost impossible to estimate machining accurately. - Purchasing function not complex. - No product development:- customers' drawings.
c.	Production Control	- Emphasis is on control rather than planning. - Extremely complex problem:- - high work-in-progress - long queues at machines, but - under-utilisation of equipment - high "job idle" time - long job throughput time - high ratio of indirect employees - frequent overtime or sub-contracting - data collection an extensive task, and - complex programs needed for computer aids

Figure 2.1 (continued)

d.	Production Activities	- High accuracy working:- Low tolerances. - High quality workmanship. - No installation or after-sales service. - Inspection against drawings, but no testing.

3. <u>OUTPUTS</u>

a.	Products	- Wide range of varied products and product values. - Small or unit batch sizes. - Production to specific orders, not for stock.
b.	Sales	- Totally unpredictable:- Short horizons and short-term forecasting. - Market research little value after initial launch. - Delivery on time less crucial to supplier than customer (potential lost production). - Customer liaison key activity in this area.
c.	General Economic Characteristics	- Labour intensive production:- Key is to maximise utilisation of labour resources. - Planning and forecasting concerned with output averages, rather than with specific jobs. - Little working capital required, but need to provide for replacement of expensive equipment.

2.3 Characteristics of a Jobbing Shop Manufacturing Machine Tools

2.3.1 Inputs

2.3.1.1 Site

There are no special site requirements, other than protection from the elements. Obviously, the more integrated activities are, the less materials movement will be needed, but in theory there is no reason why all machining facilities should be at the same location. Perhaps the important thing about the site is that requirements, in terms of dimensions, will be determined by the size of the processing machines, not the size of the products.

2.3.1.2 Labour Force

"A high proportion of the labour used is skilled. (6). The direct labour force must certainly be highly skilled, and also mobile, in that it will be necessary in the cause of maximum utilisation of labour to move machinists from one machine group or even one machine section to another. Buffa notes that research has shown that the greater the flexibility of the labour force the higher will be the utilisation of labour. (7) Wild suggests that foremen will tend to be specialists (8) because all the work on a section at any time will be of an individual, or unique, nature and may require a wide range of practical guidance or assistance from the foreman. The foreman, also, will be responsible, within guidelines from his superiors, for the actual distribution of suitable work to the operators. (9)

A "comparatively large number of indirect, supervisory or clerical workers" (10) will be expected in a jobbing firm as against a mass or continuous production firm. This again is because the variety of products makes the supervisory task more taxing in this type of manufacture, and thus one man can deal efficiently with a smaller number of subordinates.

2.3.1.3 Equipment

"General purpose equipment, both production and service, (e.g. materials handling, etc.) is normally used and a great deal of flexibility must exist in the systems in order that the company might accommodate demand fluctuations, product design changes, special customer requirements, etc.". (11) Some of the machines will represent large capital outlays, but despite the expense, it is probable in the interests of flexibility that there will be a greater number of machines than operators on the shop floor.

Because there is not a predictable manufacturing routing, or a set list of machining operations involved in the production of all parts, a wide variety of machines will be required. However, this will produce the advantage that a single machine breakdown is unlikely to have a critical effect on total output, whereas in mass production it would bring a whole production line to a stand-still.

2.3.1.4 Materials

Manufacture consists almost entirely of operations upon raw materials, and few proprietary parts - nuts, bolts, washers, etc. - are required. The variety of products, however, creates a problem in assessing what stocks, if any, of material should be held. Tooling steels of many different dimensions will be used, and there is the risk of holding costly stocks for long periods, or the alternative risk of losing orders because materials are not available for the manufacture of items to meet a customer's delivery requirement. An important factor in determining policy will be the delivery lead time which material suppliers can offer, and the discount available for bulk purchasing. The location of a factory in relation to prospective suppliers will affect this.

2.3.2 Processing

2.3.2.1 Layout

Wild states that the appropriate method of organising facilities in jobbing production is:- "Lay-out by Process or Functional Layout". This means that "all operations of a similar nature are grouped together in the same department or part of the factory. For example, separate areas may exist for drilling operations, milling, grinding, fitting and so on".(12) The same author lists the characteristics of this type of layout, in many cases, it seems, making the assumption that a jobbing type of production will exist. In most respects his observations correspond with the advantages of process layout noted by Radford and Richardson (13). The points made are given briefly below, though many of them will require further examination in other sections.

- "Specialist supervision is possible, and the grouping of operatives of a similar type and skill within the same department promotes cohesiveness ..." (14). The variety of products makes specialist supervision necessary, but "cohesiveness" might easily become departmental insularity and cause problems between machine sections. Nevertheless, the gaining of greater experience and skill within a more limited field may help to make supervisors and setters more proficient in their work. (15)

- Similarly, the type of layout might "enable individual incentive payment schemes to be used", (16) but in jobbing production this is likely to cause friction between groups, as product variety makes operations so difficult to estimate accurately. It is unlikely in any case, unless the trade union involved has little influence, that it would be possible to conclude agreements based on sectional performances, rather than a shop-wide performance given that the level of skill was the same throughout. A bonus scheme needs to rest on performance against some standard which both management and workers consider fair and appropriate. Such standards are almost impossible to set in jobbing production. Further discussion of the practical problems with an incentive payments scheme, in the context of the subject firm, appears in Chapter 4.

- "The nature of the layout permits flexibility in production" and makes it easier to change the quantity or type of components produced. (17) These are essential features of jobbing production, as is the fact that:- "This same flexibility brings disadvantages, since process layouts normally operate with a comparatively high level of work-in-progress, and throughput time is high". Further, there is a "possibility for loss or neglect or some jobs/items", because there is no set timing or pattern of operations from one job to the next. (18) However, this means that individual machine breakdowns or individual workforce absentees do not stop the whole production process, and also means that a variety of sub-contract work can be taken on to fill spare capacity on machines. (19)

- Maintenance and the provision of services - water, power, removal of scrap-is simpler than in other forms of layout, but the cost of materials handling is high(20) because items must travel greater distances between one processing station and another. (21). This is unavoidable in one-off manufacturing because of the variety of products and the unpredictability of operations' routings.

- Production planning, defined as "dealing entirely with pre-production activities, i.e. the construction of a schedule by which products will be made in the correct quantities and in the time available" (22) is "simple", in that time horizons are short and unit batches are usual, which means that no facilities are tied up for lengthy periods of time with a single job.

\- But "production management and particularly production control in jobbing manufacture is one of the most complex and challenging aspects of industrial management"(23). With this type of layout, each machine must be dealt with as an individual unit for the purposes of controlling processing, whereas a layout by product, or flow layout deals with each production line of machines as a unit, because each product has a set routing to be followed.(24)

\- It is also possible with process layout to take more account of the different potential production capacities of both machine and men. In a flow layout these operate in fixed relationships one to another, which means in fact that all operate to the capacity of the slowest machine or worker (25). On the other hand this emphasises the production control function through introducing two more variables.

\- Because workers are not employed on defined, limited tasks, a greater degree of operator skill is likely to be needed in a factory laid out by process, which may create problems or expense in terms of training or hiring operators.(26)

\- Use of floor space is uneconomical in process as compared to flow layout. Equipment cannot be arranged as compactly because there is no direct line of feed from one machine to another.(27)

2.3.2.2 <u>Production Planning</u>

Organisation of pre-production resources in jobbing production is not an involved process. In the first instance an order will be placed by a customer on the basis of a price quotation from the supplier. It is unlikely that there will need to be negotiation over specific job prices, although annual agreements may be made with regular customers on labour rates, or contribution levels. An example of this, concerning sales within the larger organisation (if the firm is part of a group of companies) is found in transfer pricing agreements.

The crucial factor in deciding whether jobs are profitable or not is the accuracy with which machining times for the various operations can be predicted, (28) yet, paradoxically, most estimates are extremely unlikely to be accurate. This does not reflect a lack of ability on the part of the estimators, but rather the unique, unrepetitive nature of the products. Although higher value jobs are likely to be subjected to serious and detailed scrutiny by estimators - perhaps even in consultation with machinists - it is still probable that actual machining times will vary from the estimates a great deal (29). The only accurate method of charging for work is by totalling hours after the event, but the customer who does not expect a price quoted before a job starts is very rare. Such a system could only be worked between divisions of the same organisation.

Historical data, relating performance on past jobs, are thus unlikely to repay detailed analysis with a view to improving estimating accuracy. However, performance against estimates is still desirable so that errors of quotation are not perpetuated (30). Any adjustment which is felt necessary will be in the form of an arbitrary overall percentage increase on estimates, or at the very most, a variety of percentage increases applied to machine groups or sections.

Since purchasing is basically only concerned with the provision of raw materials, it too is a simple function, requiring a low ratio of staff to the number of orders to be placed and probably dealing with a small number of suppliers. Actual numbers of orders throughput will depend upon raw material stocking policy. Make or buy decisions will only have to be taken at times when capacity is over-stretched, and only the alternative costs of overtime and sub-contracting need to be analysed.

There is no call for product development work, since machine tools will have no market outside their application to one customer, who, indeed, will supply the drawings from which the article is to be made.

Detailed production planning, down to devising a schedule for "time co-ordination of production in advance of performance" (31), does not pay sufficient dividends to warrant the efforts required, in jobbing production. Wild summarises the problems:-

"If it were possible to prodict accurately all operation times for all jobs; if we could be certain that no machine failures or labour absences would occur; if we could be sure that there would be no mistakes during operations; and if we knew the exact time required to transport items between all machines, then theoretically a precise and accurate schedule could be constructed. But of course we know none of these things ...". (32)

2.3.2.3 Production Control

"One of the most complex and challenging aspects of industrial management", according to Wild, is this:- "during production activity" involving the implementation of the production planning decisions - ensuring that products are manufactured according to the previously determined production plan. In this type of manufacturing, "production control procedure is known as order control, since the principal objective is to ensure that a particular order is delivered on or before the time required".(33)

The following features of jobbing production cause complexity in production control:-

a. Unique or varied nature of products.

b. Variable nature of demand for parts.

c. General purpose, often expensive, equipment. (34)

These create the following problems to be dealt with by production control procedure:-

1. Comparatively long manufacturing intervals from receipt of order to despatch of goods.
2. Very high work-in-progress stocks, and a large number of individual customers' orders in progress at any given time bringing continuous need to decide and to revise resource allocation priorities.
3. Long queues of jobs between machines, yet paradoxically,
4. Underutilisation of equipment, as flexibility demands there be more machines than men.
5. Frequent overtime and sub-contracting of work.
6. Comparatively large number of indirect, supervisory or clerical workers.
7. Great deal of "job idle" time, i.e. the total processing time is greatly in excess of the sum of operation times: Wild notes that in a machine shop in a jobbing production factory of which he had personal knowledge, the ratio of total time in the shop to the sum of operation times for jobs was 20.1.(35).

The complexity of controlling and analysing progress in this type of production has led many firms to investigate the possibility of using computerised aid programs. The problem is that these firms, where control aids are most needed, are also likely to be the ones least able to allocate large budgets for such facilities. Thus, in the South Essex research by the Woodward group it was found that:-

> "In unit production firms, mechanisms of control were relatively simple and unsophisticated. Control was exercised almost entirely through the personal authority pyramid, work was largely unprogrammed, and end results were difficult to predict". (36)

Developments in mini-computers have helped to overcome the problem of the expense of the hardware involved, but jobbing firms are by nature highly individual, and the development costs of the "software" programs to suit them remain high. As the size of the firm increases, and it becomes able to afford a higher budget in this area, the complexity of its operation increases at an even faster rate, requiring ever more sophisticated software.

Rackham, of the Woodward research group, concluded that "The greater the degree of variation in the product range and of innovation, the more difficult the problem of time control" (37). And one must add to this that the complexity of the control problem, in jobbing manufacturing, increases as the size of the production unit becomes larger, but increases at a far more rapid rate, because there are no standard operations routings or machining times to simplify resource allocation decisions.

Buffa notes that research in theoretical situations suggests that in a machine limited system (i.e. where labour is always available) resource allocation according to the shortest operation time (S.O.T.) among competing jobs, provides the best results in terms of the lowest mean flow time and that a "truncated S.O.T." rule helps towards overcoming the difficulty of very long waiting times for individual jobs, by establishing a maximum allowed waiting time. In a labour limited situation (where machines are always available), which is more likely in United Kingdom firms, given that maximisation of labour utilisation is essential to economic tooling production, Buffa notes that labour is obviously best assigned to the machining centre with the longest queue. Ability to do this, however, depends upon the degree of flexibility, or mobility, within the labour force. The greater the flexibility, the higher the likelihood of maximising labour utilisation.(38)

This author's conclusion is that job shop scheduling systems can improve operations and will probably increase the size of shop which can be managed effectively (39). Computer firms have attempted to find a method of bringing the cost of scheduling programs within the budget of small firms by developing "all purpose" suites of programs, which with minor tailoring, are supposed to fit any operating environment. Recent work by T.B. Tate at Aston University suggests, however, that there are distinct limitations to the uses of such "package systems". (40)

2.3.2.4 Production Activities

The parts and jobs produced require a high degree of accuracy and working within very small tolerances. High quality standards may be as important as pricing in making a firm competitive in this field. Only the very largest jobbing shops will be able to perform all operations required on all jobs internally. In most cases, as already noted, the more uncommon or more specialised types of activity - including probably gear cutting and plating - will be carried out by sub-contractors.

2.3.3 Outputs

2.3.3.1 Products

Jobbing shops are characterised by the "wide range of varied products" manufactured, often in small or unit quantities.(41). The value of these products varies to almost the same extent, but the key factor determining the selling price will usually be the number of labour hours rather than the cost of the material used. (Obviously there are exceptions to this when, for example, expensive special material is required for a job). No installation or after sales service is provided, and testing responsibility ends with final inspection.

2.3.3.2 Sales

This area is totally unpredictable. The sales horizon is short, and only a short term order load - perhaps 3 to 6 months - would be expected to be held at any one time, although occasional longer term contracts concerning repeat orders or orders to be delivered in parts might form the basis of a longer term load. No amount of market research will help to predict the future, though general economic trends may suggest whether there is a likelihood that firms will be investing capital in new ventures, requiring new machine tools, or consolidating around current activities, limiting their needs to replacing or reconditioning existing tools. Essentially it is a service as well as a product that is being sold.

On-time delivery of specific jobs is not usually critical for the producer's cash flow, though it may be to the customer though a loss of potential production. It is impossible to predict accurately the likely date of the completion of processing at the quotation stage, even if full estimating for the job is carried out. By the time that the order is received, the current shop load will have changed with the addition of other new orders. A contingency factor must be built into delivery date quotations to allow for alterations in the load.

Yet even in this situation, where the dates given will be little better than guesses, delivery dates may form a part of the bargaining process on major contracts. Rackham notes how this may cause problems:-

> "Sales or commercial managers responsible for the bargaining process rarely have to accept the responsibility to take the blame if delivery dates are not met, and there is

therefore a tendency for the bargains made to be somewhat unrealistic from the start".

In fact, where a firm was producing "hard-to-make items which were easy to sell if the quality was high", the production function, as Perrow suggests, was "much more important than sales"(43). The only time when this was not true was in the initial period of a firm's operation, when active marketing was essential in order to become established in the chosen field of production. Over a period of time the firm's quality, cost and delivery reputation become as important as marketing activity in determining the sort of orders which are received.

Where the firm is a part of a larger organisation, the initial marketing impetus may not be required, as there may be a ready made market internally associated with advantageous transfer prices for the customer. The need to develop the outside market comes later, when the firm uses the reputation built up internally in an attempt to expand its operations. Uncertainties of production performance make the customer liaison role of the Sales Department a key function, particularly where sales are to outside customers.

2.3.3.3 General economic characteristics

Jobbing production will usually be labour intensive, that is to say that the final job cost will contain a larger percentage in respect of labour input than of materials input. The essence of economic production is thus to maximise the utilisation of labour resources. This is not just a matter of keeping the work force productively employed, but also of making the best possible use of specialised talents available.

Economic forecasting and planning will only take the actual values of large contracts into consideration. Elsewhere concern will be to reach a basic minimum output figure, each week or month, which it has been calculated will produce an annual profit after deduction of overheads.

Working capital can be kept at a fairly low figure, since receipts from sales should be fairly regular. However, it must be sufficient to support the relatively high levels of work-in-progress which is a feature of this type of business. It is also necessary to set aside funds to provide for the replacement of expensive equipment, or for expansion of the range of production equipment available, in line with changes in demand from the market.

Figure 2.2 Summary of Characteristics of a Machine Assembly Shop

1. INPUTS

a.	Site	- Covered area: No fixed manufacturing locations. - Dimensions governed by products, not equipment.
b.	Labour	- Skilled direct: Fitters and electricians with total mobility between products. - Specialist supervisory staff and project engineers. - Exceptionally high percentage of indirect staff.
c.	Equipment	- Full range of fitting tools and testing equipment. - No permanent machines except for drilling. - materials handling equipment to cope with heavy loads.
d.	Materials	- Four types of material inputs: - standard proprietary items (nuts, bolts and wiring) - non-standard proprietary assemblies (motors) - non-standard low tolerance machined parts - non-standard high tolerance machined parts - Make or buy decision highly complex.

2. PROCESSING

a.	Layout	- By fixed position.
b.	Production Planning	- Complex: Need for long-term forecasting and planning. - Need to estimate completion dates accurately. - Pre-production process is lengthy and involves: - market research and contract negotiations - complex operations planning and scheduling - decisions on inventory policy - product design and development

Figure 2.2 (continued)

c.	Production Control	- Emphasis is on planning rather than control.
		- Assembly area relatively simple to control:
		  - minimum work-in-progress and "job idle" time
		  - resource management easier: no machining
		  - overtime can be planned
		  - limited cost of increasing capacity
		  - assembly small percentage of order throughput time
		  - collection of data on assembly times simple
		- Complexity of production control increases as manufacture of parts is taken "in house".

d.	Production Activities	- High accuracy required of final product. - Rigorous testing and commissioning. - Installation and after sales service involved.

3. OUTPUTS

a.	Products	- Variety, but all are types of machine and ancillary equipment. - High value unit batches. - Production to order, not for stock.
b.	Sales	- Long-term forecasting essential: some predictability. - Market research very important at all times. - Delivery may be less crucial to customer than to supplier unless good delivery reputation maintained.
c.	General Economic Characteristics	- Capital intensive production: key is to maximise turnover of working capital. - Planning and forecasting concerned with specific jobs. - Considerable working capital required.

2.4 Characteristics of a Machine Assembly Shop, Producing High Value Equipment

2.4.1 Inputs

2.4.1.1 Site

This must be a covered area, protected from the weather. The actual dimensions will be decided by the size of the product, not the producing equipment. There will be no fixed manufacturing stations, with the exception of work benches for minor electrical and mechanical sub-assembly operations. The site will consist of an area of re-allocatable floor space.

2.4.1.2 Labour Force

Direct labour consists of skilled fitters and skilled electricians. Mobility of labour is essential, in that all need to be able to work on any machine that is built. This does not, of course, preclude them from having special ability with particular types of machine. Indeed this is one reason why a specialist supervisory staff is important to sort out work allocation. Supervision may take the form either of foremen, responsible for certain types of assembly - electrical, mechanical, pneumatic, hydraulic - or of project engineers totally responsible for individual products. A combination of the two types of supervision may help to sort out more minor practical problems without involving project engineers.

Parts manufacture requires a variety of different levels of skill from the mass production of standard components - nuts, bolts, bearings, etc. - to the unit production of special high cost motors and gearboxes. The pros and cons of making or buying the parts from which machines are constructed will be dealt with in a later section.

Because the pre-production and administrative functions are extensive, the ratio of direct to indirect employees is even higher than in jobbing production. A design staff will be required and both marketing and purchasing are likely to need substantial staffs. As commissioning and installation are integral parts of contracts, personnel must be employed to cover these, and the after-sales services, functions.

2.4.1.3 Equipment

A complete range of fitting tools will be required, but there will be no permanent machining locations in the assembly area, with the possible exception of small drilling machines. Equipment, particularly for electrical testing, may be expensive. Overhead hoists will be required for materials handling, as well as fork-lift trucks. Internal manufacturing of "non standard" parts would require jobbing type general purpose machining equipment.

2.4.1.4 Materials

Four different types of material requirement can be identified:-

- Standard proprietary items - nuts, bolts, bearings, electrical connections, etc.
- Non-standard specialised proprietary assemblies - motors, gearboxes, frames, etc.
- Non-standard purpose made machined parts with low tolerances and, therefore, needing skilled machining - any parts which can directly affect the actual product to be made by the machine will come into this category.
- Non-standard purpose-made machined parts with comparatively high tolerances, needing lower grade machining - parts such as the drive shaft which do not have direct contact with the product.

The "make-or-buy" decision is thus highly complex. The basic objective of such a decision, as always, is the minimisation of total costs. The method of costing alternatives is known as incremental cost analysis, but this is far from being a straightforward procedure, or set of rules. As Christopher and Wild note:-

> "Not only do many non-quantifiable factors affect such decisions, but also very many seemingly peripheral cost factors often need to be taken into account. For example, the decision to purchase items may necessitate the acquisition of additional storage space, materials handling equipment, expansion of the purchasing department, the inspection department, etc. Furthermore, the cost implications of a decision to cease production of an

item in favour of purchasing will clearly depend upon the extent to which the manufacturing resources relinquished can be used in the manufacture of other items.

Factors such as control of quality, reliability of suppliers, dependence upon suppliers, responsibility for product research, design flexibility, etc., must also be taken into account. In many situations such factors cannot be quantified, and consequently it is normal to consider the incremental cost analysis as a necessary but insufficient aspect of make-or-buy decision-making". (44)

Essentially it is a quantifiable first step which may be used as an indication of whether it is worth moving on to a consideration of other factors involved.

The initial decision, at the time the firm is set up, is more directly quantifiable, but will depend on predictions of the amount of business which will be done over a given period of time. If this is relatively uncertain, it may be politic to keep capital investment in fixed assets to a minimum until and unless output should reach a "take-off" point, beyond which a change of policy may be considered. This would favour an initial policy of buying as many of the required parts as possible.

On the other hand, once past this "take-off" point, it may be that the firm will feel that its growth potential is limited if it remains totally reliant on outside manufacturers, and that it will be more in control of its own destiny if it can manufacture some parts "in house".

As the size of the unit increases and output grows, the stage may arrive where it is worthwhile buying, or setting up, subsidiary organisations to produce all the required parts, but if this stage is reached then the basic character of the firm will have changed.

No set rules can be laid down as to what policy any firm of this type should adopt or which parts should be made and which bought. This will vary within the individual circumstances of the firm. What is, however, vital to note is that each of the four types of parts will require more or less different forms of manufacturing facilities:-

- Standard proprietary parts are most economically made using mass production techniques.
- Non-standard proprietary assemblies require an assembly shop, which can be standard in that all items produced may be, for example, gearboxes or electrical motors, and specialised in that all the gearboxes produced are different from each other. The components making up the assemblies will in many cases be common, and might therefore be manufactured in a machine shop in reasonable batch sizes, or even purchased from mass-producers.

- Low tolerance purpose-made parts require a highly skilled machine shop. Batches are generally of unit size, and it is not usually possible to use stock items. This type of part is basically produced by a jobbing shop with a toolmaking level of skill.
- High tolerance purpose-made parts must also be made in a jobbing shop, but the machinists may be low - or semi-skilled.

There now appears to be a logical next question: Is it possible to distinguish which order might be the most appropriate for undertaking internal manufacture of the four types of parts? The first and last groups seem fairly obvious. It has already been suggested that once a firm took on provision of its own standard proprietary items it would have progressed from high value unit production to something approaching manufacture of standard assemblages, and these parts are likely to be the last ones which a firm looks to take "in house".

The first will be the low-tolerance purpose-made parts because these are the ones requiring the closest liaison between manufacturing and design. Also, a small labour force of highly skilled machinists will provide a facility for correcting faults on the lower skilled machining work put outside, avoiding possible delays on assembly. It is a feature of the type of business under consideration that design changes may be necessary after finalisation of the original specifications. These changes can result, for example, from product development by outside proprietary suppliers. If the firm needs to send parts needing modification outside every time, there is a considerable risk of falling behind the assembly schedule and even of machine construction being brought to a halt, awaiting arrival of a modified part. Establishment of an "in house" skilled machine shop will provide cover for such situations.

The order in which the other two groups might be taken "in house" is not as clear cut. For example, the non-standard proprietary assemblies have much in common with the type of work in which the firm specialises, in that they concern the assembly of a number of standard and some non standard parts into a finished unit or product. The lower grade machined parts, on the other hand, use the same sort of general purpose machines as are used in manufacture of the low tolerance parts.

Both also have disadvantages. The non-standard assemblies involve initial design costs, or the cost of buying a licence to use drawings of existing manufacturers, and a subsidiary "make-or-buy" decision will have to be taken about the constituent parts of the assemblies. But even the commonest components will rarely be used in sufficient quantities to allow bulk buying, unless it is accepted that stocks may be held over lengthy periods of time. Responsibility for and the costs of product development programmes will have to be borne internally.

The high tolerance machined parts, on the other hand, present potential labour relations difficulties. These parts will not be suitable for production by the existing staff of highly skilled operators. Management thus faces a decision as to whether to put men of a different grade of skill on the same shop floor or set up a new and separate facility for the lower skilled workers. The latter solution involves considerable capital cost and also doubles the problem of under-utilisation of resources.

A third solution is to maintain a larger work-force of the skilled variety and accept that they will at times be working on items below their level. This involves a quantifiable consideration of the fixed external costs of buying from a sub-contractor against the internal cost of using a higher grade of labour below its full potential. It will also depend on attitudes towards work satisfaction and on the actual number of lower category parts included in the final product. But there is the advantage that, should demand for the firm's products increase, the skilled labour force will be large enough to cope immediately with an increase in production of low tolerance components.

Ultimately, if there should be little significant difference in the cost advantages and disadvantages of producing the non-standard assemblies or the non-standard, high tolerance, machined-parts internally, the decision will rest on which offers the greater benefits in terms of the finished product. For example, components such as gearboxes and motors usually have long lead times if bought outside and may determine the total throughput times for orders. If it can be shown that internal manufacture would significantly reduce this lead time, then the firm will benefit through having its capital tied up for a shorter length of time. Alternatively, if sub-contractors are found to be unreliable on deliveries, manufacture of the high tolerance machined parts internally might remove the possibility of a valuable product being delayed on account of an inexpensive part.

2.4.2 Processing

2.4.2.1 Layout

In this type of manufacturing the product remains stationary until completion, and the labour force required to carry out operations move to it. Wild refers to this as "Layout by Fixed Position", and cites ship-building and civil engineering as examples. He does not, however, suggest the essential characteristics of this form of layout, but leaves them to be deduced from comparison with the two other forms "Layout by process or function" and "Layout by product" or flow layout (45). Radford and Richards on (46) make no mention of this third type of layout.

- Specialist supervision will be possible because a small number of projects will be in progress simultaneously, and the essence of economical production and site usage will be to minimise work in progress and avoid any slack or "job idle" time during assembly.

- Material handling costs will be minimised: No movement of parts will take place once the complete kit is delivered to the assembly location. Efficient kitmarshalling will ensure that parts are conveyed to this location in the most economical loads.

- Provision of services may cause some difficulties, in that different sizes of machine assembly will require different amounts of floor space. Permanent fitting bays will not be a practical method of maximising usage of the available site. Most powered tools used, however, will need to be highly mobile in any case, since they may have to be used on various areas of a machine assembly. In general, provision of services is less important with this type of production - removal of scrap and availability of water are not ongoing requirements, and general overhead lighting can be supplemented by mobile inspection lamps where necessary.

- Just as in flow line production a single machine breakdown brings a whole line to a halt, with immediate consequences in lost production, so here a single problem - a missing or malfunctioning part, for example - could bring assembly to a halt, because of a necessary build sequence. In most cases the problem will have less serious implications, because a number of sub-assemblies must be brought together into the final product. Thus it may well be possible to redeploy labour involved whilst the problem is attended to, and thus avert delays to completion of the project.

- Inspection of parts can be simply incorporated at the kitmarshalling point, and final inspection and testing can take place at individual assembly locations. The latter does mean however, that any equipment needed for running tests will need to be mobile.

- While layout by project or fixed position might facilitate introduction of bonus schemes linked to completion dates, delays will more commonly result from the necessity to incorporate modifications, rather than from labour force inefficiency. In civil engineering projects, the system of "job-and-finish" is quite commonly used as an incentive for working "unsociable hours" or in adverse weather conditions. This would not appear to be suitable to engineering projects, however, because of possible industrial relations problems. Bonuses will thus be offered, if at all, in the form of overtime, which the foreman can work out such that each man has the chance of a share.

- This method of layout offers maximum flexibility and variety of facilities within the limitation that the product range shall consist only of special purpose "free-standing" equipment.

- It is totally impossible for whole jobs to be lost or neglected, but parts may get misplaced or lost either through inefficient kitmarshalling in the stores area or by fitters on the factory floor.

- Limited maintenance and cleaning will be needed, and it will be relatively easy to accommodate.

- Production control will be simple because of the small number of projects in progress at any one time. Relative priorities will be easily identifiable.

- Production planning will be complex:- This type of layout relies on the fact that once a project is commenced, all parts will be available as needed; engineers will be available to carry out tests on completion; transport will be arranged to convey the item to a customer, freeing the floorspace occupied by it for another project, without delay.

2.4.2.2 Production Planning

The co-ordination of all the pre-production activities is a complex problem in this type of manufacturing. An essential pre-requisite to any planning is a statement of demand, whether known definitely, or estimated. It is for this reason that Wild stresses that in intermittent production "two-way communications between production planning and marketing are essential". (47)

- The marketing function is much more extensive than in jobbing production. Almost all contracts will be the subject of negotiations between manufacturer and customer over price and delivery date. In order to know how new orders will be fitted in with the existing manufacturing programme, a production schedule must be maintained.

- To undertake production scheduling, the following information is required:-

1. operations planning details
2. knowledge of the available resources - labour, materials and equipment
3. knowledge of the relative priorities of existing jobs
4. a required delivery or completion date for the job (48).

Of these, the first step, operations planning, presents the greatest difficulties. The term is used here in the widest sense of the definition:- Deciding how the product is to be made. As such it involves taking "make or buy" decisions regarding the component parts of the final product. Once all decisions have been taken, the arrival of all parts has to be co-ordinated in line with the scheduled start of assembly operations. This involves not merely ensuring that parts do not delay completion, but also that capital is not tied up for unnecessary lengths of time in kits of parts assigned for a particular job. The financial consequences of parts arriving too early might be as serious as parts arriving late.

- If a standard range of machines is produced it is probable that stocks of some parts will be held in order to reduce the overall time between placement of an order and delivery of a finished article to a customer. An inventory policy must be established, based on the predicted demand for different machines. The cost of making wrong decisions here is substantial, for the parts of machines which have the longest purchasing or manufacturing lead times, and thus the only ones which can significantly affect overall production time, are also the ones which are the most specialised and expensive. Provisioning in advance of fixed orders involves definite risks and will be worth while only if the delivery time factor is likely to have a marked influence on securing contracts. An important function of the marketing department is thus to assist in minimising these risks by making its demand predictions on the basis of a full investigation of the market potential.

Where the machines are custom made few components will merit stock-holding, other than common mass-produced items where bulk purchasing is more economic. A wide variety of non-standard assemblies such as motors and gearboxes will be required and, in order to avoid the development costs involved, these are likely to be purchased from specialist manufacturers. Whether these are outside firms or subsidiaries of the assembly operation will depend largely on the scale of the business. Only very large scale production of machines would justify maintenance of incorporated subsidiaries.*

- Design and development is a constituent part of the manufacture of custom made machinery. Customers provide specifications, but the detailed design work will be part of the service expected of the manufacturer, in the same way that he will leave detailed design of motors and gearboxes to the suppliers of those items.

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* Make or buy decisions are dealt with in greater depth in section 2.4.1.4

- The percentage of the throughput time which will be taken up by the assembly of the machine is small. The time consuming stages are in the pre-production areas, chiefly in design, operations planning and estimating, and lead times on specialised components purchased from outside suppliers. It will thus not be surprising to find that an even higher ratio of indirect staff are employed than in jobbing production. This will not take the form of higher numbers of first line supervisors or clerical staff, but rather of an increased need for specialist departments and specialisation within departments. The Purchasing Manager, for example, may find that he requires the services of a buyer with experience of electrical suppliers; the Marketing Manager that he needs technical sales staff familiar with a variety of different industrial environments.

- The long pre-production time makes it essential for this type of business to plan production over long periods, and work scheduling must involve the pre-production departments as well as the machine assembly operations. Over-loading in any department will result in delay to the completion of the final product. The high value of individual finished products makes it essential to set up a network model for production from the time the order is received. This will help to establish the areas where any slippage will be critical to the final delivery date. Each product network forms a part of a total production network or schedule, which will identify the wider implications of delay on a single machine assembly.

Although networks require more complex calculations than bar charts, Wild points out that:-

> "One of the principal disadvantages of bar charts when used for scheduling is the fact that the inter-dependence of jobs or operations is not shown, consequently, it is difficult to assess the full implications of delays in completing jobs, and it is not easy to attach priorities objectively to the different jobs that go to make up an entire schedule. The use of network analysis in production planning helps overcome such problems".

He goes on to suggest that this form of planning will normally be undertaken with the assistance of a computer, which will be able to calculate the best method of allocating a given set of resources, and also show, by reverse or due date scheduling, against established manufacturing or purchasing lead times the point at which each part must be started, or ordered, if it is to arrive at the correct time for kitmarshalling and assembly.

- In a business concerned with production of "one-off" specialised equipment, production organisation is likely to take the form of temporary project teams, drawn from the relevant departments. This will provide the most efficient method for handling any problems that occur and for monitoring progress made against the production schedule or individual jobs. Where standard machinery lines become established there may be a case for making such teams more formal, perhaps under the leadership of product managers. This will be determined by the scale of demand for the standard lines - whether they are capable of providing full-time occupation for such a team.

2.4.2.3 Production Control

Because the emphasis in this kind of business is on accurate and meaningful planning, production control is a relatively simple process. This is not to say that it is without potential problems, however, as the assembly time required for a custom made machine may be as uncertain as the manufacturing time for a part of it in a jobbing shop. But, because of the factors noted below, over-running on the assembly time allowance for a machine will not have far-reaching disruptive effects on the whole production programme:-

- Although there is a long interval between receipt of an order and despatch of finished goods, only a small percentage of this time is taken up by the assembly of the machine. Indeed this time is kept to a minimum and job idle time eliminated as far as possible in order that capital should be tied up in the expensive kit of parts for the minimum time.

- Because of the high value of the jobs and their requirements in terms of site for building, relatively few orders will arrive at the assembly stage simultaneously which means that priority decisions, and the effects of those decisions where resources are scarce, will not involve complex calculations.

- The problems of resource management are significantly alleviated because machine assembly involves one less variable than jobbing production:- Site, labour and finished parts, but not machining operations. Theoretically the mechanical and electrical fitters have complete mobility between jobs, and the allocation of labour between different products can be adjusted as a first stage in dealing with any orders falling behind schedule.

- Whereas overtime working may be required, because of the unpredictability of assembly times, particularly at times when there is a high work load, it will be possible to plan overtime taking into account other possible methods of handling the problem, such as using temporary contract labour to assembly electrical panels.

- Another alternative method is to increase permanently the capacity of the assembly area. This involves only the limited extra cost of taking on additional labour; there will be no outlay for production equipment, although eventually it will be necessary to expand the site.

- Because the actual assembly operations do not make up a major part of the job cost, completion within estimates is not critical to the profitability of the job as a whole. Also it is completely unpredictable how much time will be needed for testing and commissioning the machine. There is no point, in this situation, in programming the production of succeeding machines down to the nearest hour. The number of days, or even weeks, to be set aside for machine assembly will probably give a sufficient degree of accuracy. Only a full order book will produce pressure to progress as immediately as possible from one machine to the next.

- Collection of data on assembly operations is straightforward because of the limited number of jobs in progress at any one time. Computerised aids will be more useful in the pre-production stage, assisting with network planning and kitmarshalling.

However, all the above factors are based on consideration of an assembly area alone, and if the firm is producing some or all of its own parts for machines, then the complexity of the overall production control function is increased. It now becomes a question of co-ordinating manufacture with the assembly start date, and in the case of non-standard parts high contingency factors must be built into the programme because of the potential cost of delay.

This means that items will be started at an artificially early date, that their throughput time will probably be extended, increasing work-in-progress stocks, "job idle" time and the length of queues at machines. It will probably also lead to loading to a lower percentage of capacity as a guard against poor performance to estimates. In sum, the production control procedures required here will be as complex as in tooling production, with the one difference, that planning of production will be possible over a longer term because of the very long throughput time of machine assembly orders.

2.4.2.4 Production Activities

The finished product as a whole will be expected to perform its function to a high degree of accuracy. Thus, although some of the parts which make it up may have high manufacturing tolerances, high quality workmanship will be required of the fitters and electricians.

Not only will individual parts be inspected, but total finished job will be subjected to rigorous testing and commissioning to the satisfaction of the customer's engineers. Installation service, or at least supervision of installation and on site testing, will form part of most contracts, and after sales servicing of equipment may be an important selling factor as well as a lucrative method of using any spare capacity of commissioning engineers.

On the shop floor, jobs will be assigned to teams of fitters with a variety of specialist abilities. The size of the teams will partly depend upon the most economical building method, partly on the amount of time assigned for assembly completion, and partly on the amount of free labour in the assembly department. It may be that, to avoid downtime, a large team of fitters will be initially used to work on a number of sub-assemblies and part of the team re-assigned as other projects reach the assembly starting point. The ideal will be to have each distinguishable assembly stage carried out by the most economical size of team.

2.4.3 Outputs

2.4.3.1 Products

These could be of either or both of two types:-

1. a standard range of machinery
2. machinery which is custom made

In the latter case, the variety of the product range would be ever increasing although the product type would in all cases be restricted to special purpose machines and ancillary equipment.

The patterns of the business will be fluctuating and unpredictable if it cannot establish at least some set "lines" and gain the advantages of the increased certainty of costs with repetitive production. On the other hand, complete involvement in a single range of machines, or association with a single industry, will leave the firm highly susceptible to the effects of technological innovation or the economic decline of that industry.

Production will always be in unit batches, for even if two of the same type of machine are on the shop floor at the same time, a separate team of fitters will be employed on each one.

All products will have a high unit value, and production will be to specific customer orders, and not for stock.

2.4.3.2 Sales

Where set lines are concerned there may be some degree of demand predictability. Because of the long throughput time of orders, and the high number of expensive indirect staff employed, forecasting horizons have to be long term. To this end, market research has a continuing function:- It is essential to investigate any areas from which orders might be forthcoming. Marketing must be backed up by efficient and rapid procedure for analysing the costs of new projects, in order that it is quite clear what degree of concession, in terms of price, might be made in the course of negotiations with prospective customers. Negotiations might be lengthy, but the high value of contracts to be won justifies the time spent.

Delivery on time may be less crucial to the customer in this type of production than it is to the manufacturer. The latter has a capital investment, as well as floor space, tied up in the product, though of course the customers may suffer through lost production potential if the delivery is late. The key, perhaps, will be the manufacturer's reputation for meeting fixed delivery dates: Where this is good, the customer may include the machine in forward planning his production programme and will be keen to accept delivery at the earliest date; if not good, or variable, it may be that an on time completion finds the customer unready to accept delivery and looking to delay acceptance of the product and thus also avoid the necessity of paying for it or storing it. Regular customer liaison will help to make sure that this situation does not occur.

2.4.3.3 General Economic Characteristics

Machine assembly is a capital intensive business where the cost of the component parts used greatly exceeds the cost of the direct labour by which they are assembled into a finished product. The essence of successful operations is, thus, to maximise the turnover of capital resources. This is not simply a question of maintaining minimum stocks of parts, and of minimising the time between order input and delivery - the two are not always compatible - but also of making provision on major contracts for instalments of the agreed selling price to be paid at given stages of progress on a job, thus passing some of the burden of committed capital resources on to the customer.

Economic forecasting starts from a fixed target sum for the year, which will produce a given level of profit, but it subsequently examines the method by which this sum is to be reached on the basis of individual contracts secured and those which market research identifies as the most promising. The value of work invoiced will be expected to vary considerably from one month to the next, although progress payments or payment by instalments will have a smoothing effect on this fluctuation.

The firm's capital reserves require careful shepherding in order that interest payments on any funds which it is necessary to borrow are kept to a minimum. The basic size of the working capital available must be quite large - how large will depend on the size of the assembly operation - because capital may be tied up in a number of projects at the same time, and may also have to be set aside for expensive development work, the cost of which might not be immediately recoverable.

Figure 2.3 Summarised Comparison of Characteristics of Jobbing Production and Machine Assembly

	JOBBING PRODUCTION	MACHINE ASSEMBLY
1. INPUTS		
a. Site	Designated, permanent machine locations	Open plan, re-allocatable space
b. Labour	Skilled machinists and fitters. Large supervisory staff (specialists)	Skilled fitters and electricians. Large pre-production staff (specialised areas)
c. Equipment	Much capital invested in plant	Little capital invested in plant
d. Materials	Raw materials	Finished components
2. PROCESSING		
a. Layout	By process or functional layout	By fixed position
b. Production Planning	Limited and simple - only short-term planning is possible	Extensive and complex - long-term planning is essential
c. Production Control	Maximum complexity - emphasis is on control rather than planning.	Simple - emphasis is on accurate planning which makes control easy.
d. Production Activities	High accuracy work. Responsibility ends at final inspection	High accuracy finished product. Responsible for Testing, Installation and Service
3. OUTPUTS		
a. Products	Unrepetitive - varied jobs and values	Possibly some standard range, but basically a variety of high value equipment
b. Sales	Unpredictable - output by periodic averages. Little negotiation over prices	Some predictability - market research essential. Output by specific job values. Considerable negotiations over

Figure 2.3 (continued)

	JOBBING PRODUCTION	MACHINE ASSEMBLY
3. OUTPUTS (continued)		
c. General Economic Characteristics	Labour intensive. Low working capital, but need to budget for outlay on capital equipment	Capital intensive. High working capital, only need to set small amounts aside for additional production equipment, but need to budget for research and development

2.5 A Comparison of Jobbing Production and Machine Assembly

Considerable differences have been identified, in the preceding pages, between these two types of manufacturing. Rather than referring back to the summaries given in figures 2.1 and 2.2 an abbreviated list is included (figure 2.3).

It now remains to examine this list and pick out which of the differences look to be seriously incompatible and would be likely to cause problems for a business attempting to combine the two sorts of operation.

2.5.1 Inputs

2.5.1.1 Site

Two separate units will be required because of the different usage of floor space, but there is no reason why these should not be contiguous or make use of some common materials handling equipment - fork-lift trucks or overhead hoists for example.

2.5.1.2 Labour

Independent direct labour resources are needed, except that there could be mobility of fitting staff between the jobbing shop and the assembly area. Separate specialist supervisory staff will be needed for each type of manufacturing.

The real problem area concerns pre-production and administrative staff. The number required to be involved in these areas differ greatly and there is little scope for aggregating numbers to serve the fluctuating demands of both types of production, because of the degree of specialisation required of many of the staff and the different pre-production throughput times for each type of job. For example, a central pool of estimators might, because of a lull on the jobbing side of the business, all be put onto various machine assembly contracts which will require many days of work. If a number of short-term tooling jobs then arrive at the section, are these to wait until estimating has finished on the machines? Or are specified estimators to lay aside their current work and risk the chance that it may, because of a continued flow of tooling work, have to be re-assigned to another estimator? On the other hand, to set up completely isolated groups of estimators for each product area risks the possibility that one group will be overloaded and the other underloaded. The best solution to utilising the time of the estimators might be to have part of them on fixed allocation to each type of work, and a central percentage mobile between the two types. But this leaves the danger that the estimator might produce both types less efficiently. The organisational structuring of the organisation is considered later, in section 2.7.

2.5.1.3 Equipment

The types of equipment required will be different except for small drilling machines and, as mentioned, some of the materials handling equipment, although it should be noted again that if manufacture of non-standard parts for machine assemblies was undertaken internally the same general purpose machines would be used for this as for jobbing toolmaking. Difficulties may be encountered in the Accounts Department when the question of apportioning overheads comes to be considered. Depreciation of equipment will be almost totally chargeable against jobbing orders, but other overheads such as the cost of maintaining pre-production departments may be more difficult to divide. Without realistic attempts to apportion overheads as they are relevant to each type of product, however, it will be very difficult to assess the performance of each, and to decide future strategy for the whole business.

2.5.1.4 Materials

While there is a complete difference between the material inputs to each area there are potential advantages of each to the other:- Outputs from the jobbing shop could form part of the inputs to the assembly area; the one gains a market for its talents, the other a close and, hopefully, controllable supplier. This will, indeed, be an important consideration in the decision as to whether to make or buy non-standard component parts required by the assembly shop. The advantages are standard to most decisions of this kind:-

1. Provided the jobbing shop is working at a similar

variable factory cost to the sub-contractor, the parts produced should cost less, because of the sub-contractor's profit margin.

2. Easy contact between design and production makes it possible to offer the maximum design flexibility, and to cope with last minute modifications.

3. Production of parts to an appointed assembly start date can be controlled.

4. Dependence on outside suppliers is reduced.

5. Faults can be rectified swiftly, saving potential delay to major contract completions.

6. Production of these parts can be planned well in advance - lead times are almost certain to be shorter than those on special assemblies purchased for the same job from outside suppliers - which will provide an element of predictability in the work loading of the jobbing shop.

But the potential disadvantages are equally common to this type of decision:-

1. There will be a temptation to fill any spare capacity in the jobbing shop with parts manufacture which might

be available at a cheaper rate outside; this may camouflage overmanning and prevent alternative solutions - such as short-time working or redundancies - from being considered.

2. The risk and cost of overrunning estimates in the production of parts will be carried internally instead of a fixed price being agreed with a sub-contractor.

3. If job priorities are not clearly identified, there is the risk of the effects of other short-term jobs on the production of parts by a due date:- If the jobbing shop falls behind on scheduled production, parts will be delayed unless arrangements are made to move them forward in the production sequence but, if such arrangements are made, there may be important effects on the jobbing shop's other orders.

4. Because machinery parts will be ordered from the jobbing shop well in advance of their need in the assembly area and will be introduced early into the shop load as capacity "fillers", their throughput time will be longer and consequently the risk of parts getting forgotten or lost is increased.

5. In assessing the relative performances of the two types of production, a formula will have to be worked out to assess the credit which is due to the jobbing

shop on account of the parts it manufactures for the assembly area:- This transfer price or opportunity cost evaluation may be difficult to work out if the problems above should occur.

2.5.2 Processing

2.5.2.1 Layout

Given the separate siting of the two units, the different layouts required do not present a problem.

2.5.2.2 Production Planning

One of the problems in this area has already been mentioned above under "Labour". The two types of production have different requirements in terms of the number of specialised pre-production staff and a decision must be taken both as to whether to aggregate the staff in an attempt to maximise labour utilisation or delegate them to specific production units and as to how, as an overhead, their costs should be apportioned to each unit.

Clearly, sufficient pre-production staff must be maintained to deal with the greater requirements of the machine assembly unit and there may possibly be savings on the number of senior administrative staff employed where common functions, such as purchasing, can be subordinated to a single departmental manager. Methods of grouping together activities in this type of firm will be proposed in detail later, in section 2.7.2.

2.5.2.3 Production Control

Here, also, there is a great difference in the numbers of staff required. More indirect staff will be found on a jobbing shop floor than in an assembly area. Besides foremen, labourers and storemen which are required in both, progress chasers, production control staff and booking clerks will also be found in the jobbing shop.

The data processing requirements of the two are also different but, if it is decided to computerise data processing for the jobbing shop, data collection for the assembly area - which would not justify computerisation on its own - might, with saving of clerical time, be incorporated into the same suite of programs. If a limited budget is available for computer aids, it may be difficult to evaluate objectively the comparative advantages of expenditure to assist production planning in the assembly area or to aid production control in the jobbing shop area.

2.5.2.4 Production Activities

That all products are expected to be of a high standard allows a single policy to be adopted for quality control. A single Inspection Department can thus deal with all work, though the assembly area has an additional requirement in the form of testing, commissioning, installations and servicing engineers.

2.5.3 Outputs

2.5.3.1 Products

All products are highly specialised and there is a considerable degree of variety in each type of production. There may, however, be some degree of repetition in both types of manufacture:- Larger tooling contracts can involve the staged delivery of a number of identical products, over a fairly long period of time; it is logical to expect that a machine which has proved to be successful for one customer in a certain industry will be in demand from other customers within the same industry. In the latter case it has been noted already that a firm's growth potential may depend on its ability to establish a set range of machines which will produce the basis of each year's turnover.

2.5.3.2 Sales

A totally different sales approach is required for the two types of manufacture. With the exception of possible major tooling contracts, individual jobs will not have a decisive influence on the achievement of the output target, which is likely to be set at an average level for each month, aimed at an anticipated profit for the year as a whole. The emphasis will be on dealing efficiently with incoming enquiries and on post-order sales liaison to keep customers informed of progress and any delays. Price negotiations are only likely over major contracts, and market research and sales forecasting will have little value after the initial study to identify the potential demand for the services offered. The geographical area of the market will be limited, at the most, to the country in which the firm is based, since the value of the products will not justify high transport charges or importation tariffs.

Fall down on delivery on any machine assembly, on the other hand, will have a significant influence on the achievement of output targets for a given period, since these targets will be composed of the individual prices of jobs scheduled for completion during that period. In this type of manufacture, the number of expensive pre-production staff employed and the long throughput time of orders make long term forecasting essential. Market research and an active marketing policy of investigation and negotiation of potential orders become very important.

Accurate costing of jobs ensures both that the firm will be as competitive as possible in its quoted price and that the risk of losing money on the contract will be as small as possible. It also gives those negotiating with the customer a measure of the leeway for offering a discounted price. Post order sales liaison remains important in order to keep the customer informed of progress and any changes from the original scheduled date for delivery.

The geographical area of the market is not as limited as that of jobbing shop machining and toolmaking. The value of the finished product will justify transportation over greater distances and, according to the degree of specialisation of the machinery produced, markets may be world wide. This will naturally result in greater outlay in the pre-order period to cover the negotiating procedure and will also increase the cost of providing installation and servicing engineers.

2.5.3.3 General Economic Characteristics

Here also there are essential differences between the two types of production. Jobbing machinery is labour intensive where machine assembly is capital intensive. A combination of the two, in which the jobbing shop is producing some of the parts required by the assembly area, increases the labour content of the total job cost but does not significantly affect the total amount of capital which is tied up in the kit of parts for any machine.

One potential advantage is that "in house" production of parts might lead to a lower overall cost through the saving of sub-contractors' profit margins, but this depends upon the ability of the internal facility to complete in terms of the variable factory cost, and efficiency against job estimates. The costing advantage of buying machined parts from sub-contractors is that a fixed price is agreed beforehand and it is the sub-contractor who then takes the risk of any machining inefficiency. Use of sub-contractors would thus make costing of enquiries more predictable and accurate.

Funds need to be set aside for the replacement or addition of expensive general purpose machines which are used in jobbing machining, whereas limited provision for equipment needs to be made in the machine assembly budget. The amount of capital invested in plant makes the jobbing shop much more expensive to set up, but once set up it requires a relatively smaller pool of capital to keep it going: Despite high work-in-progress stocks, capital will be tied up in this type of work in smaller amounts than in the extensive kits of parts for machine assemblies, although if a system of payment by instalments can be introduced for the latter, the customer will be providing some part of the capital investment.

On the other hand, in machine manufacture it will be necessary to set aside some portion of annual profits for use in research and development, both to keep existing machines competitive, and to finance investigation of potential new products. No such arrangement will be necessary in jobbing toolmaking, where the customer will provide or directly finance any design work necessary and development work will not be required.

2.6 Relating Characteristics to Organisational Structure

The remainder of Chapter 2 outlines briefly the way in which the above characteristics of the two types of manufacturing, and the problems envisaged in their combination within a single business, might be most appropriately handled in terms of internal organisational structure.

Two possible approaches were examined:-

1. A total systems, or cybernetic, approach.
2. An organisational analysis approach.

2.6.1 Total Systems Approach

For two basic reasons it was decided that this approach, as laid out in various works by S. Beer (50), was not appropriate or practicable for use in a single division within a firm:-

1. Cost

   The small scale of the business under examination meant that a limited budget could be designated for the provision of control and information systems. However, given the highly complex production control problem, noted in the characteristics above, sophisticated computer "software" would have had to be developed. A total system such as Beer suggests would also have required a large initial outlay on "hardware".

2. Unproven Nature of the Theory

   Clearly there was a risk involved in making an experiment in cybernetic management, since there was no successful precedent to follow. In Chile, under Allende, Beer had attempted to put his ideas into practice at a national level. The results, in terms of the effectiveness of the system, were inconclusive, but the fact that the method was unacceptable enough to a portion of the population for it to be discontinued following Allende's fall casts doubts on its applicability in a complex industrial environment where the human factor was so important. Without substantial re-education of the people involved, such that the system was accepted as beneficial to all, a microcosm of politics, in the form of industrial relations or even individual workers, might render the system inoperable. Taking into account the specific financial situation of the subject firm (outlined in section 1.6) the risks involved in attempting to adopt a total systems approach were unacceptable.

A number of important observations are made by Beer in making out his case, however. These will largely be referred to where relevant in the rest of this section, but two warnings which he gives are worth noting at the outset:-

1. "The firm is always dangerously short of information, about itself (and) about its environment".(51). He cites the example of two British Prime Ministers who, in 1952 and 1972, noted that their economic policy decisions were based upon data which were respectively twelve months and six to eight months out of date. (52) The problem is also noted in a paper by Bostock: More up to date information is expensive, and it is hard to justify the need for it by cost/benefit analysis. (53)

2. Traditional control systems are not swift enough in reacting to changes. What Beer refers to as the "relaxation time" (time required for the systems to be returned to a "homeostatic" or stable situation) is now longer than the interval between "shocks" to the system, because of the greatly increased pace of change. This could lead to exactly the wrong control decisions being taken (illustrated by Beer's figure 1, appended to "Fanfare for Effective Freedom"(54).

2.6.2 Organisational Analysis Approach

The remainder of Chapter 2 adopts this approach in suggesting what form the internal organisation of the firm should take. Four basic areas are examined:-

1. Hierarchical Structure - the number of levels of management and the spans of control of managers.
2. Horizontal Structure - the method of grouping activities together within the business.
3. Integration and co-ordination - information systems.
4. Decision and Control Systems

The contingent factors upon which assessments must be made in all these areas concern both the characteristics of the firm as noted above - diversity of product
size of organisation
production technology
personnel

and also the firm's operating environment, since it does not and cannot exist in isolation but depends upon services and a market outside itself.

2.6.3 Definition of Major Terms

Brief descriptions of major terms employed above and to be used again in the remainder of the section, are given below. Selection has been made from various sources (55) according to relevance to this project. It is not intended to suggest that those listed are in any way necessarily definitive or more correct than other definitions which have been given to the same terms.

1. "Organisation Structure is a means for allocating responsibilities, providing a framework for operations and performance assessment, and furnishing mechanisms to process information and assist decision-making" (56). Structure is thus taken to mean much more than simply the pattern of hierarchical status within the firm:- It is the total pattern of its internal mechanisms devised with the intention of assisting or facilitating the attainment of its objectives. Kast and Rosenzweig draw a distinction between "the static aspects (the structure) and the dynamic aspects (the processes)", but the difference is largely academic - the same authors note that structure and functions (processes) cannot be looked at in isolation from each other(57).

2. "A system is a set of objects together with relation-

ships between the objects and between their attributes, connected or related to each other and to their environment in such a manner as to form an entirety or whole" (58). Any firm dealing with outside agencies is classed as an "open" system, although this is implicit in the above definition. Mallen stresses the need for a "definable overall task to accomplish or goal to achieve" (59) - a "raison d'etre" - but this could be interpreted as a means of establishing its "wholeness" or "oneness". The term has been defined much more broadly:- "Any organised and coherent body of knowledge"(60): "A combination of things forming a unitary whole"(61). These, however, are considered a little too general for the present purpose, especially as they lay no stress on the part played by the environment.

3. System boundary is purely a term which "clearly discriminates between what is in the system and what is in the environment" (62). The boundary may thus be a matter of convenience or strategy, as was the case in the setting up of this project: Management of the subject firm decreed that work should concern Plant and Equipment Division's Coventry operations and that both the Division's Leicester subsidiary and its Engineering Group colleagues and overloads were to be treated as part of the system's environment.

4. An interface is "the area of contact between one system and another" (63). Internally this is an area

where it will be an important role of management to ensure efficient integration between various departmental sub-systems. Between a system and elements of its environment, interface or "boundary spanning positions" control exchanges of energy, materials, people, money and information, and also attempt to balance possibly conflicting needs of internal and environmental factors - for example customer demands against efficient production requirements. (64)

5. "The environment of a system includes not only that which lies outside the system's complete control, but that which at the same time also determines in some way the system's performance".(65). In theory everything outside a system is potentially part of its environment, but in practice a firm can only afford to concern itself with what Beer terms the "relevant external world" (66). Both Ashton (67) and Kast and Rosenzweig find it useful to draw a distinction between factors which affect business as a whole - the "general" or "societal" environment - and factors which have a more direct effect on an individual organisation - the "specific, task environment".(68) In the former category they place such things as the national and international economic situation and government policy decisions. The task environment contains, for example, changes in customer demands, competition for customers and suppliers and the corporate financial situation. In the case of the subject firm, as will be detailed later, the "petty-

political" environment of the Division and its status within the Group and the Union was one of the most important features of the task environment.

2.6.4 The Operating Environment of P & ED

In order to keep discussion of features of internal structure to relevant areas, it is necessary to make general reference to the type of operating environment which any structure has to work within. The subject firm had a "variable operating environment" which meant that there was increased uncertainty in managerial decision making. Child (69) notes that the available research suggests that variability might affect organisational structure in the following ways:-

1. Arrangements to reduce uncertainty - attempts to gain greater control over the conditions under which inputs are acquired and outputs disposed of.

2. A relatively high level of internal differentiation - employment of more specialist staff than internal contingencies would normally make likely.

3. Intense integration through flexible and participative rather than formalised processes.

Child notes an important reservation:- There is a "lack of conclusive evidence to demonstrate that matching organisational designs to prevailing contingencies contribute importantly to performance ..." (70). Both the Woodward research group (71) and C. Perrow (72) have failed to provide conclusive proof for their theories attempting to link technological contingencies to performance. Perrow stresses the lack of proof for his theories, while Woodward's practical field research culminated in several observations which were unfortunately not based upon any precise measures of performance.

The structural model which is laid out below is not thus proposed as the definitive and sole solution, but merely as a suggested pattern which seems to be logical. It will be the business of later Chapters in this thesis to identify any ways in which this structure might be inappropriate.

2.7 An Organisational Structure for the Subject Firm

Figures 2.4 and 2.5, are organisation charts expressing exactly the same structure in two different ways. The former perhaps shows the hierarchy of authority and status and direct lines of responsibility more clearly, while the latter (figure 2.5) gives an idea of the way in which the structure is expected to function.

Before noting the reasoning behind the proposed structure, it is worth noting that there are drawbacks to the organisation chart approach. No two dimensional chart can hope to show the whole picture of a three dimensional situation. Both Hicks (73) and Kast and Rosenzweig (74) criticise aspects of use of the chart, but conclude that it provides a useful starting point. Beer (75) considers them solely "competent to apportion blame" or "show how the chain of command is organised". However, his alternative "Multinode" chart seems to sacrifice clarity in these respects in search of a method more closely demonstrating the pattern of

Figure 2.4 Suggested Organisation Chart for a Machine Assembly and Jobbing Toolmaking Business (76)

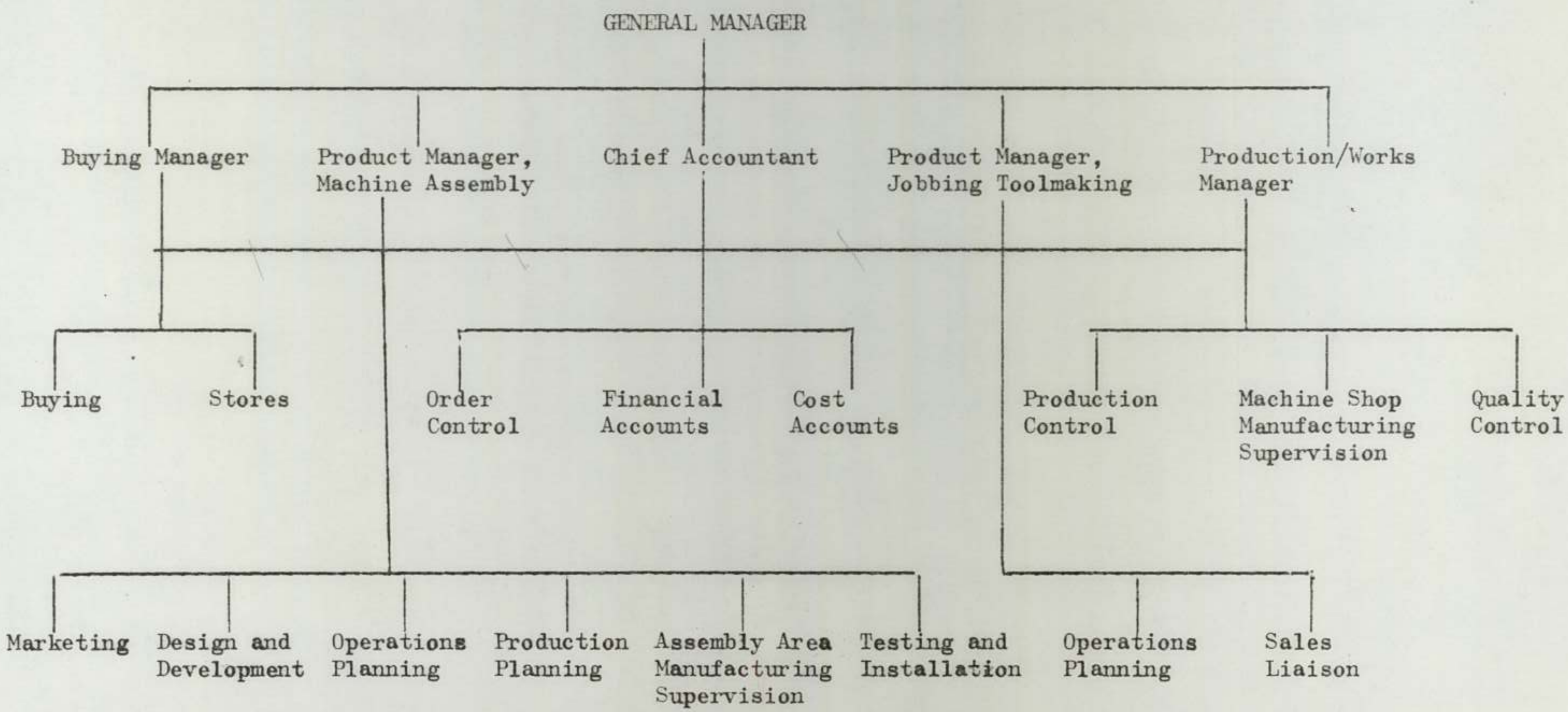
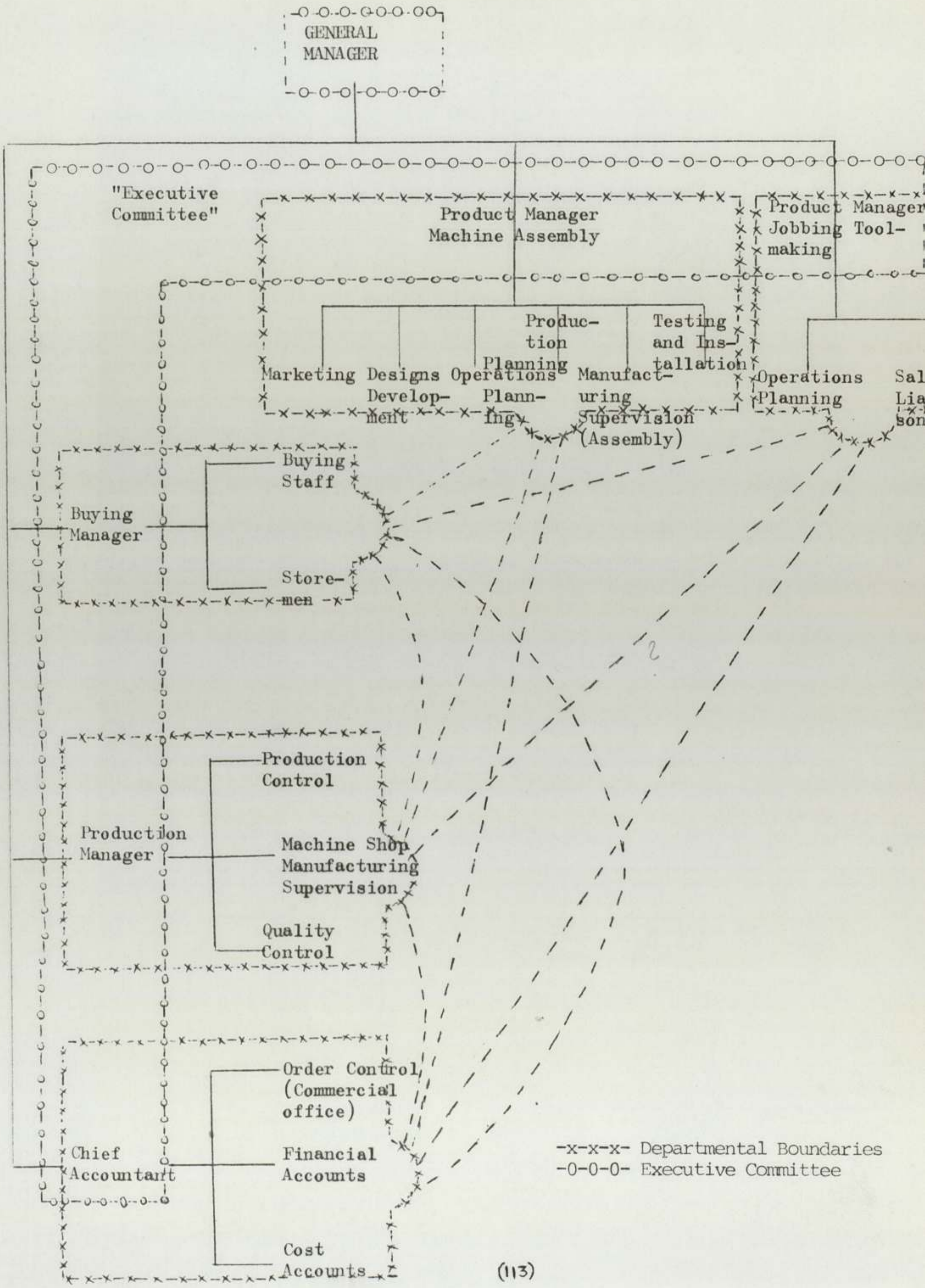


Figure 2.5 Outline of a Mixed Structure for a Machine Assembly and Jobbing, Toolmaking Business (77)



internal communications and inter-relationships, which undoubtedly exist, across the straightforward lines of responsibility.

Figure 2.5 represents a form of compromise, showing actual lines of direct authority, and superimposing lines delineating the various sub-systems, and dotted lines accepting the absolute necessity of communications between the sub-systems.

2.7.1 Hierarchical Structure

In line with Woodward's conclusion on unit manufacturing firms (78) it is suggested that there should be three levels of management:-

1. Chief Executive
2. Departmental Managers
3. Section Supervisors

The size of the business under consideration makes it essential on grounds of economy to keep the management group as small as possible. It is also suggested that the "flatter" type of structure, giving increased discretionary power to subordinates results in a better motivated workforce, though Child notes that behavioural theorists have not yet produced any quantitative data to back this up (79).

The span of control of the Chief Executive is five, as against Woodward's average of four (80). The increase results from the establishment of a matrix or mixed type of structure in which there are both two Product Managers and an independent Production or Manufacturing Manager responsible for resource allocation and capacity planning in the machine shop. Figure 2.4 does not specify all individual supervisors, but it is envisaged that the span of control of Departmental Managers would not exceed six: For example, the Production Manager would have a Production Controller, a Chief Inspector and four foremen reporting to him. Supervisory spans of control would be different from one area to another according to different job content: Whereas an Estimating Supervisor would also have his own job estimating duties to perform and might only be able to deal with work allocations and problems of a staff of about four, a shop floor foreman acting solely in a supervisory capacity would be expected to manage not less than 20 operatives.

Child (81) notes that research suggests that the more complex the work and the greater the variety of products, the lower in fact will be the supervisory spans of control. Against this, however, it must be noted that more complex work will of necessity require more skilled machinists and fitters which might be expected to decrease the number of problems which need to be referred to the foreman. Also, whereas unavailability of a supervisor to sort out difficulties in a flow line production environment will have an immediate effect in the form of lost production, in a unit manufacturing situation, especially where there are more machines than men, the machinist can move on to another piece of work until the foreman is free to deal with the problem. The effect of these two points would be that the management in the flow-line environment would "play safe", employing more supervisors than it genuinely needed in the normal course of events, while the unit producing firm would be inclined to look for savings by minimising the number of staff in this area. As a result less of a difference could exist between supervisory spans than judgement purely on production technology grounds would suggest.

2.7.2 Grouping of Activities or "Horizontal Differentiation" (82)

The method of grouping activities together which appears most logical for use in a small firm with two such distinct types of product is the "mixed" structure (figure 2.4). Economic considerations make it appropriate to centralise some services, while at the same time diversity in markets served argues for division of marketing into product or area groups. In this situation, services would not be guaranteed to be available immediately to individual operating units but the number of specialist staff required could be kept to a minimum. (83)

For example, Engineering Group, at Coventry, had established a central computer together with a service staff of programmers and analysts available for the use of all operating divisions. The capital cost of the computer would have placed it beyond the budget of, certainly the smaller divisions - Suspensions, Redditch Mouldings and P & ED. By centralisation a sophisticated range of hardware and software was made available, and costs were shared by the users according to the proportions which they could afford to bear.

P & ED itself was an example of another problem which a pooling of resources could create in that potentially the other Engineering Group Divisions, and P & ED's own assembly area for that matter, were in competition with each other for toolmaking capacity, whereas a strictly functional grouping of activities would be suitable for jobbing toolmaking or, with the addition of the temporary project teams, for machinery manufacture individually, a combination of the two into a single division of limited size will produce "cross-cutting strains and stresses": Adopting a matrix structure becomes a matter of convenience, it "is simply reflecting a situation which objectively exists in any case". (84)

A product structure for the horizontal grouping of activities could not be justified unless the demand for services of each product type was predictable, allowing precise allocation of the necessary specialist resources. In any unit manufacturing businesses, predictability would be unlikely.

The problems of taking "make or buy" decisions on non-standard manufactured parts for machine assemblies have been noted in section 2.5.1.4. An increased isolation of the two manufacturing units, under a product structure, could exacerbate these problems - benefits to the firm as a whole might not be considered if they favoured a policy which did not maximise the profits of a machine assembly product group. On the other hand, functional organisation could lead to overdependence of one unit or the other, which again might be against the best interests of the business as a whole. A simplified example of these potential situations is given in Appendix 1 to this chapter.

2.7.3 Integration and Co-ordination - Information Systems

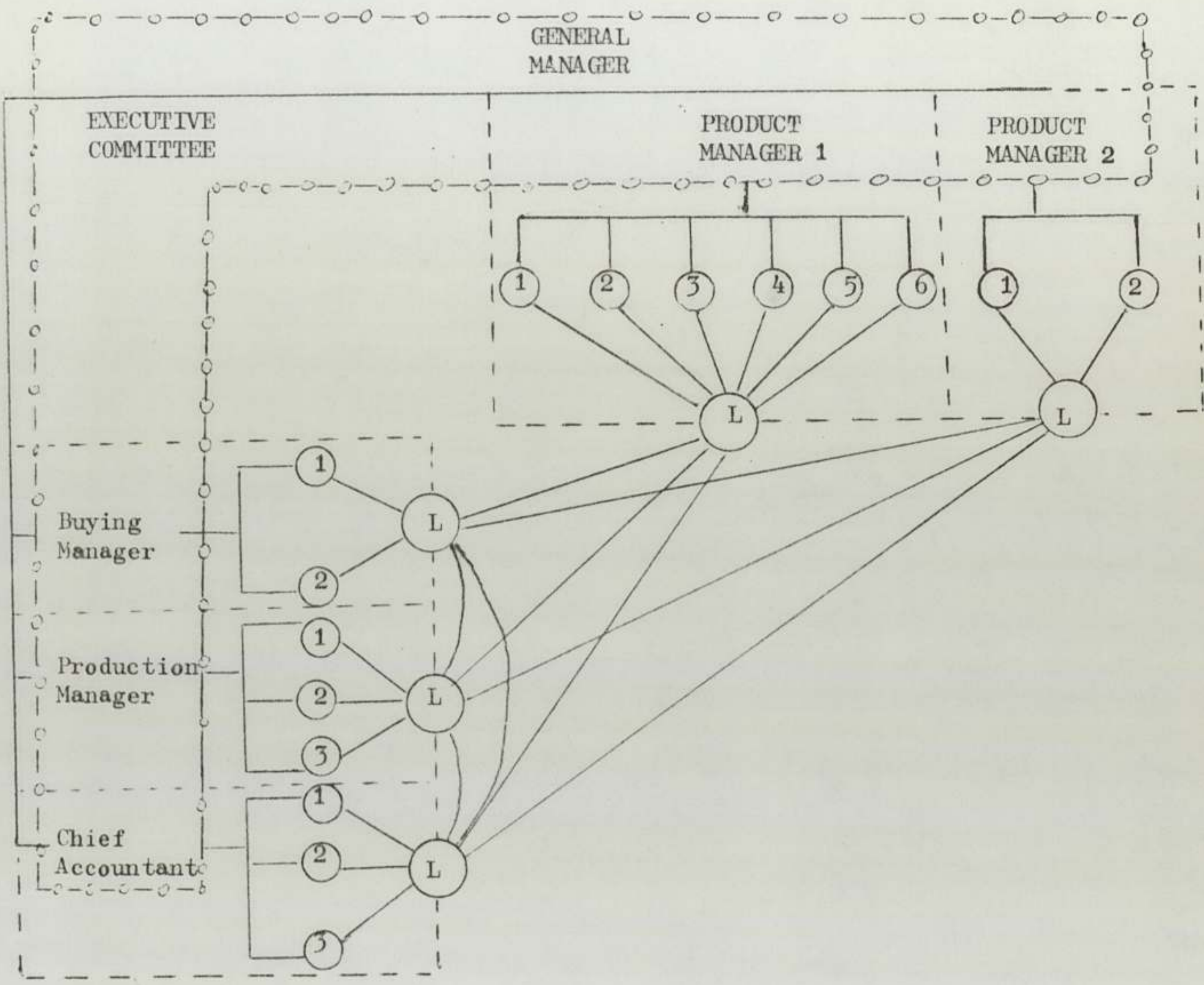
The difficulty with these "make or buy" decisions amply illustrates how essential the co-ordination of internal efforts is in a business such as the one under consideration. Three types of integrative mechanisms are identified by Thompson (85) and by Litterer (86) and these amount essentially to the same principles:-

1. Standard orders and procedures
2. Semi-formal, flexible plans and schedules for inter-departmental co-operation
3. Integration through mutual adjustment in whatever way may be expedient.

As size and predictability of operations increases, so the accent is placed upon more formal and impersonal procedures. The uncertainty and variety of the subject firm would be expected to result in more use of the second and third mechanisms:- Lawrence and Lorsch found that strictly formal, programmed integration was less competent to co-ordinate activities in such a situation and that lateral communications and group meetings tended to be used instead. (87)

Formal procedures can be laid down for the flow of paperwork between departments, but an inter departmental committee will be more appropriate to help to co-ordinate job progress through the pre-production departments. Even less formal word of mouth communications may be the best form of feedback on machine shop progress and the best method of giving a job an over-riding priority. Major machine assembly projects, requiring the full-time attention of at least a project engineer and a group of fitters, might be handled entirely outside the normal channels of the organisation by a temporary "task force", from which a

Figure 2.6 Integration of Subject Organisation through Liaison Officers



L Liaison Officer

3 Ringed numbers represent departmental sub-groups (identified in figure 1.2)

— — — Departmental boundaries

—o—o— Executive committee

total picture of progress would be reported from time to time. In the subject business this was less likely to happen because pre-production departments were involved at different stages and for varying lengths of time: There was no need for a continued full-time involvement on the part of an estimator, or a buyer, beyond the performance of his specific function.

Thus, inter-departmental committees would be expected at two levels:-

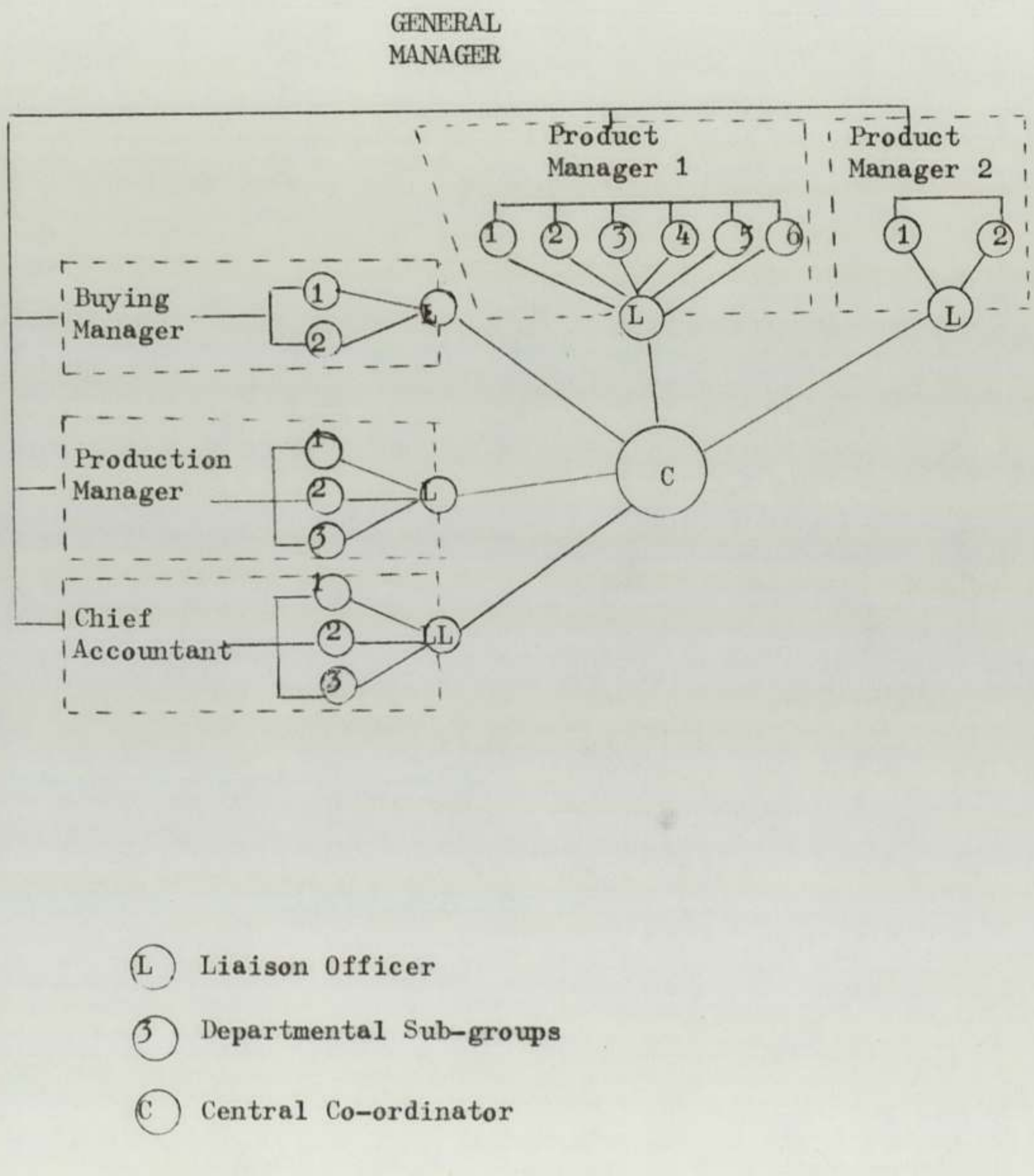
1. The executive committee; framing general policy and ensuring unity of purpose.

2. The progress liaison committee; dealing with specific jobs and containing a liaison representative from each area involved (as suggested in figure 2.6).

But this would not be expected or wanted to eliminate "third level" informal inter-departmental communication, necessitated by the large number of "exceptions" which inevitably occur in unit manufacturing.

Beer suggests that a central control room, along the lines of Britain's World War Two operations centre, or America's Mission Control at the Houston Space Centre, should be set up (88), and Child has a similar, if more limited, idea in mind with his suggestion of a special integrating role, or "co-ordinator". (89). Figure 2.7 shows how such a "clearing house for information" might help to reduce the number of relationships within the organisation, but this again would be able to cover only formal or

Figure 2.7 <u>Integration Using A Central Co-ordina tor</u>



semi-formal information processing and could not replace important low level communications.

One of the major reasons for this conclusion was that economical use of computer aids, because of the variety produced by the one-off character of the business and thus the high number of exceptions to any routine reporting procedures, was not likely to be possible. Beer's cost estimate of £10,000 (90) for the necessary hardware is not backed by any hard data and in any case, it is basically irrelevant since the main factors in costing a system would be the cost of developing the software and the ongoing expenses of the system (personnel, maintenance charges, etc.).

2.7.4 Decision & Control Systems

The limitations and potential expense of computer aids affect also the selection of decision and control mechanisms - indeed, this area and the question of integration are essentially linked together. The difference between the two is that whereas control is concerned with the vertical or hierarchical dimension, the transmission of orders, integration works in the lateral or horizontal dimension ensuring that departmental activities are orientated towards the same goals(91).

The central problem faced by a unit manufacturing firm of the type under discussion is quite precisely that:- "The greater the system's variety, the greater the control variety, and the greater the costs" (92). A small firm will not be able to afford heavy investment in control aids, or even perhaps the exhaustive studies preceding the recommendation of aid programs.

Nor will it be able to afford the higher managerial overheads required to allow decentralisation of important decision making. The Chief Executive will remain in sole charge of all strategic, policy decisions and there will be limits to the discretionary power allowed at each managerial level, though, in the interest of senior managers having time to look at wider issues, not every single decision will require their personal authorisation. (93). A Purchasing Manager, for example may elect to have all orders over a certain value referred to him, or all orders exceeding the job estimate.

Uncertainty and unpredictability, it has been noted earlier, make formal methods of integration and control less applicable in the environment under study. There are likely to be a number of distinct levels making up the control pattern of the firm. Not only will matters above a certain level be beyond the authority of an individual, but also matters below his level will be more effectively dealt with by his subordinates: One would not, thus, expect a General Manager to know which machinist was best suited to doing a certain turning operation as well as the foreman of the turning section. The General Manager, probably in consultation with his executive committee sets production objectives; departmental managers make general decisions about production methods and the order work should be done in; supervisory levels specify the details of production and allocate the work as appropriate.

Combination of the two product types produces a problem when considering the amount of discretion over job selection to be allowed to individual machinists. Whilst it is true that foremen will be able to judge the suitability of work for an operative, the operative himself is probably the only one who can determine which of the available work is best suited to his particular talents. Because of the development of specialist skills through experience, maximising utilisation of the labour force depends upon allowing discretion to machinists, with the proviso that the foremen retain the right to allocate when necessary - to cover urgent work, for example. As machinists' wages in the subject firm were based solely on the number of hours worked during a week, maximum utilisation represented probably the only method through which P & ED's machine shop could be competitive with outside sub-contractors.* While a system allowing job selection by machinists would work adequately in most cases for tooling jobs, it would create major problems with parts for machine assemblies where the assembly shop was relying on the arrival of all components by a set date.

Machinery parts thus require control through due date scheduling, but are produced alongside tooling work which is largely un-programmed. There is a definite case for having two different types of identity tag to distinguish between the two types of work and make clear for the foremen and progress chasers which jobs might require action from them if not selected by machinists by given dates. This would also have the advantage for the Production Controller that he would be able to see, through a glance at section material racks, the amount of work in each of the two categories which was on the shop floor at any given time.

Actual control of shop floor activities by the production

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* for reasons explained earlier, in section 1.2.4.

supervisory staff would be reduced to a process of "managing the exceptions" if it did not prove possible to devise an economical and effective computer scheduling system. Control, then, would depend upon monitoring feedback on actual shop floor events and taking action in a small number of cases where there was a danger of not meeting a definite delivery requirement (94) - internally this would make kits of parts for the assembly area the most important items to monitor. The provision of accurate and up to date feedback reports to the production control section would be vital in making timely and successful corrective action possible.

CHAPTER THREE

DEFINITION OF THE PROBLEM AREA

3.1 An Overview of P & ED & Its Problems

Chapter 1 introduced the operating environment of P & ED, the historical development of the Division and the resources at its disposal at the time the project commenced. Chapter 2 described the characteristic features of the types of business in which P & ED was involved and, taking into account some of the general features of the operating environment, proposed a possible pattern of organisation for the Division.

In both chapters, some general and some specific observations have been made regarding potential shortcomings or difficulties, either inherent in the attempted combination of toolmaking and special purpose machinery production or noted by previous researchers as being common in intermittent manufacturing. This section will examine in detail the problems identified in the subject division's organisation and operations under the following headings:-

1. Quantification of P & ED's problems.
2. Evaluation of the existing product range.
3. Examination of resources employed.
4. Problems with the chosen internal organisation & structure.
5. Deficiencies in internal co-ordination.
6. Processing control problems.

All of these problems will then be put in perspective against the influence of the most important part of P & ED's operating environment - its petty political position, or status within the Engineering Group.

Ultimately, the aim is to find the root causes of the Division's problems and thus each individual problem area noted above must be considered, not just in its limited context but as a part of the whole. The above headings are proposed as a matter of convenience and attention will be given to showing the obvious links which exist between them. The need for such a holistic approach was pointed out in the preamble to the previous chapter, but is worth re-emphasising here. Buffa sums up the position excellently:-

> "To understand the whole, begin with the whole, not with the components! This is not to deny the importance of understanding the components, but it reorients the focus of our examination of the components; in a systems orientation we view a component in terms of its reason for being as a part of the system. Thus, systems concepts take advantage of the results of both viewing the system as a whole and analyzing the proper role of components within the system". (1)

While it is acceptable to breakdown an organisation into its elements for the purposes of study, therefore, these elements or components must be considered with reference to their place in, or contribution to, the whole:-

"In its functioning and behaviour, the whole system is greater than the sum of its parts. One subsystem affects the others; therefore, system performance will not be represented adequately by simply summing up the performance of each subsystem". (2)

The management of the subject firm suggested that the starting point for the investigation should be the P & ED machine shop. It was here, they felt, that the Division's problems were most apparent. Initial observations confirmed that there seemed to be a total lack of control over events on the shop floor: The Production Controller was unable to predict, with any accuracy, the expected completion dates for jobs or indeed to state which jobs were in progress on the shop floor and which were being held up for any reason.

However, observations in the machine shop suggested that P & ED's problems went beyond the question of control over processing: Demonstrations of the importance of P & ED's petty political situation were apparent in the form of interference by procurement officers from other divisions in the Group and there was a lack of co-ordination between the shop floor and the administrative departments of the Division shown, for example, in the failure to communicate vital information to the shop floor on expected and revised delivery dates for materials or component parts.

The investigation proceeded to an analysis of the organisation of the administrative departments and the flow of information between the various component subsystems of the business. The total structural framework of the Division was also examined. It was then possible to begin to draw some con-conclusions as to the root causes of P & ED's problems.

As a prelude, however, it is important to develop a quantified picture of how serious the problem was, both in financial terms and in terms of production performance.

3.1.1 P & ED's Overall Financial Problem

An introduction to the size of P & ED's financial problem was given in section 1.6, with reference to statistics produced in figure 1.9, and a few points were noted where the bare figures seemed to indicate that problems might exist. This section examines in greater detail, although still in terms of total annual figures, the financial results of the Division in the five years between January 1970 and December 1974 (3).

In figure 3.1 two tables are produced as the basis for an examination of the three elements which would be expected to hold a dominant influence over the Division's finances:-

i) turnover;

ii) contribution (turnover less allocated costs);

iii) apportioned costs, or, as they were called within the Division, constant overheads.

The columns in the two tables have been numbered for ease of reference in the text.

FIGURE 3.1 P & ED ANNUAL RESULTS 1970-1974

(Source - P & ED Product Results Tables, 1970-1974
- Appendix 1 to Chapter 1)

TABLE A TURNOVER & CONTRIBUTION FIGURES, 1970-1974

Year	Planned Turnover (£'000s)	Actual Turnover (£'000's)	Percentage Of Plan Achieved	Planned Contribution (£'000s)	Actual Contribution (£'000s)	Percentage Of Plan Achieved
1970	3,034	2,242	74	995	437	44
1971	2,754	2,184	78	770	584	76
1972	2,870	1,981	69	777	596	77
1973	2,711	2,524	93	782	710	91
1974	2,290	1,895	83	619	466	75
5 Year Totals	13,659	10,826	79	3,943	2,793	71

TABLE B CONSTANT OVERHEADS* & FINAL RESULTS 1970-1974

Year	Planned Constant Overheads (£'000s)	Actual Constant Overheads (£'000s)	Actual As Percentage Of Planned	Actual Contribution + Grants & Royalties (£'000s)	Actual Net Profit/ (Loss) (£'000s)	Planned Net Profit/ (Loss) (£'000s)
1970	749	819	109	443	(376)	254
1971	856	729	85	590	(139)	(80)
1972	765	649	85	631	(17)	15
1973	741	719	97	742	23	61
1974	717	850	119	473	(377)	(63)
5 Year Totals	3,828	3,766	98	2,897	(886)	187

* 'Constants' is the term used in P & ED to signify apportioned costs or fixed costs.

The plan over the whole of the five years shows a total expected profit of £187,000 and an actual loss of £886,000, which makes a total variation from plan of £1,073,000. 1970 was obviously a disastrous year, accounting for £630,000 of this total variation over the five years (59%). Thereafter, predictions seem to have been more accurate, until the final year, 1974, when there was a huge loss of £377,000, representing a £317,000 variation from plan (29% of the total for the five years). The figures from which the variations, listed below as figure 3.2, are calculated are given in columns 5 & 6 of Table B.

Figure 3.2

ANNUAL VARIATION BETWEEN
PLANNED & ACTUAL TURNOVER RESULTS 1970-1974

Year	Variation (£'000s)	Percentage Of 5 Year Total
1970	-630	58.7
1971	-59	5.5
1972	-32	3.0
1973	-38	3.5
1974	-314	29.3
5 Year Total	-1073	100.0

The 1974 figures are probably sufficient to eliminate the idea that the 1970 figures are totally unrepresentative. What must be noted overall, however, is the unreliability of forecasting future annual output totals by using projections based on figures averaged over a number of years. The mean loss over the five year period was £214,600, but the standard deviation from this figure over the five years is £232,886. Clearly the margin which needs to be allowed for error makes average figures inappropriate for forecasting overall annual results, although this will not necessarily be found to be the case with all the individual product groups when these are examined in section 3.2.

In each of the five years, there was a failure to reach the planned turnover figure (Table A, column 3) and consequently it is hardly surprising that the actual contribution figure fell short of the plan (Table A, columns 4 & 5). More significant, however, is the fact that contributions were at a lower percentage of the plan than was turnover for four of the five years (comparison of columns 3 & 6 in Table A).

Examination of the constant overheads (Table B, columns 1-3) shows that they had only a marginal effect on the overall five year total figures, but that they were an important influence in exacerbating the very poor figures for the years 1970 and 1974, and similarly figures lower than those planned were important in keeping down the losses made in 1971 and 1972. If the constant overheads had been at the planned figures, the results for the five years would have appeared somewhat differently, as figure 3.3 shows. In this case, 1970 might well have been seen as a freak year: With that year excluded, the standard deviation for the other four would be down to £49,700, which is still too high to be very useful for forecasting, but is only a little more than one-fifth of the actual standard deviation for the five years noted in Figure 3.3.

Figure 3.3

HOW THE ANNUAL RESULTS 1970-1974 WOULD HAVE LOOKED IF CONSTANTS HAD BEEN AS PLANNED (£'000s)

YEAR	ACTUAL NET LOSS	VARIATION FROM PLANNED RESULTS
1970	306	560
1971	266	186
1972	134	149
1973	1	62
1974	244	181
TOTALS	951	1138

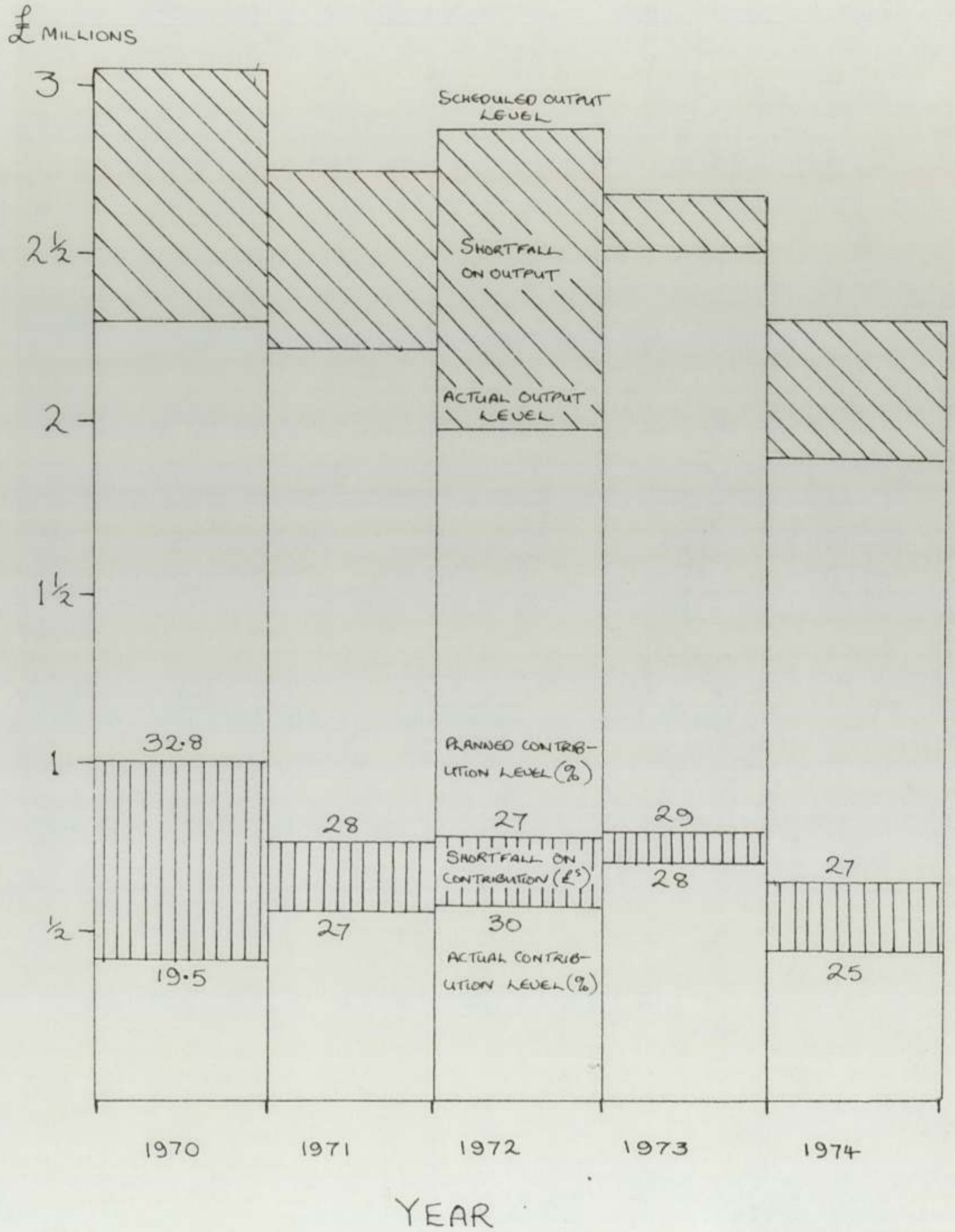
The histogram of the five years' production, see figure 3.4, perhaps provides an easier means of recognizing that there is not really any significant pattern, in overall terms, to explain why any given year was better or worse than another. Even the obvious statement, based on the 1973 figure, that the lower the shortfall on planned turnover or contribution, the greater the chance of having a good year, is subject to the point that figures may be significantly influenced by any alteration from plan of the apportioned overheads, or 'constants'.

Individual product group performance may provide some indications of trends which are reflected in the Division's financial performance and these will be considered in Section 3.2, which deals with each product group individually.

As a profit centre operating division, P & ED had been a total failure for the whole of its short life, with the exception that the figures for 1973 gave a glimmer of hope that it was actually

Figure 3.4

GRAPH OF P & ED PLANNED & ACTUAL OUTPUT & CONTRIBUTION LEVELS 1970-1974



possible for the Division to operate at a profit. The fact that the Division continued to exist at all after such a run of bad results supports, once again, the conclusion that its ability to make a direct contribution to Group profits was not regarded as vital, despite its theoretical existence as a profit centre. However, losses of the size of that recorded for 1974 were clearly unacceptable and impossible to justify in terms of the convenience of an on-site servicing and toolmaking facility.

There were two possible explanations for the failure to reach the planned output levels during each of the five years:-

1. An insufficient workload existed to justify the resources employed within the Division, and/or

2, The Division's performance on work undertaken was inadequate.

General observations on both of these are made below, although more detailed comments will be relevant in Section 3.2, which considers P & ED's existing product range.

3.1.2. Workload

One measure of the sufficiency of the workload is the amount of downtime booked during the year. In 1974, the cost of time booked "waiting for work", amounted to 5.6% of total variable factory costs. However, it would be false to assume immediately from this that the Division was loaded to 94.4% of capacity.

First, as Parkinson suggested: "work expands so as to fill the time available for its completion". (4) In a tooling business with a highly skilled workforce, it is quite reasonable to assume that, if job queues on sections were small, operatives would spend more time on their current work, seeking to achieve a greater degree of perfection, rather than taking advantage of allowed machining tolerances.

Second, the mixture of work performed was also important in the case of P & ED. There was a pool of 39 mechanical and bench fitters available within the Division at the end of January 1975 (5). These could work either in the machine-shop or in the assembly area. However, because the number of indirect employees retained to support the machine assembly operation was proportionally far greater than the number supporting the tooling operation, the actual distribution of the workload between the two types of product was a matter of key importance.

Third, the degree of mobility of the machine shop labour force had been reduced, in practice if not in theory, by the development of particular specialist skills amongst the machinists. It could thus occur that one section was short of work while another was overloaded. No transfer of labour would take place between these sections, in spite of availability of machines in the overloaded area, unless the situation was expected to continue for a long period - a matter of weeks rather than days.

In an attempt to draw some conclusions as to the extent of P & ED's workload during 1974, a theoretical calculation of the capacity of both the machine shop and the assembly area was prepared. The results of this were then applied to the planned and actual output of the Coventry factories during that year. The calculations themselves are included as Appendix One to this Chapter. For both manufacturing areas, labour was the limiting resource, lthough it must be noted that had extra labour been required for assembly area operations, this would have been available on a fixed term contract basis from outside. The Division chose, indeed, to maintain a permanent staff of electrical fitters which was less than adequate to support its normal minimum of 15 mechanical fitters and to make up the balance with contract electricians. Whereas it was possible to re-deploy mechanical fitters in the machine shop "bench" area during a shortage of work electricians had to be carried on unproductive time, or downtime, at such periods.

The conclusions of the workload calculations are considered to be valid in general terms if not, because of several assumptions which it was necessary to make, in detail. In 1974, there was insufficient machine assembly work to meet the costs of the large indirect labour force which was retained to support this type of work. Machine shop work, however, even given that one-third of the labour force was producing, at cost value only, parts for the assembly area, was doing slightly better than paying its way in terms of the contribution made per indirect employee.

The reason for the less than adequate machine assembly load was one, or a combination of, the following:-

1. Restricted capital expenditure by industry at a time of difficult economic conditions.
2. Insufficiently active marketing policy on the part of P & ED.
3. Inability of the Division to match competitors in terms of price.
4. Poor reputation within the market in terms of quality or delivery to given targets.

3.1.2.1. Restricted Capital Expenditure By Industry At A Time Of Difficult Economic Conditions

The first of these was beyond P & ED's control and there can be no doubt that it did play a part in the low volume of machinery orders handled during 1974. This is particularly relevant in the case of Dunlop, or "Union", business, where the other three factors were likely to be less important: An active marketing policy was not necessary, since the Division would almost certainly be informed of any work available; transfer price arrangements and a Union policy of keeping business "in the family", where possible, gave P & ED an advantage over competitors; the quality of products was controlled by central union standards and allowances for late delivery could be made by placing orders earlier than required.

The actual level of union business in 1974 was only 70% of the planned total (6). Having said this, however, it should be added that P & ED might have been expected to have predicted more accurately the effect of the prevailing economic climate on its union machine assembly business.

3.1.2.2. Insufficiently Active Marketing Policy On The Part Of P & ED

Certainly, one would have expected extensive liaison with Union customers in order to establish what demands they were likely to be making upon the Division's capacity during a coming year, to precede estimation of planned output levels. Indeed, with the larger machinery contracts having long pre-production load times, a number of orders would be expected to have been received by the time the plan was drawn up.

Figure 3.5 Percentage of planned output achieved, 1970-1974.

Product Code	Type of Customer and Product	1970	1971	1972	1973	1974
XC	Rubber Technology Equip. - Non-Union Customers			82%	53%	24%
XG	Non-Rubber Tech. Equip. - Outside Customers		123%	11%	34%	59%
XD	Rubber Technology Equip. - Union Customers	74%		96%	92%	82%
XJ	Non-Rubber Tech. Equip. - Union Customers		66%	37%	151%	51%
XF	Tooling - Union Customers (Outside Engineering Group)	47%	81%	56%	120%	96%
XT	Tooling - Outside Customers	32%	131%	65%	61%	90%
ASWR	Tooling - Engineering Group Customers	54%	82%	76%	84%	166%
XB	Modification & Repair Service - Eng. Group Customers	105%	59%	81%	108%	122%
XK	Spares Sales	-	-	108%	115%	85%
XH	Sub-Contract Hardening Service	225%	72%	85%	92%	70%
XU	Installation and Commissioning Service	-	152%	99%	78%	91%
XO	Design Sales	-	-	46%	92%	80%

Notes.

This is the figure for mould-making at the Leicester Susidiary factory.
This is the figure for miscellaneous sales from the Ramsgate Subsidiary factory.
Charges levied for 'fitters on loan'.
This figure includes charges levied for fitters on loan.

From figure 3.5, which shows the percentage of planned output which was achieved for each business category, it appears that only Union tyre machinery business, of the four types of special equipment, was at all predictable in advance, in the years 1972-1974. This supports the conclusion that the Division paid insufficient attention to research into the potential market over the period or, alternatively, that it was not able to command the expected share of the market.

P & ED in fact, retained only a very small marketing department at this time (a Marketing Manager, Sales Manager and Sales Engineer), and relied very heavily on other members of the Union, not merely to provide the majority of machinery orders, but also to pass on information and enquiries regarding possible outside contacts. In terms of outside customers, it had only established a continuing relationship within the Nuclear Processing Industry. If the policy of expanding equipment manufacture was to succeed, a more active policy would be necessary in this important area.

3.1.2.3. Inability of the Division to match Competitors in terms of Price

This problem should only have affected P & ED in negotiations with customers outside the Union because of the favourable transfer prices offered to other Dunlop divisions. Quotation records were not maintained for 1974 and it is thus difficult to come to any definite conclusion as to P & ED's competitiveness in this respect. The 1975 figures will be examined in Section 3.2, when the existing product range is evaluated. Some comment will also be relevant at a later stage on the length of time taken by P & ED in preparing a machinery quotation - this might be over 6 weeks from receipt of an enquiry. For the present, it is sufficient to note that the Division's management was of the opinion that its ability to compete on price was harmed by the need to fill spare capacity in the machine shop with parts manufacture for the assembly area.

3.1.2.4 <u>Poor Reputation Within The Market In Terms Of Quality Or Delivery To Given Targets</u>

In terms of the quality of the finished product, P & ED enjoyed an excellent reputation; this had been the principal influence upon the capture of contracts within the Nuclear Processing Industry. Aside from Union quality standards, the Division also had its own inspectors and commissioning engineers to ensure that both parts and complete machines were produced according to the specifications laid down, and could indeed be swiftly and efficiently modified, if this proved necessary, by the support staff of engineers and draughtsmen.

P & ED's reputation for meeting delivery targets,on the other hand, was far from good and brought complaints even from Union customers. It is not possible to quantify just exactly how much business was lost by the Division as a result of this poor reputation. However, the effect, in terms of lost production potential and late receipt of equipment was definitely quantifiable for the customer and this might be weighed against P & ED's, perhaps lower, price and result in a decision to purchase elsewhere. Alternatively, as already noted, P & ED's probable lateness might be taken into account by ordering early, with the result that if completion should be managed on time, the customer would find reason to stall delivery and thus final payment, until the date at which the equipment was actually required.

The reasons behind inability to meet delivery target dates are given within the next subsection, which considers the Division's performance on work undertaken between October 1974 and September 1975.

3.1.3 Production Performance Evaluation 1974-1975

The system of issuing monthly production schedules and monthly output reports with weekly progress updates, which was introduced by the Production Programming Manager from October 1974, provided the basis for an evaluation of production performance. The figures were collected and collated at the end of 12 months and the Production Programming Manager issued a report based upon them during November 1975. The report is included as Appendix Two of this Chapter. The figures which appeared as appendices to the report are omitted as unnecessary for its present usage.

Main concern here is with the "Major Findings" and "Conclusions" at the end of the report.

3.1.3.1 The Division's Business Mix

The Report lays great emphasis on the supposed decline of the machine shop's "traditional tooling business output" during the year and also upon the "rapid increase" in Assembly Shop output. This is described in terms of a "major change in business mix". The assessment was based upon the comparison of late 1975 figures with an end of the 1974 situation which proves, upon examination, to have been far from typical.

Figure 3.6 traces the changes in the business mix throughout the

Figure 3.6. Planned and Actual Business Mix, in terms of Output and Contribution. (Figures are percentages of annual total.)

A. PLAN		Machinery				Tooling				Other Business							
YEAR	PRODUCT CODES	XC	XG	XD	XJ	AS WR	XB	XF	XT	XK	XH	XU	XO	I	2	3	4
1970	OUTPUT		48			24	6	-	-	-	1	-	-	1	-	8½	11
	CONTRIB		43			25	9	-	-	-	1	-	-	½	-	8½	13
1971	OUTPUT	17		37½		14½	8½	7	3	-	3	-	-	1	-		9
	CONTRIB	20½		25		14	12	8	3	-	6	-	-	½	-		11
1972	OUTPUT	10½	8	22	14½	18	5½	7	7	2	2½	-	1	1½			
	CONTRIB	11	9	17	11	19½	8	7½	6½	3½	5	-	1	1			
1973	OUTPUT	14½	4	31	13	15	5	5	6½	2	2½	½	1				
	CONTRIB	19	3	28	9½	14	7	4½	5½	3½	4½	½	1	NEW PRODUCTS			
1974	OUTPUT	11	6½	24½	19	13	5½	6	6½	3½	3	½	1	XN	XL	5	6
	CONTRIB	15	6	21	16	10	8	4½	6	5	6	½	1				
1975	OUTPUT	6	15½	15	7½	11½	4½	5½	10	2	2	½		13	4½	2½	·
	CONTRIB	6½	16	17	7	9½	4½	6	7½	3	3	½		13	5	2½	·
B. ACTUAL																	
1970	OUTPUT		48			17	11	-	-	-	4	-	-	1	2	5	11
	CONTRIB		29			22	22	-	-	-	6	-	-	1½	3	3	13
1971	OUTPUT	26		31		15	6	7	4½	4	3	-	-	2	-	-	1½
	CONTRIB	30		18		16	11	8	3	7	5	-	-	1½	-	-	0
1972	OUTPUT	12	1	31	8	20	6	6	7	3	3	1	½	1	-	-	-
	CONTRIB	15	1	28½	6½	17½	8½	5	5½	5	5½	½	½	1	-	-	-
1973	OUTPUT	8	4	31	21	14	6	7	4	3	2½	½	1				
	CONTRIB	13	3½	28	18	10	8	5	4	4	5	½	1				
1974	OUTPUT	3	5	24	12	26	8½	7	7	3½	2½	½	1				
	CONTRIB	4	2½	15	9½	36½	12	7	2½	6	4	½	1	XN	XL	5	6
1975	OUTPUT	10	5	22	8	12½	8	6½	13	4½	4	1	1½	3	0	0	·
	CONTRIB	16	½	22	7½	13½	13½	10	5	7½	7	1½	2	-1½	0	0	-5½

Notes. (Product Codes)

I - Fitters on loan
2 - Factored Goods
3 - Leicester subsidiary factory
4 - Ramsgate Subsidiary factory
5 - Weighpads
6 - Stock adjustment

period 1970-1975, as measured in terms of the percentage of the total annual output and contribution brought in by each product code. Whereas the percentage of annual output produced from tooling work fell away in 1975 as compared with 1974, the proportion of output which it made up was higher than in any of the years 1970-1973, and conversely machinery rose as a proportion of total output by only a half of one percent in 1975, as against 1974, and was below the level of 1970-1973.

Looking at the rather longer term picture one is led to conclude not that the Division was experiencing a new development in terms of its business mix, but rather that in an unusually poor year for machinery sales, the Division attempted in 1974 to cover its fixed costs by expanding tooling output. The huge end-of-year loss which was recorded demonstrated that although direct labour resources might be moved from one type of manufacturing to the other, tooling businesses could not be looked to support the very large indirect labour force required for machinery manufacture at times when machinery demand was low. The natural result of this was that the importance of actively pursuing machinery orders became more obvious; along with assessing the potential and limitations of the machinery market, it was logical to examine the possibilities of expansion into new product areas; against the end product of all this market research, a re-evaluation of resource requirements would have been expected. The continuation of the end of 1974's level of machinery output for the first 6 months of 1975 augured badly for the year's total results. The upturn from August was essential if the 1974 loss was not to be repeated.

The late 1975 business mix analysis should, therefore, be seen not as a departure from a tradition of majority involvement in tooling business, but rather as a sign of a very necessary return to an earlier situation.

3.1.3.2 Short Term Forecasting

Forecasting over more than four weeks was "totally unreliable and unpredictable". It would be expected that tooling forecasts would change significantly over a four-week period, with the output of new short-term orders adding to the effect of slippage against scheduled output. Predictably,assembly shop work changed a good deal less. In fact, as Table 3 in the Report shows, apart from the October figure, explained in the Report as resulting from work brought forward, the highest variation is an increase of 30%. However, new orders for this type of work could have exercised, at most, a minimal influence on short-term schedule variations, and thus, almost all of the increase shown in the table represents slippage from one month to the next.

One would have expected the Report to lay a much greater emphasis upon the lack of basic information on the workload situation in the manufacturing and pre-production units and on job progress and hold-ups during processing. These, as well as poor manufacturing performance, represent possible reasons for failure to complete work on time. However, the Production Programming Manager concentrates his criticism on poor performance and a failure of management to pursue the programme, laid down in the schedule for their departments, conscientiously and in true knowledge of the effect of any shortfall.

3.1.3.3 Output Performance

Without some analysis of the Division's potential capacity, the performance statistics offered in the Report are much less meaningful: While average monthly output "increased from 52% to 64%" of schedule over the 12-month period, no evidence is offered that the 52% did not represent a higher percentage than the 64% in terms of the potential output of the Division. The Report does note that the actual amount scheduled does not seem to affect the percentage achieved, but with build times for machinery being longer than one month - so that one month's labour is reflected as a different month's output - the maximum potential value of output will also vary from one month to the next.

The measurement of performance in a one-off jobbing type of business is indeed a difficult task. To compare labour actuals against operation estimates is scarcely more satisfactory since, in the majority of cases, estimates can be little more than "experienced guesses".

A different standard of measurement should really be applied to the two types of business in which the Division is involved. Whereas it should be clear, at the start of a given month, what machinery and special purpose equipment may be expected to be finished by the end of the same month, considerable fluctuation, on account of the introduction of immediate short-term orders, would be expected on tooling figures. Essentially, slippage of equipment would thus be a matter of considerable concern, but slippage of tooling might be regarded as a fact of life for this type of business. Potential capacity for the second type of production - given especially that only Group tooling and general outside tooling were being measured and that no account was, therefore, taken of movements in servicing and breakdown repairs demand, or of adjustments to machinery parts demand - could fluctuate enormously during a month. Thus, for example, if, as noted in the "Conclusions" to the Report, Group tooling work in September 1975, achieved twice the predicted output level, we should expect outside tooling to fall well below plan and also machinery parts to suffer.

An improvement in the percentage of the schedule achieved would also be expected as machinery came to make up a higher percentage of the schedule. The actual amount of the increase - 12% - must be regarded as very disturbing in view of the "change in business mix" from only 41% machinery in December 1974, to 86% in September 1975.

3.1.3.4 Order Backlog & New Order Load

A distinction must surely be made here between short and long-term orders. Given a backlog in short-term tooling contracts - the extent of which will be examined in Section 3.2 - it would be hardly surprising to find that customers for this type of work reduced the amount of new work placed on the Division, particularly if they were also the customers who were waiting for a large part of the overdue work.

Reduction of the backlog of tooling work over the first months of 1975 should thus be seen in terms of an alteration of policy by the procurement departments of other members of the Engineering

Group, leading, because of P & ED's tardiness, to a larger percentage of work being placed with outside sub-contractors. Again, it must be noted that there was never any proof that the sole, or even the major reason for the development of the backlog of tooling work was poor performance by the shop floor.

Long-term orders for machinery and special equipment were less likely to be affected or discouraged by the immediate short-term backlog within the Division. However, it was possible, depending upon the priority scheduling system which governed shop floor operations, for machinery parts designated for manufacture "in-house", not to be started at the required time, in advance of their need by the assembly area for the parts kit to be completed to schedule: Hence the poor performance by the machine shop on parts required for machinery to be delivered later in the year.

The conclusion which should have been drawn from the latter fact was that either a different priority scheduling system should have been used for machinery parts such, for example, as the use of a different type of job ticket mentioned in Chapter 2, or that if the machine shop was filled to capacity with tooling work, the machinery parts should have been sub-contracted to outside suppliers. The central problem, once again, was the lack of definitive information on the capacity of the machine shop and the on-going state of its load. This meant that there would always be a tendency to place parts manufacture "in-house", because of the risk that, otherwise, the double cost of sub-contract prices and internal down-time would be incurred (7).

3.1.3.5 Divisional Capacity

There does not appear to be sufficient evidence in the Report to substantiate the conclusion which is drawn, or indeed any conclusion at all, about the potential annual output of the Division. In particular, it has been shown, in Appendix One to this Chapter, that the business mix had a crucial effect upon the potential maximum output level.

3.1.3.6 Conclusions About The Report

The intention of the criticisms aired in the preceeding pages was not to devalue the usefulness of what was essentially the first attempt made to evaluate the Division's operations. The concern has rather been to point out significant weaknesses in the observations made and also, to note what appears to be rather more logical conclusions which could be drawn from the date collected.

Many of the points investigated will be the subject of further discussion under appropriate later headings within the present Chapter. From quantification of the Division's problems, it is now the intention to proceed with an investigation of areas in which it was felt that these problems had their roots.

3.2 Evaluation of the Existing Product Range

Section 3.1.1 noted the absence of any identifiable pattern in the general overall financial performance of P & ED from 1970-1974. The present pages attempt to find such a pattern by examining the output and performance of individual product and customer categories up to the end of 1975. Section 2.5 of the model pointed out some of the major incompatibilities between jobbing, toolmaking production and the manufacture of high value specialised "one-off" units. The actual situation within the Division was further complicated by a distinction between privileged, "Union", customers and outside customers. A list of the resulting 12 categories into which output was differentiated was given in figure 3.5.

It must be established at the outset, that nothing noted in what follows is meant to contradict the fact that expansion and diversification of the product range of a business is a legitimate and commonly used method by which to seek growth or, more basically, economic survival in an environment of continuing technological change and alteration of customer demands. However dis-similar two products are, neither will be discarded by a company solely on the grounds that it is difficult to produce one alongside the other. To the economist, Beer's words no more than state the obvious. "What matters to management about two entirely different products is not whether they look alike, but whether they are profit-earners or not" (8).

Although it is the intention in this Section to question the wisdom of P & ED's involvement in so diverse a range of products and types of product, the essential nature of the enquiry as a whole is to determine whether it was possible to combine the various types within a single operating unit without each having a disruptive influence on the others.

Tables showing the actual figures for the various types of business over the period 1970-1975 are included as appendix three to this chapter, and a few specific comments will be made below as a preface to general conclusions upon the Division's product range.

Three basic categories of work are distinguished :-

1. Tooling and servicing work for Engineering Group customers.
2. General tooling work for all other customers.
3. Rubber technology equipment and other special purpose machinery.

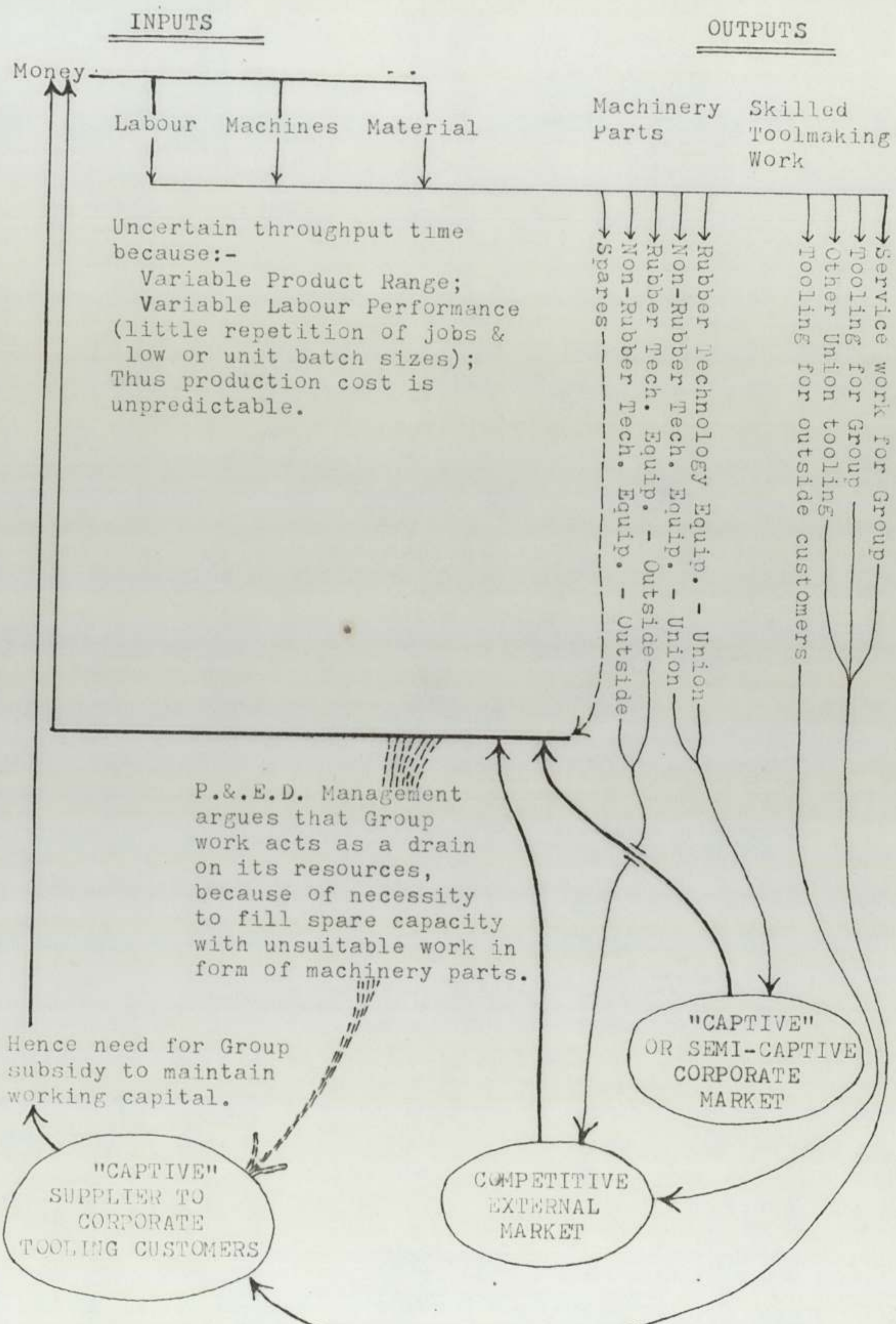
No mention will be made in this section of the "new products" introduced during 1975, since these are considered later, in section 4.2.2., as a potential solution to some part of P & ED financial problems.

3.2.1. Tooling and Servicing Work for Engineering Group Customers

The figures underlying the observations made in this section are given in tables 1A & B of appendix three to this chapter.

This work had been the original reason for the establishment of a central tooling resource, as noted in section 1.2.2. However, while it was still regarded by Supervisory staff and some middle managers as the Division's "bread and butter", senior management voiced the opinion that its continuation was against the best interests of P & ED because of the actual priority which it carried on the shop floor in comparison with machinery parts production. It has been argued in section 3.1.2. above that the Division's output potential increased more rapidly as a large proportion of its business was within machine

Figure 3.7 P. & E. D.'s Business Cycle.



assembly categories, and thus, if it can be proved that this type of business was being harmed by work for Engineering Group customers, the senior management case will be substantiated. The essence of the case is shown in figure 3.7.

3.2.1.1 Financial Performance

Despite the fact that estimated annual output could only be approximated on the basis of the previous year's actual figure, total output on Group work from 1971-1975 was only just below the planned figure. By its nature, breakdown servicing work was completely unplannable, and the other divisions of the Group were not usually able to predict their tooling requirements either.

The level of contributions received was above the planned percentage, whereas the other three types of business to be discussed fell below the planned percentage. The reason for the success in this respect is the high contribution on service work. Since the customers were charged for this work on a "cost plus" basis - i.e. a fixed charge for each hour of machining required, totalled at the completion of a job and increased by a settled percentage contribution - such work would be expected to achieve its targets. The fact that it did more than this reflects P & ED's adoption of a modified charging policy which might be best described as getting "the best of both worlds". Service jobs were estimated by a planner situated on the shop floor and the Division's Accounts Department invoiced at whichever was the higher, the total estimated time or the total actual time.

Tooling work was charged for on the basis of fixed price piecework estimates, which in reality amounted to little more than experienced guesses. Rates were governed by internal transfer prices and the Division was expected to compete with the prices which would have been charged for the same work by outside sub-contractors. In view of this, it should not be regarded as surprising that total actual contributions were more closely in line with planned levels. Performance on individual tooling jobs varied a good deal: An example of particularly bad performance is found in the four largest jobs which formed part of the backlog of work for the Wheel Division at the end of March 1975. Their total value to P & ED was £10,800, and already an excess of 615 hours of machining and fitting had been booked on them by that date, making an irrecoverable cost of £1,600 to the Division given a variable Factory Cost of £2.68 per hour. But such instances should be expected in view of the difficulty of estimating tooling work accurately and the overall figures show that they were more than made up for by jobs producing a better than estimated contribution.

3.2.1.2 Performance In Terms Of Offsetting Fixed Costs

The Division's adoption of a system of apportioning fixed costs arbitrarily across all product categories tends to devalue the amount of the contribution produced by this business. Whereas tooling categories thus carried a lower amount in respect of site, depreciation and power consumption, they received a far heavier burden in terms of the indirect staff maintained by P & ED. With this in mind, the performance of Group work, as detailed in figure 3.8, should be seen as particularly remarkable and good. It is worth noting that had all product groups succeeded in off-setting 95% of their apportioned share of the 'contract' overheads, the Division's actual loss over the 6 years would have been £221,150, less the amount received in capital investment grants and royalties (£106,383), which comes to a total of only £114,767, against the actual total loss of over £1 million.

Year	Total Actual Apportioned Overheads (constants)	FIGURES FOR ALL WORK FOR INTERNAL CUSTOMERS Planned % of total contribution	Amount of apportioned overheads to be offset	Actual amount of contribution	Net profit or loss to division	Contribution overheads %
	£		£	£	£	
1970	818,785	34	278,387	194,913	-83,474	70
1971	728,501	26	189,410	158,643	-30,767	84
1972	648,737	27.5	178,403	155,698	-22,705	87
1973	718,649	21	150,916	125,221	-25,695	83
1974	849,643	18	152,936	225,203	72,267	147
1975	658,675	14	92,215	128,537	36,322	139
TOTAL	4,442,990	23.5	1,042,267	988,215	-54,052	95

FIGURE 3.8

Annual Contribution Against Planned Percentage Of 'Constants' Or Apportioned Overheads - Work For Internal Customers 1970-1975

It would thus seem that, on purely economic grounds, the Division should have been encouraging and expanding this type of work to the utmost and seeking to persuade the other divisions to sub-contract less of their tooling requirements. The dissatisfaction of P & ED's management with this business area must be explained in terms other than their simple economic performance.

3.2.1.3 Particular Problems Associated With Work For Group Customers

As well as the difficulties normally encountered in a tooling type business, which were identified in Section 2.3, there were several additional problems resulting from the customers being part of the same Group, situated on the same factory site.

By its very nature, demand for service-type work is bound to fluctuate unpredictably and tooling demands will also vary according to the need of customers to prepare for new contracts which they themselves have secured. The urgency of service work makes it a disruptive influence on work schedules and makes it virtually impossible to predict accurately completion dates for all other work. Therefore, part of the reason why P & ED was generally behind schedule with its Group tooling work may be put down to the influence of other more urgent work for the same customers.

Necessarily, service work enjoyed the highest priority on the machine shop floor and for this privilege the customers were charged at a premium rate. In theory, Group tooling work took its place in work queues with all other business and was processed according to the principle of earliest due completion date. In fact, the proximity of the customers and their status in relation to P & ED gave them an unwritten priority second only to that of the service work. One of the complaints of P & ED's management concerned the disruptive effect which this had on all other work being processed. The situation could be particularly serious when any of the limited specialized machinery resources, for example P & ED's single Jig Grinding machine, was heavily loaded with Group work. At such times, indeed, there was often an unhealthy competition between Group customers for preferential treatment.

Service jobs also had a disruptive effect on the data collection system because delivery was generally required and achieved during the same shift in which the job appeared on the machine shop floor. This meant that inputs to and feedback from any work scheduling system used, concerning adjustments to the workload, needed to be more immediate, which would naturally increase the system's cost. However, only with such information would it be possible to take early decisions to sub-contract future work, or to add an appropriate delay factor to delivery promises for new orders in order to avoid the development of a backlog of work. P & ED's response to this control problem will be examined later in Section 3.5.

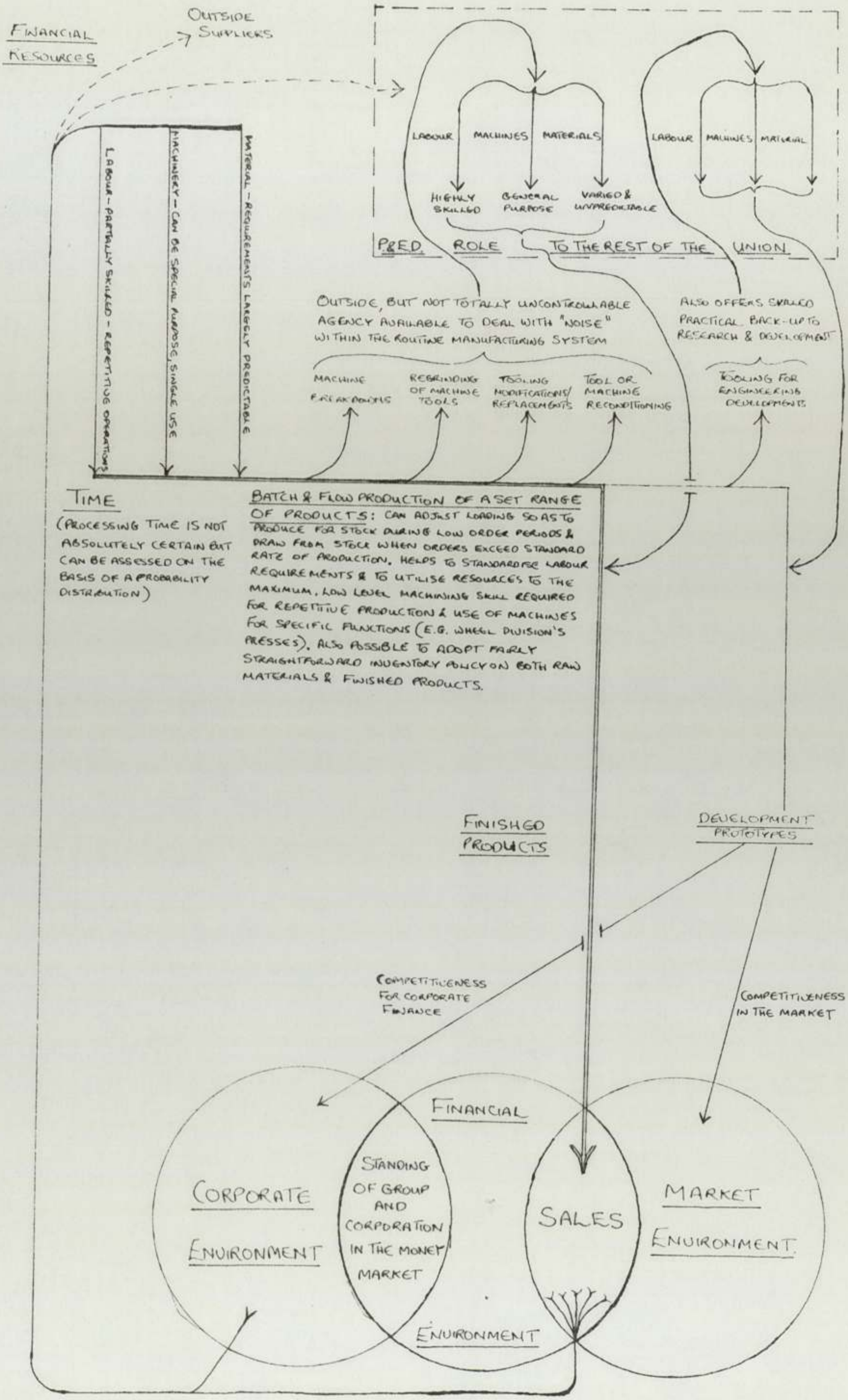
The possibility of breakdowns in other divisions was also the reason for the existence of a night shift, even during periods where there might be insufficient work to keep even the day shift machinists fully employed. A method of retaining management control over the night shift's operations needed to be developed if the shift was to be productive at times when it was not required to work on service jobs.

3.2.1.4 General Conclusions About This Business Area

The position was thus that in Group tooling and servicing work P & ED had a product area which consistently achieved a good financial performance, but at the expense of increasing the complexity of an already difficult production control environment by the addition of two classes of job with overriding priorities. This naturally made the organization of production control administration even more vital if the delivery programme was to be achieved.

Although the value of an internal tooling supplier would be expected to have offered some quantifiable financial benefits to other members of Engineering Group, through internal transfer price arrangements, it must be stressed that the real advantage for them lay in the fact that the one uncertain and potentially disruptive area of their operations was being handled by an external agency, but one which it was within

Figure 3.9. P.&E.D.s Contribution to the Smooth Production Cycle of the other Operating Divisions within the Dunlop Union.



their power to influence considerably. P & ED's contribution in this respect is expressed diagrammatically in figure 3.9. The production control problem for the other divisions was simplified: Aviation and Suspensions Divisions produced a defined range of products in batches, the size of which dould be economically determined, for which the required machinery times were reasonably accurately known from previous experience; Wheel Division operated on a mass or continuous production basis; all their unpredictable and uncertain tooling and servicing requirements were handled by clerical procurement staff, who retained freedom of choice as to whether the internal tooling resource offered by P & ED should be used or the alternative of production by an outside subcontractor.

As a central resource, P & ED's machine shop was able to maintain a machining capacity in line with the gross requirements of all the other divisions taken together and could thus offset their fluctuations in demand for tooling work against each other. It could also maintain a wider range of machining facilities than could have been justified by each individual division. However, whereas the success of the machine shop in the eyes of other Group members depended upon a combination of the cost and the quality of the service provided, P & ED as a whole was judged as a profit centre and thus it evaluated all work for Group customers, first in terms of whether or not it produced a profit and second whether it had a disruptive effect on other work and reduced potential profits. Was there, in fact, a lost opportunity cost to P & ED as a result of the work done for Group customers? The Division's management felt that there was, and it was supported to a certain extent in this by the fact that there was some degree of correlation between high output years for Group work and high loss years for the Division:

Table 1B in Appendix Three shows that output of this work was highest in 1970 and 1974, the years in which the two worst losses were made, but this pattern is not followed in the other years and the conclusion must be that particularly high output on Group work is symptomatic of problems elsewhere.

It has already been noted in Section 3.1.3.1, that 1974 was a very bad year for machinery sales and that Group tooling work provided a means of keeping at least the direct labour force of P & ED almost fully employed (downtime bookings made up only 5.6% of the variable factory costs for the year). As the machinery load increased in 1975, however, so P & ED's attitude to this work changed, and the quality of its tooling service to Group customers declined. From January to March of 1975, Group tooling output averaged only £21,350 per month - barely half of the monthly average throughout 1974. A serious backlog built up on these orders, as figure 3.10 illustrates:

Date	Value Of Group Tooling Orders		% Overdue	Output Total For Month
	Overdue	Total		
	£	£		£
1st Jan	28,700	71,500	40%	15,060
1st Feb	45,600	97,600	47%	24,800
1st Mar	49,500	91,300	54%	24,200
1st Apr	66,900	98,000	68%	23,730

Figure 3.10 The Growing Backlog Of Group Tooling Work In The First Four Months Of 1975

At the existing output rate, there was a three month load of overdue work by the beginning of April. As the machine shop was not thus providing the service on tooling work, other members of the Group naturally reduced the orders placed with P & ED: The remaining 9 months of 1975 yielded only a further £90,600's worth of Group tooling orders (excluding any orders for delivery in 1976).*

The other effect of reduced tooling output is summed up excellently by Beer:

"Now suppose that for complex reasons (Division) A's capability falls. Its productivity will then be affected..... Suppose that not only Division B, but Divisions E, F and G also use A's product. Suddenly we are in a competitive situation instead of a collaborative one, and experience shows that this is where communications break down. For an element of gamesmanship is introduced into an already complicated situation..... all concerned diverse rules and procedures for handling the situation which are supposed to be fair, supposed to be collaborative, supposed to be original. But by now, people are playing poker with the situation; trust is lost; informal rules are adopted at the divisional level which are intended to secure local satisfaction.... and oscillation has set in" (9).

Internal competition for machine shop capacity was obviously not healthy as far as the Group as a whole was concerned, and even though it might be in P & ED's best short-term interests, as a method of ensuring that the machine shop was always loaded to capacity, it was certain to damage relations with Group customers. They could be expected to react by:-

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* This calculation is based on: Total Group tooling output for 1975 - (Total value of orders at April 1st + total output up to the end of March).

1. Putting more of their tooling work out to sub-contractors, and
2. passing only urgent jobs, or ones on which sub-contract prices were set at prohibitive levels - probably because profitability was at a high risk to the internal tooling manufacturer.

The conclusion is obvious: Neither Division nor Group were satisfied with the situation; P & ED because of the opportunity cost of producing these jobs and their disruptive effect on the production of the more lucrative machinery parts; the Group, because its operating division were no longer getting the kind of tooling service which justified Group subsidising of P & ED's operations.

3.2.2 Tooling Work For All Other Customers

As Section 1.2 explained, tooling work, first for other Dunlop Divisions and then for outside customers, was taken on in the first instance as a means of using up spare capacity in the P & ED machine shop.

Although a part of such work was subject to the same unpredictability in terms of forward planning as Group tooling work, there were also some longer term tooling contracts where production could be planned to fit in wherever suitable up to 3 months in advance. This included orders on which substantial contributions were made - a series of vibration testing tools for an electronics firm, for example, regularly yielded a contribution of over 40% - but by definition, it was to be expected that any contribution on orders in this area would make them acceptable as capacity fillers. Naturally P & ED were looking to offer advantageous terms to other Dunlop Divisions, but the figures (Appendix 3, Table 2 A & B), show that this did not turn out to be the case. For Union work, there was no restriction on either the amount of information supplied for estimating a job or on the time allowed for preparation of a quotation and the customer was more likely to respond favourably to a later request to adjust the price because of discrepancies between estimated and actual labour hours required; for external work, P & ED had to compete with other possible suppliers and, once the contract price was settled, there was little chance of re-negotiation.

Thus, in 1974 and 1975, the overall contribution on outside tooling work was only 9% as against 24% and 37% respectively for other Dunlop tooling work over the same two years. However, given that contributions were positive, it would appear that such work was justified. Again, the difficulty is that there are no figures upon which to determine whether such jobs were genuinely capacity fillers, or whether there was an opportunity cost involved in accepting them in terms of lost Group tooling orders or machinery parts manufacture.

In specific areas of the machine shop, some jobs of this type did cause extended work queues to build up. Manufacture of squash, golf or tennis ball moulds and inserts for the Union's International Sports Company (I.S.C.), required a high degree of precision and would tie up the Division's single jig-grinding machine for weeks at a time. Because the same machine was required extensively by Aviation Division, it often proved necessary to break down a part-finished mould and incur a second set-up time when the job was later returned to. The moulds also had to be sent to a sub-contractor for plating and the lead-times for this varied so much that it was not possible to plan in advance for fine-finishing. Together these factors led to an average delivery of moulds to the customer 2 or 3 months overdue on the original promise: Indeed, one tennis ball mould originally scheduled for March 1975 was still outstanding in November of the same year.

In view of the potential loss of production for the customer from such delays, it was predictable that I.S.C. should look elsewhere for supplies. Actually, the summary figures given in Appendix 3 mask the true performance of the Coventry factory on this type of work, since they include also less intricate tooling work for the same customers done by the Leicester subsidiary. Analysis of P & ED's order records shows that only £54,360 of business was received by Coventry from these customers during 1975 (Appendix 4, Table 1).

In tooling work for outside customers, P & ED had a business area which, if developed successfully, could increase its degree of independence in line with its profit centre status. But typical of such orders were a series of tools produced for the nuclear processing industry: Operation time estimates were exceeded in the cause of perfection and the higher customer contributions agreed at the outset were whittled away leaving only enhanced prestige to be gained from such work.

On the other hand, the small number of lucrative jobs - such as that for electronics firms noted above - presented management with a conflict between the best interests of the division and those of the Group, through the possible delay of tooling work for other operating divisions. Indeed, the situation could be further complicated if production to schedule of an outside tooling order involved delaying the completion of a kit of machinery parts for the assembly area.

Ultimately the reason for the division's failure to perform according to plan on this product type certainly resulted from its sales department being insufficiently selective about the orders accepted. Again, as there was no definite knowledge of actual machine shop capacity, this department may be justified in its reluctance to turn away work on which it felt that any contribution might be made. Also, it is clear from an analysis of the orders placed with P & ED that it relied very heavily on a small number of regular customers - 6 accounted for ⅔ of all orders received in 1975 - and could not risk the wider effects of turning down an order from any of these (Appendix 4, Table 2).

3.2.3 Rubber Technology Equipment & Other Special-Purpose Machinery

The historical background to the development of this type of business has already been dealt with (Chapter 1, Section 2.4), and many of the problems were mentioned in the introductory part to the current chapter and exemplified by Appendix 1. The points may be summarised, as follows:-

- These were potentially the most profitable product areas to the Division itself, since there was:-

  a) a captive or semi-captive market provided by other members of the Union;

  b) limited external competition in this specialised market - for example, there were only 2 other firms in the U.K. producing rubber technology equipment;

  c) a greater ability to predict job costs as a smaller proportion of the total was made up by internal labour hours - there were also some repeat orders, with minor modifications, in the rubber technology area, which allowed reference to previous costs for greater accuracy.

  Profitability of rubber technology work was also enhanced because the Research and Development's work was carried out and financed by the internal customer, U.K. tyre group.

- Conflicting objectives thus existed: Any sales of tyre-making equipment to outside companies would boost P & ED's profits, but would presumably affect future sales of Dunlop tyres by increasing competition to U.K. Tyre Group. Since orders of this kind were passed to the Division by Tyre Group, one assumes such implications had been carefully considered.

- It is obvious from the product results given in Appendix 1, Chapter 1, that although the internal tyre machinery work provided a base for this area of the Division's operations, it offered little prospect of substantial expansion. P & ED's future depended on the other three groups within this category - i.e. on the expansion of the external market for rubber technology machinery, or expansion of the range of equipment made for both internal and external customers.

- At a lower level, conflicting priorities existed in the machine shop between the best policy for:-

  a) Maximising the Division's own profit and establishing its position as a genuinely autonomous profit centre, independent of other members of Engineering Group and, ultimately, of the rest of the Union. This would lead first to a promotion of machinery parts to the highest priority within the shop, at the expense, where necessary, of Group tooling and even servicing work, and second, to a concentration on developing its position in the external machinery market, perhaps at the expense of providing such a good service to internal customers.

  b) Maximising Group profit, which could mean subordinating divisional interests and delaying completion of machines as assigned capacity became needed for short-term tooling and service work. One of the principal complaints of P & ED's management concerned this policy: Machinery parts manufacture could be planned long-term, but the programme might then be disrupted by the arrival of short-term tooling work; no allowance for this was given when the Division's annual performance was under consideration.

c) Achieving the superordinate objective of goal congruence with the rest of the Union as a whole, which meant assessing the comparative opportunity cost of raising the priority of either Group tooling, Tyre Group machinery, or I.S.C. moulds above any of the others. It would not be possible to deal with such a dilemma effectively by establishing rigid priority rules, since the opportunity costs would not be constant.

- The situation was further complicated by the fact that a large proportion of the machinery parts, placed for production in the machine shop, did not require the high grade of skill of the operatives there, but were, in theory, capacity fillers which could have been obtained at a lower unit cost from external sub-contractors. This resulted from the fact that there was no definite knowledge of the machine shop capacity and it was only possible to guess what future tooling loads might be. P & ED's management thus argued that use of the machine shop imposed additional costs on its machinery products which might make them less competitive in this field and certainly caused reduced net profit.

- As far as P & ED was concerned, these product areas were much more than a sideline. The lull in production in late 1974 caused by a shortage of orders which led to capacity being concentrated on tooling work is one of the major reasons for the loss shown for that year.

- It was noted in Chapter 2, Section 5.1.2 that parts of the labour force are not directly transferable from one type of production to the other. In particular, back-up staff, such as draughtsmen and project engineers were not needed by the tooling side of the business. One might have expected them to be switched to development work during such a lull, but it has already been noted that R & D for the more regular rubber-technology machinery was carried out by U.K. Tyre Group.

- An analysis of Buying Department activities (details in Appendix 5), showed that 51 out of every 100 orders placed by that department were directly concerned with machinery construction. In Estimating & Technical Department, the division of work was similar to this and the Marketing Department concentrated almost totally on this part of the business except for occasional major outside tooling orders. Reduction of work in these product orders left the administrative departments of the division seriously under-employed.

- P & ED was dangerously dependent for such work, first on tyre building machinery orders - which left it vulnerable to any technological improvements in this area - and second, on Union customers. Both facts are evident from the product result figures (given in Appendix 1, Chapter 1), though the latter is masked in the 1975 order statistics given in Appendix 4, which show the influence of 2 larger "one-off" orders from non-Union customers for rubber technology equipment.

- The Division had not managed to establish a reputation or a definite product line associated with any other industry, and any work outside the rubber technology area involved greater risks, since substantial variation would be expected between estimated and actual costs - particularly in the labour hours required for the manufacture of the non-standard parts of what was always, in essence, a prototype machine as far as P & ED was concerned. An admittedly extreme example of this is provided in figure 3.11 which concerns a line of machinery for the steel industry.

Figure 3.11. Analysis of final figures for jobs DB852-860 concerned with non-rubber technology machinery

Representing an extreme example of poor labour performance on a group of related contracts to supply a line of machinery.

Quotation date : End of 1974

Delivery scheduled for : End of February 1975

Delivery achieved : In stages from 2nd week in March to August 1975.

Job no.	Labour hours Estimated	Labour hours Actual	Estimated cost (2) & contribution (£)	Invoice Value (3) (£)
DB852 & 860	996	1,070	15,480	25,385
853	301	307	8,366	6,480
854	136	211	2,559	3,078
855	243	411	4,708	4,240
856	197	382	2,179	3,240
857	227½	- (1)	22,676	13,770
858	697	1,798	27,901	13,823
859	508	797	11,533	4,752
DB852-857		2,492 (1)		
TOTAL	3,305	7,668	96,422	74,768
			Agreed extra payment of	14,585 (4)
			TOTAL RECEIVED FROM CUSTOMER	89,353

NOTES

(1) A part of the hours for jobs 852-7 were taken together due to difficulty of identifying painting costs of individual machines.

(2) The cost estimates on these jobs were worked out after agreement of prices for the contract with the customer. It is exclusive of V.A.T. and assumes a customer contribution of 30%.

(3) The Invoice Value if made up of the fixed contract price for the jobs together with subsequent modifications requested by the customer. The figures are inclusive of V.A.T. at 8%.

(4) An extra payment was negotiated with the customer at the end of the job because of the disparity between contract prices and calculated costs.

Total labour hours were more than twice what was estimated, 7,688 compared to 3,305. Such a vast difference cannot be accounted for simply by inefficiency in the machine shop, but rather reflects the inaccurate estimating.

- P & ED had an excellent reputation for the quality of its workmanship, but a poor reputation for delivery on schedule. This was bound to affect the sort of orders it received, which tended to be for precision equipment not urgently required by the customer. The orders from the nuclear processing industry are excellent examples of this type of work, but P & ED was not attractive as a supplier to customers outside the rubber technology area, who wanted more straightforward equipment with reduced processing risks or uncertainties and, thus, a more predictable constitution. It was both expensive, because of the high grade machinery labour used, and far too unreliable on delivery for customers who wanted to gain maximum returns from capital assets by programming future production from them.

- The key factor in the manufacture of machinery was the lead time on the major bought out items. Special motors and gearboxes, for example, might take as long as 12 months to be delivered by the supplier. The complete network for the construction of a machine from the receipt of the order is shown in figure 3.12. It is somewhat simplified since it does not show continuing Design & Estimating Department involvement, dealing with modifications to machines, but the critical path identified remains correct: 1,2,3,4,8,13,18,21,22,23,24,25. In theory, there was a considerable amount of slack in the time allowed for the machine shop to produce

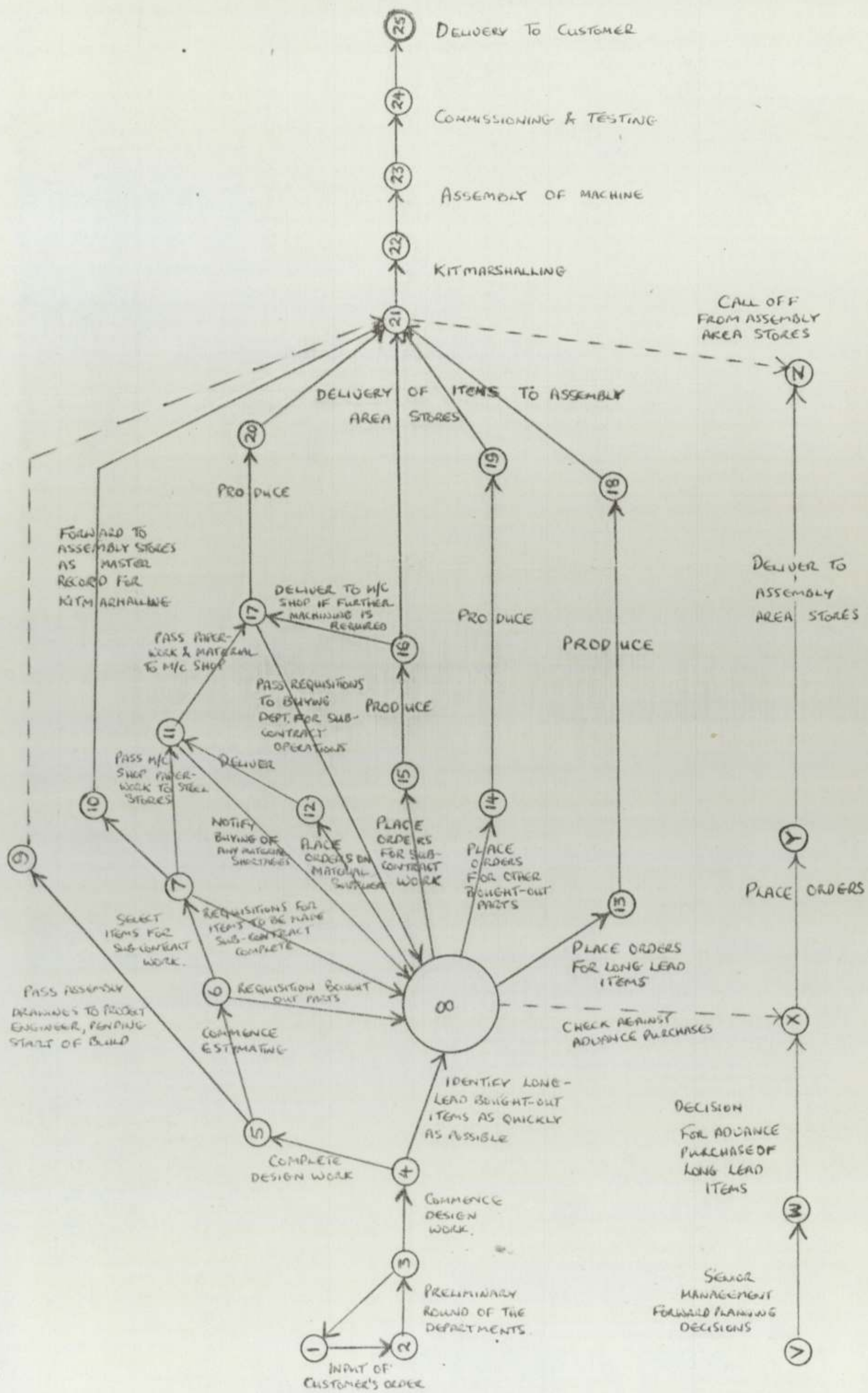


FIGURE 3.12 ARROW DIAGRAM TO SHOW STAGES IN THE MANUFACTURE OF A MACHINE

the kit of non-standard parts. Rather than produce a detailed network with specific start dates for each of the parts, so that all arrived more or less at the same time at the stores for transfer to the assembly shop, the parts were managed "by exception". It was assumed that all would reach completion by the due dates and the Assembly Shop Production Controller notified his counterpart in the Machine Shop of any missing items, or "shortages", about two weeks before building was due to commence. Whilst this worked reasonably well in most cases, it did lead to last minute 'panic' processing of machinery parts at artificially raised preferential priority. Where major manufactured parts had remained unprocessed, assembly start might be delayed, but it was usually possible for fitters to make a start on some sub-assemblies before the kit of parts for a machine was complete. The procedure also produced the maximum chance that parts, material for parts, or job routing cards for parts would get lost within the machine shop. Table 6 in the Production Evaluation Report, Appendix 2 to this Chapter, shows the consistant failure of the machine shop to deliver complete kits of parts on schedule during the latter half of 1975. Once again, the complaint voiced here was of the disruption caused to machine projects by short-term tooling orders.

3.2.4 Conclusions

The subject firm experienced even greater problems than were suggested in Chapter 2, Section 5, from the combination of tooling and special purpose machinery product types, because of the added complexity of preferential treatment for some of its customers, in particular its responsibility for providing minimum delay servicing for the other operating divisions within Engineering Group.

3.3 Examination Of Problems With Resources

3.3.1 Site

Far from being contiguous - a possibility suggested in Chapter 2.5.1.1 - in order to allow shared use of expensive materials handling equipment, the manufacturing units of P & ED were situated in different parts of the Engineering Group site, approximately 400 yards apart. A materials transfer system was thus needed between the two units to handle kits of manufactured parts. A particular problem was encountered with fabrications purchased from outside suppliers for machinery jobs. These would be delivered direct to the assembly shop stores, where they would remain because it was not known whether the Machine Shop were due to perform fine-finishing operations. At the same time, there would be no progress enquiry from a machine shop Production Controller managing "by exception". Fabrication - especially machine main frames - were exactly the sort of part which could delay an assembly schedule. This problem had been identified in the 1969 Management Service Report: "Storemen have difficulty in progressing missing items, as deliveries from Goods Inwards can go to one of several stores. Consequently an urgently needed item can be lying unused in another store. A single store, or closer control of movements into stores, is required" (10).

Nor was it easy for management to keep in touch with shop floor progress when the administrative block of the Division was so far removed from the two processing areas. What made this more serious was the poor quality of information provided by the data collection systems in use. This will be examined later in the current chapter.

3.2.2 Labour Force

While it was true, as noted in Chapter 2.3.1.2., that there was potentially high mobility of machinists between the different sections on the shop floor because they were skilled workers, in practice, the very specialised skills which they came to have, through experience, on the machine which they normally worked on, discouraged re-allocation of labour on a regular basis, in the interests of making the best use of available machinery talents. Movement between sections thus only naturally took place when there was a serious disparity btween the work-load and the existing labour allocation - a disparity which would justify a fairly long-term movement of labour. Machinists were rarely moved for periods of less than a week at a time.

Mobility also encountered human problems. Most of the direct labour force regarded it as a mark of enhanced prestige that they were no longer just "skilled machinists", but rather skilled turners, millers or grinders. To be the one asked to move to another section was almost like being told you were not as essential to your own section as your colleagues! Machinists also disliked changing supervisors or foremen, and shop floor management found it necessary to concede on this point in confirmation of the fact that section changes were to be regarded as "temporary" expedients. Men switched to the turning section because of its heavy workload thus continued to be responsible to the milling section foreman, a situation hardly likely to ensure that the best use was made of the additional processing capacity.

The low level of machinery orders meant a very unequally distributed workload amongst indirect employees. Given the higher than usual level of tooling orders, it was not surprising that informal specialisation and habitual division of labour between machinery and tooling work within the Estimating Department disappeared during this period. The unpredictability of order inputs, indeed, presented a difficulty with regard to attempting any move towards a functional system of organisation within the pre-production departments.

In general, it is evident that the expansion of the labour force, particularly of staff members, which had taken place during 1969 - statistics were given in figure 1.8 - had not been justified in terms of increased turnover by the Division. By the end of 1973, the labour force had been reduced from the December 1969 peak levels by 39% in terms of operatives and 32% staff, but it is clear that this substantially resulted from closure of the Ramsgate plant at the end of 1971. From that date, there had been only a 6% reduction in operatives and no reduction in staff, leaving a staff:operatives ratio in December 1973 of 1:2. Such a ratio could only be justified by an expansion of machinery production, yet, as tables 3 & 4 in Appendix 3 illustrate, actual production during 1974 was scarcely more than half (51.7%) of the 1973 machinery total. What is perhaps more significant is that it was only planned to reach 87% of the 1973 total. Clearly there needed to be a re-evaluation of the labour resources employed, unless management saw the order shortfall as simply the result of a short-term demand recession caused by the prevailing economic climate, and especially by the Division's dependence upon orders from firms associated with the automotive industry at a time when O.P.E.C. price increases were having particular savage effects upon its prospects.

3.3.3 Problems With The Processing Machinery Available

In line with the suggestion in Chapter 2, Section 3.1.3, it was found that the comparative states of loading of the various machine groups (itemised in Chapter 1, Appendix 2) varied considerably from time to time. To help cover this, the Division retained in the machine shop a greater number of processing machines than of operators to use them. Difficulties with mobility of labour, noted above, reduced the effectiveness of the policy. At least, however, there was little theoretical problems with under-utilisation of machinery resources since the spare turning, milling and grinding machines had already outlasted the time allowed for their value to be written off by depreciation. Indeed, there were few machines remaining in the machine shop with anything over residual or scrap value. Whilst the absence of book value in no way proves that there was little opportunity cost involved in retaining excess numbers of machines, it does at least indicate that their remaining serviceable life in full usage was limited, and that it would have been unwise to depend on their continuing to function beyond occasional usage, without breakdown problems occurring

The age of the machinery may, indeed, be seen as a contributory factor to the machine shop's problem in competing with the production efficiency of sub-contractors. However, while the Division's financial position remained so weak, there could be little thought of undertaking the capital investment on new machinery. In fact the latest acquisition, resulting from continued overloading in the large milling area, had been a machine rented on a yearly basis from the manufacturer.

In general, the machines capable of manufacturing to the lowest tolerances, or highest accuracy - the numerically controlled machines and the jig grinder and spark eroder - were consistently loaded to capacity as were the large milling machines. It was these on which P & ED competed most favourably with outside toolmakers. This was because, whereas the latter had different rates for different types of machinery operation, P & ED assessed all labour hours at a single rate £2.65p per hour in late 1974, compared, for example, with £7 per hour quoted for large milling work by outside sub-contractors).

3.3.4 Problems With Establishing A Material Stock Policy

The material requirements of the Division were unpredictable (as noted in Chapter 2, Section 3.1.4), in terms of both total amounts and the specific dimensions to be used. Stock-holding policy for the Steel Stores could thus only be laid down in the most general way and there were always the risks of steel remaining unused for long periods, or not being available as required. At a time when the policy of external steel stockists was to cut material to size as directed, inclusive in the price charged for the material, the only justification for holding an average of £40,000 value in material stock was the element of convenience which this gave in meeting the urgent breakdown servicing demands of the other operating divisions within Engineering Group. Those divisions also held material stocks, but there was no attempt at Group-wide co-ordination to reduce the risks of over- or under-stocking certain types of steel. Group management evidently recognised this problem and directed that all stocks be combined during 1975 into a central pool, from which member divisions could make purchases as required. This relieved P & ED of an unsatisfactory situation where it had not only the cost of capital tied up in stock to bear, but also the cost of the piecework bonus scheme for its own staff of three material cutters.

In theory, the Division's policy on machinery parts was to hold zero stocks in the assembly stores. All items arriving there could thus be allocated to the kit for a specific job. In practice, it was found sensible to keep stocks of standard parts, such as nuts, bolts, washers, bearings, insulated wire and electrical connections. The stocks were built up partly also because of bulk discounts available on such items and the minimum order quantities defined by some suppliers.

The Buying Department's procedure when procuring parts thus included early reference of the parts list to the storeman and his records. However, rather than asking for his examination of the total parts list, specifying items in stock, the Estimator or Buyer picked out those items expected to be in stock and merely required the storeman's confirmation that this was indeed the case. The time required for a full check of parts was not felt to be justified in terms of the savings on orders achieved. But some parts could thus remain in the stores almost indefinitely!

Figure 3.12 identified one further allowed variation on normal zero-stock policy. This concerns the purchase, prior to orders being received, of some of the longer lead items for tyre-making machinery. Furthermore, it was not unknown for complete machines to be built, without orders, in periods of order shortage in the assembly area. One instance was noted of such a machine having to be partially dismantled for repainting in a different customer's colours and in two other cases in early 1975, completed machines were 'cannibalised' to provide earlier customers with spare parts. Clearly building without specific orders could have expensive consequences.

3.3.5 Conclusions On Resource Problems

The dispersed siting of the units of the Division was unsatisfactory and indeed unnecessary, given the existence of a factory area adjacent to the administrative block (see figure 1.2), suitable for use as an assembly area and currently rented to an outside firm for storage.

The Division may have been unwilling to re-evaluate the labour resources required given the expenditure in training such employees undertaken by the Group as a whole, but such a re-evaluation was undoubtedly needed.

There was little chance that the sale of the old machinery assets would realise a substantial revenue for the Division. The space freed on the machine shop floor could not be readily put to any other more productive use and the excess machines did at least provide a hedge, if labour mobility could be increased, against fluctuations in inter-section workloads.

The Group was already taking steps to rationalise internal material stocking policy. Advance purchasing of long-lead items for tyre-machinery might certainly help to make the Division more competitive in its delivery-time quotations, which could assist in winning outside contracts. But this masks the real reason for which the Division established this policy. The truth is that it was always short of future orders for machinery and without such "experienced guesses", each year's predicted sales would have been woefully short of the level needed to pay the Division's costs and justify its continued existence.

It must be stated that such examples as those given at the end of Section 3.3.5, above, were the exceptions. In general, the "provisioning policy", as it was called, worked fairly well. However, wrong fore-casting left P & ED with part of its working capital tied up in expensive kits of parts. The most expensive equipment manufactured was a "Giant Radial Tyre-making production line". Of two "provisioned" in 1974, one remained as an unsold kit of parts in the assembly stores at the end of the following year.

Until the Division became able to work on an order load horizon of more than the next 12 months, such problems were found to recur, if only as expensive exceptions.

3.4 Problems With the Chosen Organisation Structure

A suggested organisation structure for a firm attempting to combine tooling production and special purpose machinery was offered in Section 7, Chapter 2, and the purpose of the following, is to examine ways in which the subject firm differed from the model and to assess if such differences made it more, or less, efficient.

The basic structure of P & ED is illustrated by the organisation chart offered as figure 3.13. This diagram was constructed from personal observations. The drawbacks of such charts have been noted already (2.7) and it must be confessed that this one appears much clearer on paper than it was in actual practice, where there was a degree of confusion of subordination which will be demonstrated below.

It is evident from comparison with figure 3.14, which shows the hierarchy at the end of 1969, that changes had taken place as a result of the expansion of the machine assembly business, principally the enhanced status of the Production Planning & Purchasing Managers and the development of a Marketing Department. What remains common, however, is that the Division was still organised on a functional

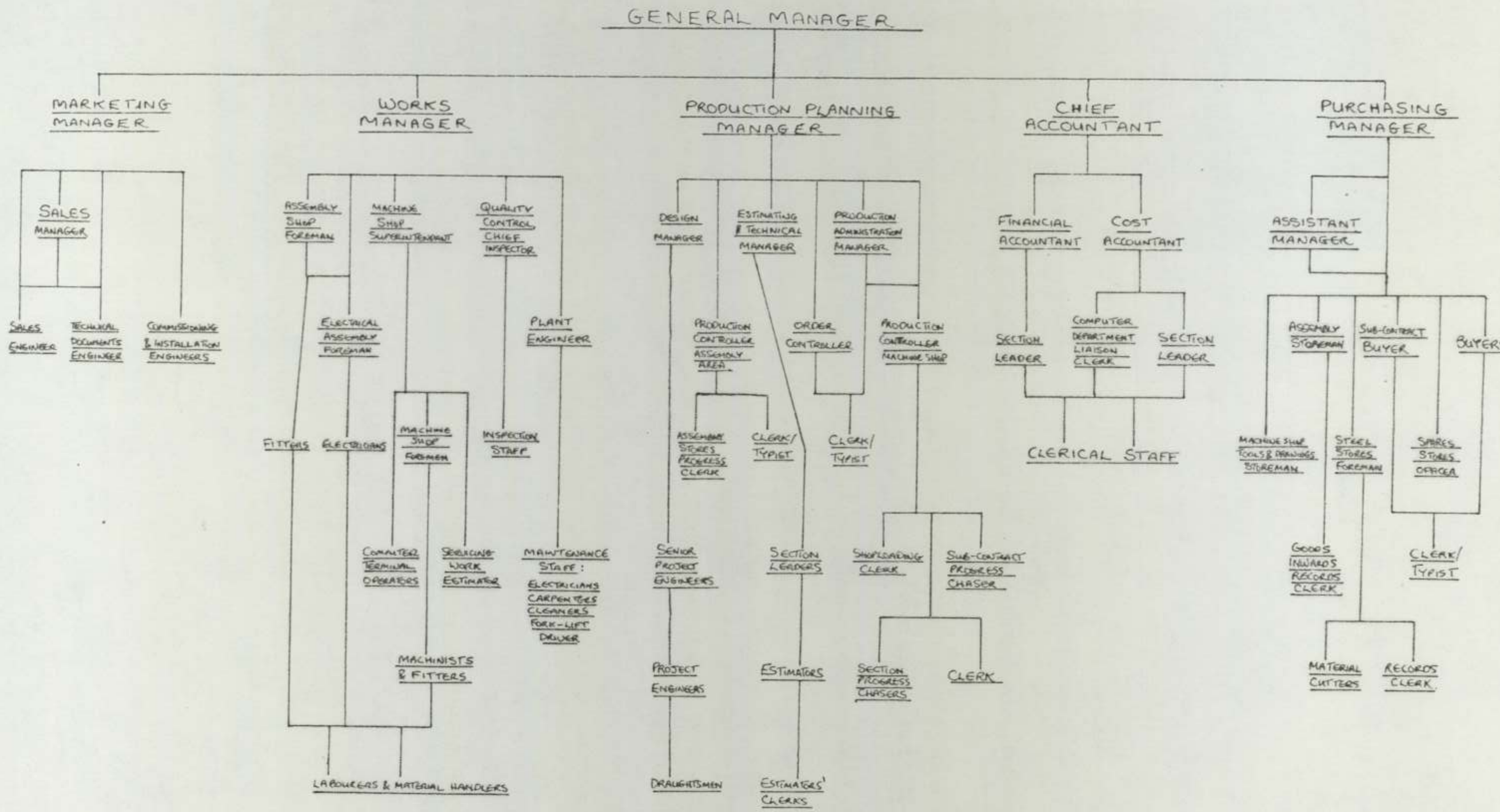


FIGURE 3.13 PLANT AND EQUIPMENT DIVISION: ORGANISATION CHART AS AT DECEMBER 1974

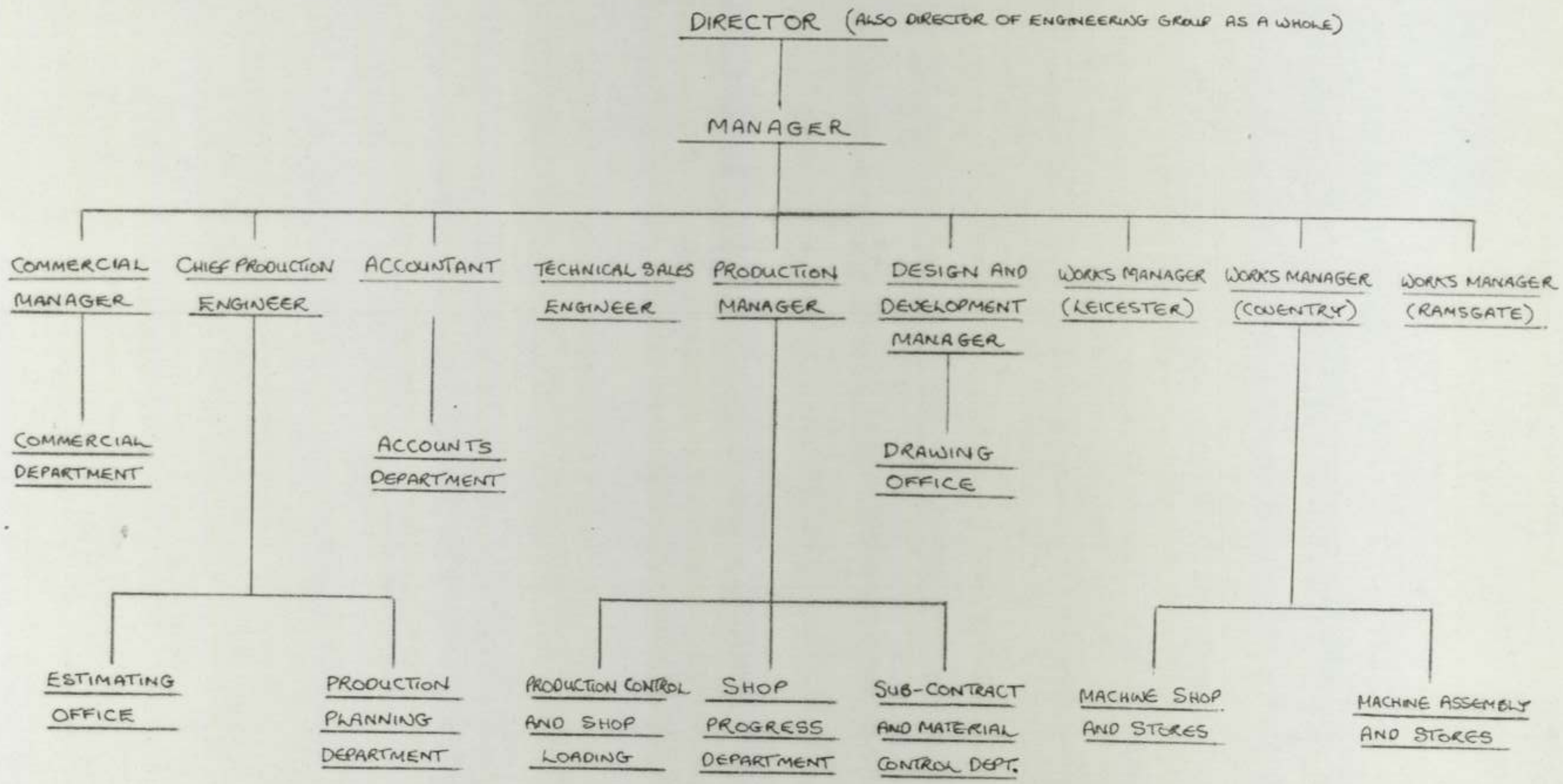


FIGURE 3.14

PLANT AND EQUIPMENT DIVISION: ORGANIZATION CHART, DECEMBER 1969 (ABSTRACTED FROM MANAGEMENT SERVICES DEPARTMENT REPORT OF THAT DATE (12)) basis, as against the mixed structure suggested in Chapter 2. A comparison with figures 2.4 and 2.5 exemplifies the difference. It is also perhaps significant that four unit production engineering firms studied by Woodward in Essex, and identified as "average, or above average performers", were all organised on a product basis and moreover that "The linking of the responsibility for planning and control with the responsibility for execution, persisted right down the line"(11).

Figure 3.13, being based on a practical situation, shows subordinate levels in much greater detail. An attempt has been made to differentiate between the comparative status of subordinates within departments, but positions on the chart are not directly comparable between one department and the next. Status tended to be gained by seniority within a department, and to be meaningful only within the boundaries of that department. Even the departmental heads did not share equal status: the Works Manager, for example, was called upon to cover day-to-day general administration during any periods when the General Manager was absent.

3.4.1 Levels Of Management & Managerial Spans Of Control

The number of managerial levels varied from one department to another, largely as a result of the different numerical strengths of such staff. The Works Manager, for example, had a total of 12 other supervisory staff in his department. To avoid having a span of control of 11, which, given the variety of the business, would surely have been impossible to work, these men were organised into two levels and a Machine Shop Superintendent delegated to be responsible for the seven supervisors or foremen on the shop floor. The inclusion of this one extra man and the seniority given to the mechanical assembly foreman in the assembly area reduced the departmental manager's span of control to four and removed him from the day-to-day running of production areas. The Marketing Department, on the other hand, had a total staff of six below the manager, all of whom had well-defined and largely independent functions. There were, thus, no subordinate managerial levels in this department. The enhanced status of the Sales Manager was merely the official recognition of the fact that because that manager would be absent a good deal from the workplace, visiting potential customers, a formal delegation of authority by him to a subordinate would only be sensible.

In practice, therefore, the number of managerial levels varied from 2 to 4 within the subject firm because departments were of unequal sizes. Organisation on lines of a mixed structure would have helped to reduce this latter inequality, since the two production units would have been the responsibility of different managers. One practical difficulty with making such a change was that it might be seen to reduce the status of the General Manager's effective deputy, the Works Manager, through reducing the size of his department.

The span of control of the Chief Executive was 5, one more, as already noted in Chapter 2, than the median found for firms of this size in the Essex research (13). The General Production Planning Manager was a recent addition, brought in by the new General Manager because of a desire for greater forward planning and processing control. Spans of control of departmental managers were not consistent; but this is natural given their different functions.

3.4.1.1 The Works Manager

The Works Manager was responsible for everything directly associated with manufacture, from the time that the raw materials or parts arrived on the shop floor to the time that the finished job had been prepared by the Despatch Storeman or the Plant Engineer's staff for transportation to the customer. He had a staff of 4 reporting directly to him.

3.4.1.2 The Production Planning Manager

The Production Planning Manager was expected to plan and control all manufacturing within the Division, to monitor progress and to feed back information to the Executive Committee on weekly and monthly production performance against the plans set by his department. He had 6 subordinates of unequal status. The Estimating and Technical Department Manager and the Design Department Manager were virtually autonomous. The Production Administration Manager acted as Deputy Head of the Department and had an accepted authority over the Machine Shop Production Controller, mainly because of a sales liaison role which he also performed with reference to tooling work other than for Engineering Group customers. The two Production Controllers, however, both made their regular weekly reports direct to the departmental manager. Both naturally had close cross-departmental ties with the production supervisors. The Order Controller kept quotation and order registers and records, and it was his job also to prepare invoices for non-Group jobs, which led him to work closely with the Accounts Department. The following diagram, figure 3.25, shows these relationships.

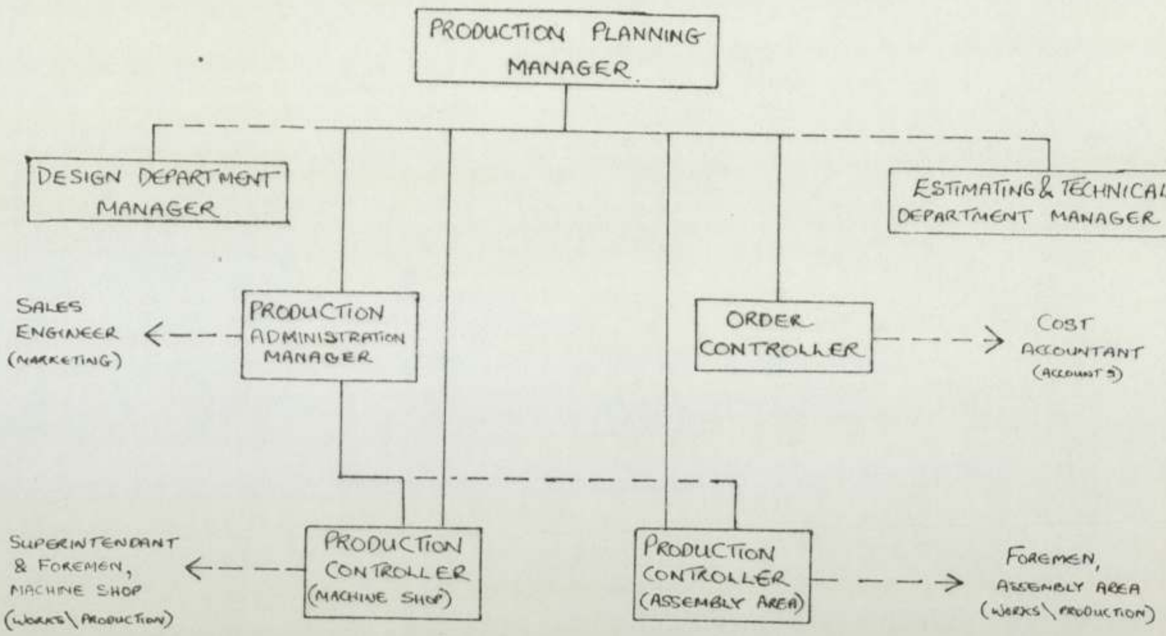


Figure 3.15 Production Planning Department: Internal Relationships & Horizontal Links With Other Departments

3.4.1.3 The Purchasing Or Buying Manager

The Purchasing or Buying Manager was responsible for procurement at the lowest possible cost of all materials and parts needed by the manufacturing departments as specified on requisition forms by the Estimating Department. He did not operate solely through his Deputy Manager, although the latter was responsible for the day to day allocation of work amongst the buyers. The Deputy took personal charge of the provision of parts for major machinery contracts, including progress calls to suppliers for latest delivery information. An order progressing diary was kept in the department and each buyer was responsible for making the calls to those suppliers whose names lay within a set alphabetical range. With an Assistant Manager, 4 Buyers and 3 Storemen, the Departmental Manager thus had a total span of control of 8, but formal procedures were laid down for the work of all subordinates and it was only in exceptional cases, where the buyer was unable to meet the cost target given on the estimator's requisition, or where a consignment arriving in the stores was not as specified on the order placed, that reference was made to the manager.

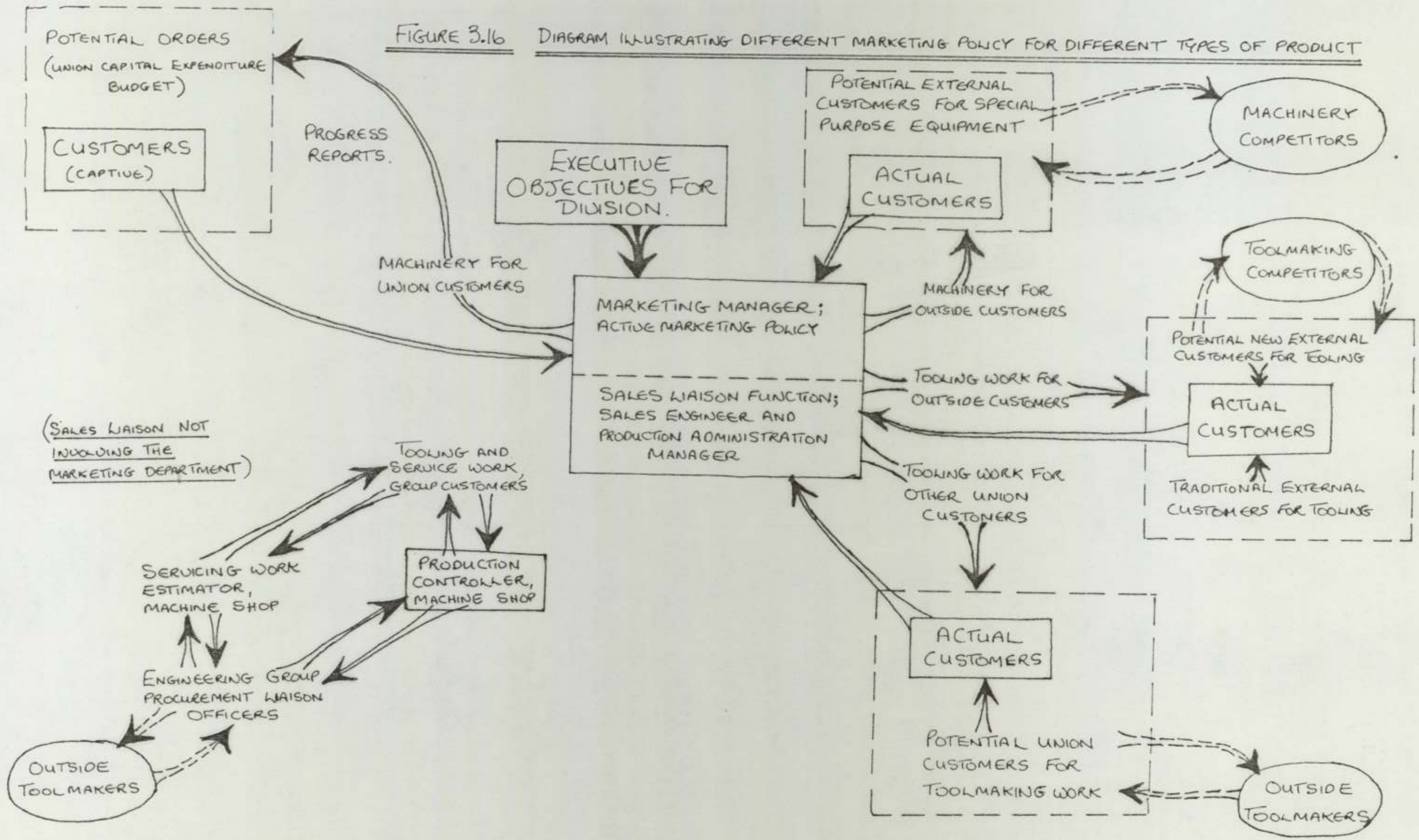
3.4.1.4 The Chief Accountant

The Chief Accountant had two direct subordinates: the cost Accountant responsible for classifying, recording, allocating to individual jobs, summarising and reporting to management on current and future costs (14); the Financial Accountant recording the revenue received and expenditure incurred by the Company so that its overall trading position could be ascertained at the end of each month (15). These two provided the data needed for the regular "control accounting" function - comparison of the actual performance with plans and budgets - leaving the Chief Accountant relatively free for his main function of "decision accounting" - promoting decisions on the basis of analysis of the profitability of alternative allocation of resources (16).
In P & ED, the failure of orders to fill the available capacity meant that decision accounting was concerned with evaluating the profitability of expanding the product range into new areas.

3.4.1.5 The Marketing Manager

The Marketing Manager had a span of control of 6, including 3 commissioning engineers who were concerned also with after-sales service on machinery projects. Marketing may be defined as "the management function which organises and directs all those business activities involved in assessing and converting consumer purchasing power into effective demand for a specified product or service ..... So as to achieve the profit target or other objective set by a company" (17).
In these terms, P & ED's Marketing Department was somewhat of an

FIGURE 3.16 DIAGRAM ILLUSTRATING DIFFERENT MARKETING POLICY FOR DIFFERENT TYPES OF PRODUCT



anomaly. Its function was under-developed and active pursuit of orders tended to concern only the machinery side of the business, and indeed even here only really with competitive negotiations for contracts with non-Union firms.

Elsewhere, the function was essentially one of liaison by the Sales Engineer with customers on order progress. In practice, this necessarily also involved the Production Administration Manager, since it was one of his functions to maintain a record of progress on all orders other than those for Engineering Group customers. Liaison for the latter types of orders was handled by the Production Controller and service work estimator on the shop floor. An attempt to illustrate the variety of marketing policy on different types of business is given in figure 3.16. Essentially, the marketing function had the form and type of personnel noted by Woodward in the Essex research (18): the Departmental Manager had previously been Design and Development Manager; the Production Administration Manager had been Technical Sales Engineer.

The Marketing Manager was also given a general brief to look at prospective new products for the Division and during 1974 had visited the United States to negotiate European manufacturing licences for products connected with oil pipelines. These attempts to take advantage of the expanding North Sea Oil Industry are dealt with in Chapter 4 of this Thesis, as one of the methods examined for improving the Division's position.

3.4.2 Particular Problem Areas With The Defined Structure

1. To promote the necessary integration of pre-production activities, it was necessary that the control of the Production Planning Manager over the Design & Estimating Managers should become very much more real. It was insufficient, in the case of machinery contracts, merely to plan the processing stages if maximum efficiency and minimum order throughput time were to be assured. Rather it was essential to ensure, for example, that estimators would be available to work on projects as soon as the project engineers were ready to pass drawings to them. This would ensure that the Buying Department, in turn, were given the maximum time to purchase any required parts and materials. The central role of the Production Planning Manager needed to be developed along the lines of the central co-ordinator noted in figure 2.7, at least for the machinery side of the business.

2. Production Control staff in the machine shop did not plan or control the progress of jobs through the shop. Rather they monitored and reported actual processing activity. They acted merely as a feedback channel. This resulted from the fact that, as subordinate levels of the Production Planning Department, they had no actual authority on a shop floor governed by the Works Manager.

   Section progress chasers were effectively under the foremen, even if they were supposed to work alongside them. As one noted accurately: "We're just glorified material handlers or labourers!" At daily meetings they reported developments on certain prescribed jobs to the Production Controller, but the latter was left in the unenviable position of supposedly controlling the actions of people over whom he had no direct authority. To impose a required order of processing, he had to work through the shop superintendent, but to avoid the necessity for this, he generally operated in practice, by making requests for 'favours' to section foremen, who were normally responsible. It was the foremen, and not the Production Control Department, who issued work as they saw fit to their machinists, based upon balancing job requirements against the particular specialist skills of machinists available.

There was bound to be a difference of approach between subordinates of the Works Manager and those of the Production Planning Manager, since they adopted different achievement measures. The former were concerned to 'keep the machinists in work', or to maximise productive occupation of labour; the latter stressed the need to process jobs in a particular order, minimising throughput time of complete jobs, and thus keeping down the amount of working capital tied up in works-in-progress stocks, to avoid the possibility of cash-flow problems.

3. In assembly area operations, as noted in Chapter 2, Section 4.2.2, planning is the key factor, and control becomes relatively simple if the planning has been done competently. Here the Senior Foreman in charge of the assembly operations was thus reliant on the area's Production Controller and order progress clerk. It was these who kit marshalled the parts for a job, checked and progressed shortages and signalled when it was possible for assembly to commence. Yet here again, in theory, the foreman and the production control staff were responsible to different departmental managers. Clarification and rationalisation of lines of authority and areas of responsibility was needed.

3.4.3 Conclusions On Structural Problems

The purely functional structure chosen by P & ED was ill-advised considering the essential differences, noted in Chapter 2, Section 5, between its two types of work. It tended to produce exactly the sorts of problems noted by Drucker:

> "Even proper functional organisation ..... makes it difficult to focus on business performance. Every functional manager considers his function the most important one, tries to build it up and is prone to subordinate the welfare of the other functions, if not of the entire business, to the interests of his unit"(19).

However, there is a limit to the contribution which structure "per se" can make in improving organisational effectiveness. It cannot be expected to resolve political problems or conflicts over objectives within an institution. Nor can it provide solutions where there is not the will or competence among managers or employees to conform to an appropriate pattern of behaviour (20).

Consideration of structure is closely linked with the question of internal integration of departments, the subject of the next sub-section. Formal structure provides little more than a basic framework for performance assessment and the allocation of responsibilities. However, one must conclude that, in the subject organisation, structural deficiencies did cause serious problems (21).

3.5 Deficiencies In Internal Co-ordination

As a means of explaining the interaction between departments in P & ED, and of illustrating the existing co-ordination problems, flow charts showing the Quotation and Order processing procedure within the businesss have been prepared. Use of these charts also allows reduction

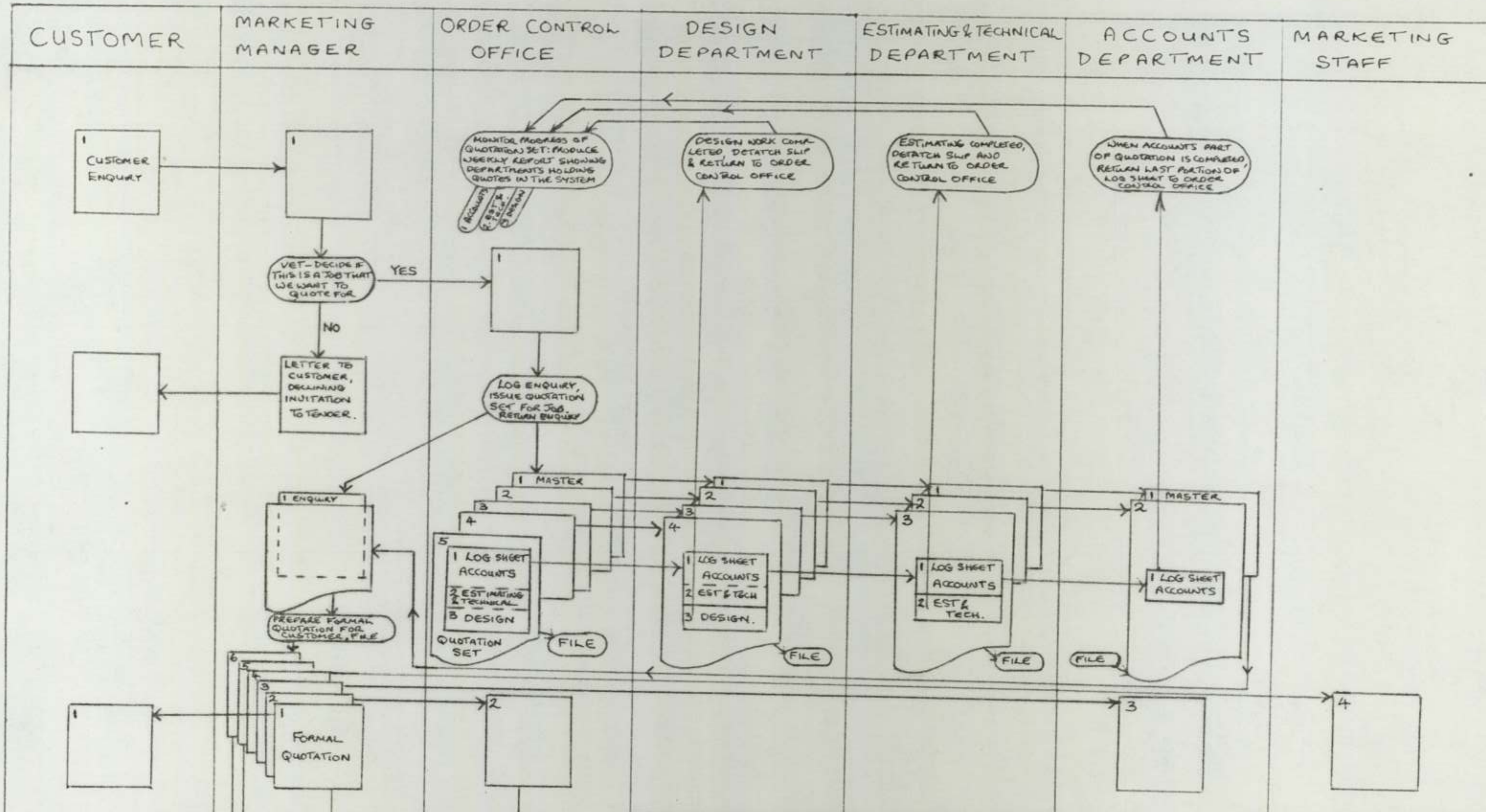


FIGURE 3.17 QUOTATION SYSTEM — FLOW DIAGRAM

of the accompanying narrative, since the charts are reasonably self-explanatory. None of this procedure relates to service jobs for Engineering Group customers; because of their urgent nature, they were dealt with directly by an estimator stationed in the machine shop.

3.5.1 Quotation Processing Procedure

This is shown in figure 3.17. The problems with the operation of this procedure basically turned around the fact that it took such a long time to prepare a quotation and return it to the prospective customer and that, given the percentage return of orders on quotations graphed in part 3 of Appendix 4, a large proportion of the design and estimating time spent preparing quotations was wasted. Indeed, the graph shows that usually fewer than 1 in 4 quotations sent out on machinery work, and fewer than 1 in 2 on outside tooling work, resulted in an order being placed. However, given that the Division was almost always dealing with unique jobs and that accurate price quotation was essential if it should both make a satisfactory contribution and be as competitive as possible, the time taken in the quotation procedure must be accepted as a necessary evil.

What perhaps could have improved the situation would have been some preliminary vetting of enquiries to see how serious the proposers were. The problem once again, however, was that in its under-loaded state, P & ED could not afford to risk losing any orders - no matter how unlikely they might seem on the surface - by declining to quote for jobs.

One habitual procedure which was likely to cause difficulties if an order should be received was the specifying of actual dates for delivery to the customers, rather than the more sensible system (to

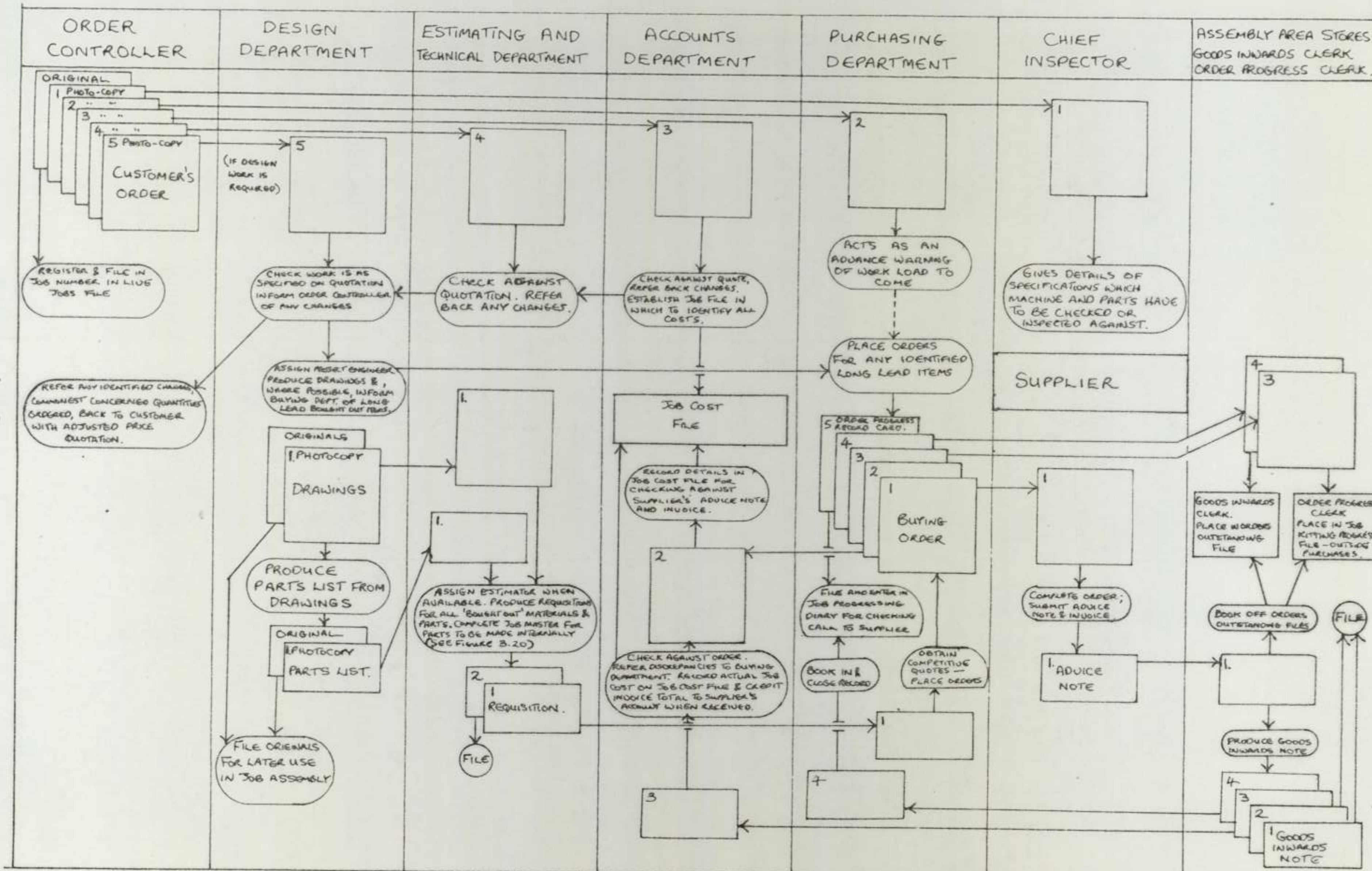


FIGURE 3.18 · PRE-PRODUCTION AREA MAIN PAPERWORK INCLUDING THAT CONCERNED WITH THE PURCHASE OF PARTS AND MATERIALS FROM OUTSIDE SUPPLIERS

which the Division changed in late 1975) of quoting a certain number of weeks from receipt of an order. With the tooling business, orders arrived, if at all, very shortly after quotations were issued, but on machinery business protracted negotiations, often including price adjustments, could take place after the formal quotation had been received by the customer. The Division simply had not altered its methods in line with its changing business.

3.5.2 Processing of Customers' Orders Through the Pre-Production Departments

Figure 3.18 describes the progress of customers' orders and associated internal paperwork through the Division's pre-production departments. Once again, it replaces a narrative description. The Buying Orders have been included to demonstrate the use made of several of the files kept: the Accounts Department Job-Cost file; the Purchasing Dept. order progress record card and progressing diary; the Goods Inwards area's orders outstanding file and job kitting progress file. A subsidiary piece of paperwork, called the "Order Progress Report" has been omitted. Such reports were made out by buyers immediately after progress calls to suppliers. They were passed to the departmental manager or deputy manager, who removed those specifying "No Change" to expected delivery date and forwarded all those with changed dates to the Order Progress Clerk in the assembly area stores, so that he could amend his job kitting record.

The main problems with the operation of this system centred around insufficient inter-departmental communication of supplementary information and the purely informal systems whereby shortcuts were taken to allow finished parts of a job to proceed from one department to the next. It was very similar to the situation noted by Rackham, of the Imperial College research unit, with reference to a firm in Essex:-

> "before production had actually begun, the Works was operating on the assumption that short-cuts would have to be taken if the delivery date was to be met. Both the Methods and the Order Control Sections felt constrained to go ahead with their part of the procedures before they had as much information as they would have liked. The going ahead before being really ready was reflected at almost every stage in the process".

The result in the case under consideration was the eventual delivery of the ordered item about 9 months after it was required. Rackham notes that the firm under study had a "high degree of variation in product range", and that the example concerned "the first run of a new product", both of which supported his case that "in this type of production, problems of time control are almost insoluble", and that difficulties were exacerbated by an "unrealism", which crept in "at the outset in the negotiation of delivery dates between the firm and its customers" (22).

One must note, however, that the firm which Rackham was describing was a small batch electronics firm. It would thus be expected that the problem with P & ED, a unit production firm, would be even more complex and unmanageable. Woodward notes that one of the features of 4 unit production engineering firms in Essex was "good inter-departmental relationships" resulting from "close integration of functions". All these firms were described as average or above average performers (23). In P & ED, however, perhaps that very "below average performer", which the Essex research workers did not have available to study (24), -

inter-departmental relationships were marked by a degree of insularity which on occasions approached "empire-building": the Production Planning Manager, for example, was very conscious of the prestige associated with the only department which really knew what progress was being made on orders, and the Buying Manager that only his department knew the latest delivery position on vital purchases from external suppliers.

The basic task of the pre-production departments was to get requisitions to the Purchasing Department and manufacturing paperwork to the shop floor as rapidly as possible in order to give the maximum chance of completing the job on schedule. On machinery projects, for example, the estimator assigned would first produce all requisitions for the purchase of parts or materials; second, manufacturing paperwork for the machine shop, including computer input forms for the data collection system in use; third, time allowances for assembly operations; and finally a costed parts list for the Accounts Department. It was common for the estimator, during periods of heavy workload, to change to another job after completion of stages one and two, and return to complete his work at a later date. As the Accounts Department did not use the costed parts list for intermediate monitoring of jobs progress, but merely totalled the estimated against actual costs for completed jobs, this did not cause any problems. Lack of monitoring by the Accounts Department did mean, however, that there was no feedback on a problem job from then until it was too late to do anything about it!

Because there was no co-ordination of activities between draughtsman and estimators, there was no certainty that work passed on by the Design Department would receive immediate attention in Estimating &

Technical Department. Recognising that his staff, as with the draughtsmen, had particular ability with certain types of job, the manager of the latter department organised his staff informally along product lines - there was, for example, one estimator who always dealt with nuclear processing industry contracts and three others, recruited from the shop floor, worked only on Engineering Group tooling orders. But with the balance of orders between machinery orders and tooling work far from constant, permanent allocation of all staff was felt to be unwise. At times the manager was found to be faced with the conflicting priorities of Divisional, Group and Union best interests in deciding whether to allocate staff to tooling orders or machinery projects. Normally the latter would lose out because tooling orders generally required only a few hours of work as against days or even weeks for machinery projects. On occasions when tooling work was forced to queue for attention, the situation could arise where the Production Controller did not receive manufacturing paperwork until after the promised delivery date for a job.

The establishment of delivery dates was indeed a haphazard process, and had changed very little since 1969 when the Management Services Report on Clerical Procedures had commented:

> "The (Production Planning) department accepts orders and assesses delivery dates. Acceptance is not formally related to capacity, but lead times are always applied. The lead time is built up from the job estimates with allowance for paperwork processing and movements between operations. This does not prevent jobs being accepted inside the lead time, especially where the Planning Department has had to do detail drawings after the order was accepted. In such circumstances more orders ought to have their delivery dates re-negotiated (25)".

On machinery contracts the customer was at least kept up-to-date with delays caused by late delivery of bought-out components. With tooling jobs it was not considered worthwhile because the Production Controller in the Machine Shop, like the Commercial Department in 1969, was working with insufficient information:

"The department tries to progress jobs to ensure that agreed delivery dates are met, but has insufficient information to do this satisfactorily. There is a high rate of failure to meet the promised delivery date, estimated at 30%. -

Tables 4 & 5 in Appendix 2 show the situation had gone way beyond this unsupported figure by 1975 and figure 3.19 supports this with figures for November of that year.

"Causes of failure are many. Too little is known about available capacity by the Planning Department who decide the delivery dates. Many orders reach the Shoploaders after they should have been despatched. Reporting back of shop progress to Commercial Department is not on a formal basis, though this is really the task of the Progress Department itself. An exception report from the Progress Department to Commercial Department showing all jobs in arears would be valuable. It would also enable the failure rate to be monitored, in conjunction with Commercial Department's order register. Lack of information at present creates an indifference to breaches of delivery promises, an attitude which is general and not confined to the Commercial Department. Short term gains in turnover followed by poor delivery performance are not in the long term interests of the Division"(26).

The situation had improved very little by the beginning of 1975. Theoretically, the Production Planning Department now received a

Figure 3.19 Analysis of November 1975 Output Schedule According To Original Delivery Promise.

Delivery Schedule For Jobs Other Than For Engineering Group Or Spares

Total of 45 orders due for completion during month of November 1979.

Of these 12	worth	a total	of	£23,510	were on schedule
6	"	"	"	£37,887	were 1-4 weeks overdue
13	"	"	"	£48,335	were 5-8 weeks overdue
and 14	"	"	"	£21,416	were 9 or more weeks overdue

The total value of orders due for delivery in the month = £131,148.

Current orders were	18%	by value	and	27%	by number
orders 1-4 weeks overdue	29%	"	"	13%	"
" 5-8 " "	37%	"	"	29%	"
" 9 or more "	16%	"	"	31%	"

Current Orders: Influence of low value, short-term round cooling jobs.
9+ Weeks Overdue: Low value problem jobs allowed to drift. Single job where customer encountered problems, accounts for ½ value shown.

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job progress report in the form of the weekly Work in Progress report from the data collection system then in use. In fact, as the next Section (3.6) will note in detail, this report provided insufficient information and had to be backed up by manual expedients such as time consuming progress meetings between the Machine Shop Production

Controller, the Production Planning Manager and the Production Administration Manager and the multitude of phone calls from the last of these to the first every week. The Production Controller generally dealt with such enquiries by delegating one of his progress chasers to conduct a manual search for all items on a job around the machine shop. On occasions when he was too busy to do this, he would make an estimate based upon the most recent work in progress report. This latter procedure could be disastrous because the report gave no indication of any problems with particular items on a job.

If the Production Planning Department hierarchy had reason to bemoan the quality of intra-departmental feedback from its shop floor progress officers, its own activities as a department were certainly not free of blame for actively discouraging an atmosphere of inter-departmental co-operation. On the whole, it is understandable that the new Production Planning Manager - by several years the junior of the rest of the Executive Committee - should attend first and foremost to establishing the importance of his function and confirmation of his status within the organisation. But he had been employed mainly to develop that very integration of pre-production activities which some of his actions seemed designed to prevent. He regarded the department's monopoly on job progress information, for example, as a sort of ammunition store providing the correct tactical weapons for probing the weaknesses of other departments, rather than as demonstrating faults in the overall system for which he might suggest solutions. The comments on overdue jobs in the monthly delivery schedule thus often referred to the shortcomings of others.

The Production Planning Manager was actually well-placed at the start of 1975 to loose off a few salvos, since it was exceptionally difficult to detect any area for which he bore specific responsibility. Marketing Department had accepted that a given job was suitable for the Division; assessments of time required for design work and technical estimating had been proposed at the quotation stage by the staff and ultimately the managers of those departments; Purchasing Department had identified the lead time of the longest lead bought out items; despite the fact that delivery promises were made by the Production Administration Manager (for all tooling work) and the Production Planning Manager (for major projects), the responsibility for meeting the dates set for tooling deliveries lay solely with the Production Department, and for completing the various stages of machinery projects on time with the various departments, from whose estimates the project plan had been drawn up.

The procedure on tooling work was to ensure, irrespective of current load conditions, that a minimum of two operations on each item of a job would be carried out during a week. Computation of a throughput time thus took the simple form of halving the number of operations on the item with the greatest number of operations. There rarely seemed to be allowance for four practical problems with this system - problems other than the basic one:

> "More study of the load position should be made before orders are accepted if the delivery failure rate is to go down..."(27)

on which there had been no improvement since the 1969 report, despite employment of a fairly expensive data collection system. The problems were:-

1. An operation which, for example, was estimated at 80 hours, would receive an "exceptional" allowance of 2 weeks for completion, a target which could only be met if the actual operating time was less than or equal to the estimated time. It was rare for this to happen in practice with operations of this duration.

2. External sub-contract operations were counted either as one of the two operations for a week or, exceptionally, as a week's work on their own. Outside sub-contractors rarely met such targets - nor was there much chance of them doing so when it took P & ED a day to arrange the necessary paperwork and perhaps another day to fix transportation to the contractor's workshop. Common sub-contract operations included plating work and gear-cutting, neither of which had short processing times, even if the contractor should have no current work already queueing at operating stations.

3. Internal heat-treatment or hardening operation lead times depended upon the build-up of an economical furnace load. Because of this it might have been more sensible to count such operations as a whole week's work. This was not done because the preceding and following operations to heat treatment were both inspections, theoretically not requiring a great deal of time.

4. In fact, all inspection operations represented a subsidiary problem. As with heat treatment, these operations were not given time allocations on job routing cards. It was thus impossible to tell from the computer reports whether these operations had been completed or not, a difficulty increased

by the fact that there was no progressing of the Inspection Department.

To find the due completion date for stages in a machinery project, the Production Planning Manager simply referred to the contract delivery date and back-scheduled all other operations from there. This would indicate both when assembly would need to start and thus the parts kit be complete and also, at a much earlier point in time, by what date the Buying Department would need to have received details from the draughtsmen or Project Engineer of required long lead bought out items.

All stages in machinery projects were bar charted on a large display board in the Production Administration Manager's office, but there was no established system either for monitoring progress within the pre-production departments against this chart or for up-dating the chart either to show slippage against the schedule within the departments, or indeed to remove old jobs and insert new ones. At the time of this researcher's arrival, one job delivered late in 1973 and several others delivered earlier in 1974, were still shown on the chart. Comparison of the plans for those still in progress with the newly instituted delivery schedule confirmed that the plans shown were hopelessly inaccurate. It was explained that nobody had the time to keep the chart up-to-date and that no one ever used it anyway! Members of other departments were not required to commit themselves to the schedule and feedback on their progress only came in the form of occasional ridicule of the displayed plan.

There was no attempt to employ a network model for planning machinery projects - even one as basic as that offered earlier in figure 3.12 -

but the display board could have been useful, had it been used properly. Part of the difficulty lay in the method used for recording the initial plans. Strips of different coloured insulating tapes, representing different departments' involvement in a given job were placed on the plastic screen overlaying a graph divided into production weeks for the year. To amend these schedules took an unjustifiable amount of time in view of the use made of the chart - but then, of course, no more attention would be paid to them unless they became more accurate.

Because of the unrepetitive and therefore uncertain nature of jobs, departmental heads were loath to allow themselves to become committed to a definite completion date for jobs and thus the idea of central co-ordination and integration of their several activities was not popular. Each preferred to be individually responsible for the work of his own department in isolation and to deal with new tasks as and when these arrived. But this meant there was no sense of urgency except where specific direction was given by the General Manager to his executive committee on orders where, for example, the Division had accepted penalty clauses in order to secure contracts.

The 1969 Management Services Report noted that:

> "The informal methods of communication are proving inadequate, as the division has expanded rapidly. In some areas new procedures should be set up" (28).

By 1975, this communication problem still existed and is exemplified by the problem at the interface between the Purchasing Department and the Production Planning Department. Despite the fact that late delivery of components bought from outside suppliers could obviously affect possible completion dates of work by the Division, there was no formal system for communicating revised delivery promises received through progress calls to suppliers from the Purchasing Department to the Production Planning Department. On machine assembly projects, because the Assistant Purchasing Manager personally monitored progress towards a complete parts kit and was also in receipt of a monthly delivery schedule from the Production Planning Manager, it was expected that he would draw the attention of the latter to any problems envisaged with respect to outside purchases. This pre-supposed that he knew the build sequence of any late items and also the total assembly time allowed for the job. Because he did not have this information he was not really placed to assess which late deliveries would affect the whole production programme and which would not.

He reported problems only to his own departmental manager, who would then refer them to the Production Planning Manager if he thought necessary. In most cases this informal link worked well enough, but the high value of the machines concerned and, therefore, the potential cash flow problems created by holding kits of parts longer than necessary, meant that the cost of any failure would be high. One example during 1975 concerned a foreign-made motor for tyre making equipment for an overseas Dunlop subsidiary. At the kitmarshalling stage it was discovered that delivery of the motor was overdue. Subsequent enquiries showed that a revised delivery date had been received and that this date was in fact over a month after the equipment was scheduled for delivery to the customer.

A different example of the "ad hoc" growth of systems within the pre-production departments is provided by the records kept in the Order Control office. One got the impression that, because order input rarely reached capacity levels, this department multiplied its workload by establishing separate records to cover each and every conceivable purpose,

FIGURE 320 THE RECORDS KEPT BY THE ORDER CONTROLLER'S CLERKS

RECORD TITLE \ RECORD CONTENTS	QUOTATION NUMBER	JOB NUMBER	CUSTOMER'S ORDER Nº	DRAWING NUMBER	DESCRIPTION C = COMPLETE B = BRIEF	DELIVERY PROMISE	DATE OF REGISTRATION E = ENQUIRY O = ORDER	NAME OF CUSTOMER	VALUE Q = QUOTE O = ORDER I = INVOICE	DUE FINISH DATE FOR DESIGN WORK	DUE FINISH DATE FOR ESTIMATING WORK	DATE OF ISSUE OF FORMAL QUOTATION	DATE OF DESPATCH AND GUARD SHEET Nº	JOB PROGRESS NOTES C = COMPLETE B = BRIEF	BUSINESS TYPE	TOTAL LABOUR HOURS ESTIMATED	USER DEPARTMENT	PURPOSE
INDIVIDUAL ORDER REGISTERS FOR THE FIVE DIFFERENT BUSINESS TYPES		✓	✓	✓	✓C	✓	✓O								✓		PRODUCTION PLANNING VARIOUS OTHERS (OCCASIONALLY)	REFERRED TO THIS AND BELOW REGISTER FOR DETAILS OF NEW JOBS TO BE ADDED TO DELIVERY SCHEDULE AT MONTH END. TO LOCATE HISTORICAL INFORMATION ON REPEAT, OR SIMILAR JOBS, WHERE ONLY BUSINESS TYPE AND ROUGH DATE OF ORDER WERE KNOWN.
ORDER CONFIRMATION REGISTER		✓	✓				✓O	✓	✓O	✓	✓				✓		PRODUCTION PLANNING ORDER CONTROLLER	AS ABOVE, PARTICULARLY FOR ORDER VALUE. MAIN PURPOSE WAS TO PREVENT ANY DELAY TO NEW JOBS ENTERING THE SYSTEM, WHILE KEEPING A RECORD OF THEIR EXISTENCE. THE DETAILED ENTRY IN REGISTER ABOVE WAS MADE AFTER THE ORDER HAD BEEN ROUND ALL THE DEPARTMENTS CONCERNED.
ENQUIRY REGISTER	✓						✓E ✓O	✓	✓Q			✓			✓		PRODUCTION ADMINISTRATION ORDER CONTROLLER THE RESEARCHER	TO ASCERTAIN WHETHER ORDERS RECEIVED RESULTED FROM PREVIOUS ENQUIRIES, OR WHETHER NO QUOTATION HAD YET BEEN ISSUED BY P.& E.D. (THIS HAPPENED OCCASIONALLY WITH UNION ORDERS) TO RECORD ALL ENQUIRIES RECEIVED. TO PRODUCE STATISTICS TO SHOW THE RATE OF RETURN OF ORDERS ON QUOTATIONS IN DIFFERENT BUSINESS CATEGORIES.
DELIVERY DIARY/SCHEDULE		✓			✓B	✓		✓	✓O					✓B	✓		PRODUCTION PLANNING	TO RECORD ALL JOBS IN THE SYSTEM AT ANY ONE TIME AND THEIR DUE DELIVERY DATES. TO ADD NEW JOBS WITH DELIVERY DATES AND VALUES. THE SCHEDULE WAS PHOTO-COPIED AND DISTRIBUTED MONTHLY TO MANAGEMENT TO SHOW PRODUCTION TARGETS AND FORWARD LOAD
JOB PROGRESS FILE	✓	✓			✓B	✓	✓O	✓	✓O	② ✓	② ✓		✓	✓C	✓		PRODUCTION PLANNING/ PRODUCTION ADMINISTRATION	TO MAINTAIN A MANUFACTURING RECORD FOR EACH JOB IN ORDER TO BE ABLE TO ANSWER CUSTOMERS' ENQUIRIES. INFORMATION WAS ADDED FROM PROGRESS MEETINGS WITH PRODUCTION CONTROLLERS EACH WEEK, AND FROM SPECIFIC TELEPHONE ENQUIRIES TO THEM DURING THE WEEK. THE NEED FOR AND USE OF THIS FILE POINTED TO A FAILURE IN THE DATA COLLECTION REPORTS.
QUOTATIONS FILE	✓				✓C	✓		✓	✓Q			✓				✓	DESIGN DEPARTMENT/ ESTIMATING & TECHNICAL DEPARTMENT.	INFREQUENTLY USED IN QUOTATION FOR SIMILAR OR REPEAT WORK, WHERE NO ORDER HAD BEEN RECEIVED IN THE FIRST INSTANCE. SINCE DEPARTMENTS CARRIED THEIR OWN QUOTATION RECORDS, EVEN THE ORDER CONTROLLER CONSIDERED THIS FILE TO BE SUPERFLUOUS
CUSTOMER ORDER FILE (LIVE JOBS)	✓	✓	✓	✓	✓C	✓		✓	✓O						✓		ORDER CONTROLLER THE RESEARCHER	USED AS A PRECISE RECORD AGAINST WHICH INVOICES WERE DRAWN UP. RECORDED DELIVERY OF PARTS OF INCOMPLETE JOBS AND PROGRESS PAYMENTS USED AS MORE RELIABLE INDICATION OF JOB VALUES, OR AS ONLY SOURCE WHERE THESE VALUES HAD BEEN OMITTED ELSEWHERE.
COMPLETED JOBS FILE	✓	✓	✓	✓	✓C	✓		✓	✓O ✓I				✓		✓		DESIGN DEPARTMENT/ ESTIMATING & TECHNICAL DEPARTMENT.	USED BY THOSE INVOLVED IN QUOTATION FOR SIMILAR OR REPEAT WORK. DIRECT REFERENCE WAS POSSIBLE IF JOB NUMBER WAS KNOWN, BUT OFTEN THE ORDER REGISTERS HAD FIRST TO BE CONSULTED FOR THIS INFORMATION.
QUOTE LOAD REGISTER	✓	✓				✓	✓E		✓Q						✓	✓	PRODUCTION ADMINISTRATION	ROUGH CHECK ON AMOUNT OF WORK BEING PROMISED FOR DELIVERY IN PARTICULAR WEEKS. THIS INFORMATION WAS WITHOUT ANY MEANING AS DELIVERY DATES CHANGED AT THE TIME OF INPUT OF AN ORDER. REASONABLE GUIDE FOR GROUP TOOLING WORK, WHERE RETURN OF ORDERS ON QUOTES WAS HIGH AND LITTLE DELAY EXISTED BETWEEN ISSUE OF QUOTE AND RECEIPT OF ORDER.
TOTAL NUMBER OF DUPLICATIONS OF INFORMATION HELD ①	5	6	3	2	3C 2B	6	2E 4O	6	3Q 4O 1I	1	1	2	2	1B 1C	7	2	—	QUITE OBVIOUSLY, FAR TOO MUCH DUPLICATION: A CLASSIC PARKINSONIAN SITUATION OF WORK EXPANDING TO FILL THE AVAILABLE TIME AND JUSTIFY THE EMPLOYMENT OF TWO CLERKS IN THE ORDER CONTROL OFFICE.

NOTES: ① CUSTOMER ORDERS FILE (LIVE JOBS) AND COMPLETED JOBS FILE NOT COUNTED SEPARATELY HERE: RECORDS WERE TRANSFERRED FROM ONE TO THE OTHER AFTER JOB DESPATCH
② MAJOR MACHINERY PROJECTS ONLY.

rather than holding a single reference file with all the information relating to a given job. Figure 3.20 exemplifies the duplication of data held on the various files.

The difficulty in this area of the research is that although one can say, with reference to the Essex examples, that unit production firms which do comparatively well are generally characterised by close integration of these pre-production activities (29) it is difficult to quantify in precise terms what exactly the financial cost of poor co-ordination was to the subject division. On tooling work, administrative procedures certainly played a part in causing late deliveries, but how large a part, compared with production problems, is difficult to specify. It is also impossible to calculate the number of orders in this type of business which were actually lost because of a poor delivery reputation. The Division's customers were usually primarily concerned with quality anyway.

The key nature of lead times on bought out items on machinery contracts has already been noted. Given that such items were identified in the earliest stages of the design work, inefficiency in handling the rest of the pre-production side of these jobs should not have caused problems. Indeed, during periods of low order loads it is difficult to see how it would have any practical effect. The cost of the inefficient co-ordination would only really be seen for this work when the order load was heavy, when the actual maximum load handled during a given period would be below the potential maximum for the personnel concerned. In the subject firm this could be masked by moving staff away from the other type of business because of the functional organisation of departments.

The problems in the administrative departments really need to be considered in terms of the disorganised base which they provided for all other activities: their lack of urgency could hardly help but be reflected in the processing units of the Division.

3.5.3 <u>Problems With The Control Of Workflow Through The Production Unit</u>

This section concentrates on the Machine Shop unit of the Division. In the Assembly Area few jobs were processed at the same time and, as noted in Chapter 2, as long as the planning had been accurate, control of assembly operations was fairly straightforward. An order progress clerk monitored the arrival of parts against the parts list for a project and made out a list of all shortages at the kitmarshalling stage, divided into outside purchases and internally manufactured items. The Assembly Area Production Controller forwarded copies of this to the Purchasing Department and the Machine Shop Production Controller respectively for latest delivery information to be added. When the Assembly Area Senior Foreman decided that sufficient of the kit existed for a start to be made, he arranged issue to the shop floors. While in theory this should not have happened until the kit was complete, in practice he was so short of work for his fitters towards the end of 1974 and in early 1975 that he arranged issue at the earliest time possible, even if this would mean that at some time assembly would have to be halted pending arrival of a part. At times of reasonable load, throughput time was equal to the sum of all assembly operation times.

A problem did exist within the assembly stores area, however. Again, it had been identified in the 1969 Management Services Report: "On some machines a single part can be given different numbers for its different applications within that machine. Different numbers for the same part on different machines also occur. In the majority of cases unique identity is preserved regardless of the end use of the item..... several bins in the stores can hold the same parts under different numbers... unless storemen are aware of all the possible numbers for a part, a fitter can be short of parts which are actually in stock" (30). For ease in kitting out a job, stores held parts at "bin locations" under P & ED part numbers, rather than manufacturers' numbers: it was only the former which were given on parts lists.

The Division had never made use of the services of the Dunlop Coding Section, which cross-referenced the part numbers used by a variety of different manufacturers against a single number for company usage. This service was available, free of charge, to all members of the Union and indeed P & ED's lack of use of it presented problems when spare parts were ordered by internal customers. The Division had to refer to the coding section to find out what a given Dunlop part number, which was commonly all that was given by the customer, actually referred to.

The state of the assembly area stores by the end of 1974 was chaotic. True, a record existed of all parts in stock, but there was still no cross-reference of identical parts under different numbers and the precaution had not even been taken of locating like items in adjacent bin positions. But the main problem was that no authorisation was ever given to dispose of obsolete items. Masses of these cluttered the stores. The storemen had no way of knowing which were indeed still in use and which definitely obsolete, but he did point out several drums of 10-ply electrical wiring, imported from France for use on a tyre-building machine which had not been made since 1970.

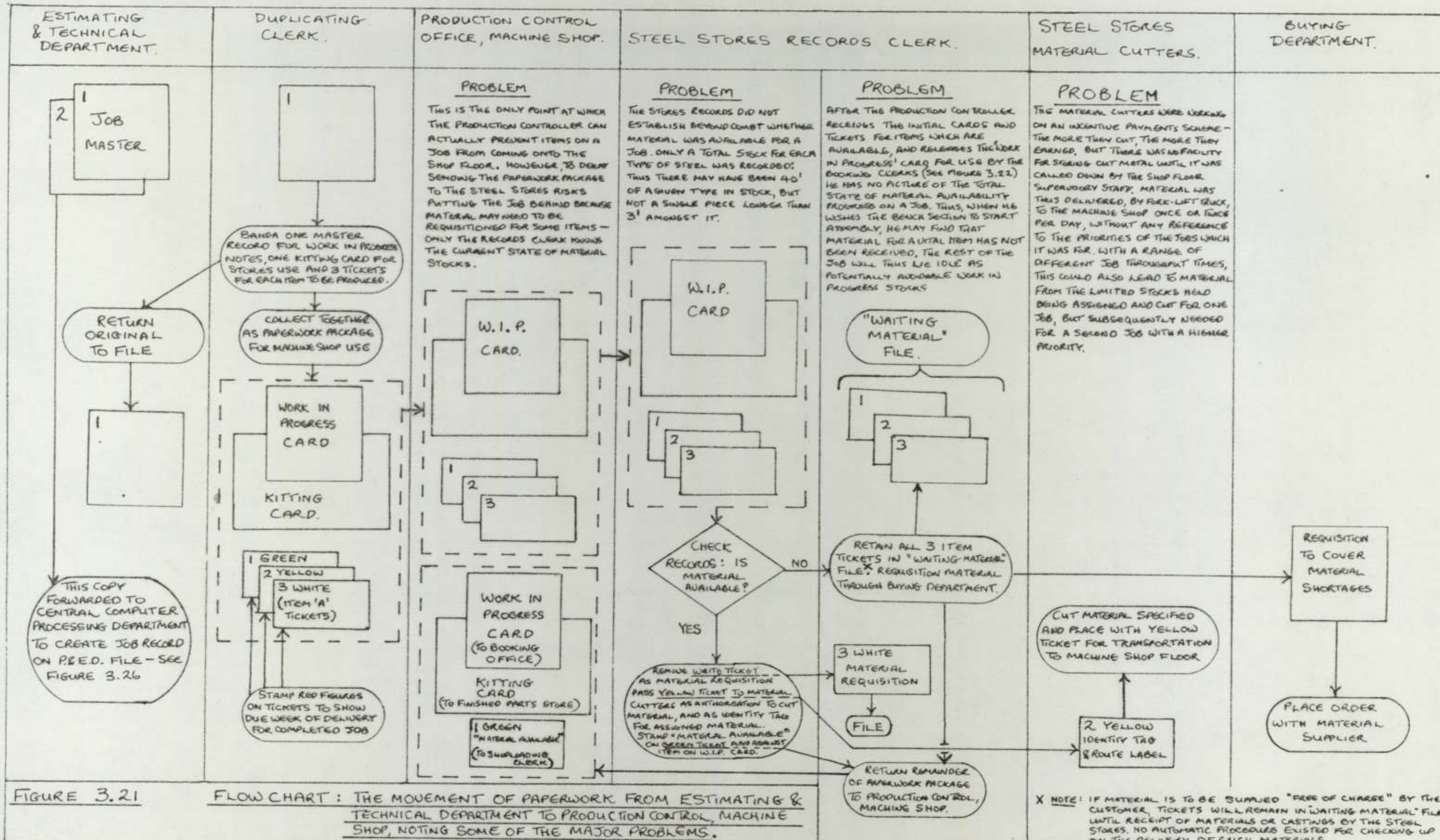

FIGURE 3.21 FLOW CHART: THE MOVEMENT OF PAPERWORK FROM ESTIMATING & TECHNICAL DEPARTMENT TO PRODUCTION CONTROL, MACHINE SHOP, NOTING SOME OF THE MAJOR PROBLEMS.

Without rationalisation of parts numbering it was unlikely that the Division's objective of minimum stock holding would be achieved, since the storeman when presented with a parts list for a new order would not be able to specify accurately what was and what was not in stock. Possible added benefits of such a rationalisation were that it would encourage the Design Department to standardise between machines on parts used and that the Purchasing Department might be able to buy items in greater bulk, where common to a number of different machines, and thus take advantage of discounts offered by suppliers. Lack of such a system precluded use of electronic data processing to perform mundane repetitive clerical functions - a possibility examined in Chapter 4.

It was in the machine shop that the Division's management was convinced that the real problem lay and, therefore, a large part of this research project was concerned with the procedures for the control of processing in that area. Figure 3.21 explains the transmission of manufacturing paperwork from the administrative area to the Production Control Office and also outlines the main practical problems with the method in which the system operated. An earlier section in this chapter (3.4.2) noted the problems of the Machine Shop Production Controller resulting from his lack of authority over processing staff. This made it absolutely essential if he were to exercise a meaningful function that he should be in effective control of the release of all paperwork and materials onto the shop floor. Only by restricting the choice of jobs available could he ensure that foremen would follow the required priority order. The theoretical operation of the system for controlling shop floor operation is shown in figure 3.22 No item should have been started until the green priority ticket was received by the section progress chaser from the shoploading clerk. In fact, the system never operated

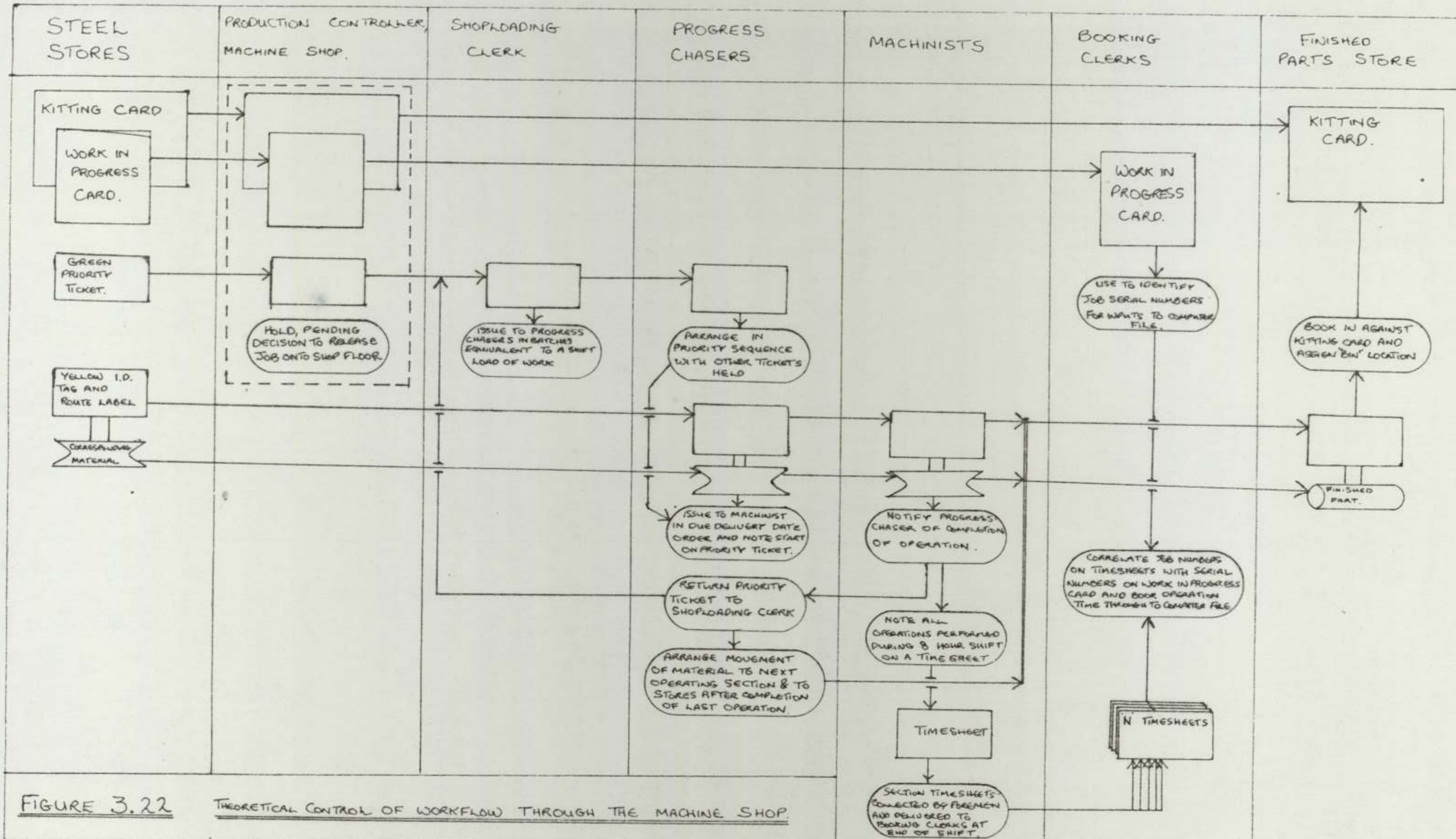

FIGURE 3.22 THEORETICAL CONTROL OF WORKFLOW THROUGH THE MACHINE SHOP.

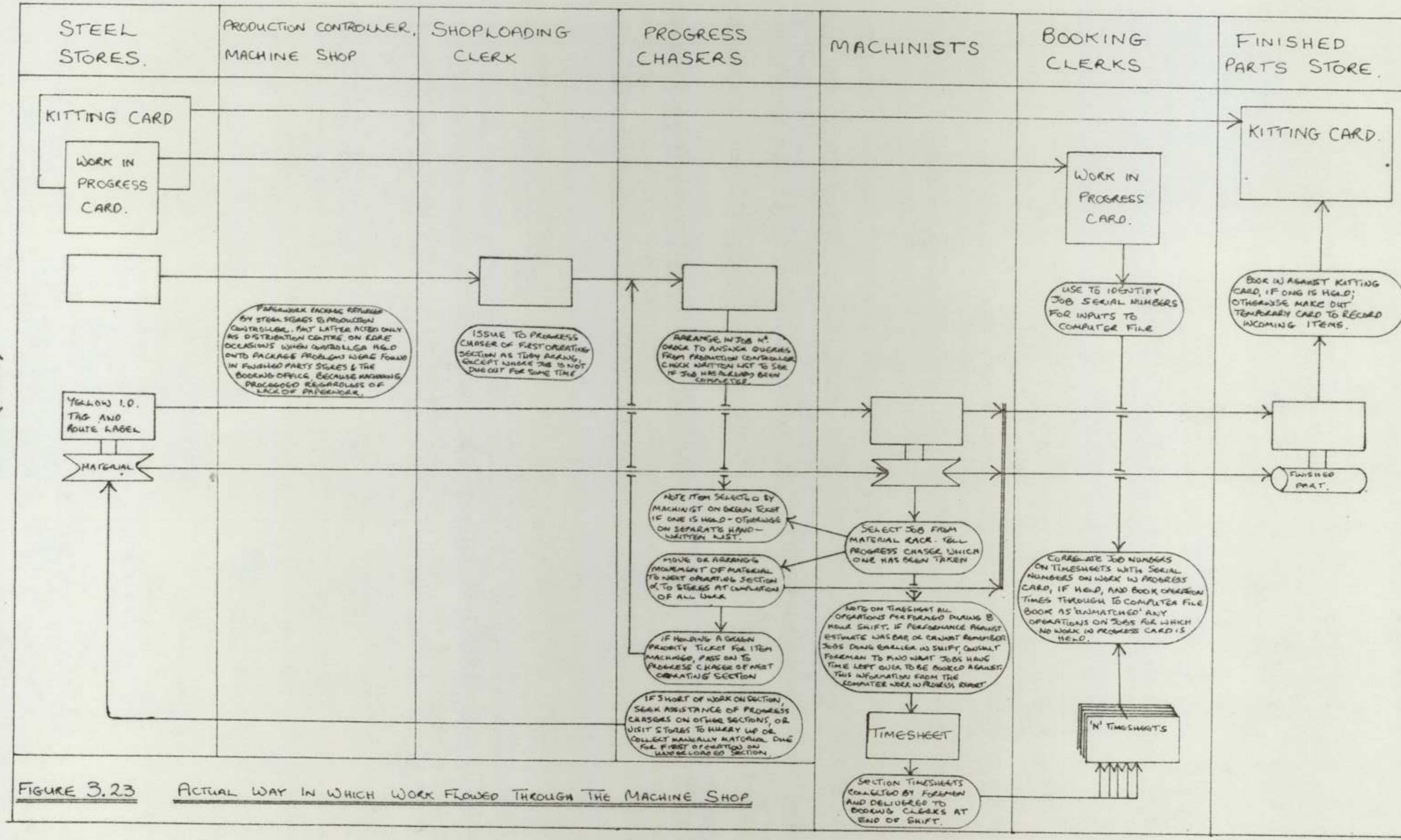

FIGURE 3.23 ACTUAL WAY IN WHICH WORK FLOWED THROUGH THE MACHINE SHOP

in this way, but rather as shown in figure 3.2 3. The green ticket was merely a duplicate copy of the yellow route label. Thus, once the latter arrived at the section material rack with the material - direct from the steel stores in the absence of any pre-processing material store - the machinist had all the information which he needed to make a start on the job. At least the progress chasers could monitor what work was actually done on their sections and this required expeditious use of a handwritten list of work which was done before any green priority ticket was received.

Work was scheduled for operation according to the due delivery date for the complete job. A large red number signifying this date was stamped across the priority ticket. This alone represented an unsatisfactory basis for determining comparative job priorities. The instruction was simply that the operation with the lowest number should be done first with no account being taken of expected throughput time for different items and no subsidiary instructions being given to indicate how choice should be made between two items with the same due date. No latest start date for items was given and, on parts manufactured for the assembly shop, the due date marked again referred to the machine delivery date, making no allowance for the required machine assembly time. The deficiencies of the system were shown by the use made of red stick-on labels to denote that a job was "urgent"; this was given official recognition by the purchase of a supply of red labels with the word "urgent" printed on them. Such jobs, it was decreed, should be placed at the front of work queues. All this really did was alter the problem faced by the progress chaser and the foreman: they now had to decide which of two "urgent" jobs should be processed first (31).

LEVEL	METHOD OF DETERMINING PRIORITY	ADVANTAGES	DISADVANTAGES	LIKELY SOURCE OF CLASSIFICATION
"HIGHER AUTHORITY"	BY CUSTOMER	POLICY RULES LAID DOWN TO MAXIMISE BENEFITS OF DIVISION'S ACTIONS TO THE GROUP AND CORPORATION PARENTS	DISRUPTIVE INFLUENCE OF POLICY: MAY WELL NOT BE IN BEST INTERESTS OF THE INDIVIDUAL DIVISION'S PROFITABILITY.	GROUP EXECUTIVE CORPORATE MANAGEMENT.
DIVISIONAL SENIOR MANAGEMENT	SPECIFIC PENALTY ON LATE DELIVERY	MAXIMISE PROFITS BY MINIMISING PENALTIES	EFFECT ON OTHER ORDERS: MAY LEAD TO LOSSES OF POTENTIAL FUTURE ORDERS AND MARKETS.	GENERAL MANAGER EXECUTIVE COMMITTEE.
	FUTURE POTENTIAL: UNQUANTIFIABLE PENALTY ON LATE DELIVERY	GOOD FIRST SHOWING IMPORTANT IN ESTABLISHING NEW PRODUCT OR CAPTURING SHARE OF NEW MARKET.	RISK OF DAMAGING GOODWILL RELATIONSHIP WITH PRESENT CUSTOMERS FOR THE SAKE OF UNCERTAIN REWARDS.	GENERAL MANAGER MARKETING MANAGER
	COST: WORKING CAPITAL TIED UP IN A JOB	CASH FLOW MAXIMISED	BUT CAPITAL TIED UP IN NUMBER OF SMALLER JOBS MADE LATE BY CONCENTRATION ON MAJOR ONES WILL REDUCE BENEFITS OF ACTION.	GENERAL MANAGER CHIEF ACCOUNTANT.
	VALUE OF JOB	GOOD OUTPUT TOTAL FOR THE PERIOD	QUESTION AGAIN ABOUT AGGREGATE VALUE OF JOBS DISRUPTED BY CONCENTRATION ON A SINGLE HIGH VALUE JOB.	EXECUTIVE COMMITTEE MANUFACTURING MANAGER
	SPECIFIED START AND FINISH DATES FOR INDIVIDUAL ITEMS ON JOBS	SHOW ANTICIPATED SPREAD OF THROUGHPUT	PROVIDES NO CONCRETE BASIS FOR A DECISION OUTSIDE FIRST AND LAST OPERATIONS: LIKELY TO LEAD TO ONE OF THE 2 BELOW APPROACHES	PRODUCTION PLANNING
MIDDLE MANAGEMENT	REQUIRED DELIVERY DATE OF JOB	ACCEPTABLE METHOD OF CHOOSING BETWEEN SHORT THROUGHPUT TOOLING JOBS: AT LEAST JOBS WILL COME OUT IN THE RIGHT ORDER.	TAKES NO ACCOUNT OF EXTENDED THROUGHPUT TIMES ON MAJOR CONTRACTS OR PARTICULARLY COMPLEX OPERATIONS	MANUFACTURING SUPERINTENDANT SALES PERSONNEL
	DUE START DATE OF ITEMS	ON TIME START GIVES BEST CHANCE OF FINISHING ON TIME	CONCENTRATION HERE MAY LEAD TO OVER-PUSHING A JOB AT THE EXPENSE OF OTHERS. START DATE IRRELEVANT AFTER FIRST OPERATION	PRODUCTION CONTROL
	TARGET DATES FOR ALL OPERATIONS	PROVIDES FINITE FORMAL CONTROL OF PRODUCTION	TOO FINITE & TOO FORMAL TO WORK IN UNPREDICTABLE JOBBING ENVIRONMENT, WHERE KEY TO SUCCESS IS FLEXIBILITY. BESIDES, HIGH SYSTEM COST	PRODUCTION PLANNING OR PRODUCTION CONTROL
	LOW REMAINING JOB CONTENT.	MEET REQUIRED "OUTPUT QUOTA": CONCENTRATE ON JOBS WITH HIGH VALUE\HOURS REMAINING RATIO TO ACHIEVE BEST SHORT TERM RESULTS.	RISKS ADVERSE LONG TERM EFFECTS. SHOWS DEGREE OF PANIC & LOSS OF CONTROL. BUT RESULTS GUARANTEED POPULAR WITH SUPERIORS	MANUFACTURING SUPERINTENDANT
	HIGH REMAINING JOB CONTENT.	LOOKING FOR SUCCESS ON LONGER TERM HORIZONS	AT THE EXPENSE OF MEETING SHORT TERM QUOTAS. DANGER OF ANTICIPATING LATER PROBLEMS WHICH MAY NOT EXIST	PRODUCTION CONTROL
	SUB-CONTRACT OPERATION AT SOME STAGE	SUB-CONTRACT REPRESENTS AN UNCONTROLLABLE AREA OF UNCERTAINTY: RISK MINIMISED IF THIS IS OUT OF THE WAY AS EARLY AS POSSIBLE	UN-NECESSARILY DISRUPTIVE TO OTHER WORK. REAL ANSWER TO THIS PROBLEM IS FIND SUB-CONTRACTORS WHO CAN MEET DEFINITE TARGETS	MANUFACTURING SUPERINTENDANT PRODUCTION CONTROL
	ITEMS DUE THROUGH BOTTLENECK SECTIONS.	GET ITEMS INTO BOTTLENECK QUEUE AS EARLY AS POSSIBLE TO ENSURE BEST CHANCE OF GETTING THROUGH ON TIME	POINTLESS GIVING PREFERENCE TO GETTING ITEMS INTO A QUEUE EVEN IN QUEUE NORMAL RULES OF COMPETITION FOR SCARCE RESOURCE APPLY	PRODUCTION CONTROL MANUFACTURING SUPERINTENDANT
LOWER MANAGEMENT (SUPERVISORY LEVEL)	FIRST COME FIRST SERVED	EVERYTHING HAS TO BE DONE IN THE END, AND THIS WAY IS EASY AND SEEMS "FAIR".	COULD LEAD TO A SITUATION WHERE NOT A SINGLE JOB LEAVES THE FACTORY IN A GIVEN PERIOD. MAXIMISES WORK IN PROGRESS.	FOREMEN AND PROGRESSING STAFF
	LONGEST MACHINING TIME ON SECTION	EARLY RESOLUTION TO POTENTIAL SOURCE OF FALL-DOWN AND ALSO ONE LESS MACHINIST TO WORRY ABOUT FOR A TIME.	MAY RESULT IN LONG QUEUE OF MORE URGENT SHORT OPERATION WORK AND HOLD UP COMPLETION OF MORE THAN ONE OTHER JOB	FOREMEN
	SHORTEST MACHINING TIME ON SECTION	KEEPS JOBS MOVING: SAVES HOLDING UP ANYONE FURTHER DOWN THE LINE. ALSO ONE LESS JOB TO WORRY ABOUT OR ANSWER FOR	A SPECIES OF BUCK-PASSING: COULD HAVE DISASTROUS CONSEQUENCES FOR MAJOR JOBS WITH ITEMS REQUIRING LONG OPERATIONS.	PROGRESSING STAFF FOREMEN
	FELLOW-FEELING	PUSH JOBS WITH LONG OPERATIONS DUE ON UNDERLOADED SECTIONS MINIMISE UNPRODUCTIVE OR DOWN TIME BOOKINGS BY OPERATIVES	WRONG SOLUTION TO PROBLEM OF UNDERLOADING. SUPERVISORS SHOULD INVESTIGATE POTENTIAL LABOUR MOBILITY, RATHER THAN PUSH JOBS NOT DUE	PROGRESSING STAFF FOREMEN
	SPECIFIC SKILLS OF MACHINISTS	BEST USE MADE OF INDIVIDUAL TALENTS OF LABOURFORCE	OFTEN BEST TO SETTLE FOR LESS THAN MAXIMUM HERE IN ORDER TO GET JOBS COMPLETED AS AND WHEN THEY ARE REQUIRED	FOREMEN MACHINISTS
	JOBS ON LISTS FROM SUPERIORS.	PRESUMABLY PRESCRIBED JOBS ARE THE MOST IMPORTANT ONES AND THEREFORE MERIT THE HIGHEST PRIORITY	REALLY MEANS CONCENTRATING ON THOSE JOBS ON WHICH PERFORMANCE IS MOST CLOSELY MONITORED. HIGH RISK TO ALL OTHER JOBS.	PROGRESSING STAFF
OPERATIVE	JOB SATISFACTION	BETTER PRODUCT FROM WORKER INTERESTED IN THE TASK	SOMEONE HAS TO DO THE BORING JOBS. RISK AGAIN THAT NOT A SINGLE COMPLETE KIT OF PARTS FOR A JOB WOULD BE PRODUCED.	MACHINISTS & FITTERS
	MINIMUM SUPERVISION OF OPERATION.	POSSIBILITY THAT MORE THAN ONE MACHINE COULD BE TENDED BY A SINGLE OPERATOR SIMULTANEOUSLY	LITTLE INTEREST IN OPERATIONS MAY LEAD TO POOR QUALITY WORKMANSHIP WITHOUT INCENTIVE PAYMENTS, UNLIKELY TO BE WILLING TO TEND TWO MACHINES	MACHINISTS

FIGURE 3.24 PRIORITY DETERMINANTS AS THEY WERE SEEN BY VARIOUS HIERARCHICAL LEVELS WITHIN P.&E.D.

Because the priority system was defective, supervisory staff were called upon to use their own judgement and they operated, with a number of variations, a rough rule of "first come first served". Figure 3.2 4 lists the variations, advantages and shortcomings of this system and shows that the various levels of management were seriously out of tune with one another on what exactly constituted valid reasoning for establishing a priority sequence.

Given the type of production and the highly individual talents of the direct workers a very rigid priority schedule would have been inappropriate because it would not have maximised the usage of the labour potential. With no meaningful sequence at all, however, all the production control problems noted in Chapter 2, Section 3.2.3 were likely to be aggravated.

Even if all jobs had been done according to due date priority, there was still considerable room for doubting whether they would necessarily be delivered on time. First, the inaccuracy of operation time estimates (noted in 2.3.2.2 above) would have necessitated constant revision of the time schedule for operations and the consequent adjustment of the forward load schedule. Essentially, this means that it is possible to establish a job sequence for this type of firm but not a rigidly planned operations time schedule. Under such circumstances, parts for machinery contracts actually needed to be given artificially early "due dates" if they were to reach the assembly area on time.

Second, the subject firm's basis for deciding delivery dates for jobs, given that only the slightest and most imperfect information on the existing workload was available for the making the decisions, made those dates even more unreliable. Again, the 1969 Report had noted:

> "More study of the load position should be made before orders are accepted if the delivery failure rate is to go down"(32).

Elsewhere it notes the loading procedure:

> "Work is scheduled up to 90% of theoretical capacity for 2 months ahead ..... to leave capacity for urgent repair jobs ..... One day's transport allowance is given between each operation...... These loading rules are not rigidly applied".

Remembering that these procedures preceded any use of electronic aids to data processing, one is led to wonder rather at the size of clerical staff which must have been required to manage this scheduling job. What is certain, however, is that there was no such scheduling to a given load capacity by the end of 1974.

A delivery date was proposed at the time the quotation was made, by the Production Administration Manager. With the variable return of orders on quotations issued - use of a 12-week rolling average in Graph 1 of Appendix 4 to some extent conceals just how variable this was from one week to the next - this was clearly a ludicrous procedure. It amounted to scheduling against an unlimited capacity and it has already been shown that in a period of unusually high Engineering Group order load, at the end of 1974, it had the effect of producing an extensive backlog of work. One cannot escape the conclusion that here the manager concerned was acting in his sales capacity, using delivery dates, as noted elsewhere, as part of the bargaining process with customers (33).

But the problem went further than this because there was no basis for reassessing the delivery date accurately if and when an order should be received. Largely because of problems with the data processing system in use, which will be examined in 3.6, there was no information available on the current or future load situation within the machine shop other than the visual estimates made by the Production Controller checking work queues by noting the amount of material awaiting processing on racks at the end of individual sections.

Until the Production Planning Manager instituted his monthly delivery schedule and some attempt was made to analyse the performance of the machine shop against the plan - culminating in the report given in Appendix 2 - the situation noted in 1969 still persisted:

> "Little analysis ..... seems to be done of shop floor performance. There is a tendency to record events rather than check that events were as expected" (34).

Machine shop "control" policy was based upon the generally accepted (though never proved) opinion of the Production Controller that roughly 80% of all items placed on the shop found their way without any progressing action to the finished parts stores and that at best his job concerned dealing with the remaining 20%, neglected, lost or encountering processing problems which might be foreseen in some cases - reference has already been made to the difficulties of particularly long operations (sub-contracting, heat treatment and inspection) in 3.5.2 above - but in general were the "many exceptions" inherent to special purpose unit production (35).

The Production Controller thus waited until shortages were identified on jobs either by his own bench fitting foreman or by the assembly area's Production Controller. Such items would then be located on the shop floor and progressed with an overriding priority to completion. But this situation of a general lack of urgency interspersed with a small number of high priority "panic" jobs should not be seen as something unusual in limit production. It corresponds closely to Woodward's description of such firms in Essex (36).

On Engineering Group tooling work the Production Controller, of necessity, monitored events more closely. Here, as noted in figure 3.16, he was involved in a customer liaison role. Because feedback from the production area to the administrative departments was too slow or inaccurate, it was considered that he was the only person in a position to answer satisfactorily the progress enquiries of the customers. The Production Controller's procedure here was thus to transcribe at the beginning of a month the operation routings for all items on all orders for delivery to Group customers during that month onto a list which he issued for monitoring to his progress chasers. His source for these routings was the data-collection work-in-progress report, but he had to up-date this by adding any recent orders for which details were not yet on file. Progress towards completion was monitored by daily meetings between the Production Controller and all the progress chasers. The effects of using these lists were that the due date priority system became totally redundant; Group tooling work gained an actual priority second only to service work; no progressing of any jobs not on the list took place, since nobody ever checked on them; files of priority tickets held by progress chasers were organized into job number sequence, rather than due-week number sequence as had been intended, in order to facilitate checking up on prescribed jobs.

There can be no doubt that the progress chasers favoured use of the lists rather than the priority tickets. Their average age was over 50 and they had become used to lists. One of them noted that the previous system had been simply to write down jobs as they arrived on the section and hand them out from as near to the top of the list as possible - virtually a first come first served system. In a survey of how the green priority tickets were used, another commented: "Ah well, we've got the list to work to now ..... it's the last that's really important, so you just try to get any parts on it off your section as quickly as possible. I just clear the green tickets out every once in a while, or sometimes one of the other lads comes for a ticket after he gets the job".

The Group tooling lists were also a useful expedient when the Production Controller was preparing for progress meetings with his superiors, usually occupying one afternoon per month. He was expected to report on all work-in-progress, except for servicing work, and figure 3.25 shows that this meant upwards of 200 different orders. Some use could be made of the data collection report, but this only appeared at the start of each week and progress meetings generally took place on Friday afternoons. Even the superficial visual monitoring of this number of orders, the largest of which would have over 100 individually manufactured items, left the Production Controller little time to attempt to exercise any sort of control function.

He was also hampered by the lack of information feedback from the Purchasing Department to the Production Planning Department. It was common for parts of a job to be bought from outside proprietary suppliers or from specialist sub-contractors. The Work-in-Progress card noted which items these were, but gave no information as to when delivery was expected, who the order had been placed with, or what the number of the order raised by P & ED was. Without the latter information, it was not even possible for the Production Controller to check delivery dates directly with the Purchasing Department, since the latter held their records in order number sequence. The Production Controller thus had

Figure 3.25 Number of Jobs in Progress in Machine Shop During one month.

Example A - January 1975

	Product code	No. of Jobs
i) January deliveries scheduled; machine shop responsibility:	ASWR	128
	XD	12
	XF	5
	XT	34
	XJ	4
	XG	4
	XP	1
	XM	10
	ALL	198
ii) February deliveries in progress during January:	ALL	23
iii) Machine assembly jobs for which machine shop was producing parts:	ALL	11
iv) Spares jobs:	XE, XK	35
v) Total number of jobs on which the Production Controller, machine shop, was expected to give up to date information:		267

Example B - April 1975

	Product code	No. of Jobs
i) April deliveries scheduled; machine shop responsibility:	ASWR	187
	XC	1
	XD	11
	XF	5
	XG	8
	XJ	4
	XP	2
	XT	32
	ALL	250
ii) May deliveries in progress during April:	ALL	33
iii) Total number of jobs on which Production Controller, machine shop, was expected to give up to date delivery information, excluding parts kits for the assembly shop, and spares orders:		283

to contact the Order Progress clerk in the assembly stores who held a record of all outstanding orders placed by the Division in the sequence of the job on which they were to be used. Since the clerk's main purpose was to keep up-to-date with the shortage situation on machinery contracts, his information on orders for machine shop jobs was rarely up-to-date and the Production Controller would thus have to refer a given order number back to the buyer for progress information. The procedure was unnecessarily tortuous and time consuming. Inevitably, the Production Controller once again restricted himself to dealing with exceptions: shortages identified by the bench section progress chaser at the time the work was allocated to one of the fitters.

Ultimately, the success of any shop control system depended on the reaction of the shop floor workforce. Just as the progress chasers were habitual list users, so also the machinists were used to freedom to select for themselves the work most suitable to their talents and foremen had always been appointed by seniority, in years or skill, from the section workforces. Historically, the role of foremen was to make sure that men had work to do and to sort out any actual processing problems such as difficulties with the accuracy of drawings supplied by customers. In a purely toolmaking environment, where the results depended on maximising usage of the available specialist labour force, these concerns were indeed paramount. But the introduction of machinery parts required by a specific date enlarged the administrative role required of foremen, unless they were to be guided by work queues established by the Production Control staff. No such queues were ever organised, but one must question whether, given the lack of authority of the Production Controller over the shop floor operating staff, such an exercise might not anyway have proved futile.

The real key to the Production Controller's failure to exert a controlling influence over processing was probably the lack of information at his disposal. One of the main information aids should have been the electronic data collection system in use. Evaluation of this is the subject of the following pages.

3.6 Evaluation of the Data Collection System as a Basis for Processing Control

The Management Services Report of 1969, parts of which have been cited above, was concerned to establish how P & ED's problems might be alleviated by making use of the Engineering Group Computer Centre. A suite of programs was devised by the Group Management Services Department:

> "In order that shop supervision, progress section, accounting departments, etc., can keep up-to-date with what is happening on the shop floor ....."(37).

This was in 1971, 3 years before the Production Planning Department was set up, and the intention was to provide an information feedback system for supervisory staff and administrative departments. It should be noted at the outset that the system, titled "EGO 3", was intended to form the data collection base upon which a work scheduling system could later be set up. The latter part of the project was cancelled by P & ED.

One of the major reasons for this decision was financial. Use of the Group computer involved the Division in carrying a part of the costs of the Computer Department. Data Collection alone cost £30,000-£35,000 per year, which for a Division with an annual turnover of £2¼-2½m., and a contribution of £500,000-£700,000 was already considered by management to be excessive.

Schoderbek, Kefalas and Schoderbek note that the four detriments of the complexity of a control system are the number of elements comprising the system; the attributes of the specified elements; the interactions amongst the elements; the degree of organisation inherent in the system (established rules and procedures). They conclude that "The greater the systems variety, the greater the control variety, and the greater the costs"(38). Unit production has the advantage of great flexibility of operation, but this together with the uncertainty inherent in the type of manufacture means, as noted above, that a similar variety, flexibility or complexity is required of control systems. The Division's management evidently felt that the benefits of such an advanced system would not defray the expense of it. Given that the Computer existed (and therefore had to be paid for out of Group funds whether used or not), and that it had spare capacity on which the system could have been run, one might argue that in terms of the Group as a whole the economy was a false one, if there were indeed any benefits to the Division. Against this one has already noted the problems with rigid work scheduling in the existing human environment. The difficulty with employing complex, and thus expensive, information programs is in quantifying their value to the organisation (39).

3.6.1 Necessary Features of an Information System

The key characteristics of a successful system are identified by Schoderbek, Kefalas and Schoderbek:-

1. Production of timely and accurate information.
2. Accessible to exception inquiries by the user.
3. Organised for exception reporting rather than reporting all events.

4. Capable of additions at future dates to meet changed circumstances.
5. Acceptable to intended users (40).

These will be used as a basis for examining the EG03 system, together with the common pitfalls in the design of such systems identified by R.L.Ackoff:-

1. Give users as much information as possible rather than merely that which is relevant.
2. "A manager needs what he wants" - in fact the decision system model should be the basis for selecting the information to supply to a manager.
3. Decision-making will improve given the information needed; this depends upon "how well the managers can use the needed information".
4. More communication means better performance; but only if appropriate measures of performance are used within a suitable organisation structure.
5. A manager does not have to understand how the information system works, only how to use it; but unless a manager is trained to evaluate and control the system he will end up being controlled by it (41).

3.6.2 Preliminary Comments on the Use of EG03

Comments criticising the data collection system have been made on various points in the preceding narrative, but the first point which must be stressed here is that many of the problems stemmed from the way in which it was used.

1. During the first 3 years of its life there had been no maintenance of the system or re-evaluation of the requirements of user departments. This led, for example, to the continuation throughout the period of 2 reports specifically designed for use with an incentive-payments scheme which had never come into operation.
2. Nobody in the Division really understood the system: none of the 3 copies of the Manual Procedures issued to P & ED could be located. Having secured a further copy from Group Management Services, the researcher gained dubiously deserved recognition as "the computers expert". A copy is included as Appendix 6, Chapter 3.
3. The only Department which seemed to have made significant use of the reports produced during the first 3 years of the program's life was the Accounts Department; as they only used the main work-in-progress report for the tabulation of actual job costs against estimates at the time orders were invoiced, the accuracy of all but the total figures was irrelevant. Detailed inputs were thus never checked. One particular problem created by the Cost Accountant's requirements from the data collection system was that job details were not cleared from the master file immediately after delivery of an order, but rather some weeks later, when the Accountant was certain that there were no further late invoices to come from supplies or subcontractors.
4. The main inputs were the job details and estimates, entered by the Estimating & Technical Department, and the actual labour hours, entered from timesheets made out by individual machinists. Neither of these areas made any use of the reports subsequently produced and both thus had no vested interest in the accuracy of inputs. Shop floor foremen looking to avoid excessively overrunning on machining times often had their machinists book hours against jobs

which they knew had been delivered but were still on the work-in-progress file.

5. The newly arrived Production Planning Manager looked to use the EGO3 system as a planning instrument. He found it totally unsuitable and criticised it extensively; but the system had not been designed for planning, but rather for monitoring and feedback.

6. By the time this project started, an extensive amount of erroneous and redundant data had collected on the computer master file, which meant that the extent of the existing order load could not simply be tabulated by extracting totals from the file. Rather a total of 2 man-days was required to cross-check which jobs were actually live and then tabulate totals for them alone, and the results were still inaccurate because of a suspect method of allowing for machining falldown against estimates* and less than useful because the workload was not identified against any specific period. An analysis of the inaccuracy of the computer reports which was made in September 1975 is given in Appendix 7.

7. Because of the lack of help gained from the system in use there was a general apathy towards the idea of electronic data processing amongst the staff of the Division which was to affect their attitudes to proposed amendments aimed at making reports more accurate and useful.

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* The procedure was to aggregate the hours remaining on jobs in progress and then add an allowance of 50% for "inefficiency", since operations were generally found to take about 1½ times as long as estimated. Assuming the latter figure was correct, the calculation should surely have been based upon: (Aggregate Estimated Time + 50%) − Total Hours booked to date.

See also actual example in Appendix 7..

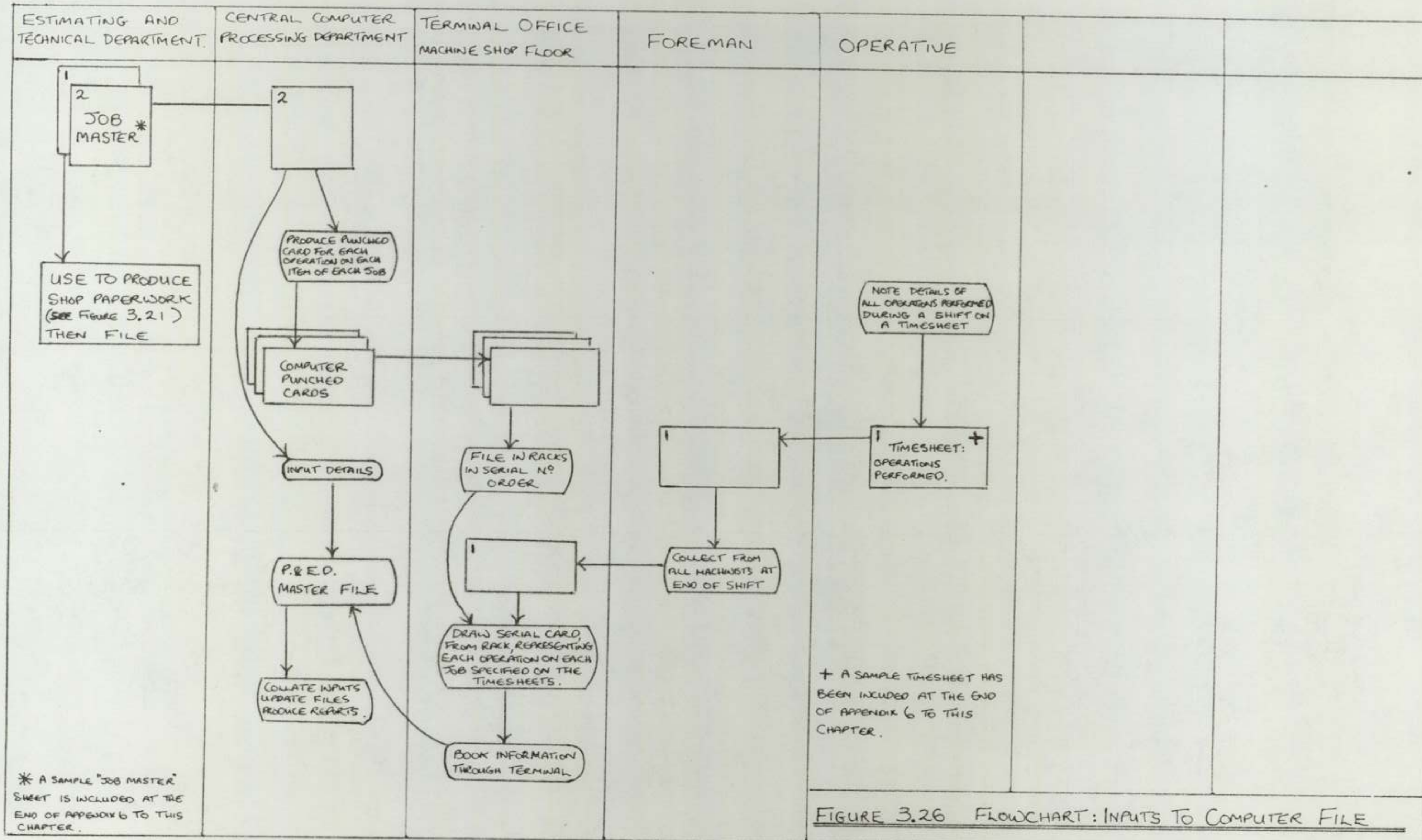

FIGURE 3.26 FLOWCHART: INPUTS TO COMPUTER FILE

3.6.3 Input Procedures

The procedure for the input of information onto the computer master file is given in figure 3.2 6. Data basically consisted of two types:-

i) Operation estimates or standards provided by the Estimating Department.

ii) Operation actuals provided by the machinists and input by clerks using a terminal situated on the shop floor.

3.6.3.1 Possible Sources of Inaccuracy On Setting Up Job Files

1. No use was made of the Manual Procedures to ensure accurate input of estimates. This led to exactly the sort of errors outlined in the Manual Procedures.* Job paperwork might be forwarded to the machine shop before these inaccuracies were identified and rectified. Machining operations could thus be booked against details not on file and would thus appear as "unmatched time bookings". Only the Division's Cost Accountant showed any interest in later relocating such information against the corrected details on file.
2. Although three amendment forms were made available for making subsequent alterations to the details held on file, the Estimating Department, in 1974, only rarely used "No.3" and was not even aware of the existence of the others. A potentially useful means of keeping files up-to-date was thus lost. In particular, if the delivery date field was not accurate on the file, use of the computer for direct load analysis was not possible.
3. There also existed the possibility of errors made by the Group Computer Department's staff in punching operation cards from P & ED's

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* See Appendix 6, Section 2, Pages 1 & 2.

hand-written "Job Masters". The fact that those staff were not familiar at first hand with the Division's operations meant that they were placed less well to interpret uncertain figures or letters on these forms. Punched cards were used because they were the cheapest method available, keeping on-line computer time to a minimum, and thus most practical for the small budget allowed by P & ED. The disadvantages of this method of input were the greater time it took to get information onto the file and the less rapid access for exception inquiries to the user.

3.6.3.2 Possible Errors in Adding Actual Operation Times to Job Files

1. The basis for bookings from the shop floor was the machinist's time-sheet. Operators often did not fill these in as they changed jobs during shift, but rather recorded all work done shortly before handing their sheet to the foreman at the end of the shift. There was a fair chance this way that they would not recall accurately the item letters or job numbers and practically a certainty that the time recorded by them would not be accurate.
2. The terminal clerks reported the following day the check numbers of any operators who had not handed in time-sheets. If these men had not made sheets out, they gave the foreman a list of what they could remember and he would then arbitrarily select from the computer work-in-progress report sufficient extra work to fill up the 8-hour shift. The inaccuracy of the report had been made so plain to them by the Production Control Department that they retained no respect for it whatsoever. Not only thus did work get recorded against the wrong file location, but also it remained as "outstanding" at its correct file location. Time bookings which appeared against operations for which time estimates were not required represented the most obvious

example of faulty recording on time-sheets. The work-in-progress report issued on 2nd March 1976, contained a total of 440 hours booked against such operations.

3. Informal discussions with machinists revealed that they generally masked any particular bad performance against estimated time by spreading the extra time taken amongst other jobs done during the same shift. In the rare cases where estimators did look at historical data on previous performances when estimating for new orders they would thus be faced with artificially contrived performances.
4. Machinists were particularly negligent about signifying whether or not particular operations had been completed. This made it extremely difficult to use the work-in-progress report to monitor the movement of items on a job towards completion, particularly as it was not always necessary or possible to adhere to the operation routing specified by the Estimating & Technical Department.
5. The booking clerks who input the actual times for operations by means of entering the pre-punched cards received from the computer center into the shop floor terminal also occasionally made mistakes. They might enter cards with incorrect serial numbers or for incorrect operation numbers and,providing the correct keying procedure was used, the faults could not be identified by the computer centre.
6. The clerks would not identify incorrect entries made by machinists since all they needed to make inputs was the job serial number and operation number. All the rest of the information was pre-recorded on the punched cards: there was no reason for them to check if, for example, the operation type or machine group was as shown on the punched card.
7. Because the Division used different alphabetical two-letter prefixes to distinguish between jobs for various customers, the numerical

characters assigned to jobs were not necessarily unique: at a given time these could be jobs number RE100, VH100, SA100, GA100 and DB100 in progress on the shop floor. Serial numbers for the computer cards could not thus use the same numerical characters for ease of correlation by the booking clerks. Since operatives did not fill the serial number in on their time sheets, the file of work progress cards, which should have been an aid to the Production Controller, had to be kept in the booking clerk's office in order that they could be used to locate serial numbers for jobs. Having to go through this process provided another possible source of errors as well as unnecessary extra work which a simple rationalisation of job numbering could remove.

3.6.3.3 The Deeper Root Of The Input Problem

It seems probable that all the practical problems noted in the previous two subsections stemmed from a common root. This was a psychological or human problem: neither of the two areas responsible for inputs had any vested interested in the accuracy of the data fed into the computer files, since neither made use of feedback reports from the system. Since a specific job was unlikely ever to be exactly repeated there was little point in the estimator being fed information on performance against his estimated times. Some broad feedback on the total performance over a period of time of the different machinery sections might be useful, but any detailed information would be of purely academic value. In the machine shop, foremen and machinists alike knew that management's interest centred firstly around the balance of productive as against waiting time or downtime and only secondly on percentage performance against estimates. The best way to make both of these look good was to "cheat" bookings, using errors on the master file.

Management's only chance of dealing with this problem was to impress on all employees the essential importance of accurate information to the success of the organisation as a whole. This would involve making more information on how the Division was doing available to the workforce, which management was unwilling to do - presumably fearing that industrial relations problems might occur as a result of any move towards industrial democracy. It is sufficient for the purposes of this project to note that this view is far from unchallenged. Flanders, for example, accepted that there appeared a difficulty in recording the freedom of democracy with successful planning, but added that the manager deceived only himself if he believed he could still be the true autocrat and concluded that the future success of industrial relations depended at works level on institutions to produce "conflict-resolving co-operation and sharing in responsibility" (42).

3.6.4 Reports From The Data Collection System

A complete list of the reports generated by the data collection system, EG03, is given together with pages extracted from four of them in Appendix 8 to this Chapter. A list of 7 common defects of reports from management information systems given by Schoderbeck Kefalas and Schoderbek provides a useful basis for judging these reports:-

1. Lack of trend analysis for examining the current situation;
2. Information gathered by different units within the organisation with different results and analyses in mind;
3. Reports arrive too late to effect the desired change;
4. Lack of summarising of information;
5. Failure to identify causes of variance;
6. Lack of confidence in the data;
7. Lack of understanding of the data(43).

Since EGO3 was merely a data collection system, it would not be expected to provide trend analysis or to identify causes of variance. The other 5 defects were all to be found in some or all of the reports produced. For convenience, they are taken in a different order below.

3.6.4.1 Lack of Summarising of Information

In the interests of economy, the same reports were used by different departments within P & ED with substantially different requirements. Thus, for example, the work-in-progress report, usually consisting of more than 2 pages, was used not only by manufacturing supervision and the Production Controller to monitor progress on orders, but also by the Accounts Department, to monitor actual job labour costs. The latter department, however, needed only a summary of total hours booked per job and not the detailed information included.

The Production Planning Department also used the report to calculate the workload. Defects with this have already been pointed out, but the important thing to note here is that they also required summarised information on, this time, total hours per machine group rather than the detail provided by the report. In their case, a summary was also required of the new job load as given in the "orders not started" report (EGO3 05).

The Cost Accountant also needed the total number of hours on unmatched bookings for each job, but the Report, EGO3 02, detailed individually all bookings. Ideally, one would have expected very few unmatched bookings to occur and it is, in part, a sign of the inaccuracy of inputs to the system that this report often ran to as many as 30 pages. However, much of this report was also taken up with bookings on service jobs, where, because of the urgency of the work, machinery was started or even completed before details of the job were entered onto the master file.

These faults serve as evidence that the reports were not well-matched to user requirements, a problem for which P & ED's failure to re-define at some stage after 1971 just what the different Departmental requirements were must obviously bear a considerable portion of the blame. In particular, one wonders why the two incentive payments scheme reports had been allowed to continue throughout the period. Since the scheme never came into operation, the detailed information it contained was of no use and, if the summary sheets included were of use as indicators of shop floor performance, to have the same information re-produced in two different ways was surely an unnecessary luxury.

The Accounts Department also noted that the 'operations exceeding estimate' report was less useful than it might have been because jobs were listed in descending order of the "likely overspend" or number of hours by which the estimated time was likely to be exceeded. On machinery contracts, the Division often split a job into sub-sections or sub-assemblies by using "stroke" numbers (e.g. DB0825/001), but these were taken as individual jobs on the operations exceeding estimate file. This did not merely mean a tiresome addition sum for the accounts clerks, but could mean that an incorrect picture was painted of the job as a whole: the extract given in Appendix 8D, for example, shows 5 of at least 13-stroke numbers on job number DB825, but if the other 8 did not appear elsewhere on the report the accountant could not tell whether overall the job was one on whicn there were any major problems or not. Certainly, the report did not identify any causes of the variance on any of the jobs, but as noted it could not be expected to do so.

The Machine Shop Production Controller was responsible for making out requisitions for items which had to be sent outside for specific subcontract operations, such as gear-cutting or plating. Again, there was no report summarising the items requiring these operations and thus the only way advance arrangements could be made was by sorting through the "work-in-progress" and "orders not started" reports. Despite the delay in getting items sent out, the Production Controller preferred instead to be notified by his sub-contract progress chaser that items were waiting an inspection.

3.6.4.2 Lack of Confidence in the Data

Given what has already been said regarding input inaccuracies, it is hardly surprising that the Production and Production Planning Departments were unwilling to rely on the reports alone as the basis for workforce allocations or completion date predictions.

The extracts given as Appendix 8B & 8C exemplify some of the inaccuracies. There are operations on 8B which have not been booked against at all, despite the fact that subsequent ones have been booked as finished. There are also a number not signified as finished despite the fact, again, that the final bench assembly operation is shown as complete and one may assume, therefore, that the item was completed (Job number CCR 9178 item E). Indeed, given that the CRR prefix denoted a service job and that delivery of the job was due in November 1974, it was certainly not still in progress in December 1975, the date of the report.

A more extreme example of file inaccuracy was found on the "orders not started" report issued 12th September 1975. Here, there were a total of 23 service jobs over 1 year old and one of them had been scheduled for completion at the end of April 1972. Without regular file maintenance, there was no way for such data to be removed from the files and whilst it existed there could be little confidence in the accuracy of the file as a whole. Also, unless the machinists could be relied on to fill in their time sheets accurately, any analysis of actual times against estimates was pointless.

3.6.4.3 Lack of Understanding of the Data

The data given in the reports was straightforward and easy to understand, but two points might perhaps be legitimately mentioned under this heading. First, there was insufficient understanding within P & ED as to exactly what the purpose of some of the reports was. Potentially, for example, report 13, "Previous day's time-bookings, Job number order", could have been used by the Machine Shop Production Controller to monitor against the week's work in progress report the progress made towards the completion of items and jobs.

This could have considerably eased the task of manual checking of progress before his reports to his superiors and enabled him to deal more readily with telephone enquiries on job delivery positions. Instead, it arrived daily in his office along with several other reports and was piled in a corner for use as scrap paper.

Second, there was obviously inadequate understanding on the part of those who originally specified the reports to be produced of the Division's type of business. Exception reports, such as 03 "Operations Exceeding estimate for machine groups 1-26", only serve any genuine purpose where "normal" or "predictable" circumstances exist for the most part. The fact that unit manufacturing is characterised by many exceptions tends to make such reports pretty well meaningless. Report 03 in the case of the subject division represented almost a total list of all work done: in other words it was virtually a duplicate of report 13 mentioned above, because time estimates in this type of business would be expected to achieve both little accuracy and a variable amount of accuracy. Thus, the report of previous day's time-booking in clock number order (no. 12), could not genuinely serve as an indication of which machinists were particularly inefficient. Indeed, its use for such a purpose would merely have acted as a deterrent to machinists normally prepared to accept the challenge of a difficult operation.

3.6.4.4 Reports Arrive Too Late to Effect the Desired Change

The defects, in terms of the extra time taken, of the use of a punched-card computer system have already been noted above. Because of booking procedures, all reports were at least one day-shift out of date when they were received.

Machinists' time sheets were collected at the end of the day shift, but not entered by the booking clerks until the following day. Daily reports received each morning thus concerned work done two days previously. This meant, for example, that if the Production Controller had monitored the report of the previous day's bookings to check that jobs were not being started before they should be, any action which he might wish to take as a result would need to bear in mind the fact that such jobs might now have progressed through further operations or be near to completion of a single lengthy operation. The damage was thus done, in terms of a disruption of the required sequence of jobs.

The work-in-progress report was further out-of-date. It was printed each Monday, but would not arrive in P & ED until lunch-time, or even until Tuesday morning. It included all bookings made up to the end of the preceding Friday shift - all work performed up to the end of the Thursday shift. If it was then used by the Production Planning Dept. to calculate the remaining workload, an operation occupying a further day, the resulting load figures were certain to include an element of at least 2½ shifts of work subsequently completed. Assuming that 100 of the machinists and fitters were actively employed over this period of time, a total of 2,000 extra hours would appear on the load analysis. On the other hand, any new jobs entered over those 2½ days would not be included in the calculation and thus a detected imbalance in workforce allocation between sections might already have been removed or even reversed.

Again, in defence of the EG03 system, it must be repeated that by its nature it was never intended to be predictive but merely an event feedback.

3.6.4.5 Information Gathered by Different Units Within the Organisation With Different Results & Analyses in Mind

Not one of the reports produced attempted to identify jobs which were overdue on the specified delivery date. The operators' time analysis reports 21 & 22, and the previous day's time bookings by clock number, report 12, tended to focus attention on the amount of unproductive time booked. Reports 21,22,3 (operations exceeding estimate) and 16 (potential overspend) concentrated on what, given the nature of the business, was surely an analysis of efficiency. Such things may have been of some use or interest to the Works Manager's department and perhaps to the Accounts Department. However, by the end of 1974 the former made scant use of any of the reports and the latter department made no use of any of those mentioned above.

The main department using computer reports was Production Planning and its interest centred around job deliveries, making the reports as a whole of little value in their existing format. Once again, it must be stressed that the fault lay probably more in the failure of the users to revise the specification of their requirements from the system; in their failure to attempt to discover what it could provide for them; in their unwillingness or inability to understand or to use it properly; and probably in insufficient involvement of the Division's higher management in the initial phase of the project back in 1971.

Specifically, the Division made little attempt to bring its internal manual systems into line with the computer system so as to make the best possible use of it. An example of this is found in the method used for identifying modifications or rework which was required on many of the larger jobs undertaken. All such work, regardless of customer, was given the prefix 'ALT', but carried the same numerical characters as the job on which the extra work was to be done. The Accounts Department complained that in costing jobs they had to carry out a search of the work-in-progress report to see if extra work had been sanctioned, but there was in fact no way under the existing numbering system that the computer could establish against which order the extra work should be allocated: was ALT100 extra work on RE100, VH100, DB100?

Another fact which suggests lack of liaison between the Group Computer Centre and the Division at the time that the EG03 system was set up was the existence of an historical file, recording all orders which had been manufactured by the Division.

The analyst dealing with the system in the computer centre could not recall a single instance of this file being used and indeed consultations with staff in P & ED confirmed that they did not know it existed, nor what procedure should be used for recalling information. In unit production there would in any case be little or no call for such information.

3.6.5 Conclusions on the Data Collection System

It appears that the EGO3 system was devised without any detailed knowledge of the operating environment to be served. The reports seem attuned to a more predictable and repetitive form of manufacturing. The system enjoyed neither the respect nor the interested participation of its users. In part, this resulted in little of use being produced, but in part it was itself the cause of the system being less relevant than it might have been.

Without proper arrangements for periodic file maintenance and with no vested interest on the part of those responsibile for the inputs in the accuracy of their entries, inaccuracies were bound to occur and extraneous data to build up on the master file.

3.7 The Problems of P & ED's Petty-Political Environment

Discussion of the Division's problems would be incomplete without reference to the difficulties posed by its position in relation first to Dunlop Engineering Group and second to the Union as a whole.

3.7.1 Outside Interference with Processing Control

Naturally, any specific objectives of the Divison must be subordinate to those of the Group of which it was a member, but similarly the Group objectives must yield to the superordinate objectives of the Union. It has already been shown in 3.3 above that this presented P & ED with an exceptionally difficult problem in terms of establishing comparative job priorities. The Division found it impossible to establish rigid rules to govern priority conflicts because in no two cases were the comparative costs to the Union of giving precedence to Group or to other Union businesses likely to be the same. Since tyre-making machinery was not necessarily immediately turned to productive use as soon as it was installed, delivery one week late did not always mean a week's lost production of tyres. Whilst Group servicing work merited immediate attention to minimise production loss through machine or tool breakdowns, tooling work was of a much more variable urgency. Manufacture of new tools for development projects might be critical to the winning of new contracts; replacement tools for future use were less urgent.

In the absence of formal rules, the other operating divisions of Engineering Group took advantage of their proximity to the Division to press their own claims for preferential treatment. Rim and Wheel Division's procurement officer, for example, did not restrict his visits to P & ED's machine shop to a regular progress meeting with the Production Controller. Rather he would move from section to section exhorting foremen, progress chasers and even individual machinists to process his division's work before anything else on the material racks. As a result of the previous, purely service nature of P & ED, men on the shop floor were inclined to accept the authority of such members of other divisions.

An outstanding example of this concerned a piece of work being done by P & ED Coventry for its Leicester subsidiary. The manager of the latter factory, who had previously worked at Coventry, visited the machine shop and ordered the operative working on the spark eroder to make an immediate start on the job. When this was later checked by the bench-fitting foreman with the Production Controller and then with the Production Administration Manager, it was discovered that the Leicester manager was in fact still haggling over the price and thus that the order was not yet officially confirmed.

At other times an approach might be made by senior managers of other divisions through P & ED's Works Manager, a man known to value the special relationship of P & ED to the other members of the Group. On one occasion, for example, an Aviation Division official visited the Machine Shop Production Controller to enquire about the earliest delivery possible on a tool requiring a single 20-hour operation on the spark eroder. P & ED had only one of these machines and the Controller noted that unfortunately it was loaded with other work for Group customers for the next 3½ weeks. The official went away dissatisfied with the 4-week delivery quotation offered. Half an hour later, the Production Controller received a specific directive from the Works Manager that regardless of the other work the Aviation Division job was to be the next one processed on the spark eroder.

This case was exceptional only in that reference had been made back to the Production Controller. At other times, on his frequent visits to the shop floor, the Works Manager gave directives straight to foremen or machinists. The Production Controller justifiably complained that he could not be expected even to know which jobs were in progress, let alone to control that progress.

3.7.2 The Limited Nature of P & ED's Profit Centre Status

It has already been noted in Chapter 1, Sections 2.4 & 2.6, that there was considerable room for doubting whether P & ED could genuinely be described as a profit centre. Its position as virtually a captive supplier to Engineering Group customers gave it no genuine choice about the jobs which it accepted from them and its system of pricing, based on fixed hourly rate for all operations, where subcontractors charged different rates for different types of machining, determined that the type of work placed by other divisions would be that requiring complex or intricate operations.

In judging the Division's performance, however, no official allowance was made for its tied position. It was considered simply as an operating division and had continually to excuse the losses which it made. This situation was bound to grate upon a General Manager brought in specifically to improve P & ED's performance, especially when he could see the disruptive effect which Group work had on his potentially profitable machinery business. His response, which helped to produce the backlog of Group tooling orders early in 1975, shown in figure 3.10, was to direct that tooling work should not in future be allowed to displace machinery parts in work queues. Because there were no recognised queues this was interpreted on the shop floor to mean that machinery parts should receive preference over tooling work.

There can be no doubt that the simple measure of financial performance did not provide a true reflection of P & ED's contribution either to the Group of which it was a member or to the Dunlop Union.

The conclusion is inescapable that P & ED's operating difficulties were generated not so much by the, albeit difficult, combination of jobbing, tooling production and high value purpose-built machinery, but rather by the attempt to combine work for privileged customers, which had previously been handled by a cost centre operation, with profit-based work for other Union or external customers. The variety, or complexity, of the situation to be handled was thus increased beyond that suggested in Chapter 2 by the different standings of the Division's customers.