INTEGRATED INFORMATION SYSTEMS FOR A CONTRACT BASED COMPANY

MICHAEL JOHN DEACON BSc (Hons)

Master of Philosophy

THE UNIVERSITY OF ASTON IN BIRMINGHAM

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THESIS SUMMARY

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Synopsis.

The collection, calculation, analysis and reporting of manufacturing costs is of great importance to all manufacturing companies. Tight monitoring and control of these costs is espescially important on long lead manufacturing contracts.

This research looks at the current developments taking place in cost accountancy and sets this in context with a specific job-shop manufacturing company - GEC Energy Systems Ltd., Special Contracts Division.

A computerised system was successfully developed and implemented which improved the integrity, feedback and control of contract costs within the company.

The thesis concludes by proposing a number of design features for costing systems to be implemented in job-shop manufacturing companies.

Key Words.

Manufacturing costs
Contract costing
Cost collection
Cost accountancy
Computerised

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CONTENTS.

CONTENTS

CONTENTS

LIST OF FIGURES.

Page No.

LIST OF FIGURES

Page No.

1. INTRODUCTION.

1.1 Thesis Outline.

The central theme recurrent throughout this work is that of Cost Accountancy within a manufacturing company. Three areas in particular have been the focus of attention, namely the collection, allocation and analysis of manufacturing costs.

The research was carried out in conjunction with the University of Aston, in Birmingham, and GEC Energy Systems Ltd., Special Contracts Division (SCD), in Bradford. SCD is a medium sized company which manufactures electric motors to customers' specific requirements. These products are characterised by manufacture in small batches, long lead times, and a high quality input.

This thesis initially looks at the objectives of cost accountancy and the impact which Advanced Manufacturing Technology (AMT) is having in this area. It then goes on to analyse the particular problems facing Special Contracts Division, with regard to its cost accounting system, and considers the techniques which are available to help provide the company with an improved monitoring and control system for manufacturing costs. This work culminated in the provision of a computerised system which was developed using a fourth generation language. The thesis traces the development and implementation of the new system and discusses the lessons that were learnt. Finally a number of proposals are made for the key design features which should be present in a computerised "cost collection and analysis system" to be implemented within a manufacturing company similar to SCD.

1.2 Reasons Why Companies Use Cost Accountancy.

Cost accountancy developed because of the need for manufacturers to find the true cost of their products in order to check that selling prices covered all the costs incurred and that sufficient profit was made. Pollard's study of the Industrial Revolution shows that early factory owners gradually became more aware of the need to analyse costs. For example, Josiah Wedgewood (of Wedgewood pottery) said in 1776 that he had been :-

> "puzzling his brain all the last week to find out the proper data and methods of calculating the expenses of manufacture, sales and loss, etc., to be laid upon each article of manufacture, but without success." [1]

Prices were, therefore, fixed arbitarily and represented the manufacturers judgement as to what the market would bear or what the competitors were charging. However as Pollard points out :-

> "accuracy in accounting was less essential at a time when selling prices tended to be so far above total costs, no matter how calculated, that almost any pricing policy was bound to show a net surplus, at least among the leaders in their industries." [2]

Today, however, manufacturing organisations are more complex and operate on smaller profit margins. Cost accountancy has mainly developed in this century as fierce competition has forced manufacturers to provide systems which can track expenses accurately and hence allow them to reduce costs and profits in order to become more competitive.

So what is the nature of modern cost accountancy? The Institution Of Cost And Management Accountants has defined cost accountancy as :-

> "The application of costing and cost accounting principles, methods and techniques to the science, art and practice of cost control and the ascertainment of profitability. It includes the presentation of information derived therefrom for the purpose of managerial decision-making." [3]

Owler and Brown, who have written one of the most widely used texts in the area of cost accountancy [4], discuss the objectives which provide us with a clearer understanding of the present day purposes of cost accountancy. The main points are as follows :-

- to classify and analyse the cost of products and operations which are recorded and summarised under nominal account headings.

- to determine the production cost of every operation, unit, job, contract, process, department or service.

- to indicate to management inefficiencies in the use of materials, time, and machinery, etc. Analysis of the causes of unsatisfactory results may indicate corrective action.

- to provide data for profit & loss accounts and balance sheets, not only for the whole business but also for departments or individual products. These may be required on a weekly, monthly or quarterly basis.

- to provide actual costs for comparison with estimated or standard costs. The actual costs also serve as a guide to future estimates or quotations, and assist management in their price fixing policy.

- finally, to present comparative cost data for different volumes of production, and manufacturing methods, so that economies of production can be made.

There is no doubt that cost accountancy will continue to develop in the future. The way in which this development takes place will be influenced by new manufacturing techniques, such as flexible and computer integrated manufacturing. These technologies are now bringing into question the relevance of current cost accounting procedures because they are, in some cases, changing the elements of manufacturing cost. This point is discussed further in the review of literature.

One technology which has already had a great influence on the development of cost accountancy and which will now be discussed, is computer technology.

1.3 The Impact of Computers on Cost Accountancy.

The first computer to be used for business purposes began operation in 1951. Since then growth has been extremely rapid and computers have had a major impact on the development of cost accountancy.

Until the early 1950's computers were very expensive and physically large. As a result they were usually used to perform one specific task, and then only by the few companies who could afford and accomodate them. Programming had to be done using machine language, or binary code, which was both tedious and labour intensive.

In the late 1950's, however, computers were becoming smaller and less expensive, and the emergence of the second generation languages, or assemblers, eased the task of programming. Thus the use of computing was extended to many more people.

It was, however, the development of the micro-chip and the third generation languages, such as COBOL, FORTRAN, BASIC and PASCAL, which has spurred the great increase in information processing during the last 20 years. This has influenced cost accounting in many ways.

Computers are most advantageous when used in high volume, repetitive work. Many of the operations involved in cost accounting, such as data acquisition, checking, arithmetic, allocation, accumulation, presentation and storage, are often governed by fixed rules and are repetitive and time consuming when done manually. Today, all these functions can be performed by computers, with resulting improvements in consistency, speed, and accuracy.

Since storage, retrieval and manipulatiion of data on a computer is relatively inexpensive, it is now feasible to have a larger number of account classifications. Also, because of the computer's ability to do arithmetic very rapidly and its ability to sort and rearrange data, the computer can add up amounts in individual classifications, provide summaries, and calculate percentages and other statistics, much faster than is feasible in a manual system.

Anthony and Reece [5] make comparisons between computer based systems and manual systems which highlight the main advantages and disadvantages of computers. These are summarised below :-

- Computers operate much faster. Although entering data is, in many cases, relatively slow, once entered operations are performed very rapidly.

- Computers are essentially 100% accurate. Unlike people they do not make arithmetic or copying errors. However, the people who write computer programs and enter data may make mistakes resulting in inaccuracies.

- Computers perform operations at reduced costs. However, the cost of programming a computer to perform a particular operation is more expensive than teaching a human to do the same task. The initial high programing costs must therefore be offset against the low operating costs. Hence the computer is only really suited to high volume repetitive work, and some tasks will remain manual.

- Computers and associated equipment cost more than the cost of journals and ledgers used in manual systems.

- Computers do not use judgement; they do exactly what they are instructed to do by their programs.

Anthony also highlights a further disadvantage. As well as programs being expensive to develop they are also expensive to revise, thus:-

> "There may therefore be a tendancy for an undesirable rigidity in programs, a reluctance to change them as conditions change." [6]

However, as new technological advances lead to simpler and less costly programing, the resistance to change will be eased, and there will be an increase in the number of tasks that can be performed more economically by a computer than by humans.

One such development is fourth generation languages. These languages can increase programmer productivity and reduce system development times "by ratios of between 4:1 and 10:1" [7], thus reducing programing costs and the resistance to change.

It can therefore be seen that computers and computer technology have had a significant impact on cost accounting, as they will no doubt continue to do so in the future.

1.4 Problems Facing Special Contracts Division.

Many of the problems facing SCD regarding its cost accounting system were due to three main factors :-

- the fact that the system was manual,
- the influence of the main customer, and
- the operation of the system.

The problems resulting from the use of a manual system may exist in many other manufacturing companies operating a similar system, although in varying degrees. Firstly, the manual sorting, calculation and allocation of cost data was tedious and labour intensive, and secondly, all these functions were prone to errors which led to further time consuming checking to ensure accuracy. In SCD's case the resulting turnround of information was not fast enough for effective monitoring and control of contract costs. Also, because so much time was spent on making information available, only a few contracts could be analysed in further detail.

The second problem area was due to the influence of the main customer, nameley the Ministry of Defence. All contracts placed on SCD by the Ministry were non-competitive defence contracts of either a 'cost-plus' or 'fixed price' nature. Development contracts were costed on a cost-plus basis, that is, the contract price was based on the total manufacturing cost plus a percentage profit. Normal production contracts were fixed price, that is, the price was estimated by the company and agreed by the customer. If the company could manufacture the product under the fixed price then it would make a profit. If this was not achieved, then the company would have to accept any losses.

Due to the nature of SCD's products (described later in Chapter 2) lead times could range from 2.5 to 4 years. With such long production times it was important that the estimates for fixed price contracts were as accurate as possible, and secondly, that actual costs were monitored and controlled so that a profit could be shown at the end of the contract.

With cost-plus contracts it was clearly in the customer's best interests to monitor costs closely. For fixed price contracts close monitoring was more in the company's intrests, but the customer was equally keen to ensure he was not being 'overcharged', especially when original estimates may have been revised (by mutual agreement) due to unforeseen circumstances over such a long contract duration. For example, large wage increases, sharp rises in material or sub-contract costs, or the purchase of expensive machinery requested by the MoD.

In order that both the company and the customer could monitor and control costs satisfactorily, it was necessary to :-

- separate both labour and material costs into direct and indirect amounts,
- separate direct labour into factory (production) costs and engineering (technical) costs, and
- separate sub-contract costs from direct material costs.

These factors increased the difficulty of allocation, accumulation and reconciliation of contract costs. Furthermore, costs were periodically audited by the customer, therefore it was important that each cost could be traced back to its source.

The third and final problem area resulted from shortfalls in the nature and operation of the company's cost accounting procedures. Most of the documents (tickets, reports etc.) used to collect cost information originated from systems which in essence were no longer in operation. Thus many of the documents had obsolete boxes which were either left blank or used for another purpose. There were also cases where no allocated space was provided for information required. Both these problems led to missing data and time consuming information finding exercises.

A further problem was lapses in discipline, mainly by non-accounting departments, in following some of the cost accounting procedures relating to the provision of data. These bad practices were tolerated for so long, without corrective action, that they eventually became 'accepted' inconveniencies.

Some of these problems had become apparent to SCD and it became clear that improvements in its cost accounting system could be made. A research project was therefore commissioned to identify the areas for improvement and provide a new system which would provide more effective monitoring and control of contract costs.

1.5 Objectives of the Project.

The objectives of the project were therefore :-

- to identify, define and analyse the manual cost accounting system.

- to determine the minimum information requirements based on the above analysis and the future needs of the company.

- to draw up a specification for a new integrated system.

- to design, develop, and implement the proposed system.

- to assess the success of the implemented system.

- to propose the information needs and design features required of a computerised "cost collection and analysis system".

- to produce a thesis giving a full account of the above activities.

2. SPECIAL CONTRACTS DIVISION.

2.1 Origins of the Company.

Special Contracts Division (SCD) is part of The General Electric Company plc of England (GEC). GEC is Britain's largest electrical and electronics company, employing over 165,000 people with sales of £5,976 million (1985/86 figures). There are many specialist operating companies covering a wide range of products, from nuclear power and space programs to push-button telephones and televisions.

The present GEC company results from mergers in the late 1960's between Britain's three largest electrical manufacturers : - The General Electric Company, English Electric, and Associated Electrical Industries, who themselves embraced the famous names of Marconi, Elliot-Automation, Metropolitan-Vickers, and Thomson-Houston.

The origins of SCD began with the Phoenix Dynamo Manufacturing Company, which began trading on the Thornbury site near Bradford around the turn of the century. Later this became a major factory of the English Electric Company employing about 5,000 people. When English Electric merged to form GEC, the site at Bradford became a division of GEC Large Machines.

2 SPECIAL CONTRACTS DIVISION

Following a reorganisation of Large Machines in 1982, Special Contracts Division came into being. The company specialised in the development and manufacture of electric motors for use on board nuclear submarines. SCD was an autonomous unit but also a division of GEC Large Machines, and as such reported to Large Machines' Head Office in Rugby.

More recently in 1986, another reorganisation meant that GEC Large Machines and GEC Medium Machines became GEC Machines. As far as SCD was concerned this was just a change in name and the management reporting structure remained unchanged. However, the reorganisation meant that SCD's main business had become removed from the mainstream activities of the Machines group. Therefore, in 1987 SCD became a division of GEC Energy Systems Ltd. (ESL), whose main business was the development and manufacture of products for the nuclear industry. SCD remained an autonomous unit, but now reported to ESL's Head Office at Whetstone near Leicester.

At the time of the research SCD employed about 200 people with a turnover of just over £5 million. (1985/86 figures).

2.2 The Company's Products.

The products made by the division are all high integrity, state-of-the-art products, mainly for the Ministry of Defence. About 50% of the turnover is accounted for by the Main Coolant Pump Motor (MCP). These motors drive the pumps which circulate cooling water through the pressurised water reactors of nuclear submarines.

A further 25% of the turnover is accounted for by the Circulating Water Pump Motor (CWP). These motors circulate seawater through the condensers of the propulsion system of nuclear submarines.

The remaining 25% is represented by Switchgear, used in conventional diesel-electric submarines. SCD supply spares to the Australian, Chilean, Brazilian, and Canadian Navies.

MCP and CWP motors have two design features which make design and manufacture very difficult. Firstly, due to the radioactive nature of the cooling fluid in a nuclear power plant circuit, no leakages can be tolerated. The conventional method of sealing, that is, between the impellor drive shaft and the impellor casing, is unsuitable because of the possibility of wear and leakage occuring. See Figure 2.1.

To prevent this problem the motors are inserted between flanges in the cooling circuit and the circulating fluid passes between the stator and the rotor, as shown in Figure 2.2.

Now to avoid the fluid coming into contact with the motor windings, thin cans are welded to the inside of the stator and the outside of the rotor, thus the design is sometimes referred to as a 'canned motor'.

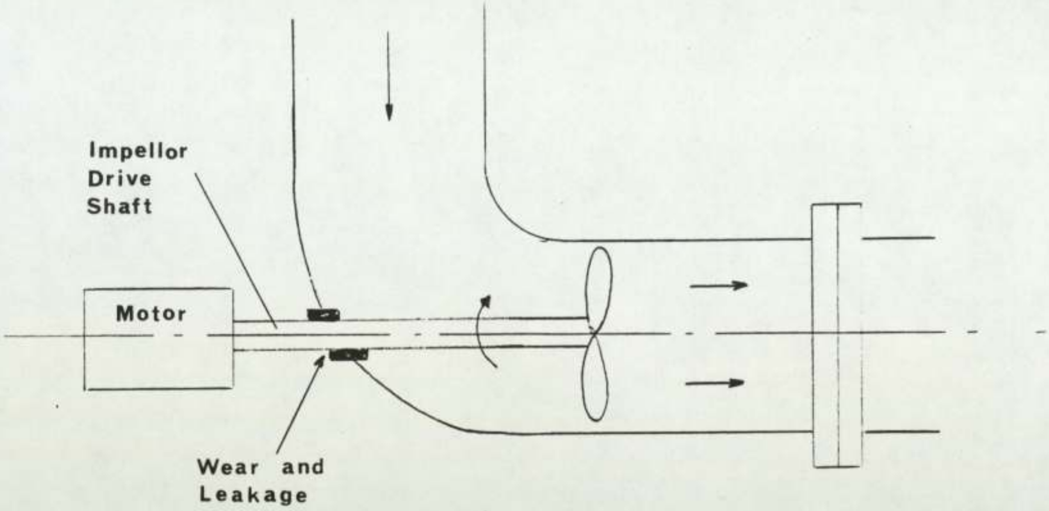


Figure 2.1 Conventional Method of Sealing Between Pump and Motor.

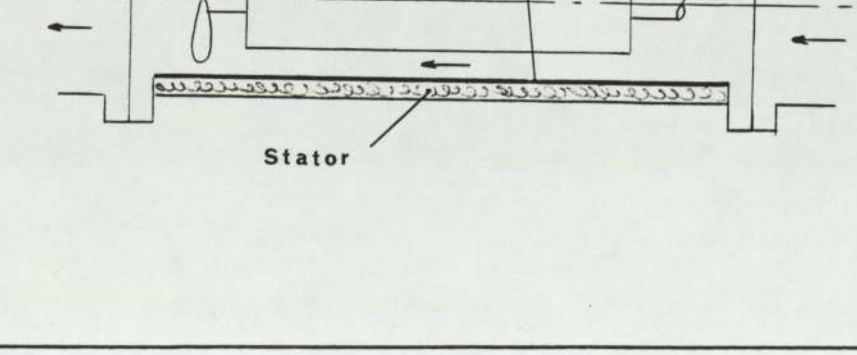


Figure 2.2 Cross Section of Canned Motor.

Since the motors are inserted in a circuit which operates at high pressures and under radioactive and corrosive conditions, many of the metallic components are made of stainless steel, thus increasing the difficulty of welding operations. The design and manufacture of the bearings also becomes more difficult since they have to be lubricated by the circulating fluid.

The second feature which makes design and manufacture difficult is the requirement for low electrical noise characteristics. This is because of the undesirability of a submarine emitting detectable noise signatures which could identify its position. Conventional diesel-electric submarines avoid detection by switching off motors, but in a nuclear submarine the motors must be kept running at all times to avoid overheating of the reactor. To achieve the low electrical noise characteristics, design and manufacture of the rotor core and windings is critical, and all the winding has to be done manually.

MCP and CWP motors are designed to run non-stop and maintenance free for ten years. The integrity of the motors must therefore be very high and quality control plays a key role in the manufacture of every motor. In addition to this the MoD require that all manufacture must be retraceable. Thus, a dossier shipped with every motor documents the manufacturing routes, inspection points, and test results, of each component. Due to the high quality requirements and the difficulties of manufacture mentioned above, the lead time for a motor can range from 2.5 to 4 years.

3. COST ACCOUNTING TECHNIQUES.

3.1 Introduction.

In the first chapter we looked at the reasons why cost accounting has developed. This chapter examines some of the techniques which are available to help provide companies with effective monitoring and control systems for manufacturing costs.

One of the principal functions of cost accounting is the allocation of costs to cost centres, products, contracts, jobs, processes, or departments. The general theory underlying the allocation of costs is that the cost centre, product, etc., should be charged with the costs for which it is responsible. Batty explains this further :-

> "Where possible and practicable, because of the desirability to attach responsibility, a particular payment should be allocated (i.e. charged in total, or pro rata on the total, according to actual usage or benefit received by a product) instead of being apportioned (i.e. charged in total, or pro rata on the total, according to estimated usage or benefit received by a product)." [8]

The word 'product' in this context can be taken to mean contract, job, process, department or cost centre. From now on, only 'product' will be referred to.

In order to achieve the above aim the total costs of a product have been classified into a number of elements.

3.2 Elements of Cost.

Authors of cost accountancy texts have classified the elements of cost in slightly different ways. For example, Langley & Hardern [9], Neuner [10] and Devine [11] classify them simply as :- direct material, direct labour and 'other' costs. Owler & Brown [12] and Anthony & Reece [13] have separated administration, selling and distribution costs from the 'other' costs. However, since selling and distribution costs at SCD are relatively small, the classification provided by Batty [14] is preferred. It is this breakdown which most closely resembles that used at SCD.

The total cost of a product can be subdivided as shown in Figure 3.1 below :-

1 Direct Material 2 Direct Labour 3 Direct Expenses	direct or prime costs	TOTAL COST
4 Indirect Material 5 Indirect Labour 6 Indirect Expenses	indirect costs or overheads	

Figure 3.1 Elements of Cost.

The first three costs, termed direct or prime costs, are those which can be traced directly to a product. The other three, termed indirect costs or overheads, are those costs which cannot (or are not) charged directly to a product, but are apportioned according to estimated usage. A brief description of the six elements of cost will now be given.

3.2.1 Direct Material.

All material that can be traced directly to a product is 'direct material'. The word 'material' in this sense includes raw materials, part finished components & sub-assemblies, and finished components & sub-assemblies. All costs incurred in procuring material can be included as direct material, provided such costs can be traced directly to the specific material. Freight charges, import duties etc., are examples of costs which can be easily traced to a specific material. In theory the costs incurred in purchasing and storing materials should be charged directly, but in practice it is often too difficult and expensive to trace these costs, so they are considered as overheads.

3.2.2 Direct Labour.

Employees who actually work on, or are directly connected with, the conversion of direct material into finished products are known as 'direct labour'. The wages payed to these employees are therefore direct labour costs.

Chargehands, supervisors and foremen, who are normally considered as indirect labour, can sometimes be treated as direct labour.

For example, if a foreman supervises men working on a particular product, and no other, then his wages could be treated as direct costs, even though he is not actually working on the conversion of material.

3.2.3 Direct Expenses.

Any costs other than direct material and direct labour which can be traced directly to a product are 'direct expenses'. Examples of direct expenses are :-

- manufacture or hire of special tools.
- cost of special layouts, designs or drawings.
- any costs incurred on experiments or tests.
- maintenance costs for special equipment.
- overtime premiums, provided overtime was considered when the order was taken.

All these expenses can be considered as direct expenses provided that, although tools and drawings may be used again, there is no reasonable expectation that they will, and that no other products are likely to benefit from special layouts, maintenance or experimentation.

3.2.4 Indirect Material.

Materials which cannot be traced directly to a product are 'indirect materials'. Examples of indirect materials are machine oil, stationery and small items consumed by service departments. A service department is a department which has no costs that can be traced to a specific product. So for example, Personnel, Accounts, Works Canteen, Engineering and Maintenance are all normally considered as service departments.

Direct materials such as screws, nuts, bolts and glue may be treated as indirect materials if their cost is insignificant in relation to the prime cost.

3.2.5 Indirect Labour.

'Indirect labour' consists of all wages and salaries paid to service department staff. Also included are wages paid to prodution department staff, such as chargehands, supervisors and foremen, whose time cannot be traced directly to a particular product.

3.2.6 Indirect Expenses.

'Indirect expenses' are incurred by both production and service departments and will include costs for heating, lighting, rent rates, insurance and depreciation.

The guidelines for the elements of cost above are similar to those given by most cost accounting texts. However, within SCD there are some significant differences from these standard practices.

Following the general philosophy that products should be charged with the costs for which they are responsible, some of the costs incurred by service departments are charged direct. It is possible for departments, such as Production Engineering, Engineering Design and Development, Quality Assurance, and Project Control, to charge a portion of wages and salaries directly to a specific contract. For example :- a production engineer may design a special tool for a certain contract; an engineer may solve a problem relating to some rectification work unique to a particular contract; or a quality engineer may visit a sub-contractor to inspect progress of work on a specific contract. In cases such as these the costs incurred are considered as direct labour and charged to the contract concerned. When the work done in these departments cannot be traced directly to a specific contract, then the labour costs incurred are considered as indirect labour and charged to departmental overheads.

In the same way that the elements of cost have been classified, cost accountancy authors have also classified cost accounting systems.

3.3 Cost Accounting Systems.

It is not the purpose of this section to discuss the different cost accounting systems in great detail. However, we will briefly look at the main differences between the costing systems available to manufacturing companies. For more detailed information see :- Owler & Brown [15], Neuner [16], or Langley & Hardern [17].

The two major classifications of cost accounting systems are :-

- the job costing system, and
- the process costing system.

3.3.1 Job Costing Systems.

A job costing system is used when non-standard, one-off (or small batch) jobs are manufactured to a customers' specific requirements. Builders, civil engineers, shipbuilders, furniture manufacturers, and general mechanical engineering firms, are all examples of the types of industry that use job costing.

Costs are collected against each job, and a separate cost account is set up for each job number. As work proceeds the cost account shows the accumulation of direct material, direct labour, direct expenses, and overheads. The overheads are recovered by using one of a number of recovery methods. These methods are discussed later in section 3.5.

3.3.2 Process Costing Systems.

The second major costing system is process costing. This is generally employed when a standard product is being made which involves a number of distinct processes, performed in a definite sequence. Oil refining, chemical manufacture, paper making, flour milling and cement manufacturing are all examples of the types of industry that use process costing.

Costs are collected at each distinct stage over a period of time, and an average cost per unit is then obtained for each accounting period.

3.3.3 Hybrid Costing Systems.

It is recognised by many authors that costing systems do not fall neatly into the category of either job costing or process costing. Many 'hybrid systems' are in use which have features of both the main systems.

'Batch costing', used by many engineering companies, treats each batch of components as a job, and then calculates the average cost of each unit. Another variation is 'multiple costing', used when products such as cars and washing machines are assembled from a high number of components all manufactured by different methods. Costs therefore have to be found for operations, processes, jobs and units, which together give the total cost of the product finally assembled.

Different names are also used to describe both process and job costing. For example, 'unit costing', 'operation costing' and 'operating costing' are all other names for process costing systems. Unit costing is the name given to the system which finds the costs of natural units, such as a sack of flour or a barrel of beer. Operation costing is the name used in mass production systems such as oil refining and chemical manufacture. Operating costing is the term applied to the system used to find the costs of performing a service such as the supply of gas or electricity.

'Contract costing' and 'terminal costing' are other names applied to job costing systems. These are used by industries such as builders, constructional engineers and mechanical engineering firms who build or manufacture one-off items under contract for a particular customer. Contract costing is used by SCD - each contract consisting of a small batch of motors. For further details of contract costing see, Owler & Brown [18].

3.4 Standard Costing.

All the above systems are used to record actual costs. Cost accounting authors distinguish between two techniques of recording costs. The first is 'historical costing' which is concerned with recording actual costs, the second is 'standard costing' which :-

> "makes use of pre-determined standard costs relating to each element of cost - labour, material and overhead - for each line of product manufactured or service supplied." Batty [19]

It is generally agreed that by themselves actual or historical costs are not a realistic means of measuring efficiency. If, however, the actual costs are compared with standard costs, then the differences or 'variances' can be used to highlight inefficiencies. If these are brought to the attention of the people responsible they may indicate where corrective action can be taken.

Standard costing techniques can only be used in companies that produce standard products or components. Batty points out that it is:-

> "only when job costing is being employed, when jobs are entirely non-repetitive, will a modern system be based on historical costs. If standard costing is not a practical proposition, then control of costs may come through budgetary control." [20]

3.5 Overhead Recovery.

Previously it was indicated that it may not be possible, feasible, or even desirable to allocate all costs directly to a product. These indirect costs, however, must still be recovered in some way. This is usually done by allocating an overhead cost, which is added to the direct costs of each product. The allocated overhead cost is calculated by multiplying a suitable allocation base, such as direct labour hours, machine hours, or material cost, by a predetermined overhead rate.

The predetermined overhead rate is calculated as follows :-

- Firstly, estimates are made of the indirect costs which will be incurred in each cost centre over a given period.

- The estimated costs for the service cost centres are then accumulated in production cost centres.

- Finally, the total estimated costs are divided by the estimated allocation base for the same period (e.g. the estimated number of labour hours), to give an overhead rate per unit of the base used.

Figure 3.2 shows the steps involved in the calculation of total component cost using the labour hour base to determine the amount of overhead cost.

So why are predetermined overhead rates used? It would be possible to calculate actual overhead rates at the end of each accounting period, but this is rarely done because of the advantages of using a predetermined rate.

Firstly, if overhead rates were calculated monthly they would be affected by conditions peculiar to that month. For example, heating costs in winter are higher than those in the summer.

A machine shop employing 20 men is estimated to consume an average of £1,500 of indirect costs per week. Each man works a 39 hour week, thus :-

Overhead Rate = $\frac{1,500}{39 \times 20}$ = £1.92 per labour hour

If one man, paid £4.50 per hour, takes 30 minutes to produce a component from material valued at £1.50, then :-

Direct Material Cost = £1.50
Direct Labour Cost = £4.50 x 0.5 = £2.75
Overhead Cost = £1.92 x 0.5 = £0.96

Therefore,

Total Component Cost = £1.50 + £2.25 + £0.96 = £4.71

Figure 3.2 Calculation of Total Component Cost.

Since there is no purpose in reporting that products manufactured in winter cost more than those manufactured in summer, fluctuating indirect costs, such as heating, are averaged over the whole year.

A second advantage of using a predetermined overhead rate is that product costs can be calculated more promptly. If overhead rates were calculated at the end of each month, then the overhead costs could not be allocated until this was done. By using a predetermined rate, overhead costs can be allocated to products at the same time as direct costs.

Finally, the calculation of an overhead rate once a year requires less effort than performing the same calculation every month.

The main disadvantage of using predetermined overhead rates is that the applied overhead costs are likely to be different from the actual overhead costs incurred, thus resulting in under or over recovery of overheads. The amount of unabsorbed or overabsorbed overhead in a given month is usually held in temporary suspense on the Balance Sheet in the expectation that unabsorbed overhead in one month will be offset be overabsorbed overhead in another month, and vice versa. Any balance at the end of the year is usually divided between the Cost Of Goods Sold, Finished Goods Inventory, and Work-in-Progress, in proportion to the relative size of each account.

The selection of an allocation base which a company uses to determine its overhead rates, will depend largely on factors such as, the nature of the manufacturing system, type and volume of products produced, usage of machines and materials, company size etc. If different overhead rates are used for each department, it may even be desirable to use more than one allocation base so that more accurate recovery of overhead costs can be made.

The most common bases used to determine the overhead rate are the following :-

- unit
- material

- labour cost
- labour hours
- machine hours

3.5.1 Unit Basis.

The unit used for the base may be, for example, a kilogram, a metre, or a hundred items. This method of applying overhead is most suitable in small businesses using simple manufacturing processes, or in large companies manufacturing a small range of products in large volumes.

3.5.2 Material Cost Basis.

Some companies use a percentage of the cost of materials consumed to determine the amount of overhead. This is suitable in concerns using materials of approximately the same value in each product manufactured, or in companies where the amount of material used per hour is constant.

This method, however, has some limitations outside the above mentioned uses. Since many of the indirect costs, such as indirect labour, heat, light, power, etc., are consumed on a time basis, the method is unsuitable unless the value of materials used bears some direct relation to the amount of time taken to manufacture the product. This sort of relationship is possible where product output is controlled by machines.

3.5.3 Labour Cost Basis.

The labour cost basis is similar to the material cost basis in that it relies on the same rate of pay for all direct workers. It is the most widely used base, with simplicity of operation seeming to be the main argument for its use. The weakness of this method can, however, be illustrated using a simple example. If a semi-skilled worker is payed £3.50 per hour and a skilled worker is payed £5.25 per hour for the same kind of work, then the amount of overhead charged for the skilled worker would be 1.5 times more than that charged for the semi-skilled worker. Yet, when both men have worked one hour they have used the same amount of overhead.

In cases where most of the workers in the same department receive the same rate of pay, then the labour cost method can be used with some accuracy when a separate overhead rate is calculated for each department.

3.5.4 Labour Hour Basis.

Unlike the previous three allocation bases, the labour hour basis considers the time factor in applying overhead cost. However, this method does involve the additional clerical expense of recording the labour hours used on each job. It is used to good effect in companies that operate highly manual manufacturing systems.

3.5.5 Machine Hour Basis.

The machine hour basis is similar to the labour hour method and is most suitable where work is performed primarily by machines. However, this method also requires the measurement of machine hours for each job.

In some companies it is beneficial to use the machine hour method to allocate overhead costs in, say, the machine shop, and use the labour hour method to allocate overheads in the assembly areas. By using the allocation base which best suits the department concerned, the amount of under or over recovery can be reduced.

A recent survey conducted by Schwarzbach [21] of over 100 American manufacturing companies, revealed that the labour cost base was the most widely used, with 58% of the companies surveyed adopting this method. Figure 3.3 also shows that over 35% used the time related labour hour base and more than one in four used the machine hour base.

3.6 Summary.

In order to monitor and control manufacturing costs accurately, companies must separate and calculate the different elements of product cost. They must choose the method of overhead recovery and a cost accounting system which are the most appropriate for its size, product, and manufacturing methods.

Allocation Base	% Using Base
Labour Cost	58.0
Labour Hours	35.7
Machine Hours	27.7
Material Cost	18.8

Note : Total percentage greater than 100% because some companies use more than one allocation base.

Figure 3.3 Usage of Overhead Allocation Bases.

Special Contracts Division have adopted a contract costing system to track the elements of contract costs. Overhead costs are recovered using the direct cost base because the pay for each direct worker is roughly the same. Also, since it is possible for some service departments to charge costs directly to specific contracts, this practice has been adopted. Not all of the estimated overheads in these departments are passed on to production areas, as some costs may be recovered using a service department overhead recovery rate.

Thus, it can be seen that accounting texts can only be used as a guideline, and each company must adapt standard methods and systems to suit its individual situation.

4 LITERATURE REVIEW.

4.1 Introduction.

Technology is developing at an ever increasing rate. It has been estimated that the worldwide technology explosion over the last 20 years has generated about 90% of all current knowledge in engineering and the physical sciences. As a result, manufacturers are faced with a constantly changing environment and a proliferation of technological alternatives.

In Chapter One we looked particularly at the impact of computer technology on cost accounting. This technology has had a positive effect on cost accounting and its practices, allowing cost data to be analysed more quickly, accurately, and economically than would be possible with a manual system. In many companies cost accounting procedures have not had to be changed as a result of the use of computers, except that they have allowed further and more detailed analysis of costs in cases where there was insufficient time to do so manually.

This review will now investigate how Advanced Manufacturing Technology (AMT) is reshaping the manufacturing environment and how this has led many accounting authors to propose changes in cost accounting practices. After looking for evidence of these proposed changes, all the findings are set in context with

Special Contracts Division and the development of its cost accounting system.

4.2 Review.

The main developments in AMT will be considered in each of the three main areas of manufacturing :- design, planning, and the manufacturing process itself.

In traditional manufacturing, product design involves the hand production of drawings, a demanding and time consuming task. Any changes in design mean redrawing or modifying existing drawings, regardless of how similar it may be to other products. The development of Computer Aided Draughting (CAD) systems has meant that information about a part can be displayed on a screen using computer graphics. Since this computerised information is easily changed, the task of designing and modifying a product is considerably shortened.

A significant benefit of CAD systems is their ability to quickly retrieve data. With traditional hand produced drawings it is often not worth the time and effort to search for designs of similar parts, and in practice a new design is undertaken. It is now generally accepted that about 40% of the parts in a design are already in existence, a further 40% can be designed by modifying existing parts and the remaining 20% will be the new design [22,23]. This fact has brought about the development of Group Technology (GT). The principle of GT is to bring together similar parts to form a family. The similarities are then used to advantage in both the design and manufacturing processes. This coupled with the data retrieval capabilities of CAD systems has greatly reduced the number of parts which need to be designed for a new product.

Two other important technologies which have affected the design process are Computer Aided Engineering (CAE) and Computer Aided Process Planning (CAPP). CAE is the use of software to simulate the performance of a design under various conditions. For example, a designer can simulate the performance of a part using different materials under certain stress conditions. CAPP is the use of a computer for the design of the manufacturing processes required to manufacture the computerised part design. This can take place at the same time the part is being designed, thus ensuring that it can actually be manufactured - a significant problem in traditional manufacturing [24].

The second area in which we will now consider AMT developments, is manufacturing planning. In traditional manufacturing the Economic Order Quantity (EOQ) is the method used to calculate the quantity of parts to be ordered or manufactured. However, this technique relies on inventory levels to signal the reordering of parts, and leads to over excessive inventories for parts which may not be used in the manufacturing process for some time. To improve internal inventory control several techniques were developed. The first, Material Requirements Planning (MRP), predicted the delivery date of parts in addition to the quantity required. This was accomplished by using information on the current inventory status and the make-up of the end product or Bill Of Materials (BOM). The problem with MRP was that the number of items required often exceeded the production capacity. A technique called Capacity Requirements Planning (CRP) was therefore developed to overcome this problem. After processing a master production schedule the CRP system produced a report showing the occurrences of over and under capacity. Management could then modify the master production schedule in order to smooth production capacity.

While these techniques were being developed in Europe and North America, the Japanese were evolving other techniques, the most common being Kanban, Zero Inventory and Just-In-Time (JIT). The name 'just-in-time' sums up the concept of this technique, which is, only to order or manufacture products just in time for their use. Products are not manufactured just to fit in with a schedule, nor are additional products made when they are not needed, thus inventory levels are dramatically reduced. For the JIT system to work, however, the quality and delivery of products and raw materials must be of the highest integrity.

The final area of manufacturing that will now be considered, is the manufacturing process. The use of AMT in this area is generally called Computer Aided Manufacturing (CAM). Traditionally, manually operated lathes, milling machines, grinding machines etc., are used in the production of parts. These are now being replaced by Direct Numerical Control (DNC) machines, Computer Numerical Control (CNC) machines, automated material handling systems, robots, computer aided inspection and testing, and automatic assembly.

The development of group technology is changing the way in which factories and plants are being desiged. In the traditional manufacturing environment, factories are usually designed and layed out with groups of like machines and processes together. This requires extra time to move materials and schedule machines. Today, manufacturing layouts are being formed by a number of independant 'manufacturing cells' which include the machines required to produce a family of components with the minimum amount of human intervention. One of the main benefits brought about through this approach is the reduction of machine set-up times. Since parts within a family are similar, machines only need slight alteration rather than a complete set up for a totally different batch of components. A fully automated manufacturing cell is called a Flexible Manufacturing System (FMS), and generally includes robots, programmable controllers, DNC and CNC machine tools and automated material handling systems.

The dramatic development of all these advanced manufacturing technologies has had an impact in a number of areas. As production becomes more automated traditional blue-collar workers (direct labour) are being replaced by white-collar workers (indirect labour), that is, personnel involved in research, product development, industrial engineering, programing, scheduling, maintenance etc.. The widespread use of automated machinery and inspection has also brought about an improvement in quality. This has led to a reduction in scrap and the amount of raw material required. Reduced machine set-up times mean that shorter production runs or smaller batches are now possible. On the other hand, the capital investment required is increasing as companies need to keep up to date with the ever changing technology in order to stay competitive.

We will now consider how these changes are influencing the elements of cost, and cost accounting systems. One of the effects is the reducing direct or prime costs. There are two main reasons for this. Firstly, direct labour costs have reduced as machine operators, inspectors etc., are replaced by automated machinery. For example, "in many electronics products, direct labour makes up only 3 percent to 5 percent of product cost" [25]. Secondly, direct material costs have reduced due to higher quality and reduced scrap obtained by the use of automated machinery.

The other main element of product cost, overheads, is increasing. There are also two main reasons for this. The first is the increase in indirect labour costs as indirect workers, such as planners, programmers, production and quality engineers, are replacing direct workers. The second reason is that depreciation costs are rising, due to the fact that modern machinery has to be written off in a shorter time scale so that it can be replaced by the next breed of machine.

The development of new technology is now raising questions concerning the validity of current costing methods. For example Chalos & Bader point out that :-

> "... the greater heterogeneity of output permitted by flexible manufacturing, without a corresponding loss in capacity utilisation, suggests that a job costing system is not entirely appropriate." [26]

Chalos & Bader also point out that high-tech companies are no longer tied to long production runs of similar products, a characteristic of process costing systems. Instead, they are tending towards medium volume, non-homogeneous production, which suggests that process costing methods are no longer appropriate. A hybrid system sharing both job and process characteristics is therefore suggested. But, as was revealed in Chapter 3, the need for hybrid costing systems has long been realised by both accounting authors and industries that operate batch or multi-process manufacturing processes. Nevertheless, the implementation of advanced manufacturing technology in industries and companies operating pure job or processs costing systems, will undoubtedly lead to re-evaluation of the costing systems' continued suitability.

Cost accounting systems and practices have been critisised, by some authors, for many years. In 1973 Mullinx [27] said that :-

> "Although most companies have some system of financial and cost controls, such systems are rarely as effective as they should be" "... because their various components are not effectively integrated."

Other arguments by Mullinx, such as :-

- cost accounting has been more concerned with product costs than with cost control,

- financial control systems too often provide information only in accounting terms, and

- companies fail to achieve their profit objectives because budgeted profits are frequently subject to amendment during the course of the year,

are supported by Cluet [28], Kaplan [29] and Sherwood [30] respectively.

In many recent articles, cost accounting authors have expressed the view that :-

> "Today's cost management systems are failing to provide companies with the financial information they need to manage their factories of the future successfully." [31]

and that :-

> "the cost accounting system must evolve in order to be compatible with the new manufacturing environment." [32]

In response to the developments which are taking place within the manufacturing environment, some authors have proposed changes which will be required in future cost accounting systems. For example, the main changes recommended are that :-

- Machine operating costs should be separated from overheads and charged directly to products rather than averaged over production. [33,34]

- Other overheads, such as administration, should be recovered on the basis of machine hours rather than direct labour hours or direct labour cost. [35]

- As new machines with short technological lives are implemented, capital costs should be depreciated on actual machine utilisation rather than over a fixed time period. [36]

- With tight controls over both quality and non quality costs now required, costs such as scrap, rework, product warranty and field service should be separated and accumulated for management. [37]

It can be seen that the first three changes reflect the increasing importance of new machinery and machine times, in comparison to traditional accounting systems which are largely based on direct labour and direct labour time.

So what evidence is there of these proposed changes? Firstly, Bonsack [38] and Russell & Dilts [39] acknowledge that cost accounting methods and costing systems are notoriously resistant to change, but Chalos & Bader point out that :-

> "... management should not be bound by conventional accounting practice and should be prepared to experiment with a cost accounting system best suited to its production environment." [40]

Chalos & Bader go on to cite an example of a system adopted by Hewlett Packard where two significant departures from traditional product costing have taken place. Firstly, because direct labour is a small component of product cost, it is not allocated to individual products, but simply charged to overhead. Secondly, no attempt is made to trace overhead to a specific product line. Instead it is aggregated and treated as a period cost in the Cost of Goods Sold rather than a product expense allocated to Work-in-Progress and Finished Goods Inventory.

More evidence can be found from a survey conducted by Schwarzbach [41] of 112 manufacturing firms in the United States. It was found that 27.7% of the companies used machine hours as a base for allocating overheads to products. However, it was expected that machine hours would be favoured by the highly automated firms, but only half of the 40 highly automated firms considered machine usage as a factor for allocating indirect costs.

One of the changes proposed earlier, by Schwarzbach among others, was that machine hours should be seperated from overheads and charged directly to products. In his survey, Schwarzbach found that 13% of the firms monitored costs on 'key' machines and 8% claimed they tracked costs on all machines. Again it was expected that this practice would be more commonly used by highly automated firms, but only 42.5% said they separated machine operating costs from overheads.

Thus, although a number of changes have been proposed, and in some cases implemented, the evidence is that many highly automated firms are not developing accounting systems in line with new technological developments.

Russell & Dilts [42] give two reasons why accounting systems should be developed alongside the development of the manufacturing system. Firstly, systems designed and built after the implementation of a new manufacturing system will be complex and expensive additions. Secondly, many of the benefits of automation may not be realised unless managers obtain suitable information about the automated process.

The fact that cost accountancy is not developing, may, as some authors suggest, be due to a reluctance to change, or it may be that the integration of cost accounting systems within manufacturing just receives a lower priority than the development of other manufacturing and business systems.

Evidence of the latter can be found from a survey conducted by De Meyer & Ferdows [43] of 560 manufacturers in Europe, North America and Japan. The survey showed that the Japanese were placing more emphasis on the integration of cost accounting with manufacturing than the Americans and the Europeans.

One of the questions asked was, what degree of emphasis the company intended to place, in the next two years, on better integration of a set of 21 information sub-systems. Manufacturers agreed quite convincingly on the importance of integrating quality control with other sub-systems. Conversely, all the manufacturers put a low emphasis on the integration of order entry.

It was, however, the differences between the three regions that were more interesting. The Europeans placed a high emphasis on the integration of sales related information systems. The same systems appear, however, in the Japanese data as the least emphasised for integration. The Japanese place cost accounting second in their list of priorities, which at first appears to contradict the relatively low rank given to the integration of financial performance reporting. However, De Meyer & Ferdows hypothesise that this reflects a 'bottom-up' approach, starting on the shop floor "with the nuts and bolts of cost accounting", in contrast to a 'top-down' approach reflected by an emphasis on financial performance reporting.

In general, the survey showed that the Europeans favour a top-down approach, commencing with strategic planning and sales related issues, whereas North America and Japan favour a bottom-up approach, placing emphasis on shop floor control, inventory status and cost accounting.

Continuing the theme of integrated systems, an interesting paper by Gessford [44] identifies the steps required in the development of an integrated information system. Figure 4.1 shows the building blocks of the system.

Gessford argues that before mechanised systems are possible, the basic systems, which include, product numbering, part numbering, customer order identification, and other codes, must be well defined and consistently used. Before integrated systems can be considered the systems using this basic data have to be mechanised. This usually includes systems for cost accounting, inventory, sales and bought ledgers, payroll etc.. Once an adequate integrated data base is in existence the final component in the information system model, that is computer assisted management planning and control systems, can be developed. However, as we have already seen, the evidence today (fifteen years later) is that the level of 'integrated systems' has in many cases not yet been achieved.

If SCD were to be placed in Gessford's information system model, it would appear somewhere in the 'mechanised systems' stage. Mechanisation of systems requires changes in basic systems, and

PLANNING AND CONTROL SYSTEMS

Mathematical models
Simulators
Analytical Tools

INTEGRATED SYSTEMS

Combining Applications And Functions
Simple Decision Rules
Common Data Base

MECHANISED SYSTEMS
(related to separate functions and applications)

Computers
Automatic Message Switching
Data Gathering
Display

BASIC SYSTEM STUDIES

Systems And Procedures
Coding Systems
Form (document) Design And Control
Internal Controls
Budget And Cost Control Techniques
Training And Work Measurement Activities

Figure 4.1 Building Blocks in the Development of an Integrated Information System.

SCD is currently involved in the process of reviewing and changing its basic systems to suit mechanisation (computerisation). The development of integrated systems will cause modifications in mechanised systems with consequent changes in basic systems, and the development of planning and control systems would stimulate changes throughout the whole hierarchy.

This review will finally set the findings we have discussed in context with the research, firstly regarding the development of SCD's manufacturing system, and then in terms of the future development of the Company's cost accounting system.

Many of the reasons for proposed changes to cost accounting systems are due to the influence of AMT and are thus of more concern to highly automated companies, or firms who are in the process of automation. So to what extent does SCD resemble a highly automated firm?

Figure 4.2 below compares the distribution of costs in both traditional and highly automated manufacturing environments with figures from SCD. It can be seen that the labour costs in SCD are similar to that of a traditional manufacturing system. This is not surprising since SCD operates a traditional 'job-shop' manufacturing environment with a high degree of manual labour.

The contribution made by material costs is lower than both the traditional and highly automated environments. This is due to the fact that relatively small amounts of material are used in relation to the time it takes to manufacture a motor.

Element of Cost	SCD	Traditional	Highly Automated
Direct Material	26 %	40 - 50 %	40 - 50 %
Direct Labour	15 %	10 - 30 %	1 - 10 %
Overheads	52 %	30 - 40 %	30 - 45 %

Note : Traditional and highly automated figures taken from Bonsack [45]. SCD figures are average over first six periods of 86/87 financial year.

Figure 4.2 Distribution of Costs in SCD Compared With Traditional and Highly Automated Manufacturing Environments.

Conversely, it can be seen that over 50% of the costs in SCD are overheads, more than in either traditional or highly automated firms. There are three main reasons for this. Firstly, a high number of indirect quality control staff are required to ensure the quality and integrity of the motors, thus increasing indirect labour costs and consequently overhead costs. Secondly, indirect labour costs are increased further by the larger than normal production support team needed to control and solve problems in manufacturing characterised by difficult operations. Finally, the abnormally low consumption rate of materials has the effect of increasing the relative contribution of overheads.

We can see that SCD is unusual in that, as far as the distribution of costs are concerned, the Company shows neither the characteristics of a traditional or highly automated firm, though in practice the manufacturing environment is very much traditional. So to what extent is SCD planning to make changes towards higher automation?

Although, in recent years, the Company has implemented advanced manufacturing technology, this has been driven and funded by the MoD with the aim of improving the quality of specific components. The three main purchases have been a CNC lathe, a CNC milling machine, and a computer controlled 3-dimensional measuring machine.

The nature and design of SCD's products (discussed in Chapter 2) means that many of the manufacturing processes involved are highly manual. This is likely to be the case in the foreseeable future, thus automation will not have the same impact within SCD, and other similar job and small batch manufacturers, as has been suggested.

Similarly, many of the proposed changes to cost accounting systems, resulting from high automation, are not of the same concern to SCD as they might be to more automated firms.

However, there is still much to be done to develop cost accounting within SCD, particularly in the areas of :-

- improving the collection of cost data
- computerisation of the manual system

- providing faster, more accurate and detailed analysis for all contracts, and finally
- integrating cost accounting with the manufacturing system.

5. PRELIMINARY INVESTIGATIONS AT SCD.

5.1 Previous Work in the Area of Computerisation.

A study on computerisation at SCD was carried out in 1983. It was prompted by customer anxiety over the Company's inability to forecast production accurately and program projects realistically, and also by the need to re-assess requirements for the outdated engineering computing facility. A series of interviews, conducted by the Computer Services Department, sought management opinion on the future computing requirements of all departments. A report issued in March 1984 presented a list of the requirements seen by the Departmental Managers (see Appendix A). Although many of these are non-specific or even vague, perhaps through lack of time or incentive to express them precisely, the report did make the following recommendations in order of priority :-

- immediate upgrading of engineering computing facilities.

- implementation of project management package called INTERNET 80S for the manufacturing department.

- rationalisation and expansion of systems within other departments.

Continued pressure from the customer meant that between March 1984 and October 1985 all the efforts of the Computer Services Department were directed towards the implementation of the project management software. The Internet package, which was available to SCD on a mainframe computer at GEC Computer Services (GEC CS), was implemented through the lease of a McDonnell Douglas M8000 mini computer which acted as a 'front-end' to the mainframe.

Purchasing, Payroll, Sales and Bought Ledger Systems, available from GEC CS, were also implemented, together with a word processing package which ran on the Company's mini computer.

5.2 Review of Computing Requirements.

In response to the start of this research project a management meeting was held in November 1985 to discuss 'Computer Integrated Manufacturing and the way ahead for SCD'. Prior to this, computerisation efforts had largely focused on the Manufacturing Department and the implementation of Internet. This had resulted in a lack of response to requests made by managers in other departments. At the meeting, however, the General Manager confirmed the Company's commitment to further computerisation, and the urgency for progress in this area was agreed. As a result each manager was asked to review his department's requirements (see Appendix B). Compared with those of March 1984 (Appendix A) it is clear that more considered and specific requirements were given. It is thought that this was due to the following factors, non of which existed in 1984 :-

- increased management awareness and knowledge of computer capabilities and applications.

- the General Manager's statement of the Company's commitment to further computerisation.

- the presence of physical signs which showed potential for further progress, such as the lease of a mini computer and the commissioning of this research project.

- the fact that steps towards further computerisation were being driven from top management downwards, rather than from Computer Services upwards.

Now that requirements had been reviewed, a computing policy and new terms of reference for Computer Services were drawn up so that they could be implemented.

5.3 Computerisation Policy.

Previously SCD did not have a precise computing policy so the terms of reference and policy developed in early 1986 were the first to be documented by the company. The terms of reference (see Appendix C) recognised the inbalance of previous computerisation and identified the need to broaden the scope of

Computer Services' activities to include the development, implementation and support of systems in all departments.

The main policy was that Computer Services staff should become more involved in helping to draw up and discuss system requirements, so that a full understanding of the systems could be gained and hardware and software resources could be matched to the evolving requirements. This policy was achieved by the formulation of six project teams, one for each department, which were made up of two members of Computer Services and at least two members from the respective department. The objectives of each team fell into three areas :- system definition, system development and system implementation. These are outlined below.

5.3.1 System Definition.

- to review the systems and services required by each department and to select those of highest priority on which attention would be concentrated.

- to specify the selected systems in detail.

- to propose hardware and software to satisfy the specification.

- to select a final system solution.

5.3.2 System Development.

- to prepare a program of work with the time scales and costs required to implement the systems.

- to carry out the above program, monitor progress and review development.

5.3.3 System Implementation.

- to introduce tested and documented systems and provide adequate instruction and training.

- to provide a maintenance and development service for the implemented systems.

Although not documented in the policy report, there were two further policies which soon became clear. The first was to provide, wherever possible, an in-house or bought-in application which could be run on SCD's mini computer, and thus be fully controlled and developed by Computer Services staff. This was a change from the previous policy which had used applications on computers at GEC Computer Services.

The second, was to initially implement one computerised system in each department on site. Though this may be seen as a 'public relations' policy, it was thought to be one of the most important factors in the successful development and implementation of these and future systems. The fact that each manager was now receiving attention increased the enthusiasm for computerisation throughout the company. This led to better co-operation and provided systems which were more rigorously designed and developed.

5.4 Importance of Developing Cost Accounting System.

The importance of developing the cost accounting system within SCD became apparent from the findings of the six project teams. Figure 5.1 shows, in priority order, the systems identified for computerisation by each team. It is apparent that many of the systems represent computerisation or mechanisation of the Company's basic information systems, for example, the planning card system, jig and tool record system, sales order book, drawing register, accounting ledgers etc.. The need to first mechanise these basic systems, identified by the teams, follows the model by Gessford [46] which was discussed in Chapter 4.

All the items in Table 5.1 marked with an asterisk (*) represent elements of cost accounting or a 'Contract Cost Collection And Analysis System'. Due to the complex and inter-departmental nature of such a system a special Costing System Project Team was formed so that the nature of the system and its problems could be fully understood.

MANUFACTURING DEPARTMENT

Planning Card System
Jig & Tool Record Card System
* Piecework Ticket Costing Module
Internet And Alternative Systems For Project Management

COMMERCIAL DEPARTMENT

Sales Order System
Purchase Order System
* Account Of Contract Spend System

ENGINEERING DEPARTMENT

Finite Element Development
Departure From Drawing/Concessions Registar
Drawing Registar

QUALITY ASSURANCE DEPARTMENT

Index Of Operating Procedures
Quality Plan Monitoring System
Inspection Monitoring System
* Defective Cost System

PERSONNEL DEPARTMENT

Personnel Information Management System

ACCOUNTS DEPARTMENT

Nominal, Sales and Bought Ledgers
* Costing System
* Estimating Information Management System

Note : Items marked with an asterisk (*) represent elements of a contract cost collection and analysis system.

Figure 5.1 Requirements Given Priority by Project Teams.

5 PRELIMINARY INVESTIGATIONS AT SCD

The Contract Cost Collection And Analysis System (from now on referred to as the Cost Collection System (CCS)) in existence at that time was completely manual. It had developed from a piecework system established by the Phoenix Dynamo Manufacturing Company, though piecework was no longer in existence. Briefly, it consisted of the collection of direct labour hours, material costs and other direct expenses which were allocated to specific contracts. The direct labour costs and overhead costs were then calculated and allocated. All the times and costs were collected using nine different types of ticket, about 800 of which were manually processed each week by the Accounts Department.

The main problems identified by the project team in the early discussions were :-

- the time taken to produce and make available cost information was too long.

- the control system used to check the allocation of costs was not tight enough.

- ticket data was not of a high enough integrity for completely accurate analyses to be carried out.

The team agreed that an integrated Contract Collection System was needed to tackle these problems, and provide the company with an improved cost analysis capability. It was with this aim in mind that a detailed investigation of the manual system was carried out.

6. ANALYSIS OF MANUAL COST COLLECTION SYSTEM.

6.1 Introduction.

The need for an improved Cost Collection System was identified by the costing system project team. There was, however, no individual in the Company who fully understood the complex nature of the manual system or appreciated all of its problems. A study was therefore undertaken to define the system procedures and problem areas.

It is not the purpose of this chapter to give a detailed description of the manual system. Most of the procedures involved have been summarised in the form of a flow chart shown in Appendix D.

The main concern of this section is to illustrate the problems which were experienced. It is appropriate though at this point to define some terminology which will assist the reader in the sections to follow.

Working Number.

A 'working number' is a control account used to accumulate costs against a specific area. It is made up of two elements, namely a 'contract number' and a 'work package'. Figure 6.1 below shows the typical structure of a working number.

$$\overbrace{\underbrace{\text{A B C 1 2 3 4}}_{\substack{\text{contract}\\ \text{number}}}\text{ . }\underbrace{\text{1 0 0}}_{\substack{\text{work}\\ \text{package}}}}^{\text{working number}}$$

Figure 6.1 Structure of Working Number.

Contract Number.

A 'contract number' is the identification given to an order placed by a customer and it is used to accumulate the costs incurred by the Company over the duration of a contract.

Work Package.

A 'work package' is a sub-division of a contract and is used to accumulate costs within a particular area or activity on the contract, such as, manufacturing, quality assurance, tooling, meetings, travel expenses, etc. Work packages may be set up to monitor costs in any area which is of interest or which will benefit from such attention.

6.2 Problems with the Manual System.

Overall, the time consuming nature of the manual system meant that the turn round of cost information was not fast enough for effective monitoring and control. Due to the volume of work required it took about seven working days to produce a Contract Cost Report. It was therefore only produced once every accounting period. Manual sorting and calculation were also prone to errors, which led to further time consuming checking to ensure accuracy.

Due to the length of time taken to calculate the costs for each ticket and produce essential reports, there was only a limited amount of time available for subsequent analysis. This meant that only major contracts could be monitored and analysed in detail.

One of the main problem areas was that many of the tickets were not designed specifically for the tasks for which they were being used. Most had obsolete boxes which were left blank or used for another purpose and some had no allocated space for information that was required. With some boxes not requiring any data, there were cases where information was omitted by mistake. When no space was allocated, data was presented in different places on the ticket or again omitted. Both these problems led to difficulties in readily pinpointing information and either inaccurate analysis or time consuming information finding exercises.

In an effort to improve data integrity during the collection of direct labour costs shop floor workers were required to complete a Piecework Application, see Figure 6.2. A clerk then made out a Piece Work Bill (Figure 6.3) for each Piecework Application. While transcribing information from the Piecework Application and adding further information from a planning card, the clerk

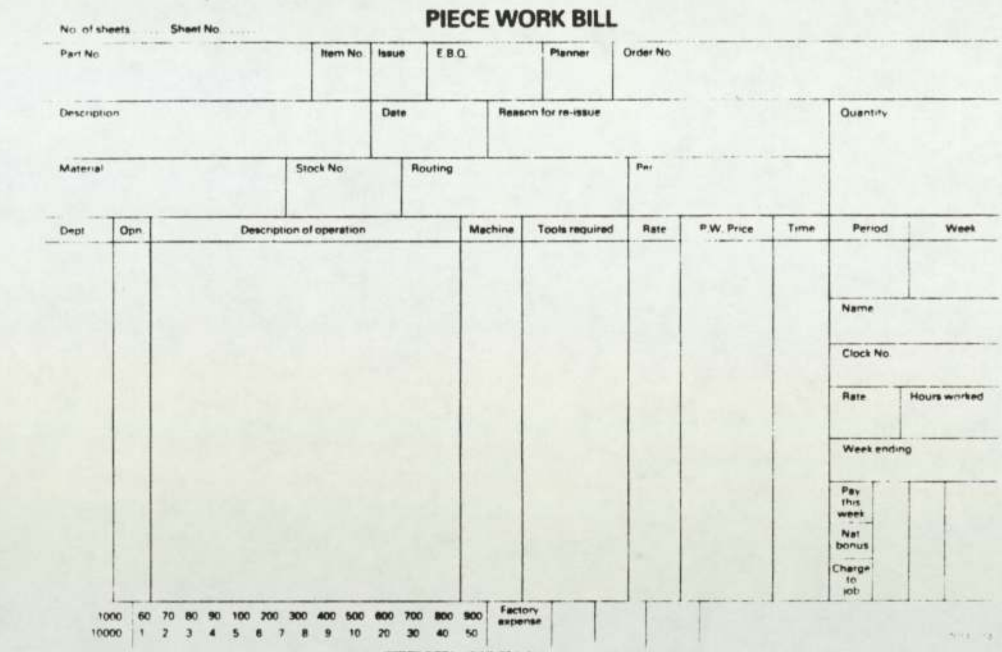
PIECEWORK APPLICATION

DRAWING No.	Item No.	Issue	Order No.
NAME	CLOCK No.	RATE	
QUANTITY	DESCRIPTION & MATERIAL		
OPERATION No.	OPERATION	TOTAL HRS WORKED	
20 30 40 50 60 70 80 90 100 200 1 2 3 4 5 6 7 8 9 10	INSPECTION		

Figure 6.2 Piecework Application.

checked for operations which may already have been booked to the contract. Operation times were also checked against historical records and large discrepancies investigated. Although data integrity was improved, the process did represent duplication of effort and was in itself not free from transposition and other manual errors.

In order to fully investigate the relative obsolescence of the tickets used, the boxes on each ticket were analysed in terms of the use implied by the box label and then by their actual use. The tickets themselves were analysed in terms of the people/department who used them, their intended use and their actual use. Figure 6.4 shows a sample Waiting Ticket and the results of an analysis. The full results are shown in Appendix E.



No. of sheets ..... Sheet No. .....

PIECE WORK BILL

Part No | Item No. | Issue | E.B.Q. | Planner | Order No

Description | Date | Reason for re-issue | Quantity

Material | Stock No | Routing | Per

Dept | Opn | Description of operation | Machine | Tools required | Rate | P.W. Price | Time | Period | Week

Name

Clock No.

Rate | Hours worked

Week ending

Pay this week

Net bonus

Charge to job

1000 60 70 80 90 100 200 300 400 500 600 700 800 900

10000 1 2 3 4 5 6 7 8 9 10 20 30 40 50

Factory expense

Figure 6.3 Piece Work Bill.

The analysis showed that both Waiting and Diversion Tickets were being used to book time to more than one overhead code. This meant that the tickets concerned could not be sorted by individual codes, thus tickets had to be duplicated and each copy amended so that a total for each overhead code was provided. Accounts clerks had to watch out for this problem, making sorting more difficult, and once detected time consuming corrective action was required. If in some cases the problem went undetected then subsequent analysis of times and costs would be inaccurate.

The ticket analysis also revealed that Piece Work Bills were being used to book time to departmental overheads, a use for which they were not intended. Although the tickets concerned

WEEKLY WAITING TIME RECORD

NAME	CLOCK No	HOURLY RATE	WEEK ENDING

FOREMANS SIGNATURE	REASON FOR WAITING	DATE	CLOCK READING	OFFICE USE ONLY				F.O. CHARGE No.
				ELAPSED TIME		PAYMENT		
				HOURS	MINS	£	P	
			Start					
			Finish					
			Start					
			Finish					
			Start					
			Finish					
			Start					
			Finish					
			Start					
			Finish					
			Start					
			Finish					
			TOTALS					1

7014 666

Used by : Shop floor operators.

Intended use : (i) Waiting time booked to one waiting overhead code only.

Actual Use : (i) Waiting time booked to one overhead code, (ii) Waiting time booked to more than one overhead code.

Box Label	Actual Use
NAME	Operators initials and surname
CLOCK No.	Operators department and clock No.
HOURLY RATE	NOT IN USE
WEEK ENDING	Week ending date
FOREMANS SIGNATURE	Foremans signature
REASON FOR WAITING	Overhead code
DATE	Date
CLOCK READING - Start	NOT IN USE
CLOCK READING - Finish	NOT IN USE
ELAPSED TIME HOURS	Whole hours spent waiting
ELAPSED TIME MINUTES	Fraction of hours spent waiting
PAYEMENT £	NOT IN USE
PAYEMENT p	NOT IN USE
F.O CHARGE No. (1)	Labour cost (charged to overheads)
TOTALS	Total hours for week

Figure 6.4 Analysis of Waiting Ticket.

could be, and were, directly processed, they first had to be sorted from those used to book time to working numbers. This represented an additional sorting operation which could possibly have been avoided.

In a similar way to Piece Work Bills, Service Tickets were used to book time to both working numbers and overhead codes, although in this case it was the intended procedure. Nevertheless, the tickets had to be sorted by charge number type, a process more difficult and time consuming than would have been the case if different tickets had been used.

In general the misuse of tickets was due to the lack of a written operating procedure laying down the exact rules and procedures to be followed. A further lapse in discipline which occured was the late delivery of tickets to the Accounts Department. This only introduced a further time lag into the system and the stop-start nature of data processing that developed as a result was inefficient. These poor practices had been tolerated to such an extent that they eventually became accepted inconveniences.

Another major problem area was the control system used to check the validity of working numbers. For example, it was possible to book time to a work package which had been either temporarily or permanently suspended. This was often not detected until Project Controllers examined the tickets after they had been sorted by contract number and work package. Tickets which had been allocated to a suspended work package required reallocation and resorting, and affected WIP posting summaries had to be recalculated.

A further cause of incorrect allocation was due to the fact that two different work package systems were used. For example, in one system (the most common) the work package for manufacturing was '21' and in the other system it was '210'. Because people were more used to booking to '21' for manufacturing, this number was sometimes used for contracts where the correct work package was '210'. This problem occurred with other work packages and led to incorrect sorting of tickets and preparation of WIP posting summaries, until the problem was detected, when ticket amendment, resorting and recalculation were required.

6.3 Conclusions.

The Cost Collection System which was in existence involved a high degree of clerical effort in the form of sorting, calculating and manipulating large volumes of data. A number of problems have been identified, most of which are due to the nature of manual systems, the obsolescence of tickets and poor discipline and control.

The computerisation of the manual system would eliminate many of the problems, bringing improvements in discipline, consistency, data integrity, accuracy and response time, as well as providing a central data base on which other systems could be developed.

7. DESIGN AND IMPLEMENTATION PHILOSOPHY.

7.1 Introduction.

In Chapter 4 it was noted that cost accounting systems in general are notoriously resistant to change. People do not readily accept change for a variety of reasons, depending upon individual points of view and circumstances. Some staff, particularly older ones and those approaching retirement age, are usually content to continue with the methods that they have become accustomed to and avoid disruptive changes in working patterns by showing little inclination to learn new ways of doing things. This resistance had been experienced in past attempts to introduce computer technology into the Accounts Department of SCD. Since it was proposed that the CCS should be operated and controlled by the Accounts Department there arose a need to overcome any doubts or reluctance about implementation of the new system. Resistance had been lessened with the renewed commitment and enthusiasm within the company for further computerisation, and also by the commissioning of this research which focused on the Company's cost accounting system. Nevertheless, a number of steps were taken to overcome remaining doubts, and encourage staff to accept the technological changes that were being proposed. This chapter describes the design and implementation philosophy that was developed in order to achieve this.

7 DESIGN AND IMPLEMENTATION PHILOSOPHY

One of the main objectives was to initiate and maintain communication with the affected staff throughout the whole system development life cycle, from the feasibility study and initial proposals to the implementation of the system. Staff were initially informed of the reasons for proposed changes and any objections or doubts were discussed on a friendly basis. This communication was then kept up by inviting staff, from senior management to potential end users, to assist in the processes of design, development and implementation. In this way their practical ideas could be implemented where appropriate and a mutually acceptable solution could be provided.

As well as co-operation between systems analysts, programmers, management and end users, a number of design features were implemented to help overcome doubts and ease acceptance and operation of the new system.

7.2 Design Philosophy.

The computerised Cost Collection System was designed so that it could be both easily operated and controlled by the Accounts Department, and used as a data base and reference system by other departments on the site. Thus every attempt was made to achieve the following design objectives :-

- The system should be as simple as possible, keeping in view the requirements of the operating department.

- Screen layouts should be clear and unambiguous.

- Dialogue design should not be overcomplicated to allow ease of understanding by operators and users.

- Checks and controls should be encorporated which are capable of detecting and reporting errors.

- Information should be produced at the right time, in the right format, and to the right accuracy.

- Special attention should be given to the security requirements of the multi-user system.

- Fail-safe and restart procedures should be incorporated within the system.

- In addition to computer operations, special attention should be given to the effective design of supporting clerical systems.

- The time and cost of encoding data from source documents should be minimised.

- Sub-systems should be designed with future integration with other sub-systems in mind.

- The system should be designed within the context of the requirements of the business as a whole.

Perhaps the most important of the design aims, one which is essential to the successful operation of a computerised system, is the validation of data and reporting of errors.

7.3 Data Validation.

The accuracy of information which is output from a computer system is only as good as the input data from which it is produced. A computer is also capable of processing data at high speed and it will process erroneous data just as rapidly as error free data. It is therefore necessary to ensure the integrity of data by implementing routines to detect errors before the data is submitted for processing. The types of validation checks that were used in the Cost Collection System were as follows :-

- Check to ensure data is correct by referencing a master file. For example, a contract number would be validated by reference to a contract master file.

- Check to ensure that data fields contain the correct number of characters. For example, an order number must be nine characters in length.

- Check to ensure that data fields contain the correct type of characters, that is, alphabetic, numeric or both. For example, the last six characters of an order number must be numeric.

- Check to ensure that data conforms to any minimum, maximum, specific, or range of values. For example, minutes must be integers greater than or equal to 0 and less than or equal to 59, or the first three digits of an order number must be equal to 'ABC', 'DEF', or 'GHI'.

- Check for missing data by making data entry to a particular screen field mandatory, either independently or dependent upon entry of data in other specified fields. For example, data entry always required in field one, or entry only required in field seven if entry made in field six.

- Check data by allowing it to be examined visually by an operator before submitting it for processing.

Some of these checks can be made easier by the use of command words and phrases available in the software language used to write the programs, whilst others require complex routines consisting of several lines of code.

Another area of design that required special attention during the development of the CCS was system security.

7.4 System Security.

The security of a multi-user system like the Cost Collection System was very important because access to sensitive information, such as employee pay rates and performance figures, needed to be restricted to a limited number of people. However, security can also be used as a method of control by restricting access to functions, such as data entry, amendment and deletion, while allowing facilities, such as enquiry and report generation, to be available to a greater number of users.

The fourth generation language used to write the Cost Collection System software had a number of security routines which were used to set up an effective security control system. The system was based on 'security categories' and 'security levels' which could be applied to files and programs in order to restrict access. The security routines allowed an 'operator identification', with up to two passwords, to be set up. Each identification could then be specified with a security category, a security level (from 1-9) and a series of terminal numbers. Operation of the system was therefore controlled in the following ways :-

- Each user could only access the system with the correct operator identification and password/s.

- Access could only be gained from the terminal/s specified to the user.

- A user could only access files and programs in the same security category as that specified to the users' identification, and then only those files and programs with a security level less than or equal to the security level specified.

By adopting this system people could be restricted from certain data entry, amendment or deletetion programs and only allowed access to enquiry or reporting programs within certain areas of the site.

Before we go on to discuss the implementation philosophy, we will look at the various methods of implementation which can be used.

7.5 Methods of Implementation.

There are a number of factors which must be taken into consideration when implementing a computerised system. The most important is the method of change-over from the old system to the new one. The three primary methods of transition are :-

- direct change-over
- parallel running, and a
- pilot scheme

The first method, direct change over, occurs when the old system is terminated and the new one takes its place immediately without any overlap. This method is only suitable for small, staightforward systems, although even these are relatively difficult to get up and running. All systems have inherent problems which tend not to reveal themselves until the previous system has been dispensed with. Direct change-over is therefore a high risk method of implementation but is used in circumstances where :-

- users are confident of running the new system,
- when time is short,
- when the staff or resources required for parallel running are not available, or
- when the new system is so dissimilar from the old one that parallel running is irrelevant.

Parallel running is the second method of change-over. This means that the new system is implemented and operated side by side with the current system. The old system is not dispensed with until the integrity of the new system has been proved. This is usually achieved by comparing the results from the new system with those produced by the old one and if they agree then the integrity of the system is assured.

The disadvantages of this method are that it is necessary to engage staff to operate both systems at the same time. This prolongs the testing period and delays system change-over. It is therefore desirable to limit the number of cycles (in this case the number of accounting periods) in which the two systems will be run in parallel.

The final method of transition is the use of a pilot scheme. Rather than committing resources to a company-wide implementation, the new system is restricted to one location or limited use. The test results obtained from running the pilot scheme determine the suitability of the system for other locations or areas within the company. This method is usually adopted when the system has far reaching consequences on the efficient performance of the business and it is therefore desirable to limit implementation to one section for testing, thus avoiding unnecessary wide-scale disruption.

Whatever method of change-over is chosen, a balance must be struck between the two following options :-

- Changing over too soon at the expense of insufficient training or adequate system testing, which will result in the system failing to achieve its objectives, and

- Unnecessarily prolonging change-over which will result in increased operating costs.

7.6 Implementation Philosophy.

Now that we have discussed the methods of change-over which can be used, we will look at the factors which influenced the implementation philosophy used at SCD. There were four main areas of influence, namely :-

- the degree of change from current working practices,
- the complexity of the system,
- gaining the users confidence in the systems performance and operation, and
- limited resources.

The proposals for the new system represented significant changes from previous working practices in a number of areas. Firstly, shop floor workers and engineers would no longer be required to fill in the current tickets, but would complete one of two newly designed tickets instead. Secondly, accounts clerks would no longer be required to sort and calculate ticket costs, but would be responsible for managing the operation of a computerised system, undertaking jobs, such as master file maintenance, ticket data entry, report running, archiving of historical data, and so on.

The second factor to influence implementation was the complexity of the system. The CCS consisted of a large number of procedures, undertaken by many people in nearly all the departments on the site and as such had far reaching effects throughout the company. A system as large as the CCS cannot be implemented overnight, therefore, by breaking down system development into clearly defined parts and implementing each part in turn, the transition can be smoothed into a series of manageable and controllable stages, rather than one large step change which would cause wide scale disruption. The development and implementation of the CCS was therefore broken down into the following stages :-

- Stage I : Provision of Basic System.
- Stage II : Provision of Features For Estimating Department.
- Stage III : Introduction of New Tickets.

The method of change-over used to implement each of the three stages was different.

For the provision of the basic system (Stage I), gaining user confidence in the performance and operation of the system was the main factor to influence the implementation philosophy. Since the Accounts Department as a whole did not have a great deal of experience in operating computerised systems (the proposed operators of the CCS had no experience) it was felt necessary to give the users confidence in both the System's integrity and in their ability to operate the system sucessfully before dispensing with the manual system. Therefore, the parallel running technique was the method of implementation used to for Stage I.

Stage II of the CCS was designed to supplement, rather than replace, procedures within the Estimating Department. Therefore, a pilot scheme was used during which the performance of the system was assesed for a limited number of contracts. When the functionality and integrity of this stage proved satisfactory, the system was implemented for all contracts.

As far as Stage III was concerned, the completion of what would have been almost twice the number of tickets required for parallel running, was out of the question. Therefore, after rigorous ticket design and training, direct change-over was used. The fact that the new tickets were much simpler to fill in, decreased the risk associated with this method of transition.

The final factor to influence the implementation of each stage, was limited resources. The chief restriction was human resources and this mainly effected the time scales for the development and implementation of the stages. Only one systems analyst/programmer was available to design, develop , test and implement the system. In the Accounts Department only two full time and one part time staff were available to manage and operate the system. Although, this was sufficient under normal operating conditions, it proved insufficient during the period of parallel running, since the same staff had to operate both systems simultaneously. Limited resources were a further reason for dividing the development and implementation into manageable stages.

Two steps were taken, however, to speed up the development process. Firstly, in the early stages when the programming load was particularly high, a large amount of work was sub-contracted out to a software house. A number of modules were specified by SCD and written by the sub-contractor. The modules were then fine tuned by the programmer at SCD. The second step which decreased the develepment time, was the use of a fourth generation programming language.

The stages in the development and implementation of the CCS have been summarised in Figure 7.1. For each stage both the method of implementation and the approximate time scales are shown.

	Activity	Time	Implementation Method
1	Stage I : Design, development and testing of programs to replace manual system.	26 wks	
2	Implementation of Stage I (including training)	10 wks	parallel
3	Stage II : Design, development and testing of estimating features.	10 wks	
4	Implementation of Stage II (including training)	2 wks	pilot scheme
5	Stage III : Design of new tickets, development of related software changes and training.	12 wks	
6	Implementation of Stage III	-	direct change-over
	TOTAL DEVELOPMENT TIME	60 wks	

Figure 7.1 Summary of CCS Development and Implementation.

8. SYSTEM DEVELOPMENT.

8.1 Introduction.

The first stage of the new CCS involved the computerisation of procedures used to process the tickets that conveyed cost information. This involved the design of programs to allow entry, verification, amendment, manipulation and output of data. In order that data from the tickets could be retrieved and manipulated once entered into the computer, a reference method had to be developed. Thus, when ticket information was entered, the system was programmed to generate a sequential serial number which was stored with the data and also printed onto the ticket using an auto-incrementing stamp. A link was therefore provided whereby ticket data could be retrieved from computer memory by entering the serial number. The entry of data from each ticket was known as a 'transaction', and it was the transaction file around which the whole computerised CCS was based.

8.2 File Structures.

The smallest definable unit of data is known as a 'data field'. Examples of data fields include :- contract number, work package, employee clock number, department, hours, labour cost, etc. Fields may be grouped together to form a 'record' which relates to a specific entity. For example, a contract record may have fields for contract number, contract description, customer code, etc. The field which uniquely identifies a record is called a 'key field'. Thus, in the above example the key field would be the contract number, since this is the field which differentiates one record from another. In the same way that fields are grouped together, records may be grouped to form a 'file'.

The Cost Collection System used two types of file, namely a 'master file' and a 'work file'. Master files contained data about contracts, working numbers, departments, employees, etc., and were used as reference bases for data validation and retrieval of basic information associated with the key field involved. For example, when a contract number was entered into the system, the contract file was accessed to check whether the number was valid, and if so, the contract description would be automatically displayed on the screen for the user's reference. Master file data generally remained static (only changing when new contracts, departments etc. were generated or when old ones became non-existent) and each of the fields were usually under the direct control of the system operator. Many of the fields in work files, on the other hand, were not under the direct control of operators, but were updated or calculated by software.

When data processing systems are designed, files, records and fields need to be specified precisely in terms of :- the names of the fields which make up each record in the file, the key fields, the maximum field length, the type of characters (whether alphanumeric or numeric) and the validation checks which can be performed to check that the data is correct before being processed. The sections which follow describe these details for each of the files used in the Cost Collection System.

The following abbreviations have been used :-

K = key field
A = alphanumeric field, and
N = numeric field

8.2.1 Department Master File.

Field Name	Type	Length	Format	Validation
department code	K	3		
department description	A	40		
average labour rate (£.p/hr)	N	7	NN.NNNN	
overhead rate (%)	N	6	NNN.NN	
last change date	N	6		

The average labour rate was only used for engineering and service departments. See section 8.2.2 for details of production labour rates.

8.2.2 CT Group Master File.

Hourly labour rates for production departments were made up of two components, namely a CT rate and a lieu rate. There were a number of CT and lieu rates in operation and an employee could be assigned any combination of the two rates. Employees were therefore allocated to CT and lieu groups, and corresponding CT and lieu files were accessed to find the current group rates. When any of the rates changed only the CT and lieu files needed to be updated, thus avoiding the time consuming amendment of all those employees who were paid the affected rates.

Field Name	Type	Length	Format	Validation
ct group	K	3		
ct description	A	30		
ct rate (£.p/hr)	N	7	NN.NNNN	
last change date	N	6		

8.2.3 Lieu Group Master File.

Field Name	Type	Length	Format	Validation
lieu group	K	3		
lieu description	A	30		
lieu rate (£.p/hr)	N	7	NN.NNNN	
last change date	N	6		

8.2.4 Employee Group Master File.

This file was set up so that employees could be allocated to an employee group. The groups were used in sorting routines to allow, for example, shop floor employees to be easily sorted from other employees. This approach avoided 'hard wiring' clock numbers or department codes into the CCS software.

Field Name	Type	Length	Format	Validation
employee group	K	2		
employee group desc.	A	30		

8.2.5 Employee Master File.

Field Name	Type	Length	Format	Validation
clock number	K	5		
name	A	30		
department	A	3		department file
ct group	A	3		CT group file
lieu group	A	2		lieu group file
employee group	A	2		employee group file

8.2.6 Wage Analysis Code Master File.

This file was used in the production of the Wage Analysis Report. A control account was set up for each wage code in the file and since wage analysis codes were allocated to each contract and stored in the contract master file, contract costs could be posted to the relevant control account on the report.

Field Name	Type	Length	Format	Validation
wage analysis code	K	4		
code description	A	30		

8.2.7 Customer Master File.

Field Name	Type	Length	Format	Validation
customer code	K	6		
customer name	A	40		
address1	A	40		
address2	A	40		
address3	A	40		
address4	A	40		
address5	A	40		

8.2.8 Contract Master File.

Field Name	Type	Length	Format	Validation
contract number	K	10		
contract description	A	40		
customer code	A	6		customer file
customer order number	A	20		
MoD order number	A	20		
wage analysis code	A	4		wage anlysis file
contract type	A	1		
closed flag	A	1		

8.2.9 Working Number Master File.

Field Name	Type	Length	Format	Validation
contract number	K	10		contract file
work package	K	6		
working no. description	A	40		
suspended flag	A	1		

8.2.10 Week Number Master File.

This file was used to set up the year, period and week to which transactions would be allocated. At the end of each week, period and year, the relevant field/s were changed by the system operator so that subsequent transactions would be allocated to the next week etc..

Field Name	Type	Length	Format	Validation
file key	K	7		
current year	A	5		
current period	N	2	NN	
current week	N	2	NN	

8.2.11 Serial Number Work File.

This file was used to record the last used serial number. Each time a transaction was made the serial number in this file was updated.

Field Name	Type	Length	Format	Validation
file key	K	7		
serial number	A	6		

8.2.12 Transaction Work File.

Field Name	Type	Length	Format	Validation
serial number	K	6		
contract number	A	10		contract file
work package	A	6		working no. file
clock number	A	5		employee file
hours	N	3	NNN	hours 0
minutes	N	2	NN	0 = mins = 59
current year	A	5		
current period	N	2	NN	
current week	N	2	NN	
ticket type	A	1		
labour value	N	9	NNNNNN.NN	
overhead value	N	9	NNNNNN.NN	
material value	N	10	-NNNNNN.NN	
order number	A	9		first 3 chrs BSF BSW, or BSK, other 6 numeric
operator identification	A	3		
transaction date	N	6		
transaction time	N	6		
deleted flag	A	1		

Notes.

- The serial number was calculated by adding one to the number stored in serial number work file.

- The current year, period and week were taken from the week number master file.

- A different data entry program was used for each ticket type and a ticket type code was allocated accordingly.

- Labour and overhead values were calculated by the ticket entry programs.

- Material values were entered straight from material receipts. Wage adjustment values, such as overtime and holiday pay were also stored in this field, but the ticket type code was different, thus distinguishing them from material costs. A negative sign was allowed for so that both debits and credits could be made.

- The operator identification and transaction date and time were taken from system variables held by the computer. These were used to record who made the last entry or amendment to the ticket details.

- The deleted flag was set to 'N' when a ticket was added to the system. This was amended to 'Y' when a ticket was deleted, thus the data remained on the system for reference, but was not considered in any analyses.

8.2.13 Clocked Hours Work File.

Field Name	Type	Length	Format	Validation
current year	K	5		
current period	K	2		
current week	K	2		
clock number	K	5		employee file
clocked hours	N	3	NNN	hours = 0
clocked minutes	N	2	NN	0 = mins = 59

The current year, period and week were taken from week number master file.

8.3 Program Structure.

This section traces the development of the program structure from Stage I through to Stage III and discusses the key elements of each stage. Figure 8.1 shows the structure of the program in Stage I. The hierarchical structure of the CCS starts with a logon security screen and main menu which leads to a number of sub-menus, which in turn link to a series of screens designed to allow a system operator to add and amend ticket and master file data and run a selection of reports. Each of the menus and programs are protected by the security system, thus providing tight control over the system's operation.

Before any transactions can be made the master files must be loaded with the information that will be used for data validation and reference. A number of screens were therefore designed to allow operators to enter and amend the fields in each of the master files.

The week number file maintenance option (selected from the system control menu) allows an operator to define the current year, period and week. This file was updated on the first day of each week before ticket transactions commenced.

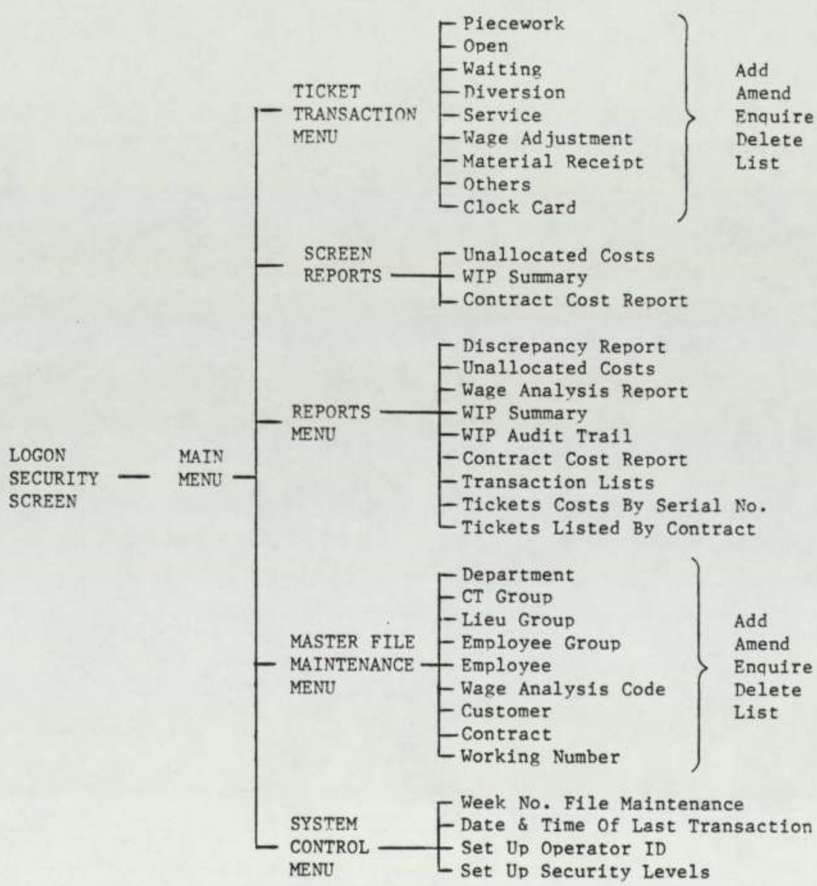


Figure 8.1 Program Structure - Stage I.

The ticket transaction menu offers a selection for each ticket type. When tickets had been received and batched into ticket type (but in no particular order since manual sorting was no longer necessary) a ticket option was selected, which offered a choice of five modes, namely add, amend, enquire, delete or list. A screen between the main menu and the ticket transaction menu informed an operator of the last used serial number so that the auto-incrementing stamp could be checked and if necessary adjusted so as to match the next number to be allocated by the computer.

```
                              Job Ticket - Enquire

Serial No.    000001    Labour Cost £9.10        Overhead Cost £40.95
Period/Week   07/4      Last Transaction Date & Time 07/07/88  10:41:32
                        Deletion Date & Time

Contract     ABC1234    Build a motor
Work Pack    21         Manufacturing
GM Y/N       N

Clock No.    12345  P01 Other, A N
Hrs:Mins      2:30

Drawing No. D12345678        Title  Widgets


Item      B      Issue     A     Plan Ref. No. MCP07A  Quantity      6
Start Op 0010  Finish Op 0050   Complete Y/N  Y        Insp Ref No. ABC/1234/88
Component Serial Numbers A001   A002  A003  A004  A005  A006
Comment
```

Figure 8.2 Typical Layout of Transaction Screen

Figure 8.2 shows the typical layout of one of the transaction screens. They were designed such that the data and data labels lined up in columns wherever possible. The data appeared in highlighted text so that it could be more easily and quickly assimilated.

We will now consider the main reporting options available during the Stage I implementation before looking at the enhancements which took place in Stages II and III.

The first report which was usually run after the ticket and clock card information had been entered was the discrepancy report. The purpose of this report was two fold. Firstly, it ensured that each employees ticket and clocked hours balanced, and secondly it highlighted data entry errors. If any of the hours were miskeyed or tickets entered twice, then there would be an imbalance between ticket and clocked hours. The report was divided into two parts. The first part listed each direct employee and showed the total ticket and clocked hours. Any imbalance was highlighted as a discrepancy. The second part of the report listed the tickets and times which made up each employee's total, thus allowing an operator to easily identify miskeyed data, double entry or the possibility of a missing ticket.

During data entry their were cases where a work package on a particular contract failed the validation checks. A special work package was therefore set up for each contract so that tickets which failed the checks could be temporarily allocated to a control account. This method allowed data entry to proceed without unnecessary interruptions and meant that all the unallocated tickets could be handled more efficiently in one operation. A special contract was also set up so that tickets with invalid contract numbers could also be temporarily allocated. After all the tickets had been entered the unallocated costs report could be run to show all the unallocated tickets.

Once all the times had been correctly entered and allocated the main accounting reports could be run. The first of these was generally the wage analysis report which was produced for each of

WAGE ANALYSIS REPORT

Department Period Week

Control Account	Wages	Recovery	Hours
Production contracts			
Development contracts			
Overheads - waiting time - diversion time - holiday pay - sick pay - overtime - misc wage adjustments			
Sub Total			
Payroll Total			

Figure 8.3 Wage Analysis Report.

the production departments. This report provided departmental wage and recovery totals for the Nominal Ledger.

Figure 8.3 shows the general layout of the wage analysis report. The departmental wage totals were reconciled with the corresponding values from SCD's payroll system, thus ensuring that all the relevant tickets had been considered and correctly allocated.

The work-in-progress report was produced to calculate the WIP totals required for the Balance Sheet. The contract cost report shown in Figure 8.4 is very similar to the WIP report and only varies in the distribution of costs within each working number.

DATE PRINTED DD/MM/YY HH:MM/SS GEC ENERGY SYSTEMS LTD. PAGE No. 1

Special Contracts Division

CONTRACT COST REPORT.

	Factory		Engineering		Direct Material			
Working No.	Labour	Overhead	Labour	Overhead	Material	Sub Cont.	Others	Total

Figure 8.4 Contract Cost Report.

For example, in the WIP report all direct material costs are accumulated together. On the contract cost report they are separated into material and sub-contract work. Similarly, the wage and salary costs on the WIP are divided into factory and engineering costs on the contract report. This is because some salaried employees, such as laboratory technicians and inspectors, incur factory costs. Both these modifications allow contract costs to be more effectively monitored and controlled.

The WIP audit trail provides details of the tickets which make up each of the column totals in the WIP report. This serves as a double check and provides the information which may be required for future auditing purposes.

In all the implementation stages some reports are available as screen options. However, due to the complexity of some reports and the column restriction of monitor screens, some reports were unsuitable for screen options and of those that were, some only displayed a limited amount of information. In each case, screen reports were only designed for quick reference, since more detailed information could be obtained from the hard copy versions.

We will now discuss the main changes which took place between Stage I and Stage III of the CCS. In the Stage I implementation only the information required to calculate and allocate costs to working numbers was entered into the system. The tickets were then passed to the estimating department for manual processing, as had previously been the case. In Stage II, however, steps were taken to reduce the amount of manual sorting and calculation in estimating by entering drawing and operation details from the tickets. A number of reports were then designed to summarise this information in various ways.

- TICKET TRANSACTION MENU
  - Piecework
  - Open
  - Waiting
  - Diversion
  - Service
  - Wage Adjustment
  - Material Receipt
  - Others
  - Clock Card
  - } **Add Accounts Data**, **Amend Accounts Data**, **Add Estimating Data**, **Enquire**, **Delete**, **List**
- SCREEN REPORTS MENU
  - Unallocated Costs
  - WIP Summary
  - Contract Cost Report
  - **Guarenteed Maintenance Summary**
  - **Direct Labour Costs**
  - **Direct Material Costs**
  - **Estimating Labour Base**
- REPORTS MENU
  - Discrepancy Report
  - Unallocated Costs
  - Wage Analysis Report
  - WIP Summary
  - WIP Audit Trail
  - Contract Cost Report
  - Transaction Lists
  - Tickets Costs By Serial No.
  - Tickets Listed By Contract
  - **Guarenteed Maintenance Summary**
  - **Guarenteed Maintenance Audit Trail**
  - **Direct Labour Costs**
  - **Direct Material Costs**
  - **Estimating Labour Base**
  - **Defect Costs By Department**
  - **Defect Costs By Inspectors Ref. No.**
  - **Productivity Analysis**
- MASTER FILE MAINTENANCE MENU
  - Department
  - CT Group
  - Lieu Group
  - Employee Group
  - Employee
  - Wage Analysis Code
  - Customer
  - Contract
  - Working Number
  - **Drawing Number**
  - } Add, Amend, Enquire, Delete, List
- SYSTEM CONTROL MENU
  - Week No. File Maintenance
  - Date & Time Of Last Transaction
  - Set Up Operator ID
  - Set Up Security Levels

Figure 8.5 Program Structure - Stage II.

Figure 8.5 shows the program structure of Stage II. The items highlighted in bold text show where changes or additions took place.

In order to avoid increasing the time scales for production of the main accounting reports (i.e. wage analysis, WIP and contract cost) by the entry of estimating data, which was not required, the data entry operation was divided into two steps. Firstly, the accounts data was entered so that the accounting reports could be produced and then at a later stage the estimating data was added. This policy required the design of an additional data entry screen for the estimating information and the redesign of enquiry and delete screens so that all the ticket information could be displayed.

As drawing numbers were now being input, a drawing number master file was set up. However, due to the large number of drawings in use and a shortage of time and resources, it took a long time to enter the information into the master file. Validation checks could not take place until all the drawing numbers were entered, therefore during the interim period drawing numbers were checked by being entered twice (to reduce the likelihood of typographical errors) and checked visually by estimating clerks.

The three main estimating reports were the direct labour, direct material and estimating labour base reports. The direct labour report showed for each contract the labour costs incurred in each department, with sub totals for factory and engineering departments. The direct material report showed the material costs incurred against each working number. The estimating labour base report gathered together all the estimating information in working number and drawing number order. Figure 8.6 shows that the report was divided into two parts designed to be read side by side.

```
Date Printed  dd/mm/yy  hh:mm:ss            GEC ENERGY SYSTEMS LTD.                               Part  1
                                          Special Contracts Division.                            Page  2

                                            ESTIMATING LABOUR BASE.
                                            =======================

Contract No.
---------------------------------------------------------------------------------------------------------
                                                                         Direct Labour Hours
Serial No.  W/P   Drawing Number   ----------- Title -----------   P01   P02   P03   P04   P17   D39   D40   D58
---------------------------------------------------------------------------------------------------------
```

```
Date Printed  dd/mm/yy  hh:mm:ss            GEC ENERGY SYSTEMS LTD.                               Part  II
                                          Special Contracts Division.                            Page  2

                                            ESTIMATING LABOUR BASE.
                                            =======================

Contract No.
---------------------------------------------------------------------------------------------------------
                                   Planning    Start      Finish    Complete
Serial No.  Drawing Number  Item  Issue  Ref. No.  Operation  Operation    Flag    Quantity   ----- Component Serial Numbers -----
---------------------------------------------------------------------------------------------------------
```

Figure 8.6 Estimating Labour Base.

The report indicates for each ticket :- the labour hours, the department in which they were incurred, the operations which were been completed and the quantity involved. Sub totals for each drawing number allowed the hours from each department to be manually accumulated and stored for estimation of future component manufacturing times and costs.

The guaranteed maintenance summary is exactly the same as the contract cost report with regard to layout, but considers work which was carried out under guaranteed maintenance contracts. These costs were therefore no longer considered in the contract cost report, as had been the case in Stage I.

Two reports were designed to show the defect costs incurred (i.e. the costs incurred by rework resulting from manufacturing errors) firsly within each department and secondly for each defect number.

The final change which took place during Stage II was the development of a productivity analysis. This information had not previously been produced by the Company, mainly due to shortages of time and resources, but with the presence of a computerised system, productivity figures were now easily available. Figure 8.7 shows the layout of the productivity analysis report. The report highlights the productivity for each employee and department. It also indicates the cost to the Company in terms of the overhead labour costs which were incurred and the loss of potential revenue.

Date Printed dd/mm/yy hh:mm:ss

GEC ENERGY SYSTEMS LTD.
Special Contracts Division.

Part II
Page 2

PRODUCTIVITY ANALYSIS.

Dept.	Clock No.	--------- Name ----------	total hrs	total waiting hrs	total div'n hrs	total overhead hrs	% waiting	% div'n	% overhead	total overhead cost	productivity	total cost to company

Figure 8.7 Productivity Analysis.

Now let us consider the main changes which occurred in the final stage of the implementation. Figure 8.8 shows the program structure for Stage III. The additions and changes are again highlighted in bold text.

The two major developments in Stage III were the rationalisation of tickets and the provision of a data archiving facility. Ticket rationalisation was achieved by the implementation of two new tickets designed to replace the old obsolescent tickets, improve data integrity and eradicate poor ticket filling practices.

- TICKET TRANSACTION MENU
  - **Job Ticket**
  - **Overhead Ticket**
  - Material Receipt
  - Others
  - Clock Cards
  - (each:) **Add Accounts Data**, **Amend Accounts Data**, **Add Estimating Data**, **Enquire**, **Delete**, **List**
- SCREEN REPORTS MENU
  - Unallocated Costs
  - WIP Summary
  - Contract Cost Report
  - Guarenteed Maintenance Summary
  - Direct Labour Costs
  - Direct Material Costs
  - Estimating Labour Base
  - **Tickets Listed By Contract**
- REPORTS MENU
  - Discrepancy Report
  - Unallocated Costs
  - Wage Analysis Report
  - WIP Summary
  - WIP Audit Trail
  - Contract Cost Report
  - Transaction Lists
  - Tickets Costs By Serial No.
  - Tickets Listed By Contract
  - Guarenteed Maintenance Summary
  - Guarenteed Maintenance Audit Trail
  - Direct Labour Costs
  - Direct Material Costs
  - Estimating Labour Base
  - Defect Costs By Department
  - Defect Costs By Inspectors Ref. No.
  - Productivity Analysis
  - **Maintenance Transfers**
  - **Staff Overhead Costs**
  - **Hourly Rated Overhead Costs**
- MASTER FILE MAINTENANCE MENU
  - Department
  - CT Group
  - Lieu Group
  - Employee Group
  - Employee
  - Wage Analysis Code
  - Customer
  - Contract
  - Working Number
  - Drawing Number
  - **Tape Allocation**
  - **Overhead Codes**
  - (each:) Add, Amend, Enquire, Delete, List
- SYSTEM CONTROL MENU
  - Week No. File Maintenance
  - Date & Time Of Last Transaction
  - Set Up Operator ID
  - Set Up Security Levels
  - **Create Tape File**
  - **Save Tape File**
  - **Restore From Tape**
  - **Merge Data**

Figure 8.8 Program Structure - Stage III.

The first of the new tickets was the job ticket, shown in Figure 8.9. The job ticket replaced piecework applications, piece work bills, open tickets and service tickets. The layout was carefully designed so that the data appeared in a logical sequence from left to right and from top to bottom. This corresponded to the way in which the data was entered into the CCS system. Notice how the accounting data appears at the top of the ticket and the estimating information at the bottom.

The second ticket implemented was the overhead ticket, shown in Figure 9.10. This replaced waiting tickets, diversion tickets, wage adjustment slips, and piece work bills and service tickets used for overheads. The layout was designed in a similar way to the job ticket, thus easing manual completion and data entry into the CCS.

Before actual implementation, a number of posters were displayed around the site to introduce the new tickets. This was followed by a series of presentations given to foremen and section leaders, explaining the reason for the new tickets, what they were designed to replace, and how they should be filled in. An instruction booklet outlining the ticket completion procedures was then distributed to each employee. To supplement these procedures a summary of instructions was printed on the back of the tickets.

All these steps were taken to ensure that both current and future ticket users were aware of the correct completion procedures. The combination of careful ticket design and training greatly improved data integrity and eliminated poor ticket completion practices. On the overhead ticket the additional step of printing

JOB TICKET

				Serial No. (Accounts use only)			
Job No.		Contract No.		Work Package			
Planned Work Y		Rectification Y		Engineering Work Y			
Date	Clock No.		Name		Hours Worked		Minutes Worked
Drawing No.		Item	Issue	Planning Reference No.			Quantity
Start Operation	Finish Operation		Complete Y/N Y N	Inspectors Reference No.			
Component Serial Numbers			Set No.	Estimated Hours		Estimated Minutes	
Description							
				Signature			

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INSTRUCTIONS

1. This ticket replaces Piece Work Applications, Piece Work Bills, Open Tickets and Service Tickets.
2. It should be used for all work that is **not** booked to Overheads, (i.e. Production Contracts, Development Contracts, Enquiry Numbers, Capital Numbers and Revenue Numbers).
3. The following boxes must always be completed if this ticket is used:–

Job No.	Date	Hours and/or Minutes Worked
Contract No.	Clock No.	
Work Package	Name	

4. If the work is planned or rectification work in the Shop then the appropriate "Y" should be circled in the Planned Work or Rectification box, and the following boxes must be completed in from the Planning Card:–

Drawing No.	Planning Reference No.	Finish Operation
Item	Quantity	Estimated Hours
Issue	Start Operation	Estimated Minutes

5. If the finish operation is complete circle "Y" in Complete Y/N box, else circle "N".
6. Operations between the start and finish operations specified must all be completed.
7. If only one operation is started or completed, then the operation becomes both the start operation and the finish operation.
8. If the work is engineering circle "Y" in the Engineering Work box and give a description of work done in the Description box.
9. The Inspectors Reference No. box should be completed for ALL rectification work in the Shop, QA or Engineering.
10. Component Serial Numbers (up to 6 per ticket) should be completed as appropriate.
11. For coils the Set No. box should be completed.
12. The ticket should be checked and signed by a Foreman or Section Leader.
13. See instruction booklet for further details.

Figure 8.9 Front and Reverse of Job Ticket.

OVERHEAD TICKET

Overhead Code	Overhead Cost (Accounts use only)		Serial No. (Accounts use only)	
Date	Clock No.	Name	Hours	Minutes

Hourly Rated Overhead Codes

1031 Waiting Time – material
1032 Waiting Time – tools/drawings
1033 Waiting Time – instructions
1034 Waiting Time – previous operation
1035 Waiting Time – cranes
1036 Waiting Time – machine breakdown
1037 Waiting Time – industrial dispute
1038 Waiting Time – work on test beds
1039 Waiting Time – setters
1041 Diversion Time – labouring
1042 Diversion Time – material handling
1043 Diversion Time – training
1044 Diversion Time – progress/clerical
1045 Diversion Time – shop steward duties
1046 Diversion Time – committee/courses
1047 Diversion Time – works experiments
1048 Diversion Time – welding qualifications
1049 Diversion Time – miscellaneous
1070 Service Labour
1088 Enquiry Costs

Staff Overhead Codes

1410 Holidays
1438 Diversion Time – welder qualification
1439 Diversion Time – test rig upkeep
1440 Diversion Time – miscellaneous
1441 Diversion Time – print room
1442 Diversion Time – union business
1443 Diversion Time – internal meetings
1444 Diversion Time – office routines
1445 Diversion Time – interviewing
1446 Diversion Time – conferences/courses
1447 Diversion Time – internal training
1448 Diversion Time – non chargeable enquiries
1449 Diversion Time – service labour
1480 Sickness

Maintenance Overhead Codes

4090 Maintenance

Description

Signature

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INSTRUCTIONS

1. This ticket replaces Waiting Tickets, Diversion Tickets, Maintenance Tickets, Piece Work Bills used for service labour, and Service Tickets used for overheads.
2. It should be used for all work booked to overhead.
3. The following boxes must always be completed if this ticket is used:–

   Overhead Code   Clock No.   Hours and/or Minutes
   Date   Name
4. Shop Floor employees should only use those codes listed on the front of the ticket under the heading Hourly Rated Overhead Codes.
5. Maintenance employees should only use those codes listed on the front of the ticket under the heading Maintenance Overhead Codes.
6. QA and Engineering staff should only use those codes listed on the front of the ticket under the heading Staff Overhead Codes.
7. The Overhead Code format for codes 1070, 1449, and 4090 is Overhead Code/Department, where 'Department' is the department for which the work was done.
8. The ticket should be checked and signed by a Foreman or Section Leader.
9. See instruction booklet for further details.

Figure 8.10 Front and Reverse of Overhead Ticket.

the valid overhead codes was taken. This reduced the allocation of of costs to incorrect or invalid codes, which had previously been a problem.

Both the overhead and job tickets were printed on thicker 80 gsm paper to increase their durability. In the past tickets had been printed on thinner paper which did not stand up to the rigours of the shop floor and constant manual sorting in accounts. They were also printed on paper which was a different colour from previous tickets thus making them quite distinctive and highlighting their dissimilarity from previous tickets.

The implementation of the new tickets required a number of changes to the CCS software. The piece work bill, open, waiting, diversion, service and wage adjustment ticket transaction screens were dispensed with. These were replaced by job and overhead ticket transaction screens.

In the previous two implementations, overhead costs were collected on more than one ticket and only those tickets containing factory labour costs were considered. However, now that all overheads were collected on one ticket, they were all entered onto the system. This allowed some additional reports to be produced. Firstly, summaries of staff and hourly rated (factory workers) overhead costs were produced, with sub totals for each overhead code and department. This removed the need to manually sort and calculate costs on overhead tickets.

The maintenance transfers report provided a summary of all the costs incurred by maintenance workers, firstly by the department to which they would later be transferred and then by overhead code.

The overhead code master file was added to allow the valid overhead codes to be entered for verification during data entry.

The second main development of Stage III was the provision of a data archiving facility. This was developed for two reasons. Firstly, it allowed data which was no longer required for frequent reference or analysis to be stored on magnetic tape. The second reason was that the removal of extraneous data from the transaction file speeded up the system, particularly the reporting functions which had to search every record in the transaction file.

Figure 8.8 shows four additional options on the system control menu. Data from a particular accounting period could be removed from the transaction file and stored on tape using the 'create tape file' and 'save tape file' options. Typically data was held on the computer for three accouting periods before being archived to tape. Should the data ever be required again the 'restore from tape' and 'merge data' options allowed data to be loaded back into the transaction file.

The tape allocation master file allowed magnetic tapes containing serial numbers to be allocated to each accounting period. When save and restore options were selected, the operator was told which tape to use depending upon the accounting period entered.

This completes the extent of the CCS development which took place during the research. The following chapter discusses the advantages and disadvantages of the system and highlights the areas in which future improvements could be made.

9. DISCUSSION.

9.1 Project Overview.

The objective of this project was to design, develop and implement a computerised system to collect, analyse and report manufacturing costs within Special Contracts Division. The main aim of this new system was to improve the integrity, feedback and control of contract costs within the company.

Special Contracts Division is a medium sized company which manufactures electric motors for use on submarines. The motors are made in small batches (6 or 7) and are characterised by long lead times (2.5 to 4 years), a high quality input and difficult manufacturing processes.

The realisation of the need to develop the Company's cost accounting system became apparent during initial investigations at SCD (Chapter 5). These investigations showed that previous efforts towards computerisation had been concentrated in the areas of production control and engineering. After a review of the Company's computing requirements the first real computing policy was defined. This recognised the imbalance of previous computerisation and identified the need to broaden the scope of the Computer Services Department's activities to involve all departments.

More importantly the review of requirements highlighted the the need to develop SCD's cost accounting system. The research therefore focused in this area and began with a look at the objectivies of cost accountancy (Chapter 1) and the techniques which are available to help provide companies with effective monitoring and control systems for manufacturing costs (Chapter 3).

The objectives of cost accounting are briefly to :-

- classify and analyse the cost of products
- determine the production cost of every operation, contract etc.
- highlight inefficiencies in the use of material, time, and machinery etc.
- provide data for profit and loss accounts and balance sheets
- provide actual costs for comparison with estimated costs.

SCD was operating a manual contract costing system which, apart from highlighting inefficiencies, achieved all the above objectives. Direct material, direct labour, direct expenses and overheads were collected and accumulated under control accounts known as working numbers. A series of working numbers made up the cost for a specific contract. Overhead costs were recovered using the direct cost base because the pay for each direct worker was roughly the same.

At SCD, it was possible for some service departments to charge costs direct to specific contracts, so this practice was adopted.

The service departments involved therefore had an overhead recovery rate allowing a portion of the total company overheads to be applied to the direct costs incurred.

The cost collection system which was in existence involved a high degree of clerical effort in the form of sorting, calculating and manipulating large volumes of data. A number of problems were highlighted in Chapter 6.

Firstly, the time consuming nature of the manual system meant that the turn round of information was too slow and only a limited number of contracts could be monitored in detail in the time remaining.

A second problem related to the tickets used to convey cost data. The obsolescence of many of the tickets led to incorrect or even missing data. This in turn resulted in time consuming information finding exercises which further increased the time taken to produce reports.

Another problem was poor discipline and control. The late delivery of tickets to the Accounts Department and incorrect allocation of costs introduced further time lags into the system.

After an analysis of all the problems it was concluded that the provision of a computerised cost collection and analysis system would alleviate many of the difficulties. Computers can be programmed to validate data as it is entered, thus improving its integrity. Calculations are essentially 100 per cent accurate and the coded procedures are consistent each time. Also, the degree of a computers processing power means that more detailed analyses can be undertaken in much less time than would be possible if done manually.

Before the new system was designed, a review of literature (Chapter 4) was conducted to look at the developments currently taking place in the area of cost accountancy. The review revealed that many accounting authors are proposing changes to cost accounting practices because of the way advanced manufacturing technologies are influencing the elements of cost and cost accounting systems.

The review went on to look for evidence of the proposed changes and found that, although they have in some cases been implemented, many firms are not developing accounting systems in line with new technological developments. One of the main reasons for this is that cost accounting methods and costing systems are notoriously slow to change. In addition some research showed that European manufacturers placed a much lower priority on the development of cost accounting than other areas of the business, such as quality.

However, it is suggested that most of the proposed changes are only relevant to highly automated firms and are of less importance to traditional 'job shop' manufacturers like SCD.

Nevertheless, it was concluded that there was still much work to be done to develop cost accounting within SCD, particularly in providing faster, more accurate and detailed analysis of manufacturing costs for all contracts, and providing feedback on the efficiency of time and labour.

Design and development of the new CCS began with the definition of design and implemetation philosophies. These were developed in order to :- set specific design standards; reduce the resistance to change as much as possible; and provide a system which could be easily operated and controlled by accounts clerks who had no previous computing experience. Chapter 7 described the steps that were taken to achieve these aims.

The complexity of the system and limited resources meant that that the CCS was developed and implemented in three stages, namely :-

Stage I - Provision of basic system

Stage II - Provision of features for estimating department

Stage III - Introduction of new tickets

Breaking down the system development into clearly defined parts and implementing each part in turn meant that transition from the old system to the new one was smoothed into a series of manageable and controllable stages, rather than one large step change which would have caused wide scale disruption.

9 DISCUSSION

Only one systems analyst/programmer was available to design, develop, test and implement the new system. In the Accounts Department only two full time and one part time staff were available to manage and operate the system. Even so, the total development time from the design of Stage I to the implementation of Stage III was 60 weeks (1 year, 2 months). This relatively short development time was achieved by the sub-contracting of some of the basic programming, but mainly by the use of a fourth generation language for the production of the software.

Chapter 8 traced the development of the system over the three stages and describes the file and program structures at each stage. The following section describes the advantages and disadvantages of the new system.

9.2 Advantages and Disadvantages of New System.

9.2.1 Advantages

- The implementation of a computerised system provided consistency in the way that cost accounting procedures were carried out.

- Automatic data validation improved the integrity of data input to the system.

9 DISCUSSION

- The system produced reports that were more detailed and accurate.

- The processing power of the computer greatly reduced the time scales for producing reports. For example, the contrat cost report, which took about seven working days to produce manually, could now be done in 10 to 20 minutes. These reports could now, therefore, be produced weekly.

- The system greatly reduced the amount of manual sorting and calculation. Although some of this time was now spent on data entry, the time savings and increased processing power allowed additional analysis to take place. For example, analysis of more contracts, provision of defect cost and overhead cost summaries, and a productivity analysis.

- The withdrawal of obsolescent tickets and the provision of specifically designed tickets, simplified the system and led to improvements in data integrity and ticket completion practices and procedures.

- The database that was created provided the basis for the development of other systems. For example, a defect costing system and an overhead system.

9.2.2 Disadvantages

- The inexperience of data entry clerks in Accounts meant that data entry was not as fast as would have been be possible with more experienced operators. The relative inexperience also increased the number of data entry errors and the turn round of reports.

- The provision of computerised systems for other departments and the corresponding increase of programs and data, led to SCD's computer being operated at a higher and higher capacity. The recommended operating capacity for most computers is about 65%. By the time Stage III of the new CCS was implemented SCD's computer was operating at between 95-98%. This produced a fairly dramatic increase in processing times, which was particularly significant during the production of reports. For example, a 10-20 minute report could take 1 to 2 hours.

- The new system resulted in an increase in the volume of paper produced. Although the volume of tickets remained about the same, the number of reports increased due to extended analysis, the provision of new reports, and the necessity for audit trails. However, ticket data was now of a much higher quality and the additional reports allowed for more effective monitoring and control.

- The system was not designed to retain cumulative contract costs. Figures from periodical reports therefore had to be accumulated manually. Although this is not a massive manual task, it is a disadvantage not to be able to see at a glance the current cummulative contract costs.

9.3 Further Developments.

Although the new CCS was successful in producing information of a higher integrity, faster, more accurately and consistently than previously, there are a number of developments which would further improve the system if they were to be implemented. Obviously, all computerised systems offer scope for continual improvement, but there comes a point when the cost and time spent on further changes outweighs the benefits to be gained. The possible developments will now be discussed.

The most tedious part of the computerised system is the entry of ticket data. The introduction of a bar coded system would speed up the input of data into the computer. This could also be extended for use in a manufacturing control system, allowing data regarding the location and progress of component manufacture to be made available more easily. The introduction of bar coding would also eliminate the use of many, if not all, the tickets, thus reducing the volume of paper circulating around the site.

However, many problems arise when such a system is considered, such as the production of bar codes for all components, planning cards, employees etc., the training of shop floor operators in the use of bar code readers and the change-over from the current system to a bar coded one. It would be necessary to carry out a cost-benefit analysis, balancing the costs of equipment, training, change-over and operation, with the benefits of faster, more accurate input, reduction or elimination of ticket costs and the benefits for other systems.

One of the disadvantages, highlighted earlier, was that the system does not provide cumulative costs. It would therefore be desirable to set up files that held the total costs accumulated against each contract and/or working number. This would require a program to be run each week or month which updated the totals in the cumulative files. This could be linked to the change of the current year, period and week details in the week number master file.

Another process which remained manual was the production of Nominal Ledger posting summaries. It would have been possible to produce a report from the system allowing the totals to be written directly into the manual Nominal Ledger. However, while the CCS was being developed a computerised Nominal Ledger was also being implemented. The consideration of a nominal posting summary was therefore deferred until the new Ledger was implemented. It would be desirable to design a facility which allowed the creation of a data file which could be read directly into the computerised Nominal Ledger after being checked.

Two further enhancements relate to auditing of the system. The first is the provision of an audit trail for the contract cost report. This was not initially developed because of the close similarity between the contract cost and WIP reports, but such an audit trail should be provided.

The second audit facility is the recording and reporting of transaction amendments. The details which should be recorded include the ticket details before and after amendment, the date and time of the change and the operator involved.

Another desirable change would be the extension of selection criterion for reports. Currently reports are selected (where appropriate) by period and week/s. Since data from a previous financial year could be restored from magnetic tape, it would be necessary to allow selection by year. The financial year would also have to be clearly displayed on the relevant reports.

One of the tasks carried out by foremen and section leaders before they send tickets to the Accounts department is to record, for each of their staff, the total hours worked together with a breakdown of the time. For example, number of hours charged direct, number charged to overhead, number spent on holiday sick etc.. After the implementation of Stage III, the input of all overheads was now possible, therefore, employee attendance/absence analysis could now be produced directly from the CCS.

Finally, it may be desirable to provide some database screen reports, such as the status of work packages on a particular contract, that is whether they are open or closed.

Now that we have looked at the advantages and disadvantages of the new system together with some possible improvements, we will consider some CCS design proposals.

9.4 Cost Collection System Design Proposals.

As each system will vary depending on the characteristics and specific requirements of a particular company, the proposals which follow are expressed in fairly general terms. They also assume that the CCS uses tickets to convey cost data from its source (shop floor, engineering etc.) to the department operating the system.

Figure 9.1 summarises the files which should be included and Figure 9.2 suggests an appropriate program structure. A good contract cost collection system should display the following key features :-

- Some method of reference between the physical tickets and the ticket details held on the computer so that amendment, addition and deletion of data is possible.

- A series of master files that allow basic ticket data to be validated on input. Data in these file can also be used for reference purposes, providing additional useful information on screens and reports.

- A facility to maintain data in master files.

- The use wherever possible of group files, such as an employee group file or a pay group file. Employees can therefore be assigned to a particular employee group which can ease sorting for reports. They can also be allocated to a specific pay group, thus making amendment of pay rates much easier.

Master Files (Used for data validation and reference)

Department File
Pay Group File (list of different pay rates)
Employee Group File (list of employee groupings)
Employee File (inc. pay group, employee group etc.)
Wage Analysis Code File
Contract File
Working Number File (list of control accounts inc. status)
Drawing Number File
Overhead Code File
Week Number File (current year, period and week)

Work Files

Serial Number File
Transaction File

Figure 9.1 Cost Collection System Files.

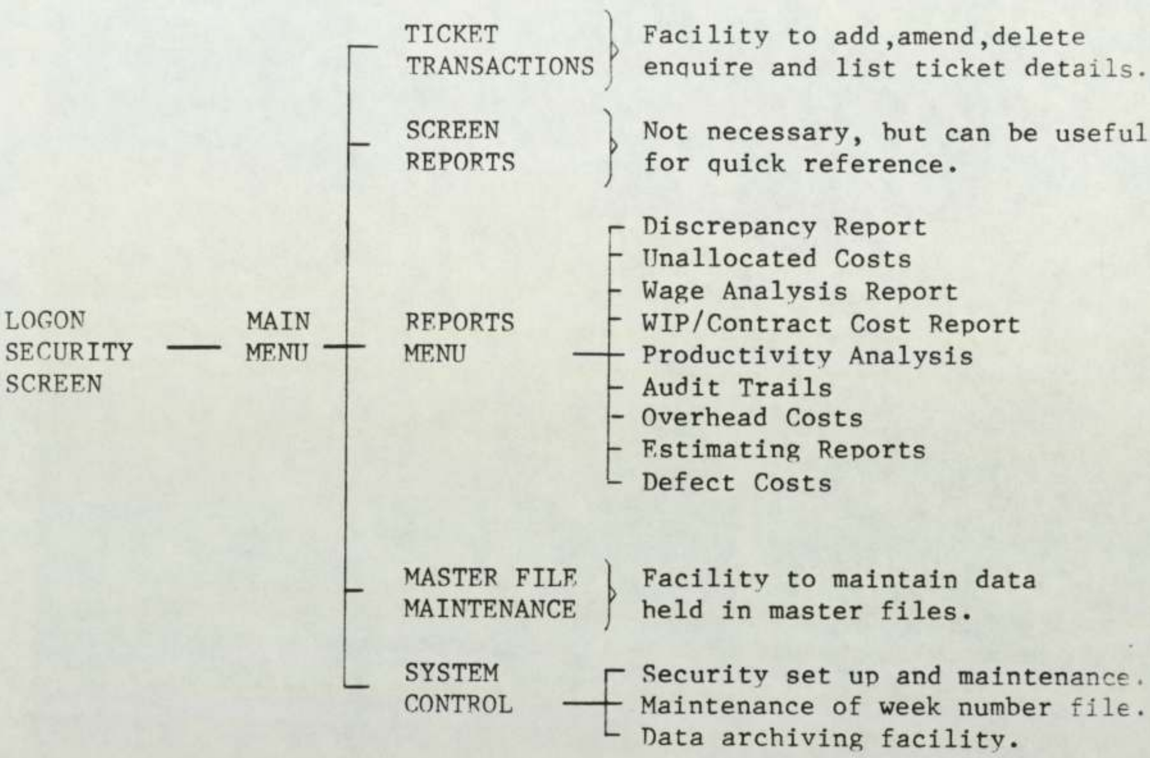

Figure 9.2 Suggested CCS Program Structure.

- A facility to add, amend, delete, enquire and list ticket details. It is recommended that data is not actually deleted, but flagged as not to be considered.

- Special control accounts that allow unallocated costs (incorrect or suspect tickets) to be temporarily allocated. This means that data entry can proceed with the minimum of interruption and all unallocated costs can be corrected more efficiently in one operation.

- A facility to temporarily suspend the allocation of costs to a control account. This can be a useful control feature to prevent overspending or incorrect allocation etc.

- A facility to check that ticket hours and clocked hours balance. (Not possible if employees do not clock). This is necessary as it allows errors to be detected and ensures the validity of subsequent analysis and reports.

- A WIP/Contract Cost Report showing the manufacturing costs accumulated against each control account. It may be advantageous to sub-divide each account to ease control. For example, factory costs, engineering costs, material costs, other costs etc.

- Audit trails to allow auditors or users to trace the changes that have occured. These may be essential should operator or system errors occur.

- A series of other reports depending on requirements. These should include, as a minimum, reports of the following form :- discrepancy; unallocated costs; wage analysis; WIP/contract cost; productivity analysis; audit trails; overhead costs; estimating reports; and defect costs.

- A security system consisting of a logon screen requiring an operator identification and password/s. Each menu option and program should have a specific security level, with access being denied to operators without a high enough security level.

- A facility to archive data to magnetic tape and restore it if the requirement arises. The removal of extraneous data which is no longer required and reduces the size of the database, thus, the system performance is increased slightly or at least maintained.

It is important to emphasise that these proposals are not strict guidelines. Each company will have to adapt the proposals to suit their situation and specific requirements. However, it is hoped that the features suggested provide a useful framework for the development of a computerised contract costing system within a 'job-shop' manufacturing company.

10. CONCLUSIONS.

- Most of the proposed changes in cost accounting practices are only relevant for highly automated firms.

- Many highly automated firms are not developing accounting systems in line with new technological developments.

- If a high integrity computerised system is to be provided which can overcome the resistance to change, considerable attention must be given to development of the most appropriate design and implementation philosophies.

- A phased development plan employing different modes of implementation can successfully overcome resistance to change.

- The utilisation of a 4th generation language not only considerably reduces program development times, but is also condusive to a phased development and implementation strategy.

- A computerised cost collection and analysis system is more accurate and consistent and can provide more detailed and higher integrity information than is possible with a manually operated system. All this can be achieved in much shorter response times and therefore in greater frequency. A computerised system can thus dramatically improve the ability of a company to monitor and control manufacturing costs more effectively.

- If the implementation of a computerised system is to be successful, the source data on which it is based must be of a high integrity. The collection of this data on purpose designed documentation is of great importance and should be given as much attention as the design of the computerised system itself.

- In order to gain the full benefits that new software brings, companies must develop their computer hardware and operations systems in line with software development schedules.

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APPENDIX A

A. TERMS OF REFERENCE FOR COMPUTER SERVICES DEPARTMENT.

- To define overall company needs and to define a company computing policy. This policy should be formed to ensure that the requirements of all users and departments are satisfied in the most cost effective manner.

- To implement the above policy through the provision and support of hardware and software systems.

- To specify, procure, install, commission and maintain all hardware and software systems.

- To provide suitable training and instruction to all users, on equipmnent and software usage.

- To produce suitable procedures and documentation for its sytems, which satisfy both commercial and MoD standards and specifications.

APPENDIX B

B. DEPARTMENTAL REQUIREMENTS - MARCH 1984.

The following requirements were highlighted by each departmental manager. They have been taken from a SCD internal report.

B.1 Manufacturing Department.

- A system of scheduling based on a bill of materials and machine load analysis.
- Changes in stores and administration procedures.
- Departure from drawing records.
- Production and planning data.
- Plant and machine tool records cross referenced to the purchasing system.
- Piecework recording for progress and time analysis.
- Process planning and monitoring.

B.2 Commercial Department.

- Extension of Internet to cover all MCP's, CWP's, and switchgear.
- Resource allocation and scheduling of projects on Internet.
- Project finance programs and some enginewering calculations.
- System to control the purchase requisition and order systems, integrated with IBS ledger, stock control system and stores receiving system.
- Facility to design internal stationary as required.
- Word processing facilities for order generation, letters, reports, manipulation of contract conditions etc.
- Access to purchase ledger enquiry systems.

B.3 Engineering Department.

- Engineering calculations.
- Computerisation of drawing schedules.
- Computerisation of departure from drawing records.
- Text processing facilities for reports.

B.4 Quality Assurance Department.

A system to monitor and control inspection activities, and an interactivce word processing system, both of which give files for :-

- Inspection documentation.
- Process and planning specifications.
- Welding specifications.
- All certification.
- Goods inward documents.
- Sub-contractor approvals.
- Data book.
- Records of measurements.

B.5 Personnel Department.

- Record of personnel data, with interogation of other specified systems available.

B.6 Accounts Department.

- Payroll on Unipay package.
- Costing interface with other accounting and estimating systems.
- Development of management accounting report generation.

APPENDIX C

C. DEPARTMENTAL REQUIREMENTS - NOVEMBER 1985.

The following requirements were produced by each departmental manager. The lists have been extracted and summerised from SCD memorandums.

C.1 Manufacturing Department.

- Extension of existing Internet backward pass analysis to include MCP contracts not yet covered.

- Bring switchgear to the same status as MCP's on Internet system.

- Facility to perform time analysis for any contract on Internet.

- Computerisation of planning cards.

- Facility to automatically produce a bill of materials for a product once an order is placed. This would be used for the purchase of bought out materials or components, and for the issue of manufacturing documentation, ie automatic production of purchase orders and automatic production of operation cards.

- To schedule all work against resource availability using Internet.

- Computerisation of tool drawing records.

- Recording and monitoring of energy usage for costing purposes.

- Recording and monitoring of waiting and diversion time via shop floor terminals.

- Text processing facilities for letters, memos, reports etc.

C.2 Commercial Department.

- Development of computerised purchase orders.

- Link ordering, expediting, purchasing, and goods receiving with the above system.

- Computerisation of booking in/out system for tool stores.

- Stock control system for MoD contingency store and other material stores.

- Plotting facilities to allow production of networks and barcharts from Internet.

- Monitoring of actual project costs against estimated costs.

- Computerisation of order book and ability to interact with accounts information.

- Computerisation of budgeting facilities, including invoicing, trading, and order input forecasts.

- Access to production data to show progress.

- Automatic prompting of payement stages to Accounts Department for invoice raising.

- Keep up with developments in the Textpro word processing package.

- Facility to change format of internal stationary.

C.3 Engineering Department.

- Technical computing facilities. Access to programs on mainframe at GEC Computer Services.

- Text processing facilities for letters, memos, specifications, and reports.

- Computerisation of drawing records.

- Computerisation of parts lists and product schedules.

C.4 Quality Assurance Department.

- Extension beyond manual updating of files on word processor, to automatic updating, where possible, by the computer when completion of actions is reported.

- Update reporting only to be allowed by persons authorised to do so, but information could be made available on a read only basis to departments concerned with a particular activity.

- The development of a Defective Cost System.

- System to control production of operating procedures, including status, responsibility for action, program dates, and overdues.

- Approved suppliers list including details of the scope of approval and the facility to recall information by key words.

- System to comprehensively monitor departure from drawing records, encorporating updating by each department on completion of its task.

- A prompting system to inform when gauges, instruments and tools are required by the shop floor and for re-calibration.

- Data collection facilities for the progress of inspection via shop floor terminals.

- The accumulation of inspection data to form dossiers on each component which can be shipped with the final product.

- Text processing facilities for letters, memos, reports etc.

- There is no need for statistical control methods. Due to the small sample size of any one component, these methods are not feasable - at least the results would not be beneficial.

C.5 Personnel Department.

- Computerisation of all personnel records.

- Text processing facilities for letters, memos etc.

C.6 Accounts Department.

- Computerisation of nominal, bought and sales ledgers.

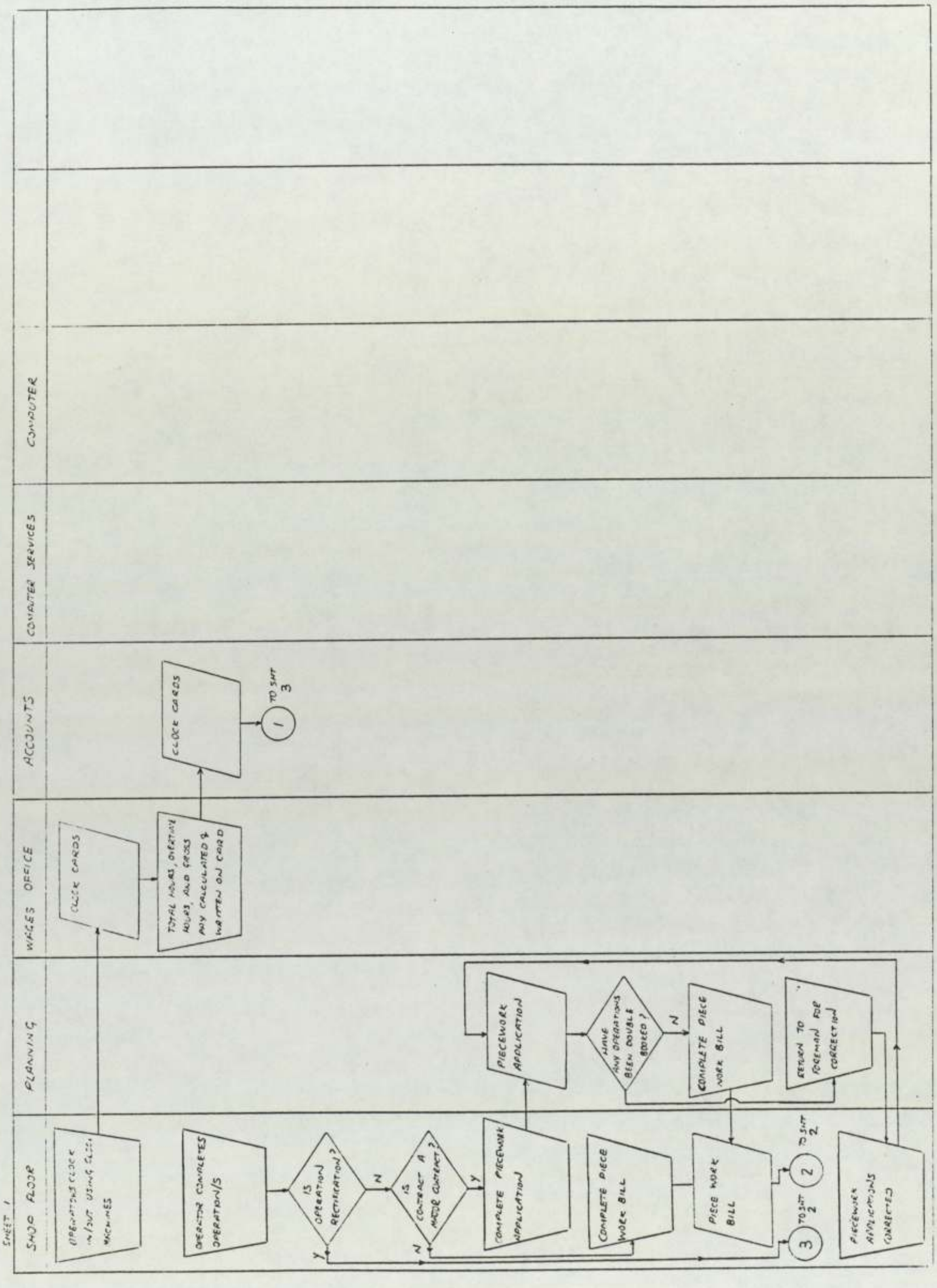
- Access to job status information to assist 'cost to completion' estimates.

- Employee attendance information for Payroll.

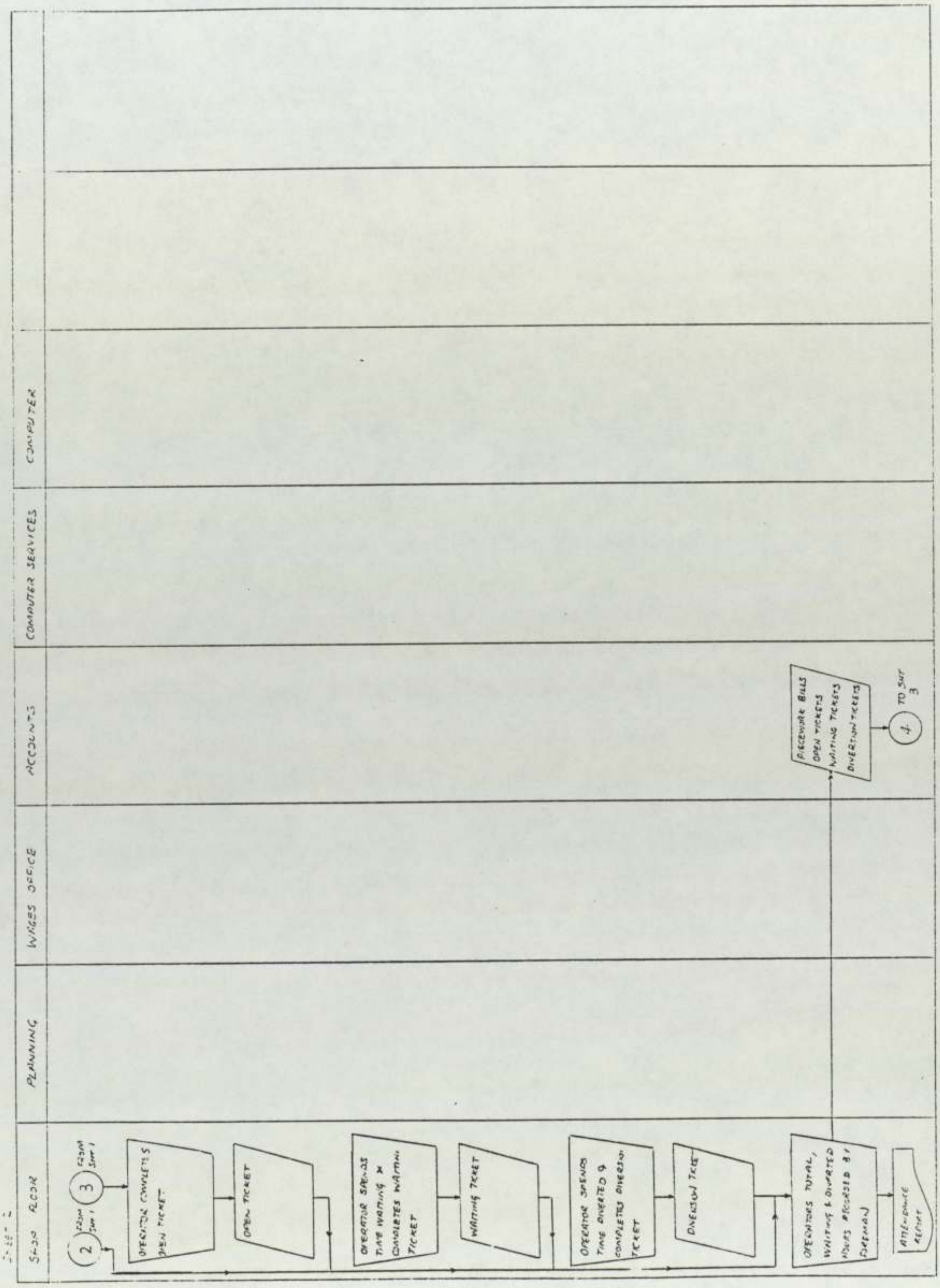
- Access to departmental budget information.

- Text processing facilities for letters, memos, reports etc.

D. FLOW CHART OF MANUAL CCS.

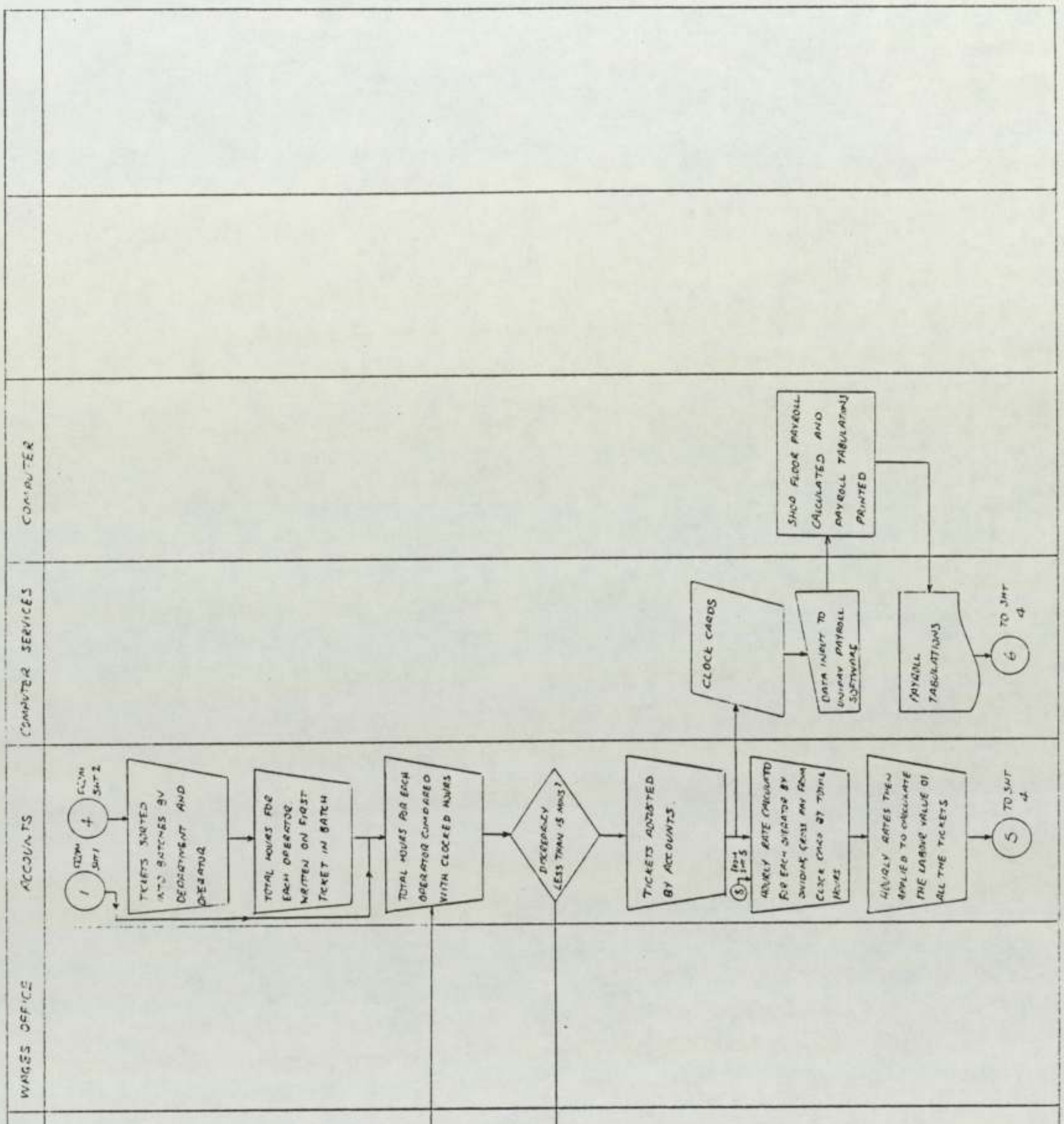


APPENDIX D



SHOP FLOOR
PLANNING
WAGES OFFICE
ACCOUNTS
COMPUTER SERVICES
COMPUTER
2
3
OPERATOR COMPLETES OPEN TICKET
OPEN TICKET
WAITING TICKET
COMPLETES DIVERSION TICKET
ATTENDANCE REPORT
PIECEWORK BILLS
OPEN TICKETS
WAITING TICKETS
DIVERSION TICKETS
4
TO SHT 3

APPENDIX D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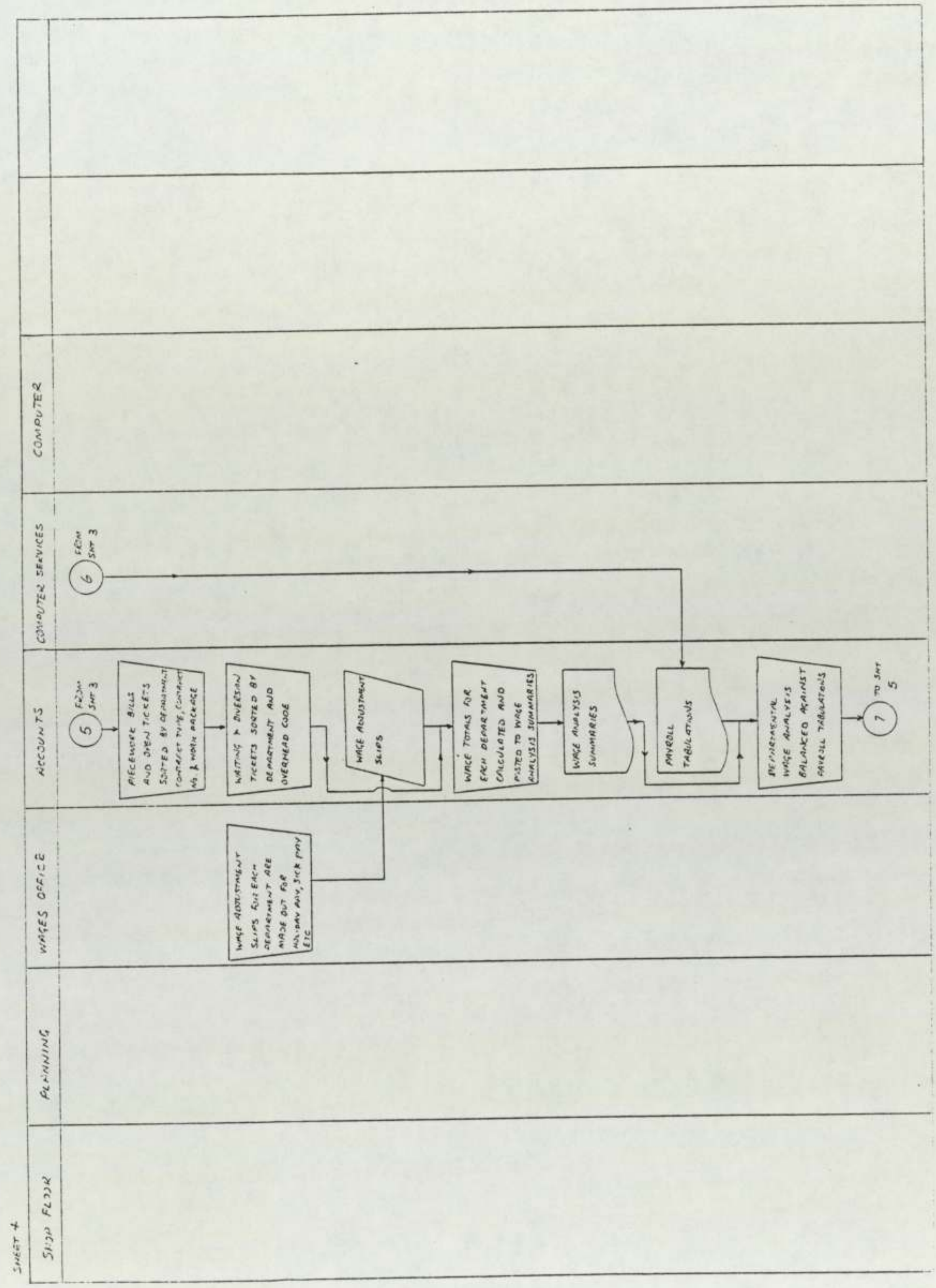
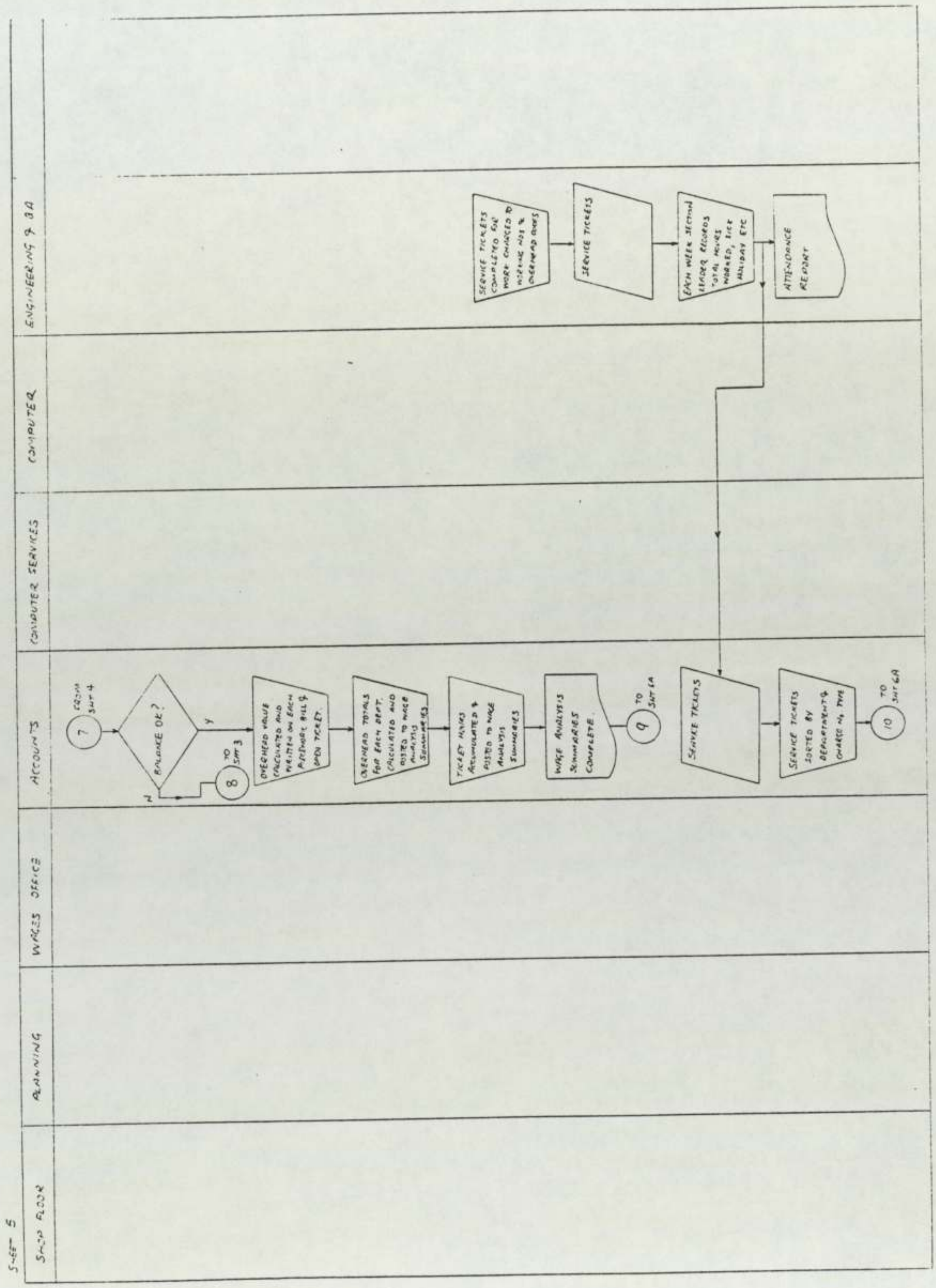
SHOP FLOOR
PLANNING
WAGES OFFICE
ACCOUNTS
COMPUTER SERVICES
COMPUTER
TICKETS SORTED INTO BATCHES BY DEPARTMENT AND OPERATOR
TOTAL HOURS FOR EACH OPERATOR WRITTEN ON FIRST TICKET IN BATCH
TOTAL HOURS FOR EACH OPERATOR COMPARED WITH CLOCKED HOURS
TICKETS ADJUSTED BY ACCOUNTS.
TICKETS ADJUSTED BY FOREMAN
HOURLY RATES THEN APPLIED TO CALCULATE THE LABOUR VALUE OF ALL THE TICKETS
CLOCK CARDS
SHOP FLOOR PAYROLL CALCULATED AND PAYROLL TABULATIONS PRINTED
PAYROLL TABULATIONS
TO SHT 4
TO SHT 4

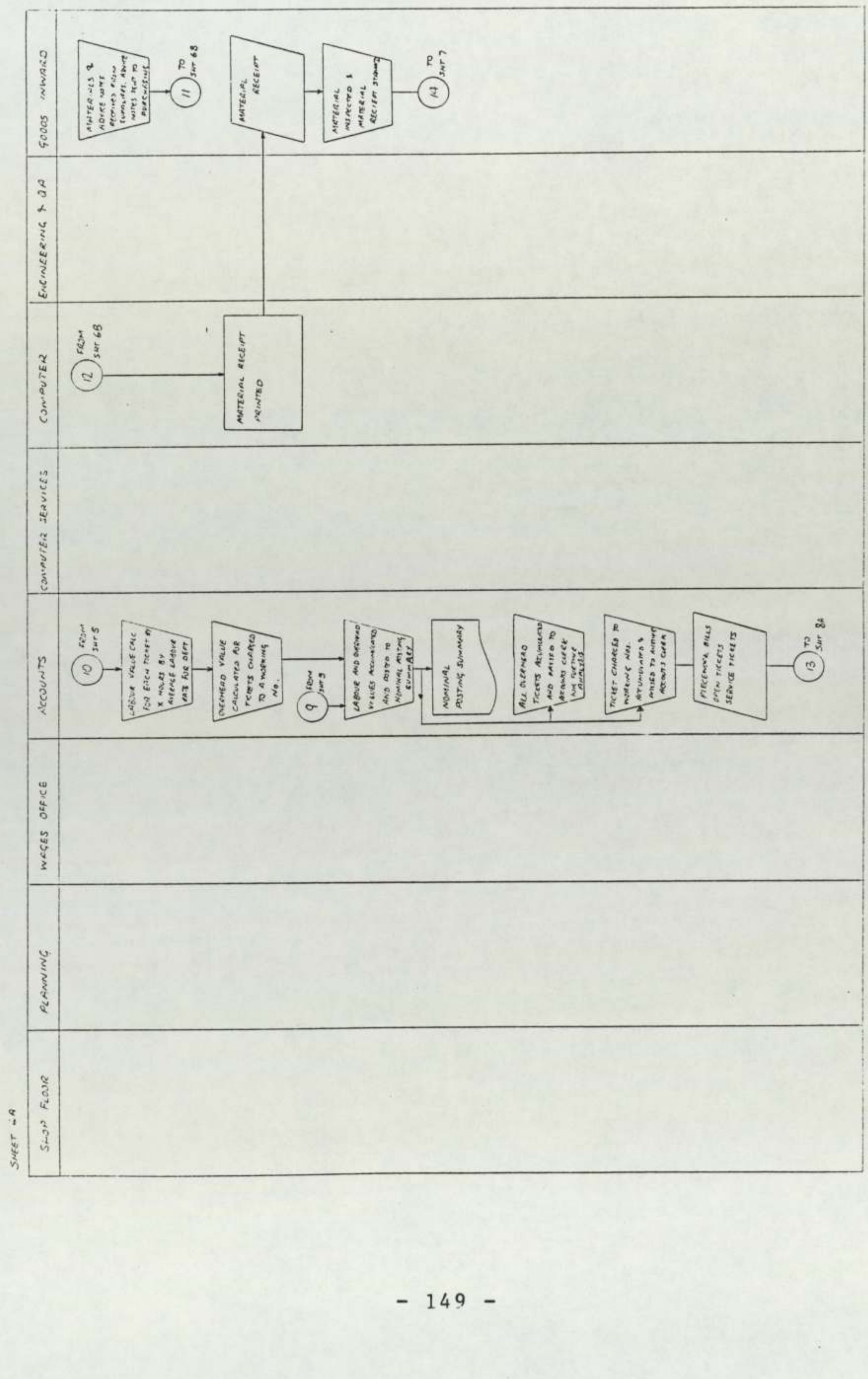
APPENDIX D


SHEET 4
SHOP FLOOR
PLANNING
WAGES OFFICE
ACCOUNTS
COMPUTER SERVICES
COMPUTER
5 FROM SHT 3
PIECEWORK BILLS AND OPEN TICKETS SORTED BY DEPARTMENT, CONTRACT TYPE, CONTRACT No. & WORK PACKAGE
WAITING & DIVERSION TICKETS SORTED BY DEPARTMENT AND OVERHEAD CODE
WAGE ADJUSTMENT SLIPS
WAGE TOTALS FOR EACH DEPARTMENT CALCULATED AND POSTED TO WAGE ANALYSIS SUMMARIES
WAGE ANALYSIS SUMMARIES
PAYROLL TABULATIONS
DEPARTMENTAL WAGE ANALYSIS BALANCED AGAINST PAYROLL TABULATIONS
7 TO SHT 5
6 FROM SHT 3
WAGE ADJUSTMENT SLIPS FOR EACH DEPARTMENT ARE MADE OUT FOR HOLIDAY PAY, SICK PAY ETC.

APPENDIX D


SHEET 5
SHOP FLOOR
PLANNING
WAGES OFFICE
ACCOUNTS
COMPUTER SERVICES
COMPUTER
ENGINEERING & QA
BALANCE OK?
SERVICE TICKETS
ATTENDANCE REPORT
WAGE ANALYSIS SUMMARIES COMPLETE.

APPENDIX D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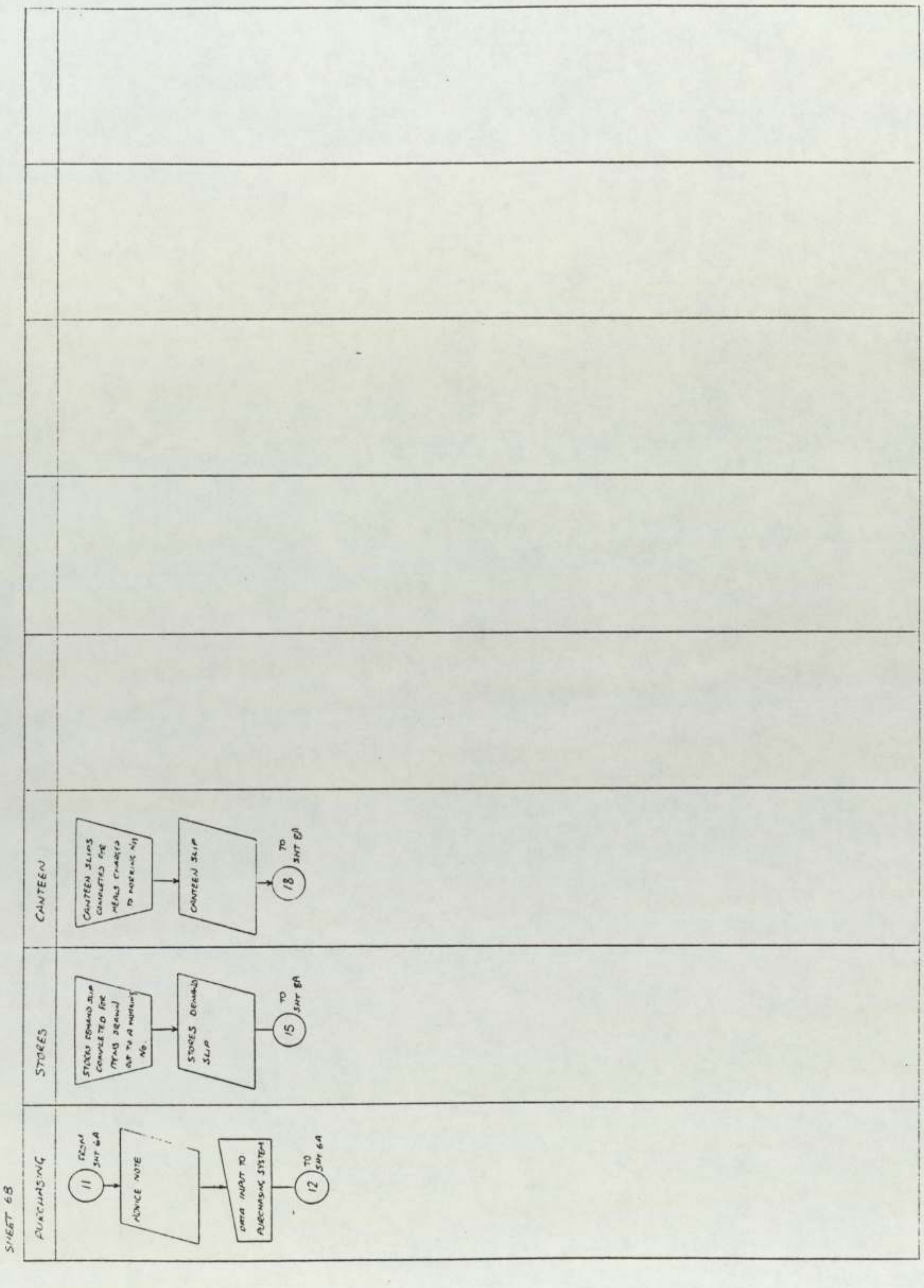
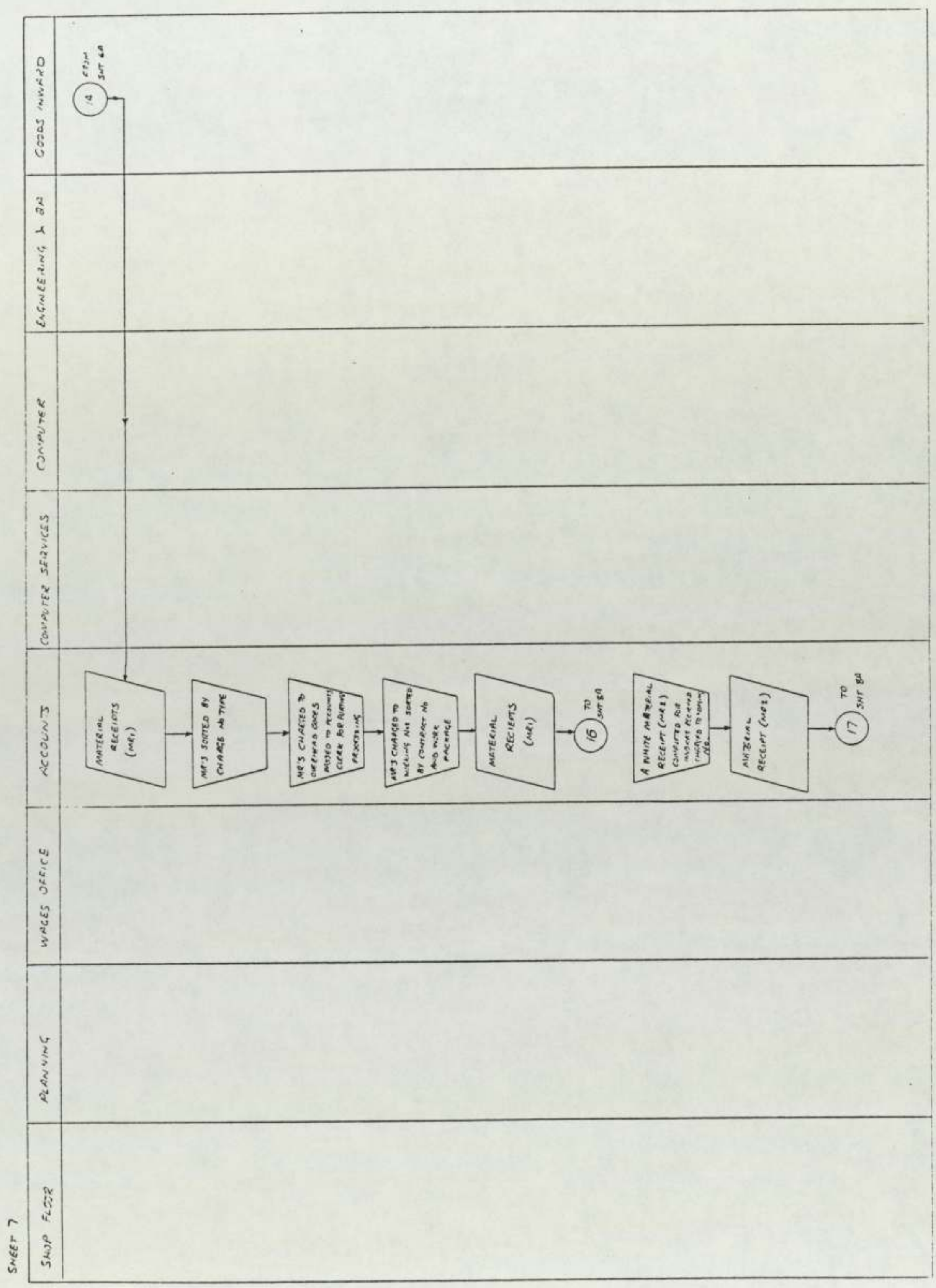
PLANNING
WAGES OFFICE
ACCOUNTS
COMPUTER SERVICES
COMPUTER
GOODS INWARD
MATERIAL RECEIPT PRINTED
MATERIAL RECEIPT
NOMINAL POSTING SUMMARY
PIECEWORK BILLS OPEN TICKETS SERVICE TICKETS

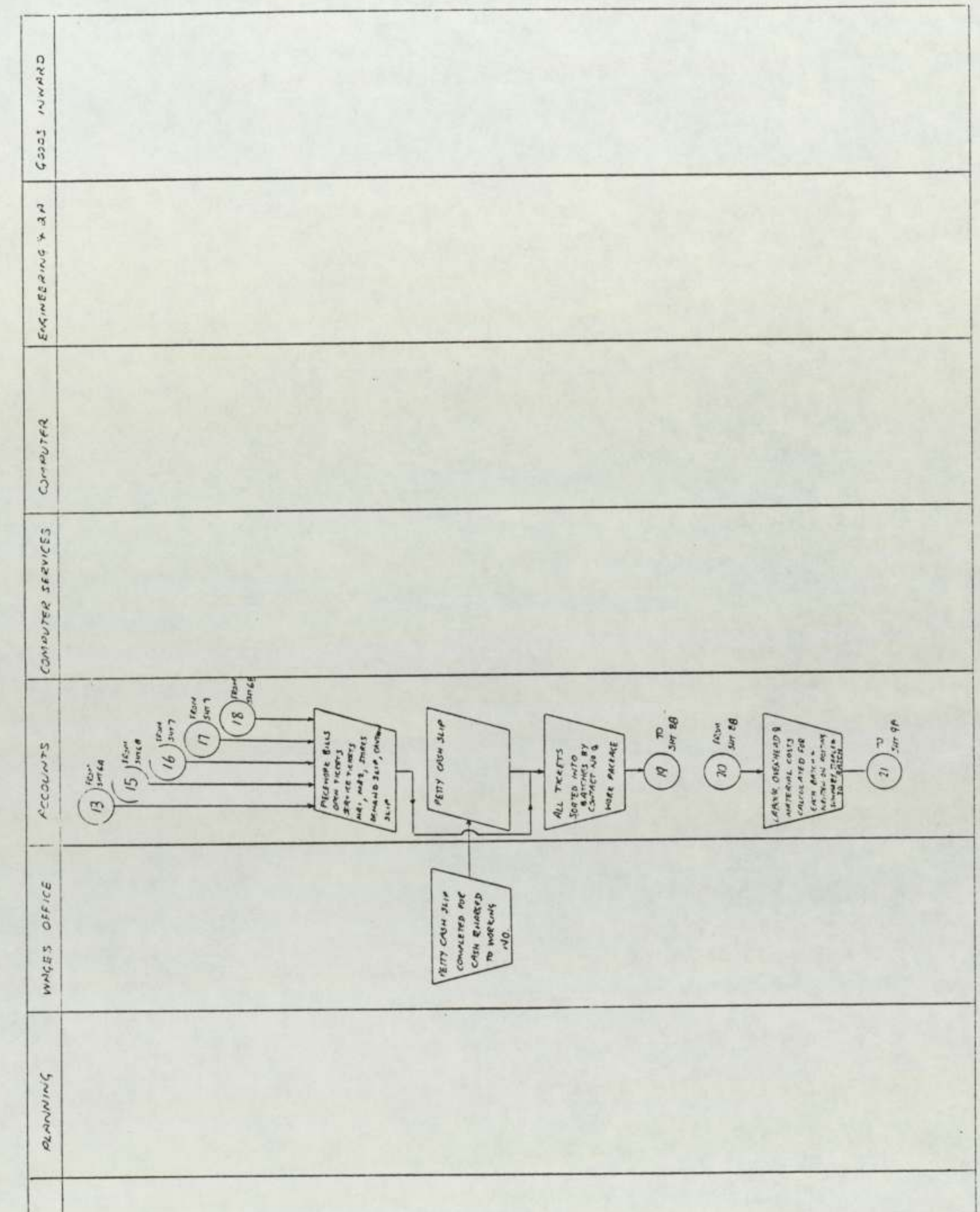
APPENDIX D


SHEET 6B
PURCHASING
11
FROM SHT 6A
ADVICE NOTE
DATA INPUT TO PURCHASING SYSTEM
12
TO SHT 6A
STORES
STORES DEMAND SLIP
15
TO SHT 6A
CANTEEN
CANTEEN SLIP
18
TO

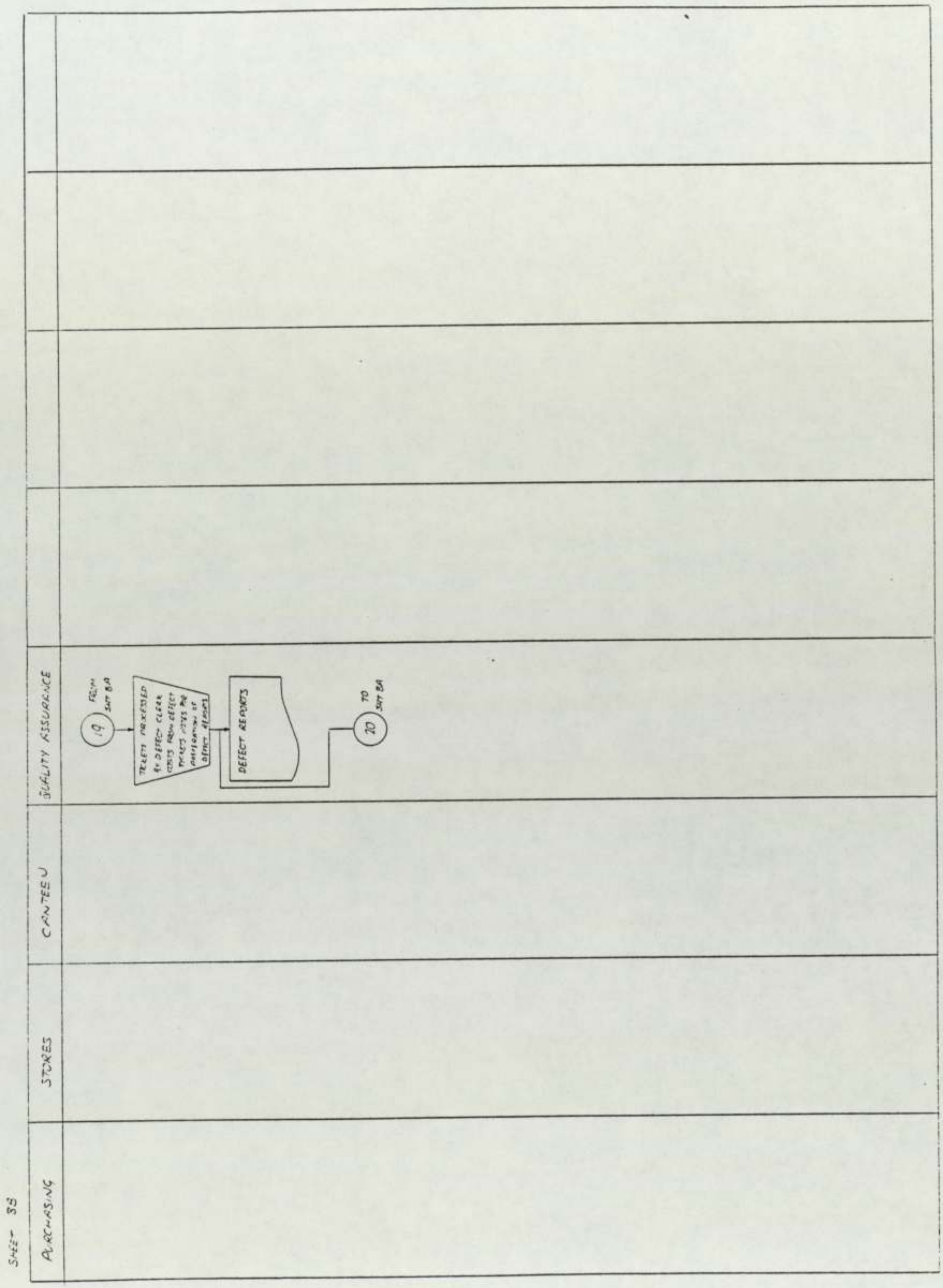
APPENDIX D

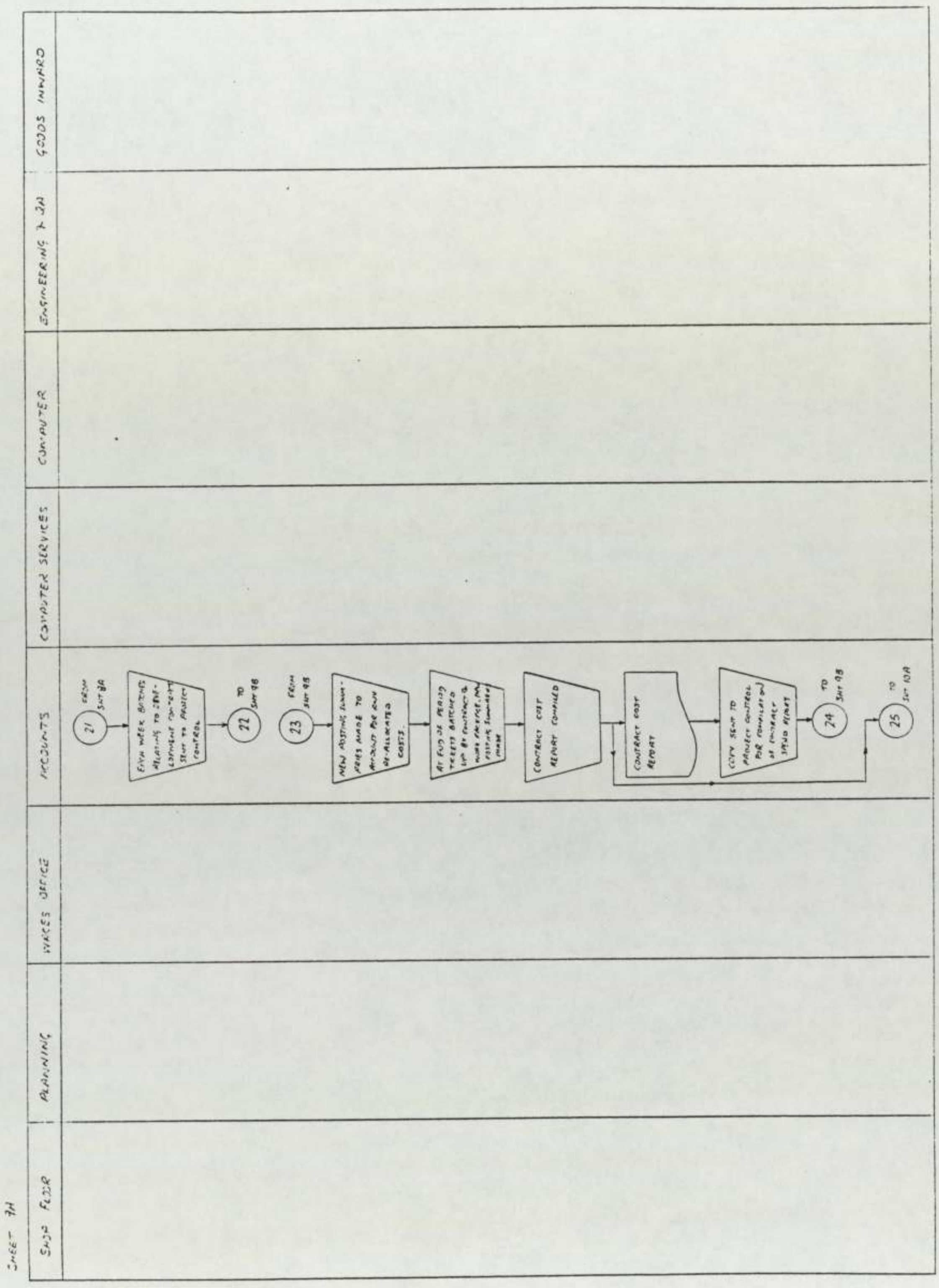

SHEET 7
SHOP FLOOR
PLANNING
WAGES OFFICE
ACCOUNTS
COMPUTER SERVICES
COMPUTER
GOODS INWARD
14
MATERIAL RECEIPTS (MR1)
16
17
TO SHT 8A

APPENDIX D

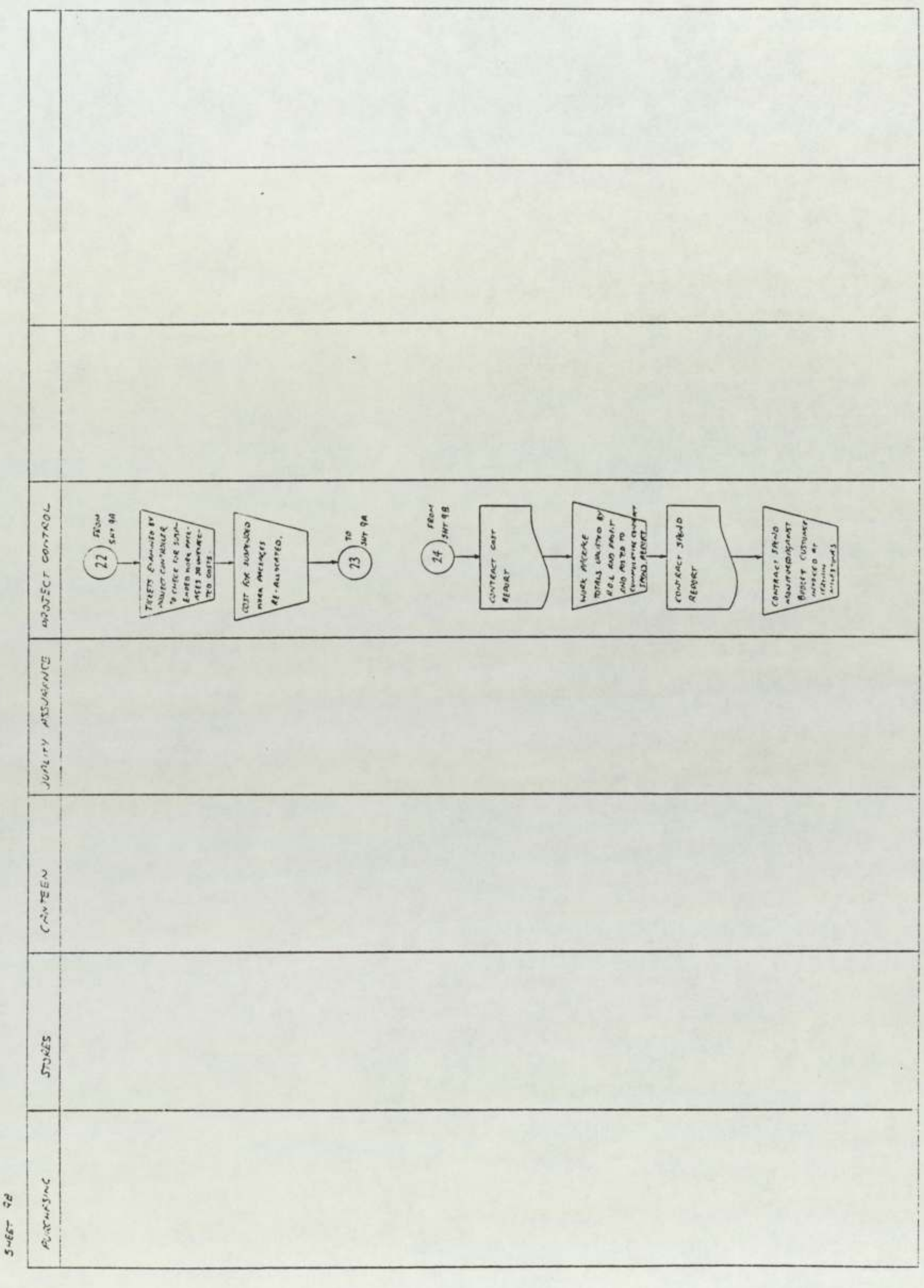

SHEET 8A
SHOP FLOOR
PLANNING
WAGES OFFICE
ACCOUNTS
COMPUTER SERVICES
COMPUTER
GOODS INWARD
PETTY CASH SLIP
ALL TICKETS SORTED INTO BATCHES BY CONTRACT NO & WORK PACKAGE

APPENDIX D

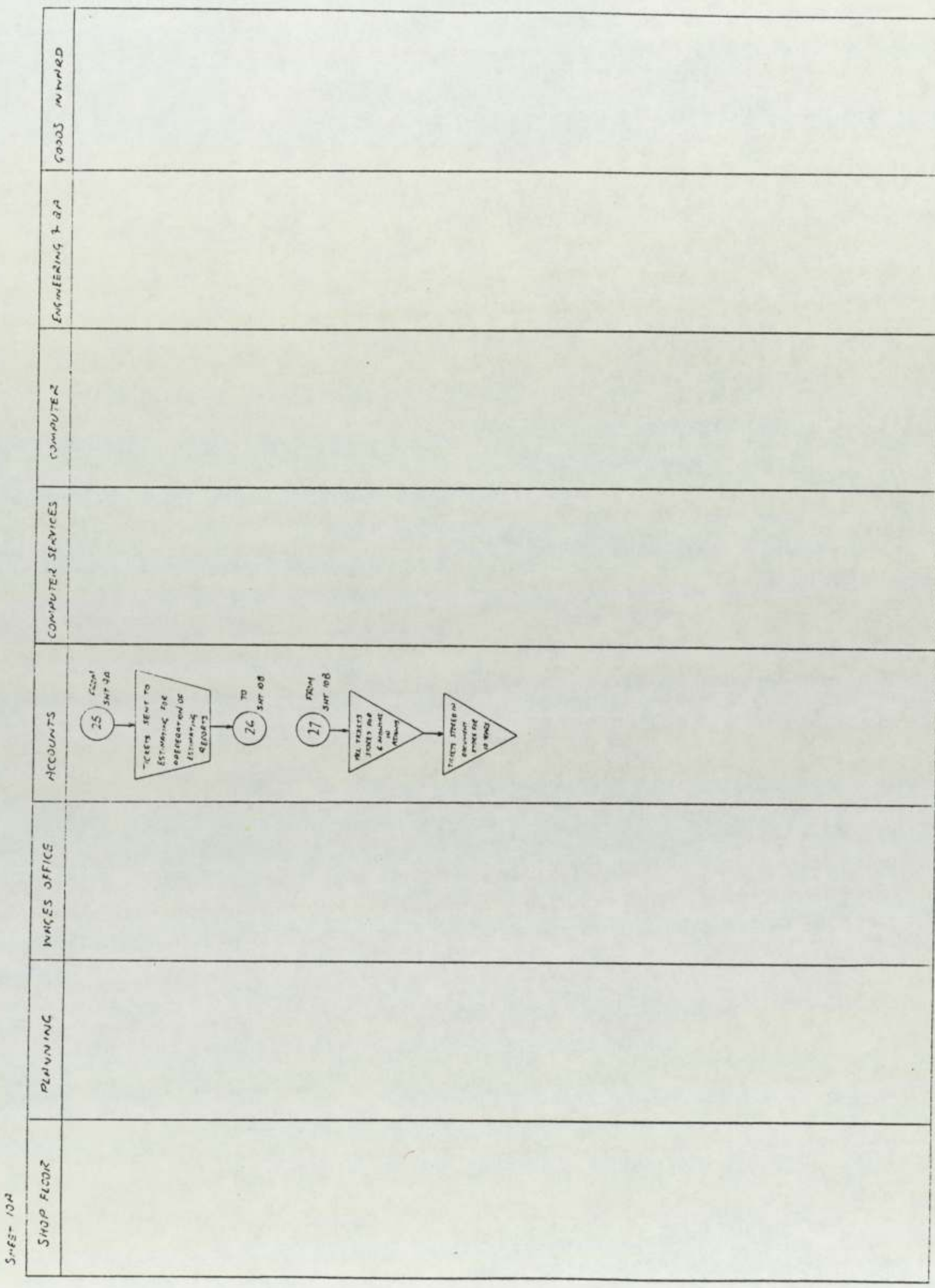

PURCHASING
STORES
CANTEEN
QUALITY ASSURANCE
19
FROM SHT 8A
DEFECT REPORTS
20
TO SHT 8A


GOODS INWARD
COMPUTER
COMPUTER SERVICES
ACCOUNTS
WAGES OFFICE
PLANNING
CONTRACT COST REPORT COMPILED
CONTRACT COST REPORT

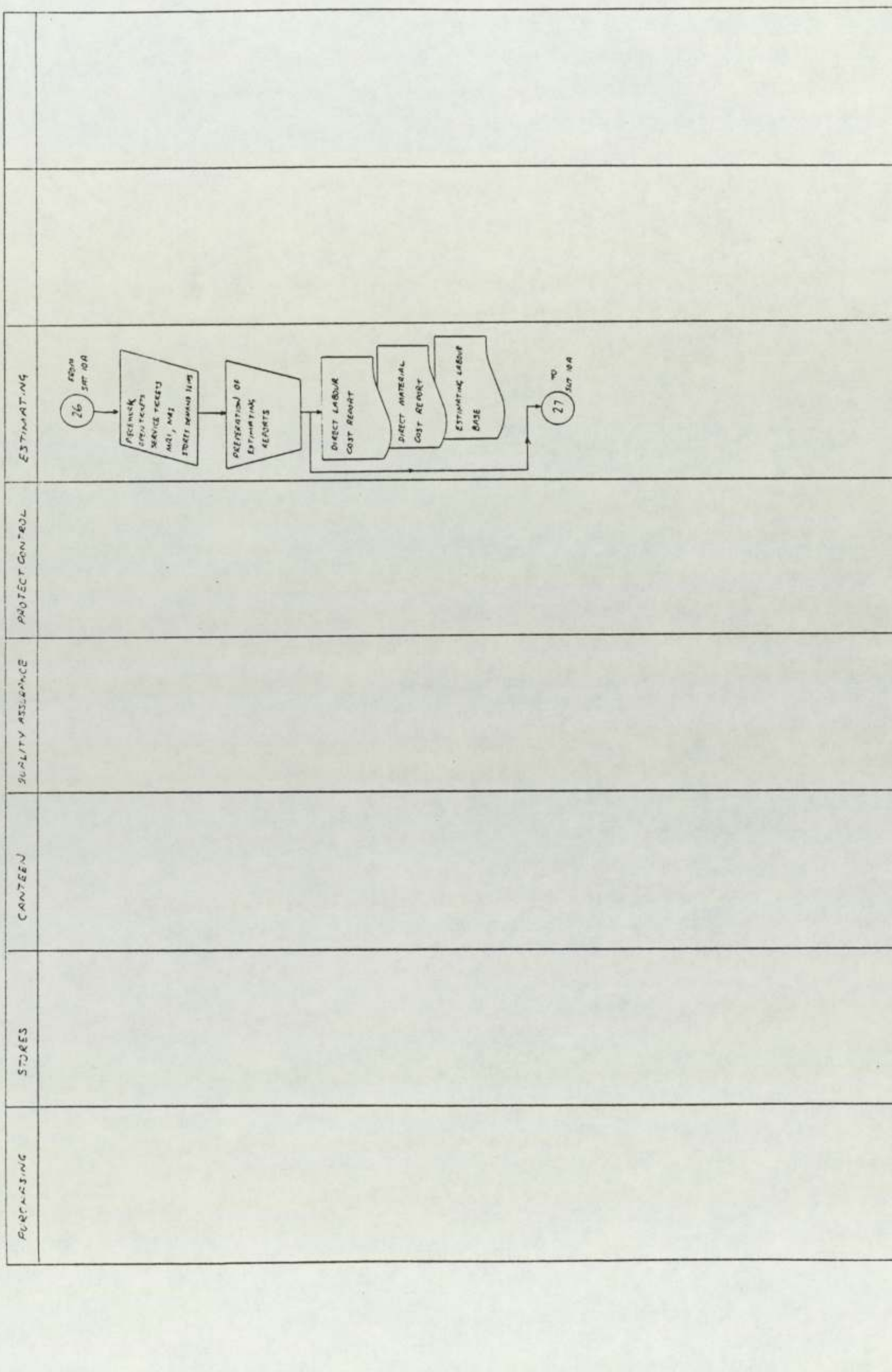
APPENDIX D


SHEET 9B
PURCHASING
STORES
CANTEEN
QUALITY ASSURANCE
PROJECT CONTROL
22 FROM SHT 9A
COST FOR SUSPENDED WORK PACKAGES RE-ALLOCATED.
23 TO SHT 9A
24 FROM SHT 9B
CONTRACT COST REPORT
CONTRACT SPEND REPORT

APPENDIX D


SHOP FLOOR
PLANNING
WAGES OFFICE
ACCOUNTS
COMPUTER SERVICES
COMPUTER
GOODS INWARD
25
26
27

APPENDIX D


PURCHASING
STORES
CANTEEN
QUALITY ASSURANCE
PROJECT CONTROL
ESTIMATING
26
PREPARATION OF ESTIMATING REPORTS
DIRECT LABOUR COST REPORT
DIRECT MATERIAL COST REPORT
ESTIMATING LABOUR BASE
27

APPENDIX E

E. ANALYSIS OF TICKETS USED IN MANUAL CCS.

E.1 Piecework Application.

PIECEWORK APPLICATION

DRAWING No.	Item No.	Issue	Order No.

NAME	CLOCK No.	RATE

QUANTITY	DESCRIPTION & MATERIAL

OPERATION No.	OPERATION	TOTAL HRS WORKED

20 30 40 50 60 70 80 90 100 200 1 2 3 4 5 6 7 8 9 10	INSPECTION

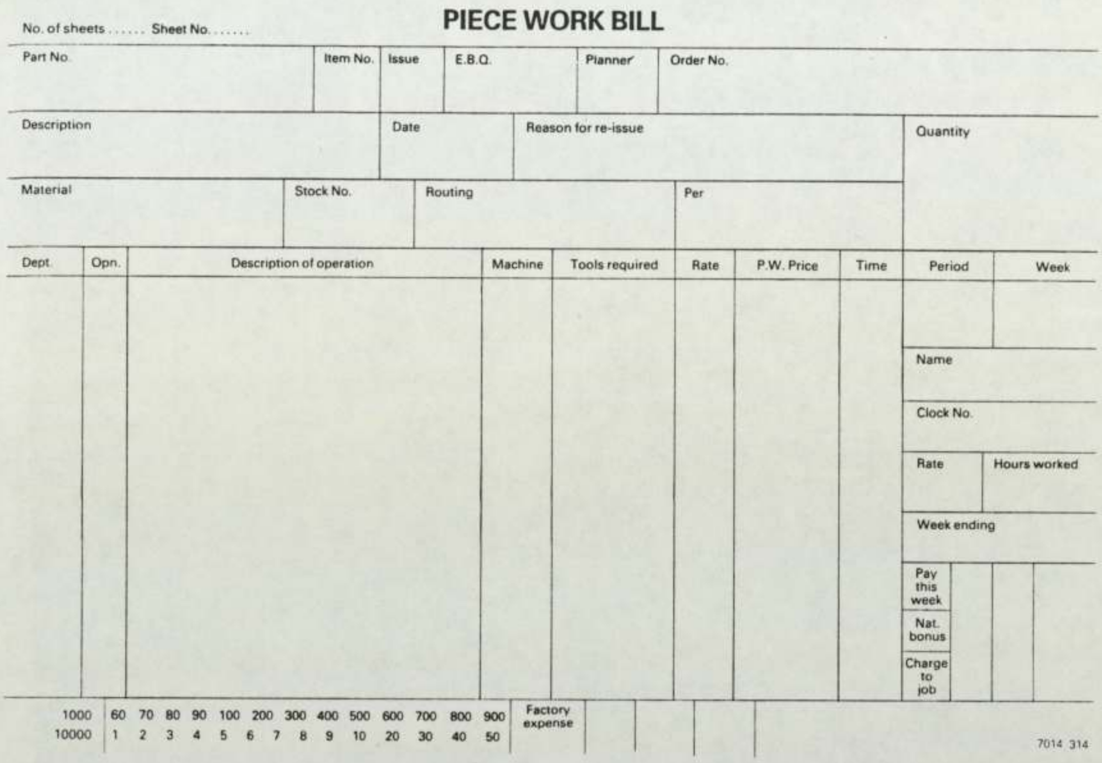
Used by : Shop floor operators.

Intended use : Time booked to major contracts.

Actual use : Time booked to major contracts.

Box Label	Actual Use
DRAWING No.	Drawing number
Item No.	Drawing item number
Issue	Drawing issue letter
Order No.	Working number
NAME	Operators initials and surname
CLOCK No.	Operators department and clock number
RATE	NOT IN USE
QUANTITY	Quantity
DESCRIPTION & MATERIAL	Drawing title, component serial nos.
OPERATION No.	Operation number/s
OPERATION	Overspill for operation numbers
TOTAL HRS WORKED	Hours worked on specified operation/s
20 30 40 ...	NOT IN USE
INSPECTION	NOT IN USE

E.2 Piece Work Bill.


No. of sheets ...... Sheet No. ......

PIECE WORK BILL

Part No. | Item No. | Issue | E.B.Q. | Planner | Order No.

Description | Date | Reason for re-issue | Quantity

Material | Stock No. | Routing | Per

Dept. | Opn. | Description of operation | Machine | Tools required | Rate | P.W. Price | Time | Period | Week

Name

Clock No.

Rate | Hours worked

Week ending

Pay this week

Nat. bonus

Charge to job

1000 | 60 70 80 90 100 200 300 400 500 600 700 800 900 | Factory expense

10000 | 1 2 3 4 5 6 7 8 9 10 20 30 40 50

7014 314

Used by : (i) Shop floor operators, (ii) Planning clerk.

Intended Use : (i) Time booked to major contracts (planning clerk only), (ii) Time booked to minor contracts (shop floor operators).

Actual use : (i) Time booked to major contracts (planning clerk), (ii) Time booked to minor contracts (shop floor operators), (iii) Time booked to departmental overheads (shop floor operators).

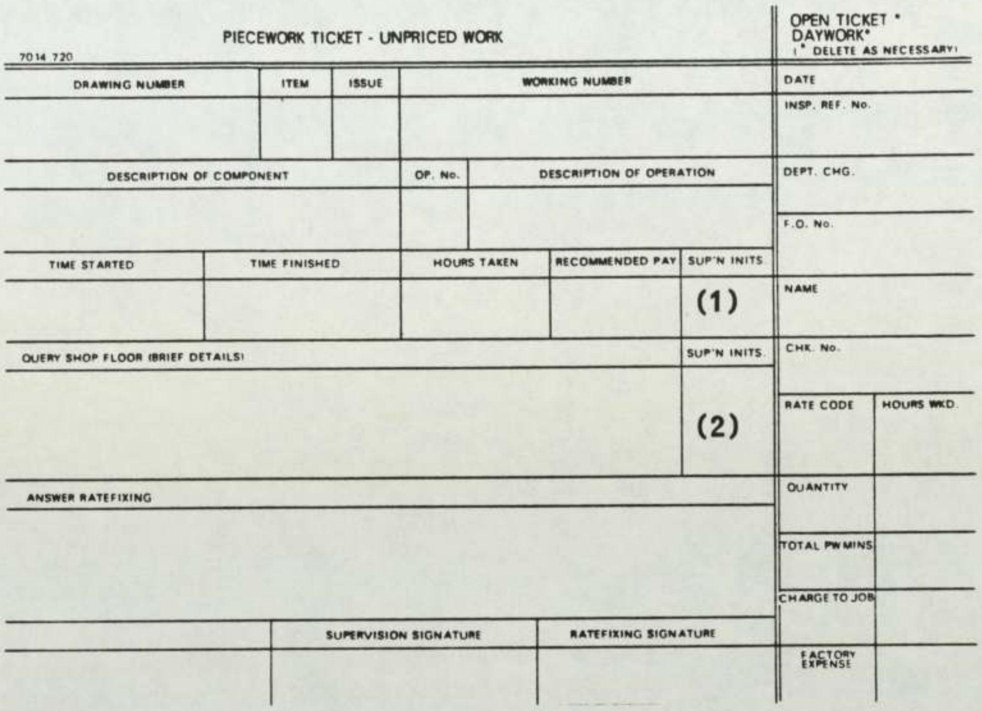
Box Label	Actual Use
No. OF SHTS.	NOT IN USE
SHT. No.	NOT IN USE
Part No.	Drawing number
Item No.	Drawing item number
Issue	Drawing issue letter
E.B.Q	NOT IN USE
Planner	NOT IN USE
Order No.	Working number
Description	Drawing title
Date	Week ending date
Reason For Re-Issue	NOT IN USE
Quantity	Quantity
Material	NOT IN USE

APPENDIX E

Box Label	Actual Use
Stock No.	NOT IN USE
Routing	NOT IN USE
Per	NOT IN USE
Dept.	NOT IN USE
Opn.	Operation number/s
DESCRIPTION OF OPERATION	Operation description, component serial numbers,foremans signature
Machine	NOT IN USE
Tools Required	NOT IN USE
Rate (column)	NOT IN USE
P.W. Price	NOT IN USE
Time	NOT IN USE
Period	NOT IN USE
Week	NOT IN USE
Name	Operators initials and surname
Clock No.	Operators department and clock number
Rate (box)	NOT IN USE
Hours Worked	Hours worked on specified operation/s
Week Ending	NOT IN USE
Pay This Week	NOT IN USE
Nat. Bonus	NOT IN USE
Charge to Job	Labour value (calculated by Accounts
60 70 80 ...	NOT IN USE
Factory Expense	Overhead value (calculated by Accounts Department)

APPENDIX E

E.3 Open Ticket (Piecework Ticket - Unpriced Work).


7014 720

PIECEWORK TICKET - UNPRICED WORK

OPEN TICKET * DAYWORK* (* DELETE AS NECESSARY)

DRAWING NUMBER | ITEM | ISSUE | WORKING NUMBER | DATE

INSP. REF. No.

DESCRIPTION OF COMPONENT | OP. No. | DESCRIPTION OF OPERATION | DEPT. CHG.

F.O. No.

TIME STARTED | TIME FINISHED | HOURS TAKEN | RECOMMENDED PAY | SUP'N INITS (1)

NAME

QUERY SHOP FLOOR (BRIEF DETAILS) | SUP'N INITS (2)

CHK. No.

RATE CODE | HOURS WKD.

ANSWER RATEFIXING

QUANTITY

TOTAL PW MINS

CHARGE TO JOB

SUPERVISION SIGNATURE | RATEFIXING SIGNATURE

FACTORY EXPENSE

Used by : Shop floor operators.

Intended use : Time booked to rectification work.

Actual use : Time booked to rectification work.

Box Label	Actual Use
DRAWING NUMBER	Drawing number
ITEM	Drawing item number
ISSUE	Drawing issue letter
WORKING NUMBER	Working number
DESCRIPTION OF COMPONENT	Drawing title
OP. No.	Operation number/s
DESCRIPTION OF OPERATION	Operation description
TIME STARTED	NOT IN USE
TIME FINISHED	NOT IN USE
HOURS TAKEN	NOT IN USE
RECOMMENDED PAY	NOT IN USE
SUP'N INITS (1)	NOT IN USE
QUEERY SHOP FLOOR ..	Overspill for operation numbers, operation descriptions, component serial numbers.
SUP'N INITS (2)	NOT IN USE

APPENDIX E

Box Label	Actual Use
ANSWER RATEFIXING	NOT IN USE
SUPERVISION SIGNATURE	Foremans signature
RATEFIXING SIGNATURE	NOT IN USE
DATE	Week ending date
INSP. REF. No.	Inpsectors reference number
DEPT. CHG.	NOT IN USE
F.O. No.	NOT IN USE
NAME	Operators initials and surname
CHK No.	Operators department and clock number
RATE CODE	NOT IN USE
HOURS WKD.	Hours worked on specified operation/s
QUANTITY	Quantity
TOTAL PW MINS	NOT IN USE
CHARGE TO JOB	Labour value (calculated by Accounts Department)
FACTORY EXPENSE	Overhead value (calculated by Accounts Department)

APPENDIX E

E.4 Waiting Ticket (Weekly Waiting Time Record).

WEEKLY WAITING TIME RECORD

NAME	CLOCK No	HOURLY RATE	WEEK ENDING

FOREMANS SIGNATURE	REASON FOR WAITING	DATE	CLOCK READING	OFFICE USE ONLY ELAPSED TIME HOURS	MINS	PAYMENT £	p	F.O. CHARGE No.
			Start Finish					
			Start Finish					
			Start Finish					
			Start Finish					
			Start Finish					
			Start Finish					
			TOTALS					**(1)**

7014 666

Used by : Shop floor operators.

Intended use : (i) Waiting time booked to one waiting overhead code only.

Actual use : (i) Waiting time booked to one overhead code, (ii) Waiting time booked to more than one overhead code.

Box Label	Actual Use
NAME	Operators initials and surname
CLOCK No.	Operators department and clock number
HOURLY RATE	NOT IN USE
WEEK ENDING	Week ending date
FOREMANS SIGNATURE	Foremans signature
REASON FOR WAITING	Brief description of reason
DATE	Date
CLOCK READING - Start	NOT IN USE
CLOCK READING - Finish	NOT IN USE
ELAPSED TIME HOURS	Whole hours spent waiting
ELAPSED TIME MINUTES	Fraction of hours spent waiting
PAYEMENT £	NOT IN USE
PAYEMENT p	NOT IN USE
F.O. CHARGE No. (1)	Labour cost (charged to overheads)
TOTALS	Total hours for week

APPENDIX E

E.5 Diversion Ticket (Diversion Time Record).

DIVERSION TIME RECORD

7014 731

NAME	CLOCK No.	HOURLY RATE	WEEK ENDING

FOREMAN'S SIGNATURE	REASON FOR DIVERSION	REC PAY	DATE	CLOCK READING	OFFICE USE ONLY				F.O. CHARGE No.
					ELAPSED TIME		PAYMENT		
					HOURS	MINS	£	p	
				START					
				FINISH					
				START					
				FINISH					
				START					
				FINISH					
				START					
				FINISH					
				START					
				FINISH					
				START					
				FINISH					
				TOTALS					(1)

* CHARGES TO MORE THAN ONE DEPARTMENT MUST NOT APPEAR ON SAME TICKET

Used by : Shop floor operators.

Intended use : (i) Diversion time booked to one waiting overhead code only.

Actual use : (i) Diversion time booked to one overhead code, (ii) diversion time booked to more than one overhead code.

Box Label	Actual Use
NAME	Operators initials and surname
CLOCK No.	Operators department and clock number
HOURLY RATE	NOT IN USE
WEEK ENDING	Week ending date
FOREMANS SIGNATURE	Foremans signature
REASON FOR WAITING	Brief description of reason
DATE	Date
CLOCK READING - Start	NOT IN USE
CLOCK READING - Finish	NOT IN USE
ELAPSED TIME HOURS	Whole hours spent diverted
ELAPSED TIME MINUTES	Fraction of hours spent diverted
PAYEMENT £	NOT IN USE
PAYEMENT p	NOT IN USE
F.O. CHARGE No. (1)	Labour cost (charged to overheads)
TOTALS	Total hours for week

E.6 Service Ticket.

GEC MACHINES LIMITED, BRADFORD **SCD SERVICE TICKET**

SCD CHARGE No. ....

Date .... Signed Received ....

COSTING DETAILS	Unit	Rate	Value

ISSUING DEPARTMENT ....

Used by : Engineers, Draughtsmen, Quality Engineers, Inspectors, Laboratory Technicians, Production Engineers, Production Controllers.

Intended use : (i) Time booked to a working number which is not work from a planning card, (ii) Time booked to departmental overheads.

Actual use : (i) Time booked to a working number which is not work from a planning card, (ii) Time booked to a working number which is work from a planning card, (iii) Time booked to departmental overheads.

Box Label	Actual Use
CHARGE No.	Working number, or overhead code
Date	Week ending date
Signed Received	Signature of employee
Unit	Hours worked
Rate	NOT IN USE
Value	Labour cost, overhead cost. (Overhead cost only calculated for working numbers)
ISSUING DEPARTMENT	Employee's department
Blank Box	See notes below

APPENDIX E

Notes.

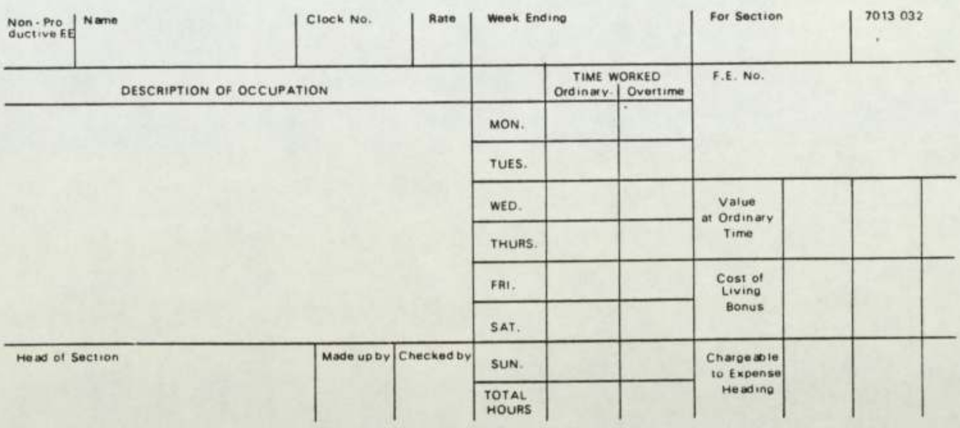
(i) Generally used for brief description of the work done or the overhead booked to.

(ii) In the case of Inspectors and Laboratory Technicians, who used the ticket to book time to work from a planning card, then the following information should have been written somewhere in or above the blank box :- drawing number, drawing item, drawing issue, operation number/s, operation description/s, component serial numbers, and quantity.

(iii) Anyone doing rectification work should have quoted the inspectors reference number somewhere in or above the blank box.

APPENDIX E

E.7 Wage Adjustment Slip.



Used by : Accounts Department.

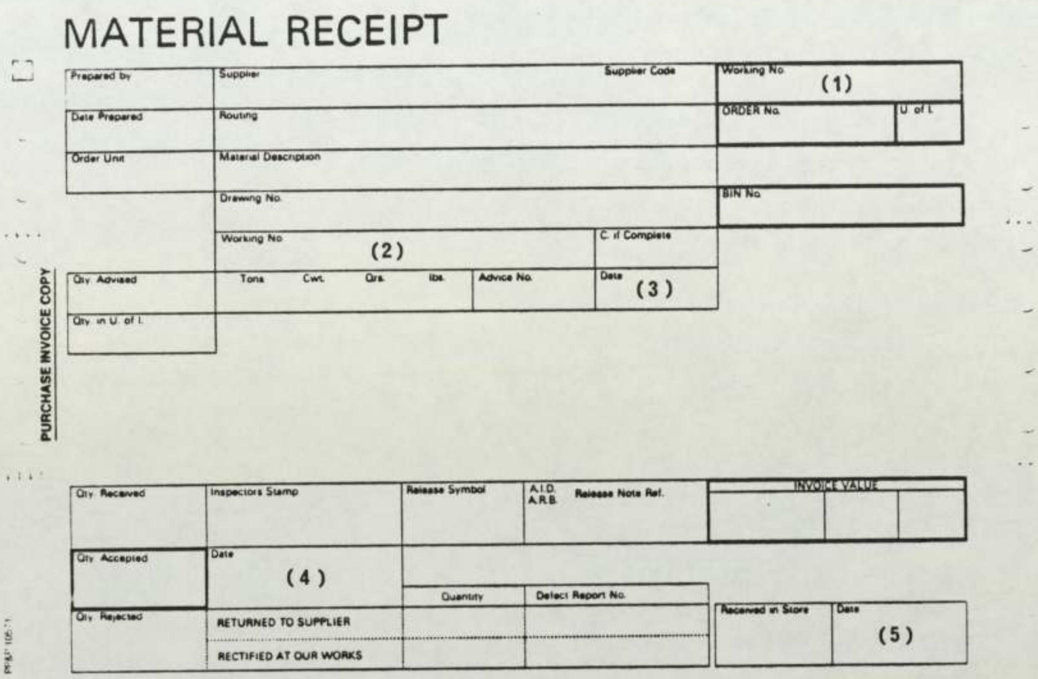
Intended use : Wage adjustments.

Actual use : Wage adjustments.

Box Label	Actual Use
Non-Productive FE	NOT IN USE
Name	Operators initials and surname (Certain codes only)
Clock No.	Department (always), employees clock Number (certain codes only).
Rate	NOT IN USE
Week Ending	Week ending date
For Section	NOT IN USE
DESCRIPTION OF OCCUPATION	Brief description of overhead code
Head of Section	NOT IN USE
Made up by	Accounts clerk signature
Checked by	NOT IN USE
TIME WORKED - Ordinary	NOT IN USE
TIME WORKED - Overtime	NOT IN USE
TOTAL HOURS	Hours (certain codes only)
F.E. No.	Overhead code
Value at Ordinary Time	NOT IN USE
Cost of Living Bonus	NOT IN USE
Chargeable to Expense Heading	Labour cost (Charged to overheads)

APPENDIX E

E.8 Pink Material Receipt (MR1).


MATERIAL RECEIPT

PURCHASE INVOICE COPY

Prepared by
Supplier
Supplier Code
Working No (1)
Date Prepared
Routing
ORDER No.
U of I.
Order Unit
Material Description
Drawing No.
BIN No.
Working No (2)
C. if Complete
Qty. Advised
Tons Cwt. Qrs. lbs.
Advice No.
Date (3)
Qty. in U. of I.
Qty. Received
Inspectors Stamp
Release Symbol
A.I.D. A.R.B.
Release Note Ref.
INVOICE VALUE
Qty. Accepted
Date (4)
Quantity
Defect Report No.
Qty. Rejected
RETURNED TO SUPPLIER
RECTIFIED AT OUR WORKS
Received in Store
Date (5)

Used by : Purchasing.

Intended Use : (i) Materials charged to a working number, (ii) Materials charged to departmental overheads.

Actual use : (i) Materials charged to a working number, (ii) Materials charged to departmental overheads.

Box Label	Actual Use
Prepared by	Purchasing Clerks initials
Supplier	Suppliers name
Supplier Code	Suppliers code
Working No. (1)	Working number, departmental overhead code
Date Prepared	Date material receipt is prepared
Routing	Deparetment to which material is to
Order No.	Purchase order number
U. of 1.	Quantity ordered in units of one
Order Unit	Order unit
Material Description	Material description
Drawing No.	Drawing number
Bin No.	Bin number (stock items only)
Working No. (2)	Inspectors reference number

APPENDIX E

Box Label	Actual Use
C. if Complete	C entered if order has been completed
Qty Advised	Quantity advised by supplier
Tons Cwt ...	Order unit
Advice No.	Advice note number
Date (3)	Date material delivered
Qty in U of 1.	Quantity advised in units of one
Qty Received	Quantity actually received
Inspectors Stamp	Inpspectors signature
Inspectors symbol	Inspectors stamp
Release Note Reference	Release note reference number
INVOICE VALUE	Material cost
Qty Accepted	Quantity accdepted after inspection
Date (4)	Date inspected
Qty Rejected	Quantity rejected
RETURNED TO SUPPLIER - Quantity	Quantity returned to supplier
RETURNED TO SUPPLIER - Defect Report No.	Inspectors reference number
RECTIFIED AT WORKS - Quantity	Quantity rectified at works
RECTIFIED AT WORKS - Defect Report No.	Inspectors reference number
Recieved in Store	Storemans signature
Date (5)	Date received in store

E.9 White Material Receipt (MR2).

MATERIAL RECEIPT *Serial No.*

Date .... Supplier ....

Purchase Order No. .... Working No. .... or Stock A / c. No. ....

	Price	£	p

COST ALLOCATION COPY

ROUTING

Receipt Made Out By ....

7014 110

Used by : Accounts.

Intended use : (i) Sub-contract work, services and miscellaneous invoices charged to working number, (ii) Sub-contract work, services and miscellaneous invoices charged to overhead.

Actual use : (i) Sub-contract work, services and miscellaneous invoices charged to working number, (ii) Sub-contract work, services and miscellaneous invoices charged to overhead.

Box Label	Actual Use
Date	Date
Supplier	Suppliers name
Purchase Order No.	Purchase order number
Working No.	Working number, departmental overhead code
Stock A/c No.	NOT IN USE
Box	Description of service, item etc.
Price	NOT IN USE
£.p	Cost
ROUTING	NOT IN USE
Reciept Made Out By	Accounts clerk signature

E.10 Petty Cash Slip.

DATE	VOUCHER NO.	NAME	WORKING NO.	AMOUNT

MPB 10169

PETTY CASH EXPENDITURE

Used by : Wages office.

Intended use : Cash charged to a working number.

Actual use : Cash charged to a working number.

Box Label	Actual Use
DATE	Date cash withdrawn
VOUCHER No.	Petty cash slip number
NAME	Name of person who withdrew cash
WORKING No.	Working number
AMOUNT	Amount of cash withdrawn